INSTILLING ENVIRONMENTAL SUSTAINABILITY AMONG FIRST YEAR ENGINEERING STUDENTS USING COOPERATIVE PROBLEM-BASED LEARNING APPROACH

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Specially dedicated to my beloved FAMILY;

Mother : Hjh Zawiah binti Johari

Husband : Jamaludin bin Mohamad Yatim

Children : SitiNadiah, Muhammad Syahir, Nurulaina, Anis Hazwani, Nur Asilah, Ain Najihah and Aida Amalina

Son in Law : Muhammad Saifullah bin Zulkarnain

Granddaughter :Naelah Al-Farafisyah

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In the name of Allah, the Most Beneficient, the Most Merciful.

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ABSTRACT

Environmental sustainability is an issue that is not new but is rather complex to define. Quality teaching has been identified as the most effective lever to transform engineering education into delivering the related outcomes for students, who would be engineers of the future. The purpose of this study is to investigate the impact of Cooperative Problem-based Learning (CPBL) in instilling students' knowledge and promoting behaviour changes associated with environmental sustainability. This study consists of two phases. In phase one, a quantitative study was conducted to investigate the level of students' prior knowledge and practice on pro-environmental behaviour among 316 first year students from three engineering faculties, prior to admission to the university. These were measured using a set of questionnaire which was adapted from several environmental attitude inventories after it was statistically tested. In phase two, a mixed method research was carried out to investigate the implementation of CPBL towards students' knowledge and behaviour changes associated with environmental sustainability, as featured in the syllabus of the first-year 'Introduction to Engineering' course at one of engineering faculties at Universiti Teknologi Malaysia. 63 first year chemical engineering students participated in this phase. In the quantitative study, the questionnaire in phase one was administrated before and upon completion of the course. Descriptive and inferential analyses were conducted using Statistical Package for the Social Science (SPSS) software. The statistical results showed that most of the engineering students had low to moderate level of knowledge and effort to practice sustainable lifestyles before the course and increased the level at the end of the course. Furthermore, a qualitative study was also performed to investigate how the use of problem and learning environment in CPBL enhanced students' knowledge and behaviour using thematic analysis. The results showed the convergence of the four domains of knowledge (declarative, procedural, effectiveness and social) among the students. Supports from the CPBL learning environment had significantly changed students' perceptions associated with environmental sustainability on knowledge, skills, responsibility and readiness to be engineers in the future. Finally, a framework for teaching environmental sustainability through formal education in engineering which is able to instil students' knowledge and promote behaviour associated with environmental sustainability was recommended for educators.

ABSTRAK

Kelestarian alam sekitar bukanlah isu yang baru tapi agak kompleks untuk ditakrifkan. Pengajaran yang berkualiti merupakan cara yang paling berkesan bagi transformasi pendidikan kejuruteraan dalam menyampaikan hasil pembelajaran berkaitan kelestarian kepada pelajar yang bakal menjadi jurutera pada masa hadapan. Kajian ini dilaksanakan untuk menyelidik impak Pembelajaran Berasaskan-Masalah secara Koperatif, atau *Cooperative Problem-Based Learning* (*CPBL*) dalam menerapkan pengetahuan dan perubahan tingkahlaku pelajar ke arah kelestarian alam sekitar. Kajian ini terdiri daripada dua fasa. Dalam fasa pertama, kajian kuantitatif dijalankan bagi mengenal pasti tahap awal pengetahuan pelajar dan amalan tingkahlaku pro-persekitaran ke atas 316 pelajar tahun satu dari tiga fakulti kejuruteraan sebelum mereka memasuki universiti. Ianya diukur menggunakan satu set soal selidik yang diadaptasi dari beberapa inventori sikap terhadap persekitaran yang telah diuji secara statistik. Dalam fasa kedua, kajian dengan kaedah gabungan dijalankan untuk menyelidik perlaksanaan *CPBL* terhadap pengetahuan dan perubahan tingkahlaku pelajar mengenai kelestarian alam sekitar, mengikut keperluan silabus kursus tahun pertama '*Introduction to Engineering*' di salah satu fakulti kejuruteraan di Universiti Teknologi Malaysia. Seramai 63 orang pelajar telah menyertai kajian ini. Bagi kajian kuantitatif, format soal selidik dalam fasa pertama telah diguna dan diedarkan kepada pelajar sebelum dan selepas menjalani kursus. Analisis diskriptif dan inferensi dikendalikan menggunakan perisian *Statistical Package for the Social Science (SPSS)*. Keputusan statistik menunjukkan bahawa kebanyakan pelajar berada pada tahap rendah hingga ke sederhana sebelum mengikuti kursus dan berlaku peningkatan di akhir kursus tersebut. Selanjutnya, kajian kualitatif juga dijalankan untuk mengkaji bagaimana penggunaan masalah dan persekitaran pembelajaran melalui *CPBL* dapat menerapkan pengetahuan dan tingkahlaku pelajar menggunakan analisis tematik. Hasil kajian telah mengesahkan penumpuan empat domain utama pengetahuan (pengakuan, prosedur, keberkesanan dan sosial) dalam kalangan pelajar. Sokongan terhadap persekitaran pembelajaran *CPBL* telah jelas mengubah persepsi pelajar terhadap kelestarian alam sekitar dari segi pengetahuan, kemahiran, tanggungjawab dan kesediaan diri sebagai jurutera pada masa hadapan. Pada akhir kajian, satu kerangka untuk pengajaran kelestarian alam sekitar bagi pendidik dalam kejuruteraan yang berbentuk pendidikan formal untuk menerapkan pengetahuan dan perubahan tingkahlaku pelajar ke arah kelestarian alam sekitar telah dicadangkan.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Educating engineering students on sustainable development (SD) has become a major concern in the 21st century society. Facing with unsustainable scenarios such as deteriorating urban infrastructures, environmental degradation, climate change and natural disasterswill challenge the skills and creativity of engineers. Parallel with this, a number of declarations, charters, partnerships and initiatives from several agencies at national and international levels have been designed to provide guidelines of frameworks for all levels of education and society to overcome issues concerning sustainability (Lozano *et al.*, 2013; Foo, 2013). Universities as a higher educational institution has a role in creating knowledge, place to reform and develop students as global learners(Anderberg *et al*., 2009). Therefore, educators are highly responsible to integrate knowledge on sustainability through effective teaching and learning approaches,to ensure that the needs of present and future generations are better understood, addressed and built upon. In accordance with the implementation of outcome-based education, student centred learning has been identified as an effective way of teaching and learning approach to teacher-centred learning.

In contrast, recent studies found that the level of knowledge on sustainability and the degree of commitment in practicing sustainability among Malaysians is low(Ahmad, 2010; Aminrad *et al.*, 2013; Karpudewan and Ismail, 2012; Marzuki, 2009). Therefore, more researches and efforts are required to overcome the issues. In view of this finding, the aim of this study is to propose a framework of student-centred learning approach using Cooperative Problem-based Learning (CPBL) to instil knowledge onsustainability and practicing pro-environmental behaviour among engineering students. This chapter discusses the background of the study, problem statement and significance of the study. In order to achieve the aims of this study, three research objectives which consist of seven research questions are proposed. The theoretical and conceptual framework used are also explained the significance of the study.

1.2 Background of the Study

Sustainable Development (SD) is a concept of resource use that aims at meeting human needs while preserving the environment for the needs of present and the future. The term SD has been popularized in “Our Common Future” of the Brundtland Report published by the World Commission on Environment and Development (WCED) in 1987. This is the starting point where issues related to SD have been wide spread around the world. In addition, the United Nations Decade of Education for Sustainable Development (DESD, 2005-2014) has been declared during the World Summit on Sustainable Development in Johannesburg, South Africa in 2002. It becomes a global platform which seeks to embed sustainable development into all learning spheres, such as reorient education and develop initiatives that specifically focused on education for sustainable development (ESD) (Lozano *et al*., 2013). The importance of ESD in reducing the impact on the social, economic and environmental burdens by efficient use of the natural resources, reducing energy consumption, reducing emissions, minimizing waste, more efficient land use and creating better employment conditions has long been realised (Segalas *et al*., 2008; Fuchs, 2012). Unfortunately, at the same time, society, economy and the environment are faced with the challenges of economic crises, climatic change and natural disasters (Mader, 2012). It has been found that the major contributor to the unsustainable future is rooted in human behaviour (Steg and Vlek, 2009; Karpudewan *et al*., 2011).

University as a Platform for Sustainability Driver. University as a higher educational institution has a power in creating knowledge, developing students competencies, integrating sustainability in education, conducting research and promoting sustainability issues to the society (Larsen *et al.*, 2013; Lozano and Young, 2012; Waas *et al.*, 2010). Weber *et al.* (2014) highlighted that incorporating environmental sustainability into engineering education is vital to both individual engineering students' success and to the profession as a whole.Universities have all the expertise needed to develop an intellectual and conceptual framework to achieve this goal. Cortese (1992) also emphasizes that universities bear profound responsibilities for increasing awareness, knowledge, technology, and tools to create an environmentally sustainable future. He also stressed that higher educational institutions must play a strong role in education, research, policy development, information exchange and community outreaching. In the same view, Lozano *et al*. (2013) also highlighted four important elements for universities to become sustainability leaders and change drivers. Universities must ensure that i) the needs of present and future generations be better understood, addressed and built upon; ii) leaders and staff must be empowered to catalyze and implement new paradigms, introducing SD into all courses and curricula and all other elements of university activities; iii) proper academic recognition of the importance of multi-disciplinary and trans-disciplinary teaching, research and community outreach for speeding up the societal transformation; and iv) need to become more proactive in creating new and discarding old paradigms via reintegrating science and arts in a trans-disciplinary way and helping societies to become more sustainable.

In realizing this interest, a number of declarations have been designed to provide guidelines or frameworks for higher educational institutions to better embed sustainability into their systems. For instance, the Luneburg Declaration in 2001 highlights nine outcomes regarding the role of teachers but the most important were: (i) to ensure that the orientation of teacher education towards SD continues to be given priority as a key component of higher education; (ii) to provide continuing education to teachers, decision-makers and the public at large on SD; and (iii) to promote the creative development and implementation of comprehensive sustainability projects in higher education, and at all other levels and forms of education. The Declaration of

Barcelona in 2004 is focused on engineering education. It calls for multi-disciplinary, system oriented, critical thinking, and participative and the holistic education for engineers. The links between all different levels of the educational systems, the content of courses, teaching strategies, teaching and learning activities, research methods, evaluation and assessment techniques, participation of external bodies in developing and evaluating the curricula, and quality control system has been identified as elements to review simultaneously (Lozano and Young, 2012).

Role of Educator. The role of educator in delivering the content of SD through effective teaching and learning approach has become one of the major foci of discussion in the World Conference of Engineering Education (WCED). Gro Harlem Bruntdlant, an international leader in SD,who chaired WCED, strongly emphasized that:

> '*Teachers play a very important role in the transition between generations, on the knowledge from one generation to the next. Consciousness-raising is vital for change. Teachers can convey to children a sense of respect and responsibility for nature and for the global environment...'*

Thus, educators play a major role in imparting knowledge and commitment towards SD among students through effective educational approaches to gain meaningful impact (Abdul-Aziz *et al*., 2013). Warburton (2003) views that the challenge for educational institutions is not to teach concrete facts about the environment problems, but to create an active, transformative process of learning that could relate theory and practice. Therefore, quality teaching is the most effective lever available to transform education and deliver improved outcomes for students. In the same view, Svanstrom*et al*. (2008) stresses that the teaching methodologies have to move beyond the content to help the students becomes a lifelong learner and agent of change for SD. In order to foster sustainable change agent, three elements that students must have were identified: i) knowledge of the environmental, economic, and social issues related to sustainability (understanding), ii) a value system and self-concept to support the change agent (motivation), and iii) change agent abilities (skills) such as resilient, commitment, empathetic, authentic, ethical, self-aware and competent. Therefore, to achieve the aims of sustainable development, educators, students and content of knowledge about sustainability issues should have a strong correlation and integration. Thus, knowledge and understanding of sustainability should be promoted to enable the population can contribute to the overall goal through outtheir daily lives (Martin, 2008; Arbuthnott, 2009). However, there is a large gap between knowledge and behaviour in practicing sustainability (Clugston, 2010; Tilbury, 2011). Therefore, transformation of teaching and learning approach from teacher-centered learning to student centered learning need to be implemented at all levels of education. Redman *et al.*, (2013) also stresses that student centered learning could provide a supportive atmosphere for sustainable behaviour.

Relationship between knowledge and behaviour. Knowledge about sustainability is commonly seen as essential for successful action or mechanism to facilitate behaviour change (Frisk and Larson, 2011). In addition, Kollmuss and Agyeman (2002) asserts that demographics, external factors (e.g. economic, social, cultural and institutional) and internal factors (e.g. motivation, pro-environmental knowledge, awareness, values, attitudes, emotion, locus of control, responsibilities and priorities)significantly affecton pro-environmental behaviour. Similarly, Kaiser and Fuhrer (2003) view the importance of environmental knowledge as a predictor of environmental behaviour. In additional, Fiedler and Deagan (2007) indicate that peoples' motivation to behaviorchange has indeed come from knowledge. Therefore, incorporating environmental and sustainability issues into the early stage of education played a key role in facilitating and fostering environmentally responsible behaviour, and provided a strong foundation for more sustainable societies (Lukman*et al*. 2013).

In contrast, Booth (2009) found that there is a large gap between people's knowledge of environmental problems and their motivation to behave towards their resolution. In the same line of view, Lukman *et al.* (2013) also points out that there is still a lack of awareness of the interrelations between environmental knowledge and human activities. Therefore, Lukman and Peter (2007) indicate that sustainability principles in education need to be integrated into research, teaching and learning. Over the last few years, numerous studies on implementing education for sustainability in higher education have revealed a great variety of approaches. More recent studies have focused on how to introduce education for sustainability such as designing pedagogy (Weber *et al*. 2014; Lockrey and Johnson, 2013; Steg and Vlek, 2009), whole-school approach (Barth and Rieckmann, 2012) and whole-of-university approach (Mcmillin and Dyball 2009). Furthermore, several programmes have been conducted at the university level to assess the outcomes of sustainability practices (Perdan *et al.,* 2000; Chau, 2007; Sherphard, 2008; Arbuthnott, 2009; Razak and Mohamed, 2009; Amran *et al.,* 2009; Ratchusanti, 2009; Chhokar, 2010; Kitamura and Hoshii, 2010; Foo, 2013). According to Dongjie (2010), more work is needed to achieve the goals of education for sustainability, not only within the higher education but across society.

Education forSustainable Development in Malaysia. Malaysia has placed a strong emphasis on sustainaibility in the development of its educational programmes since the Seventh Malaysian Plan (1996 – 2000). The Ministry of Education, Malaysia (MOE) has played an assertive role in its efforts to develop a curriculum on environmental education to educate students to be more sensitive and concerned about environmental issues, knowledgeable, skilled and committed, whether as individuals or collectively, in addressing environmental issues. A number of research studies has been conducted in Malaysia to check people's perception of environmental issues based on their respective educational backgrounds, and practices of sustainable lifestyles. It is focused on different target groups such as public, primary, secondary and tertiary students (Foo, 2013; Zarintaj *et al*., 2012; Saripah *et al.*, 2013; Tamby *et al*., 2010; Abu-Samah, 2009; Marzuki, 2009; Sumiri, 2008; Nadeson and Nor-Shidawati, 2005). According to Sharifah and Hashimah (2006), the current practice of disseminating environmental knowledge through lectures is not an effective method to meet the challenge of educating SD. However, Saripah *et al*. (2013) has pointed out that the direct effect of environmental knowledge on pro-environmental behaviour is significant. On the other hand, Mamatand Mokhtar (2009) found that the current trend of tertiary education in Malaysia giveslesser attention to affective-dominant courses compared to cognitive and psychomotor dominant courses. They also found oneffective instructional design for value dominant education at Malaysian public universities and revealed that instructional design should correlate with course objectives, contents and activities. He also noticed that normal instructional approaches such as lectures and discussions are used by the teachers to acknowledge sustainability issues. In general, it could be concluded that the level of Malaysians' perception on knowledge and practicing sustainable lifestyles are generally low to moderate.

In summary, the teaching and learning approaches currently employed are not effective and fail to bridge the gap between knowledge and practice. Educators should be knowledgeable and creative during the delivering process. Redman*et al*., (2013) suggests that the educators need to model teaching and learning activities in incorporating sustainable behaviour in the classroom. Therefore, more studies on effective teaching and learning approaches are required to inculcate students' knowledge on environmental and sustainability issues and how best to formulate a sustainability-concious society.As a conclusion, universities as a place to explore knowledge and educators become the main playerswith a responsibility to deliver the sustainability issues in a more effective way of teaching and learning approaches.

1.3 Statement of the Problem

Issues related to sustainability are the primary focus for the 21st century society. Today's engineering professionals are coming under increased pressure to practice engineering more sustainably. In engineering education, the importance of 'Education for Sustainable Development' is translated by the Washington Accord by making it a requirement for accreditation of engineering programs. Therefore, an effective and systematic approach for teaching sustainability is needed to address the issues. Student-centred learning is an approach of teaching and learning that has been proven in imparting of knowledge and commitment towards meaningful impact. In contrast, traditional approach using lecturing which is commonly implemented in current practices of disseminating knowledge onenvironmental and sustainability isfound to be as an ineffective approach to the challenge of educating for sustainability (Mamat and Mokhtar, 2009).This is supported by research findings that current educational practiceis inadequate for achieving transformative action towards sustainability (Abidin Sanusi *et al*., 2008; Foo, 2013; Salih, 2008). Furthermore, Ling (2010) found that the major problems which defined as barrier in engineering education towards environmental for sustainability are lack of awareness and appreciation of environmental issues among the academics and students. For this reason, the quest to identify 'what is the effective framework for teaching sustainability using student-centred learning' is the main focused of this study. Therefore, this research addresses to seek answers to the questions: '*What are the levels of students' knowledge and behaviour change before and after undergo the course*?' and '*Do the problems used and learning environment impact on students' learning outcomes*?'.

1.4 Research Objectives

The purpose of this study is to investigate the impact of Cooperative Problem-based Learning (CPBL) in instilling students' knowledge and behaviour changes associated with environmental sustainability. The target group is thefirst year engineering students enrolled in the 'Introduction to Engineering' courseat the Faculty of Chemical Engineering, Universiti Teknologi Malaysia. Three research objectives are identified as follows;

a) To assess the level of first year engineering students' on their (i) prior knowledge on environmental issues, (ii) prior knowledge on sustainable development, and (iii) practicing pro-environmental behaviour associated with self and social development.

b) To investigate on the implementation of Cooperative Problem-Based Learning (CPBL) as a student-centered learning environment to instil students' knowledge and behaviour changes associated with environmental sustainability, as in the first-year 'Introduction to Engineering' course syllabus.

c) To recommend a suitable framework for teaching environmental sustainability using CPBL as a supportive teaching and learning approach.

1.5 Research Questions

This study addresses the following research questions to achieve the above research objectives.

Objectives 1: To assess the level of first year engineering students' on their (i) prior knowledge on environmental issues, (ii) prior knowledge on sustainable development, and (iii) practicing pro-environmental behaviour associated with self and social development.

RQ1a. What are the most significant items to assess the first year engineering students on; (i) knowledge on environmental issues, (ii) knowledge on sustainable development, and (iii) practicing pro-environmental behaviour associated with self- and social development.

RQ1b. What are the levels of perception of the first year engineering students' on (i) prior knowledge on environmental issues, (ii) prior knowledge on sustainable development, and (iii) practicing pro-environmental behaviour associated with self- and social development?

RQ1c. Is there any significant difference across gender of students regarding their (i) prior knowledge on environmental issues, (ii) prior knowledge on sustainable development, and (iii) practicing pro-environmental behaviour associated with self- and social development?

RQ1d. How significant the relationship between students' knowledge and students' pro-environmental behaviour among the first year engineering students?

Objective 2; To investigate on the implementation of Cooperative Problem-Based Learning (CPBL) as a student-centered learning environment to instil students' knowledge and behaviour changes associated with environmental sustainability, as in the first-year 'Introduction to Engineering' course syllabus.

(i) Quantitative Study

RQ2a. Does CPBL approach impact on students' (i) knowledge on environmental issues, (ii) knowledge on sustainable development, and (iii) students' behaviour in practicing pro-environmental behaviour associated with self- and social development before and after CPBL?

RQ2b. Is there any significant difference across gender of students regarding their (i) knowledge on environmental issues, (ii) knowledge on sustainable development, and (iii) practicing pro-environmental behaviour associated with self- and social development before and after CPBL?

(ii) Qualitative Study

RQ2c. Are the four domains of knowledge (declarative, procedural, effectiveness and social) inculcated in the design of CPBL problems?

RQ2d. In what ways do the use of problems in CPBL approach give impact to students' knowledge and behaviour change, associated with environmental sustainability?

Objective 3: To recommend a suitable framework for teaching environmental sustainability using CPBL as asupportive teaching and learning approach.

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RQ3a. What is there commended framework for teaching environmental sustainability using CPBL as a supportive teaching and learning approach?

1.6 Theoretical Framework

A theoretical framework is produced to describe the theories and concepts that are relevant to the focus of the study. It helps the researchers to relate the theoretical background to the educational principles and research objectives. Ennis (1999) states that the theoretical framework is a structure that identifies and describes the major elements, variables, or constructs that organize the research focus. In this study, the theoretical framework is based on the constructivism learning theory and theory of student involvement. Both theories are served as the backbones of the Cooperative Problem-Based Learning approach, as shown in Figure 1.1.

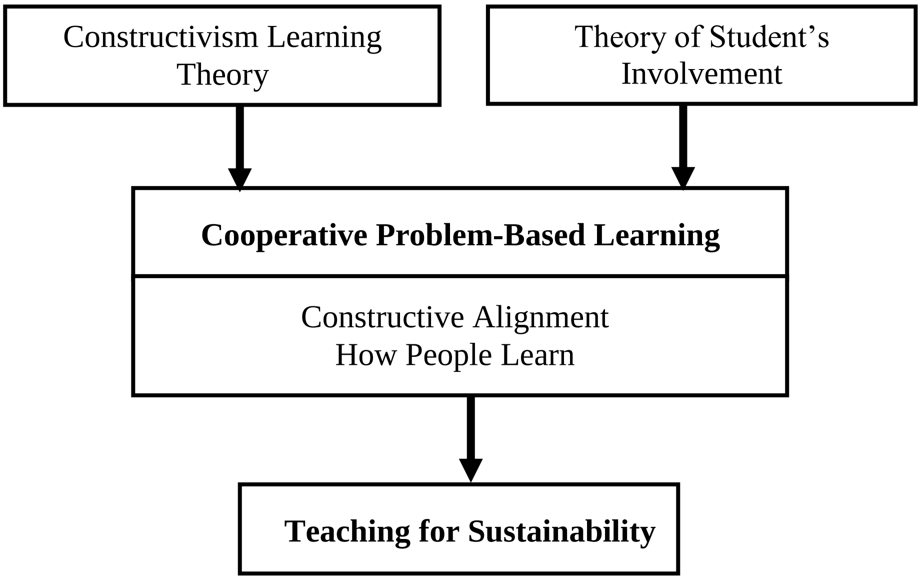


Figure 1.1 Theoretical Framework of Research

According to Segalas *et al*. (2010), the reorientation of pedagogy and learning environment is essential to achieve effective education in sustainable development. Therefore, Cooperative Problem-Based Learning (CPBL) as a student-centered learning environment has been investigated in this study to achieve the aim of the research.

Constructivism Learning Theory. The constructivist learning theory states that students move from experience to knowledge by constructing their own knowledge, building new learning from prior knowledge and developing their learning through active participation (Moreno, 2010). Constructivist as an educational approach explains how humans construct knowledge on the basis of their existing knowledge and necessary means for the development of information construction ability (Mariappan *et al.* 2005). Constructivism emphasizes learning as an active, subjective and constructive activity placed within a rich and meaningful context for the learners. In addition, the main idea of constructivism is that an individual constructs one's own knowledge and learning outcomes, which are personally important for the individual.

A constructivist approach in education has been developed on the basis of paradigm shift from the traditional learning approach to student-centred learning approach (Briede, 2013). Student's construction of knowledge is based on their past knowledge, the timelines of new knowledge, and the student's ability to understand the connections. Learning environment in constructivists could build several positive, such as learning should be an active process, students should construct their own knowledge, collaborative and cooperative learning should be encouraged, students should be given control of the learning process and the opportunity to reflect on their own learning.

There are two strands of the constructivist perspective; i.e. cognitive and social constructivism. Cognitive constructivism is based on the work of Swiss developmental psychologist Jean Piagetin 1972. Piaget's theory of cognitive development proposes that humans cannot be 'given' information which they immediately understand and use. Instead, humans must 'construct' their own knowledge. They build their knowledge through experience. Experiences enable them to create, change, enlarge and make more sophisticated through two complimentary processes; assimilation and accommodation. In a Piagetian classroom, the teacher role is important to provide a rich environment for the student to explore knowledge and encourage them to become active constructors of their own knowledge through experiences to encourage assimilation and accommodation.

Social constructivism emphasizes education for social transformation and reflects a theory of human development. Constructivists who favour Vygotsky's theory (1896 – 1934) suggest that social interaction is important for learning, where by students could construct new concepts based on current knowledge (Bruner, 1990). The students select information, construct hypotheses, and makes decisions, with the aim of integrating new experiences into their existing mental constructs. Furthermore, learning is a social process that is shaped by external forces and that meaningful learning occurs when individuals are interacted and engaged in social activities (Mcmahon, 1997; Prawat and Floden, 1994; Ernest, 1991).

In this study, the foundation of CPBL framework as student centered learning approach is based on the constructivism learning theory (cognitive and social). CPBL is the infusion of Cooperative Learning (CL) principles into the Problem-Based Learning (PBL) cycle, has been implemented as a teaching and learning approach to instilenvironmental sustainability among the first year engineering students.The design of learning environment in CPBL is based on Constructive Alignment (CA) and How People Learn (HPL) framework (Mohd-Yusof and Hassim, 2004; Mohd-Yusof *et al.*, 2011; Mohd-Yusof *et al.*, 2012). According to Biggs (1996), constructive alignment requires the outcomes to be aligned with assessment tasks and teaching and learning activities. Whilst, the 'How People Learn' framework consists of four criteria that defines an effective learning environment that is conducive for learning: knowledge, learner, assessment and community-centered (Bransford *et al.*,2004).

Theory of Student Involvement. This theory is developed by Alexandra W. Astin in 1984 states that for growth and learning to occur, students must be engaged in their environment. The amount of student learning and personal development is directly proportional to the quality and quantity of the students. On the other hand, the theory of involvement emphasizes active participation of the students in the learning process, encourages educators to focus less on what they do and more on what the student does: how motivated the student is and how much time and energy the student devotes to the learning process. According to Astin (1984), the connection between particular forms of involvement and particular outcomes is an important question that should be addressed in future research. He also addresses the five basic postulates of the involvement theory; 1) involvement refers to the investment of physical and psychological energy in various objects (such as student experience), 2) involvement occurs along a continuum (that is, different students manifest different degrees of involvement in a given object, and the same student manifests different degrees of involvement in different objects at different times), 3) involvement has both quantitative (how many hours the student involve) and qualitative (whether the student review and comprehends rich information), 4) the amount of student learning and personal development associated with any educational programme is directly proportional to the qualityand quantity of student involvement, and 5) the effectiveness of educational practice is directly related to the capacity of the practice to increase student involvement.

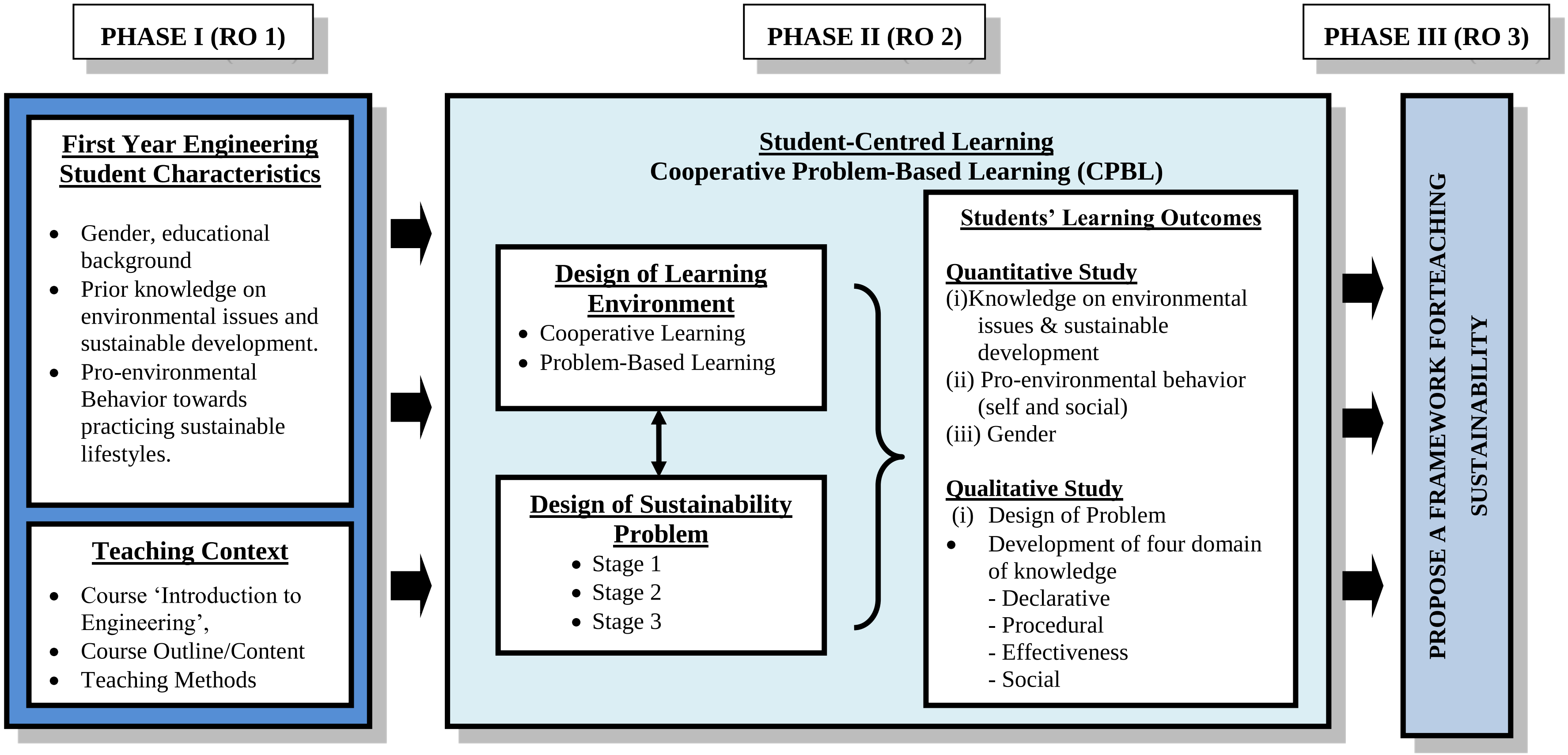
In this study, the CPBL learning environment is designed for the students involvement with the real problem related to sustainability issues via teamwork. Related industries and agencies are solicited and included in the problem to make it realistic (Mohd-Yusof *et al*., 2013). A problem consists of three stages with increasing level of difficulties. In each stage, a student or team member will actively participate in several activities either in or outside the classroom. To enhance more information about the problems, students are required to conduct interviews. They will be evaluated by their team members through peer rating evaluation. Therefore, the philosophy of constructivism and theory of student involvement are underpinned in this study to instil environmental sustainability and to promote behavior change in practicing sustainable lifestyles. Through the design of sustainability problem and process of learning, the students actively construct their own knowledge from their personal experiences with others and the environment.

1.7 Conceptual Framework

A conceptual framework is an analytical tool with many variations and contexts, such as schematic diagram or written narrative flow, variables, types of data collection, data interpretation, relationships between variables and concepts used in the study (Miles and Huberman, 1994; Svinicki, 2011). According to Maxwell (2005), it is most important to understand the conceptual framework as related to what is the research plan, what is going on with the issues and why the research is carried out. The framework of this study is followed by the work of John Biggs' 3P Model of student deep learning (Biggs, 1989). First year students were selected as a research population. According to Erickson *et al*.(2006), there are two main reason why the first year at university level is the most important year to make any changes; 1) this is the early stage that students will acquire as much information without any rejectionand 2) students' assumption and expectations about teaching and learning change while they are in year one at college, as stated in Perry's Research on student development. Therefore, first year stage at university levels are very crucial to introduce the new knowledge and learning environment. The conceptual framework of this study is shown in Figure 1.2. It consists of three phases, namely Phase 1, Phase II and Phase III. Each phase is designed to answer the research objectives and research questions.

(i) Phase 1

This phase is carried out to assess the level of first year engineering students' on their (i) prior knowledge on environmental issues, (ii) prior knowledge on sustainable development, and (iii) practicing pro-environmental behaviour associated with self and social development. Phase 1 includes both student characteristics and aspects of the teaching context. Student characteristics consist of educational background, race, gender, prior knowledge about environmental issues and sustainable development, and practicing pro-environmental behaviour. According to Kollmuss and Agyeman (2002) environmental knowledge has an effect on behaviour. A quantitative study has been carried out to investigate their prior knowledge and pro-environmental behaviour. Several sets of pre-established questionnaires are used to develop research questionnaire and statistically tested to answer the following research question (RQ1a, RQ1b, RQ1c and RQ1d). The research questionnaire is developed to suit with the Malaysian students' background.



*__PHASES__ – represents the flow of research and answer the research objectives.

Figure 1.2 Conceptual Framework of Research

At this stage, the researcher attempts to investigate the most significant items to assess students' knowledge on environmental issues and sustainable development, and practicing pro-environmental behaviour. Structure of Observed Learning Outcomes (SOLO) taxonomy (Biggs and Collis, 1982) and Precaution Adoption Process Model (PAPM) by Weinstein and Sandman (1991) are used as measurement tools to assess students' knowledge and behaviour, respectively. Similar instrument is used in this study to investigate students' knowledge and behaviour change before and after intervention.

Teaching context consists of the course, course outline and teaching methods. 'Introduction to Engineering' course conducted at the Faculty of Chemical Engineering, UniversitiTeknologi Malaysia is selected as a research study area because of the following reasons; 1) issues on sustainability is included in the course contents, and 2) Student-centered learning environment is implemented as a teaching and learning approach. Therefore, this course is supported researcher to answer all the research objectives and questions.

(ii) Phase II

This phase is carried out to answer the research objective 2 (RO2) which consists of research questions (RQ2a, RQ2b, RQ2c and RQ2d). This study is to investigate on the implementation of Cooperative Problem-Based Learning (CPBL) as a student-centered learning environment to instil students' knowledge and behaviour changes associated withenvironmental sustainability, as in the first-year 'Introduction to Engineering' course syllabus. Cooperative Problem-Based Learning (CPBL) is one of the student-centered learning methods. CPBL is a hybrid of two models of learning methods, namely Cooperative Learning (CL) and the Problem-Based Learning (PBL). CPBL model is the integration of CL into the PBL cycle (refer Figure 2.7). Two premises in constructive alignment are grounded to develop the CPBL model, which are 1) constructivism, where students construct meaning through their learning activities and 2) instructional design that aligns learning outcomes of teaching and learning activities, as well as assessment tasks. However, in this study, the elements of assessment is not the focused of interest because the ‘Introduction to Engineering’ course has a comprehensive assessment instruments to assess individual or team development. CPBL has been proven to enhance motivation, professional skills and engage learners in deep learning (Mohd-Yusof *et. al*., 2012; Helmi *et al*., 2011; Mohd-Yusof *et. al.*, 2011).

Student-centered learning has been identified as an effective educational approach that focuses on the needs of the student, design of the curriculum, course content, interactivity of courses and skills development. Perdan*et. al.* (2000) indicates that what is needed is an integrated approach to teaching environmental sustainability which should provide students with an understanding of all issues involved, as well as to enhance their awareness of how to work and act sustainably.

A case study of mixed method research methodology is emphasized. A quantitative study is conducted before and after the CPBL. A survey questionnaire (Appendix E) is administrated and analysed on descriptive and inferential using SPSS software. Concurrently, a qualitative study is carried out to investigate how the used of problem and learning environment in CPBL enhance students’ knowledge and behavior change associated with environmental sustainability. Students’ reflection journals are analysed using thematic analysis. Four domains of knowledge are identified from the students’ reflection. Both results are compared and triangulated.

(iii) Phase III

In Phase III, the framework for teaching environmental sustainability is recommended. This framework could provide as a guide for the educators in teaching and learning strategies and activities.

1.8 Significance of the Study

This study recommends an innovative framework for teaching environmental sustainability using Cooperative Problem-Based Learning (CPBL) among first year engineering students. The findings would be beneficial to several interest groupsas follows:

1. Students

   To provide students with a deeper understanding on sustainable development, one of the requirements stated for a quality academic programmes, in Malaysian Quality Assurance (MQA) and Engineering Accreditation Council (EAC). To produce a high quality and holistic graduates with the ability to integrate knowledge, skills and attitudes are required as a future engineer. Students' involvement in a systematic learning environment could be equipped with strong problem solving skills for creativity, practical ingenuity, communication skills, decision-making, leadership and sustainable mindset.

2. Educators

   To provide some insights on how educators would design their teaching and learning activities associated with environmental sustainability issues to gain a meaningful outcomes on students. It will guide educators on 'How to craft a problem associated with environmental sustainability issue?' and 'How to conduct students-centered learning environment using CPBL'. CPBL as a student-centered learning approach that only not offers knowledge contents and builds professional skills but also promote pro-environmental behaviour change. CPBL could accommodate the new challenges and needs in producing "The engineers of 2020" who are equipped with strong analytical skills for creativity, practical ingenuity, communication skills, professionalism, leardership and sustainability mindset. Educators also act as role models for students in order to place sustainability awareness into practice.

3. Educational Institutions

To be implemented at all educational levels. The as an aid in curriculum development and design on teaching sustainability. It acts as a guide in designing course content, pedagogical approach, support facilities and learning activities.

4. Industry

To produce high quality of graduateswith the ability to integrate knowledge, skills and attitudes associated with environmental sustainability in preparing for the status of an industrialized nation by the year 2020. Most industries need engineers with passion, system thinking, ability to innovate, work in multicultural environments, solve engineering problems and adapt to changing conditions. Therefore, this framework would help shape our students and graduates to fulfil the stakeholder needs.

5. Society or Community

To promote students with pro-environmental behaviour change. This is the most important elements to encourage sustainability initiatives in our society or community. Research findings have found that the human activities are the main contributors in unsustainable environments (Segalas, 2010). Research findings also found that proper delivery of knowledge content associated with environmental sustainability could affect behaviour change (Kollmuss and Agyeman, 2002).

1.9 Scope of the Study

The purpose of this research is to investigate the impact of Cooperative Problem-Based Learning (CPBL) in developing and improving students' knowledge and behaviour changes associated with sustainable development. These elements are observed and identified among first year chemical engineering students enrolled in the 'Introduction to Engineering' courseat the Faculty of Chemical Engineering, UniversitiTeknologi Malaysia.

In this study, a mixed research method has been employed where the qualitative method is triangulated within the quantitative one. According to Creswell *et al*., (2003), the mixed research would provide a comprehensive analysis of the research problem. This study consists of two phases; however the first phase is via quantitative study carried out to investigate the levels of students' prior knowledge and pro-environmental behavior associated with sustainable development before entering the university. A modified questionnaire of students' knowledge-behaviour instrument is developed from several sets of related questionnaires and statistically tested to be adjusted with Malaysian students' background. Structure of Observed Learning Outcomes (SOLO) taxonomy and Precaution Adoption Process Model (PAPM) of changing individual behaviour were used to measure the levels of students' knowledge and behaviour change, respectively. Confirmatory factor analysis (CFA) using the Analysis of Moment Structures (AMOS version 18) is employed to determine the most significant items that are reliable to assess students' knowledge and pro-environmental behavior.

The second phase of this study is carried out to investigate the impact of the design problem and learning environment in developing students' knowledge on environmental sustainabilityand behaviour change using a case study ofmixed method research approach. Specifically, there are three elements in constructive alignment for outcomes based education; i.e. course content, learning strategies and task assessment. However, task assessment is not considered in this study. A group of first year chemical engineering students enrolled in the 'Introduction to Engineering' course was observed, in which Cooperative Problem-based Learning (CPBL) is implemented as a teaching and learning approach. Students were divided into groups of three to five. The design instrument wasadministrated before and after the course to assess students' knowledge and pro-environmental behaviour. Descriptive and inferential analyses were conducted using Statistical Package for the Social Science (SPSS version 18). Concurrently, qualitative study through observation and students' reflective journal were analyzed to determine how students would inculcate their knowledge of the design problem. Thematic analysis was performed to analyze the instruments. Finally, a conclusions were drawn and discussed, followed by recommendations.

1.10 Limitations of the Study

This study is limited to the following condition:

1. The respondents of this study are restricted to two groups; (i) first year engineering students from three selected engineering faculties (civil, chemical and electrical) at Universiti Teknologi Malaysia, and (ii) first year engineering students at Faculty of Chemical Engineering, University Teknologi Malaysia for the academic year of Semester 1, Session 2012/2013.

2. 'Introduction to Engineering' course is a compulsory course to be taken by all first year engineering students at Faculty of Chemical Engineering, Universiti Teknologi Malaysia has selected as the focused study because issues on sustainability via a case study is included in the course content.

3. Student-centered learning approaches is implemented as teaching and learning approach to fulfil the requirement of outcome-based education.

4. This study is restricted on content of knowledge associated with design of sustainability problem and CPBL learning environment. Assesment task is not under research interest.

5. The criteria of the respondents in this study is related to educational background and gender.

6. The quantitative study on students' knowledge and pro-environmental behaviour are based on the self-reported data of the university students.

1.11 Definition of Terms

This research uses some common terms,however some are further clarified for better understanding, as follows;

1. Sustainable Development

Sustainable Development (SD) means different things to different nations and organizations. It is commonly stated as development that meets the needs of the present generation without compromising the ability of future generation to meet their own needs (Brundtland Commission, 1987). In this study, students' knowledge on understanding the basic concept of sustainable development will be determined.

2. Sustainability

In general terms, sustainability is the ability to maintain balance of a certain process or state in any system. It is also defined as the ability to improving the quality of human life while living within the carrying capacity of supporting eco-systems. In this study, sustainability is refered to the patterns of action and consumptionwhichmeet the basic needs to provide a better quality of life, such as, minimize the use of natural resources, emissions of waste and do not jeopardize the needs of future generations (Mont and Bleischwitz, 2007).

3. Environmental issues

Environmental issuesare classified as complex problems such as climate change, global warming, environmental degradation, ozone layer depletion and greenhouse effect that related to humans activities and the natural world. The environmental issues currently affecting society and a comprehension of how to identify and resolve environmental crises, individually or as a group (Dupler, 2003).

4. Pro-environmental behaviour

Pro-environmental behaviour can be defined as the action of an individual or group that advocates the sustainable or diminished use of natural resources (Sivek& Hungerford, 1989). According to Kollmuss and Agyemen(2002), ‘pro-environmental behaviour’ is the sort of behaviour that consciously seeks to minimize the negative impact of one’s actions on the natural and built world’. Pro-environmental behaviour consists of self- and social development.Self-development are feeling of obligation to act in a particular way. Self-development are potent influences on environmental behaviour because people try to avoid the guilt and remorse experienced when they are broken.While, social development refers to the behaviour of others with a belief about what people could built network and support in a particular situation (Koger and Winter, 2010).

5. Student-centered Learning

Student-centered Learning is an approach in which students influence the content, activities, materials, and pace of learning. This learning model places the student (learner) in the center of the learning process. The instructor provides students with opportunities to learn independently and from one another and coaches them with the skills they need to do so effectively (Barr and Tagg, 1995). The construction of knowledge is shared and learning is achieved through students' engagement with activities in which they are invested.

6. Teacher-centered Learning

Teacher-centered learning is the traditional form of studying that the teacher would decide how the class would be run, what the class would be learning and what is to be tested with little input from the students. Lecturing is an example of teacher-centered learning approach.

1.12 Thesis Structure

The thesis structure consists of seven chapters, which is presented in Figure 1.3.

Chapter 1. This chapter explains the big picture of this research. It provides the introduction, background, statement of the problem, research objectives and questions, significance, scope and limitations of the study. It reviews the national and international issues on sustainable development in the context of educational responsibility, focused on university, educators and students. Overall, this chapter elaborates the aims and the conceptual framework of the study.

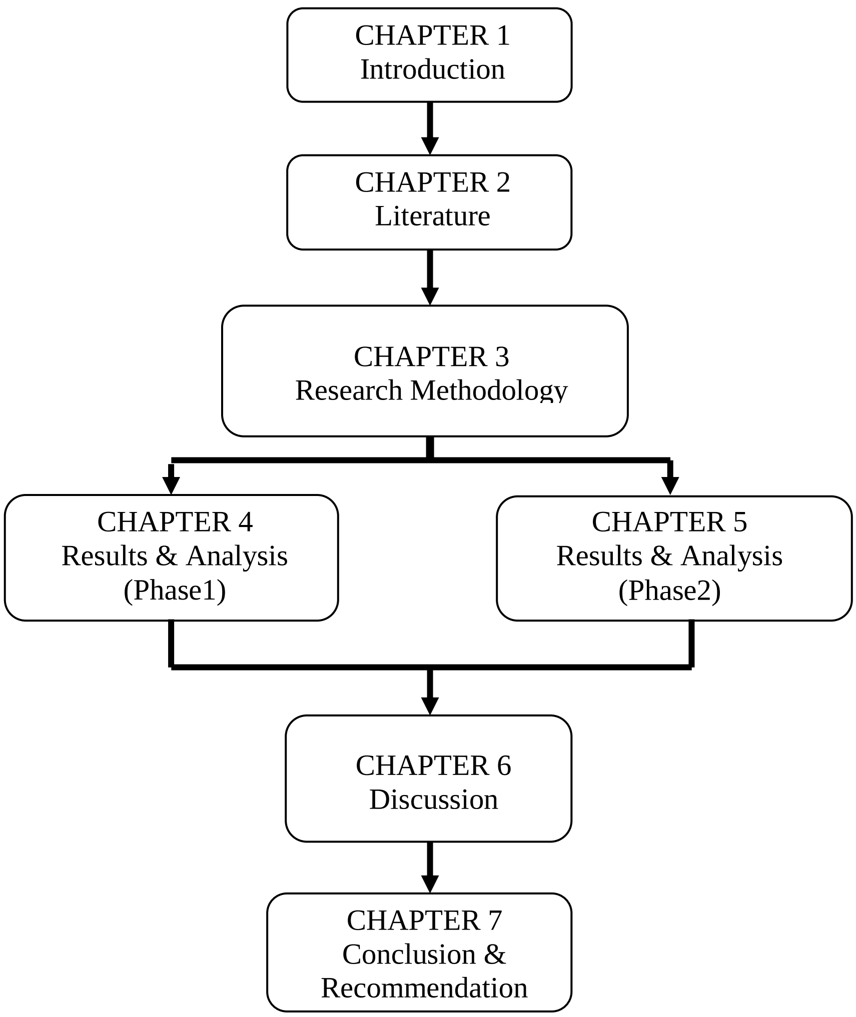


Figure 1.3 Flow of Thesis Organization

Chapter 2. This chapter builds a theoretical foundation for the research by reviewing literature regarding the issues of sustainability and the current efforts that have been executed in tackling the issues at national and international levels. Barriers that have faced by the educational institution are also highlighted. Overall, this chapter also explores several models of education on sustainability.

Chapter 3. This chapter describes the process of conducting the research methodology. A case study with mixed method research methodology is carried out on the first year chemical engineering students to investigate the impact of implementing CPBL on students' knowledge and behaviour change before and after intervention. It discusses in detail the instrumentation, the research population, sampling methods, data collection, data analysis and support tools for data analysis. It also highlights the research protocol and ethics while conducting the research.

Chapter 4. This chapter presents the results and analysis involved in Phase I. A quantitative study is conducted to answer the research objective (RO1) and questions (RQ1a, RQ1b, RQ1c and RQ1d). The number of respondents involved is 316 first year engineering students from three different faculties which are Faculty of Civil Engineering, Faculty of Chemical Engineering and Faculty of Electrical Engineering at UniversitiTeknologi Malaysia. The specific objective of this phase is to investigate the level of students' prior knowledge about environmental issues, basic understanding about the concept of sustainable development and the way they practice sustainable lifestyles. A questionnaire has been designed and tested to determine the most significant items to measure each construct. The results are presented and discussed at the end of this chapter.

Chapter 5. This chapter aims to integrate both quantitative and qualitative results to reveal the research objective (RO2) and questions (RQ2a, RQ2b, RQ2c and RQ2d). In this phase, a case study is conducted to observe the implementation of the CPBL approach in instilling students' knowledge and pro-environmental behaviour before and after intervention. The number of respondents involved 63 Chemical engineering first year students who enrolled in ‘Introduction to Engineering’ course at the Faculty of Chemical Engineering, Universiti Teknologi Malaysia. In quantitative study, the design instrument in Chapter 4 has been utilized and administrated before and after CPBL. Concurrently, a qualitative study is conducted to observe the teaching and learning activities. The design of problem and learning environment were observed.Students’ reflection journals are analysed using thematic analysis. Finally, both results were compared and interpreted.

Chapter 6. The outcomes of Phase I and Phase II are discussed in this chapter. It integrates the findings of both quantitative and qualitative studies. This chapter also proposes a suitable framework of teaching and learning to instilenvironmental sustainability.

Chapter 7. This chapter summarizes the research findings and states the conclusions. It presents the conclusions, recommendations for practices and future research at the end of this chapter.

1.13 Summary

This chapter discusses the importance of knowledge and pro-environmental behaviour associated withenvironmental sustainabilitythat aligned with the current needs in maintaining and improving the quality of life. Five importance elements as back ground of studyare highlighted; (i) University as a Platform forSustainability Driver, (ii) Roles of Educators, (iii) Relationship between knowledge and behaviour, and (iv) Education for Sustainable Development in Malaysia. In order to achieve the aims of this research, three research objectives withnine research questions are determined. This chapter also includes the theoretical and conceptual framework that underpin in the study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discusses the overview of education on sustainable development, evolution of the declaration, environmental issues,pro-environmental behaviour, SD requirement in engineering education and the scenario of education of environment and sustainable development in Malaysia. On the other hands, this chapter also focuses on the influence and barriers of environmental, gender, pedagogical approaches, behaviour change and current models for implementation of sustainability.

2.2 Education for Sustainable Development

The definition for “Education for Sustainable Development (ESD)” is provided by the Sustainable Development Education Panel of the United Kingdom (September 1998), which states that “ESD enables people to develop knowledge, values and skills to participate in decisions about the way we think individually and collectively, both locally and globally, that will improve the quality of life now without damaging the planet for the future”. In other words, ESD can be defined as the learning which is needed to maintain and improve the quality of life of the present and future generations to come, and education as a tool to achieve sustainability. As mention by Labodova *et al.* (2012), the aim of ESD is to empower people to participate in shaping a sustainable future, promote critical thinking and problem solving, include a variety of learning and teaching methods, and encourage participation and collaboration. Furthermore, as quoted from Chapter 36 of Agenda 21, Rio Declaration 1992, "giving student knowledge and skills for lifelong learning will help them find new solutions to their environmental, economic and social issues. If students understand sustainability as an aspect of their social and ethical responsibility, they will become citizens who see themselves as connected to the natural world and to other humans. Thus, they will have the capacity to facilitate the development of activities that sustain rather than degrade".

ESD has developed from a mixture of environmental and development education ideas. The years 2005 to 2014 has been declared as 'the Decade of Education for Sustainable Development by the United Nations (UN)'. There are four major thrusts to begin the work of ESD (UNESCO, 1986): (i) improve basic education, (ii) reorients existing education to address sustainable development, (iii) develop public understanding and awareness, and (iv) training. Shani and Docherty (2009) stated that the different definitions and interpretations of sustainable development leads to four distinct features;

i) Sustainable development occurs at several levels, ranging from global to regional to organizational to the team and to individuals.

ii) Sustainable development is an intergenerational phenomenon. It is a process of transference from one generation to another. In other words, individuals, teams, and organizations are able to transfer learning processes and best practices continuously.

iii) Sustainable development consists of at least three domains: social, economical, and ecological. Although sustainable development can be defined in terms of each of these domains alone, the interrelationship between the three domains is what makes the concepts of utmost relevance within the context of human behaviour at work.

iv) Sustainable development is a complex process, with phases and activities that centre on continuous development of human systems

Furthermore, Lukman and Glavic (2007) indicate that sustainability principles in education need to be integrated into research, teaching and learning. Values and awareness about sustainability, integration into the curriculum, teaching and learning methods, and development that are required in order to increase knowledge. Therefore, universities have unique characteristics to discuss sustainable development discussion through research and education (Graedel, 2002). As summarised by Rodrigo *et al*. (2012) there are four main approaches can be found in incorporating SD into higher education curricula;

i) Some coverage of particular environmental and/or social issues and material in an existing course (Thomas, 2004)
ii) A specific SD course added to the curriculum (Abdul-Wahab *et al.*, 2003)
iii) SD intertwined as a concept within pre-existing disciplinary-oriented courses, with the relevant SD component issues matched to the nature of each specific course (Abdul-Wahab *et al.*, 2003; Boks and Diehl, 2006; Peet*et al.*, 2004; Quist *et al.*, 2006)
iv) SD offered as a specialization within the framework of particular faculties or schools within an institution (Kamp, 2006)

Nevertheless several elements of sustainability, such as global sustainability, energy, engineering education of the future requires innovative efforts to deliver the required characteristics.

2.3 Evolution of the Declarations for Sustainable Development

Table 2.1 displays a great number of declarations about the importance of education for sustainability in higher education that have been signed (Lozano *et. al*., 2013; Ozmen and Karamustafaoglu, 2006). The first attempt was the Tallories Declaration (1990) that prompted the declaration about environmental degradation, pollution, depletion of natural resources, and the threat to human and biodiversity survival. It also addresses that universities must work together towards environmental sustainability through curricula, research, operations, and outreach.

Table 2.1 Chronology of some initiatives taken by higher education institutions

Year	Event/declaration
1990	Tallories Declaration
1991	Halifax Declaration
1992	Association of University Leaders for a Sustainable Future
1993	Kyoto Protocal/Declaration
1993	Swansea Declaration
1993	COPERNICUS University Charter
1999	Environmental Management for Sustainable Universities (EMSU)
2000	Global Higher Education for Sustainability Partnership (GHESP)
2001	Luneberg Declaration
2004	Barcelona Declaration
2005	Graz Declaration, Decade of ESD (2005-2014)
2009	Abuja Declaration
2009	Turin Declaration
2014	End of DESD
2014	Nagoya Declaration on Higher Education for SD

The Halifax Declaration (1991) underscores the roles and responsibilities of universities in improving the capacity of the citizens of all countries to address environmental and development issues. The Kyoto Declaration (1993) stressed on the ethical obligation of universities to the environment and sustainable development principles. It also mentions the need for universities to collaborate. Furthermore, the Swansea Declaration (1993) tries to address the degradation of the Earth's environment, the pervasive influence of poverty, and the urgent need for sustainable practices. The GHESP (2000) seeks to develop and share effective strategies, models and best practices for promoting higher education for sustainability. Higher education must play a central role in the process of achieving SD. In another declaration, the Luneburg Declaration (2001) highlights nine results but the most importantbeing; (i) to ensure that the orientation of teacher education towards sustainable development continues to be given priority as a key component of higher education; (ii) to provide continuing education on sustainable development to teachers, decision-makers and the public at large; and (iii) to promote the creative development and implementation of comprehensive sustainability projects in higher education, and at all other levels and forms of education. The Declaration of Barcelona (2004) focuses on engineering education. It calls for multi-disciplinary, system-oriented, critical thinking, and participative and the holistic education for engineers. The links between all the different levels of educational systems, the content of courses, teaching strategies, teaching and learning activities, research methods, evaluation and assessment techniques, participation of external bodies in developing and evaluating the curricula, and quality control system are identified as elements to be reviewed simultaneously.

In Graz Declaration (2005), the university leaders are encouraged to promote creative development and implementation of comprehensive and integrated sustainability actions in teaching and learning, research, internal and external social responsibility, and to foster cooperation between universities and community stakeholders. This declaration is concluded by emphasizing the Decade of Education for Sustainable Development, from 2005 to 2014. The Abuja Declaration (2009) stresses the importance of inter-institutional collaboration, especially university-industry-government linkages. Furthermore, Turin Declaration stresses that sustainability cannot be achieved by merely engaging natural sciences, but must also engage life sciences, social sciences and the humanities. Therefore, several strategies should be developed and employed such as; broad, global engagement to promote awareness on sustainability issues, restructuring of education and research to incorporate and integrate cutting-edge knowledge, in order to move towards integrated holistic approaches, problem-solving, and systems-thinking. Moreover, there are the needs of the university to educate students at all levels in the issues concerning sustainable development.

2.4 Sustainable Development Requirements in Engineering Education

In spite of a number of initiatives such as the Tallories Declaration (1990), Kyoto Declaration (1993), Luneburg Declaration (2001), Barcelona Declaration (2004), Graz Declaration (2005) and Abuja Declaration (2009), several guidelines or frameworks have been designed for higher educational institutions to better embed sustainability into their programmes. Recently, there has beenan increase in the number of universities engaging with SD. However, universities still need to become more proactive in making SD as an integral part of their programmes and this is a continuous process, as discussed in detail by Lozano *et al.* (2013). Four important elements for universities to become sustainability leaders and change drivers are highlighted as follows;

i) Must ensure that the needs of present and future generations be better understood, addressed and built upon;

ii) Leaders and staff must be empowered to catalyze and implement new paradigms, including introducing SD into all courses and curricula and other university and college activities;

iii) Proper academic recognition of the importance of multi-disciplinary and trans-disciplinary teaching, research and community outreach for speeding up the societal transformation;

iv) Need to become more proactive in creating new paradigms while discarding the old ones, via reintegrating science and the arts in a trans-disciplinary way, to help societies become more sustainable.

The university as a higher educational institution has a role in creating knowledge, integrating sustainability in education and research and the promotion of environmental issues in the society (Larsen *et al*.,2013; Lozano, 2010; Waas *et al*., 2010). Thus, over the past several years a number of studies have been focused on how to integrate sustainability into higher education, such as faculty research and administrative practice (Rusinko and Sama, 2009), integrating SD into curriculum at all levels (Boks and Diehl, 2006), applied SD to many disciplines (Foo, 2013), SD as societal learning process (Mulder *et al*., 2012), using Bloom Taxonomy to teach sustainability in multiple contexts (social, environmental, economic, technical) (Pappas *et al*., 2012), using case-stud y method (Karatzoglou, 2013), using project-based learning environment (Lockrey and Johnson, 2013) and using problem-based learning environment (Aziz *et al*. 2013). Therefore, there are many approaches to define the SD learning outcomes that engineering students should have when upon graduation. Some programmes at some universities are providing significant exposure, but others are not. Further investigations are needed, to determine how well students are being served at present, and how they may be better served in the future.

2.5 Environmental Issues and Pro-environmental Behaviour

Global environmental issues are classified as complex problems such as climate change, global warming, environmental degradation, ozone layer depletion and greenhouse effect. According to Botkin and Keller (1987), people have been important ecological factors, creating major changes in the environment and having major effects on the rest of life on our planet. In a book entitled ‘Global Environmental Issues’, editor Harris (2012) highlighted that there are three broad reasons why such problems in environmental issues are so hard to resolve. First, the sciences of environmental issues are complex. There are many interrelated dynamic systems, within which and between which feedback mechanisms occur. Second, there are many stakeholders involved in both the causes and the solutions to environmental problems. Organising all of these stakeholders to act in a coordinated manner is difficult. Third, resolving global environmental issues will require changes in our own consumption and pollution of natural resources, which means changes to lifestyles. This will require commitment at the personal level, which not everyone is willing to make.

In contrast, Hulme (2008) notices that, scientific and technological change will enable humanity to overcome environmental issues, find new solutions, and provide a more sustainable way forward. However, new innovations sometimes lead to new problems, such as salinisation of irrigated soils, the persistence of pesticides in ecosystems and excess nitrate in ecosystems. Developments such as fertilisers have increased yields, but resulted in farming systems which are, highly dependent on energy. Use of fossil fuels has created anthropogenic global warming, while nuclear energy leaves the concerns of dealing with nuclear waste, etc. It shows that new forms of science appear to be a very complex way of solving issues, but when a more straightforward method would benefit, there are sometimes associated ills. Therefore, the role of science is required in the future to ensure beneficial developments are taken up and to identify and mitigate social ills. This is the current and future challenges of education on how to deliver and instil sustainability awareness among the citizen at all age levels.

In Malaysia, a number of research studies have been carried out to assess the impact of environmental knowledge towards pro-environmental behaviour. The results revealed that the level of knowledge and behaviour with respect to environmental concerns is generally low to moderate (Hassan *et al.*, Desa *et al.*, 2011, Abolore, 2012). This finding is supported with the news taken from the New Straits Time, August 27, 2013 where the Minister of Urban Wellbeing, Housing and Local Government, Datuk Abdul Rahman Dahlan stated that Malaysians produce 33,000 tonnes of household solid waste daily in 2012, exceeding the projected production of 30,000 tonnes by 2020, as shown in Figure 2.1.

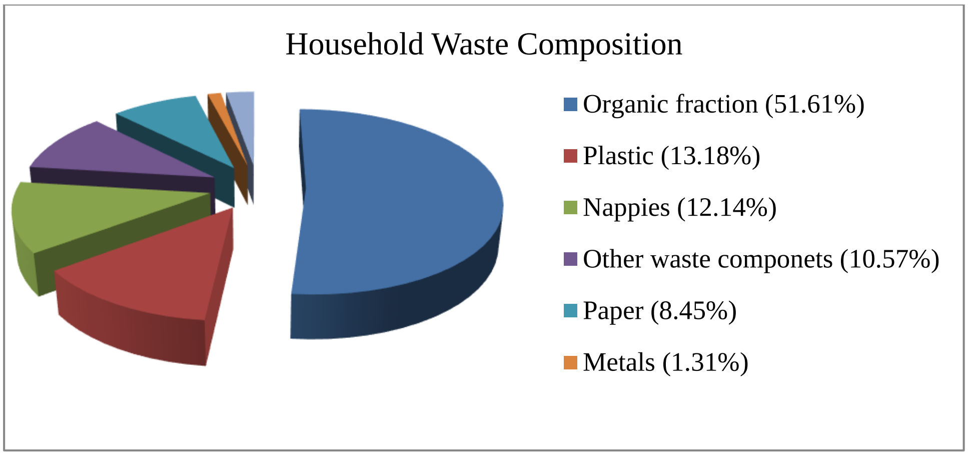


Figure 2.1 Percentage of Household Waste Composition in Malaysia

2.6 Influence and Barriers of Environmental Knowledge on Pro-environmental Behaviour

The oldest and simplest models of pro-environmental behaviour were based on a linear progression of environmental knowledge leading to environmental awareness (attitudes) and that, leads to pro-environmental behaviour as shown in Figure 2.2. Accordingly, Kollmuss and Aygeman (2002) concluded that changing behaviour was very difficult. However, this model was soon proven to be wrong where some research showed that in most cases, increase in knowledge and awareness did not lead to pro-environmental behaviour. Yet, this assumption is still applied in many related pro-environmental behaviour programmes.

Figure 2.2 Early Models of Pro-environmental Behaviour(Kollmuss and Agyeman, 2002)

Kollmuss and Agyeman (2002) also assert that demographics, external factors (e.g. economic, social, cultural and institutional) and internal factors (e.g. motivation, ecological knowledge, awareness, values, attitudes, emotion, locus of control, responsibilities and priorities) significantly affect ecological behavior. Furthermore, Pappas (2012) declares that environmental knowledge is considered synonymous with sustainability. He addresses sustainability in the following five contexts; social/cultural, economic, environmental, technical and individual. On the other hand, Frisk and Larson (2011) conclude thatpro-environmental behaviour are motivated by much more than declarative knowledge.Furthermore, knowledge of sustainability is commonly seen as essential for successful action or mechanism to facilitate behavior change.

Similarly, Kaiser and Fuhrer (2003) view of the importance of environmental knowledge that could be a predictor of environmental behaviour. Environmental knowledge can also be differentiated into several points of view. Additionally, Fiedler and Deagan (2007) indicate that people's motivation to behavior change has indeed come from knowledge. Moreover, environmental education and education for sustainable development have a strong correlation. Therefore, incorporating environmental and sustainability issues into the early stage of education plays a key role in facilitating and fostering environmentally responsible behaviours, and provided a strong foundation for more sustainable societies (Lukman *et al.* 2013). From literature review, a numerous studies and declarationare designed to provide guidelines of frameworks for all levels of education and society to overcome issues concerning sustainability (Lozano *et al.*, 2013; Foo, 2013). In Rio 2012, the United Nations Conference on Sustainable Development marked another key milestone for sustainable development and higher education. A five-point strategy was covered in the action plan as teaching, research, institutional practice, community development and engagement. In summary, the role of higher education in promoting sustainability through deeper understanding on environmental knowledge is very crucial.

Educating for sustainability becomes one intervention point for promoting pro-environmentalbehaviour. Educators are responsible to create a learning environment that could interact students with society and the environment now and into the future.

In order to effectively educate for sustainability, pedagogical approaches must become more reflexive, integrative and collaborative (Dupuis and Ball, 2013). The design of problems associated with sustainability plays a major role in achieving meaningful outcomes. In teaching sustainability, it is not the amount of knowledge available that determines behaviour, but the strength of the convergence of different forms of knowledge. According to Segalas *et al*., (2010), the reorientation of pedagogy and learning environment are essential to achieve effective education for sustainable development.

According to Frisk and Larson (2011), pro-environmental behaviours are influenced by much more than declarative knowledge. Kaiser and Fuhrer, (2003) highlighted that the joint and convergent of four domains of knowledge are important in order to effectively educate for sustainability. The four different domains of knowledge are declarative, procedural, effectiveness and social knowledge, described as follows;

(i) *Declarative knowledge* describes knowledge about an environmental system such as information about the ecological structure, functioning of ecosystems, and social-ecological interactions (Kaiser and Fuhrer, 2003 and Redman, 2013). Declarative knowledge usually consist of answer to the question of how environmental systems work in factual, technical, mechanical or biophysical terms.

(ii) *Procedural knowledge* addresses the issues of how to achieve a particular conservational goal, such as how to sort garbage into recyclables and non-recyclables for proper disposal. This domain of knowledge is more predictive for ecological behavior than declarative knowledge (Tanner and Kast, 2003).

(iii) *Effectiveness knowledge* addresses the awareness of consequences associated with different behaviors, essentially answering the question, whether the behavioural sacrifice is worthwhile (Kaiser and Fuhrer, 2003). Effectiveness knowledge influences behaviors through people's perceptions about how or even if their behaviours really impact the environment or others (Redman, 2013). Kaiser and Fuhrer (2003) assume

that to acquire effectiveness knowledge, declarative and procedural knowledge are also vital.

(iv) *Social knowledge* encompasses knowledge regarding the motives, intentions, and actions of other people (Kaiser and Fuhrer, 2003). Social knowledge embodies what is typically described as social norms by behavioral scientists. The importance of social knowledge as a predictor of behavior is especially critical in a normative field such as sustainability, where societal values are central in guiding what we ought to sustain and how.

In contrast, Blake (1999) identifies three barriers to action pro-environmental behavior i.e. individually, responsibility and practicality, as shown in Figure 2.3. Individual barriers are barriers that are lying within the person, having to do with attitude and temperament. These barriers specifically influence people that do not have a strong environmental concern such as laziness and lack of interest. The second barrier of responsibility is related to people who do not act pro-environmentally and feel that they cannot influence the situation or should not have to take the responsibility for it, such as lack of trust, lack of efficacy and do not own property. The third barrier, practicality, is defined as the social and institutional constraints that prevent people from acting pro-environmentally, such as lack of time, lack of money and lack of information. This model combines the external factors (e.g. institutional, economic, social and cultural)with internal factors (e.g. motivation, environmental knowledge, awareness, values, attitudes, emotion, locus of control, responsibilities and priorities).

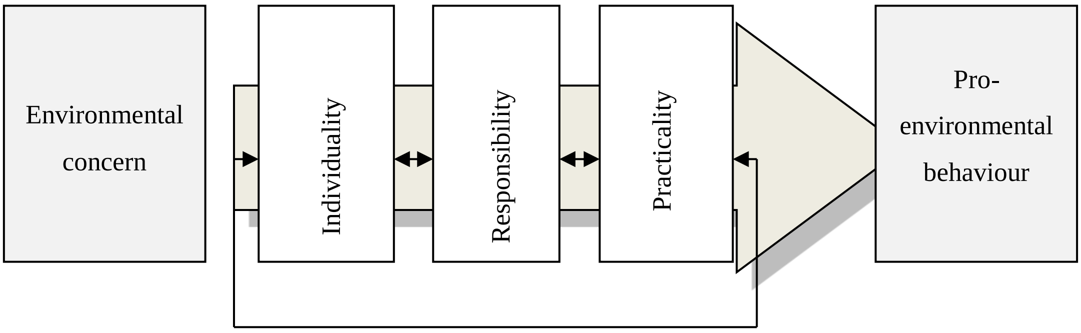


Figure 2.3 Barriers between environmental concern and pro-environmental behaviour (Source Blake, 1999)

2.7 Issues on Gender

Who cares about the environment? Numerous research has found that the female gender tend to show greater environmental concern and more pro-environmental behaviours than their male counterpart (Casey and Scott, 2006; Hunter, Hatch and Johnson, 2004; Karpiak andBaril, 2008; Snelgar, 2006; Stern *et al.*, 1993; Zelezny*et al.*, 2000;Mohai, 1992). They also found that women clearly play a significant role in contributing to environmental devastation, especially when they participate in overconsumption, overpopulation (reproduction), and pollution.But, they are also more knowledgeable, experienced and concerned about sustainable environmental practices than men (Kabeer, 2001). According to Koger and Winter (2010), gender differences do not suggest that environmental problems are men's fault. In contrast, research conducted by Johnson *et al*. (2004), McStay& Dunlap (1983) and Zelezny *et al.* (2000) found that men are more likely to attend political meetings. In the same view, Stern *et al.* (1993) showed that compared with female students, males have more positive attitude and much more concern about environmental issues. On the other hand, research on gender show that female students might be more sensitive to environmental issues (Davidson and Freudenburg, 1996; Tikka *et al.*, 2000; Keles, 2011 and Lukman *et al*., 2013). On the other hands, Sahin *et al*. (2012) construct a structural equation model to examine the links among attitudes, values, and behaviors pertaining to sustainability, participation in outdoor recreation as well as gender and tendency to follow mass media for university students. Furthermore, attitudes and values were found to be significant determinants of university students' behaviors pertaining to sustainability with large effect size above 0.5 (Cohen, 1988). Results implied that the university campus should be well equipped with the necessary infrastructures that will satisfy the needs and encourage female students as well as male students to motivate them take appreciative outdoor activities. Thus, the effect of gender on sustainability becomes an interesting issue that requiredfurther research work.

2.8 Education Issues on Environment and Sustainable Development in Malaysia

Education in Malaysia is under the responsibility of the federal government and all educational matters are under the jurisdiction of the Ministry of Education (MOE). It is a centralized system with common curricula and examination systems throughout the country. The national Sustainable Development policy is well-documented in several Government blueprints. The emphasis on sustainable development is clearly reflected in the previous Prime Minister Mahathir Mohamad's Mid-term Review of the 8th Malaysia Development Plan (2001 – 2005). With regards to ESD, the MOE views that providing quality education for all children, regardless of their backgrounds, is one of the effective strategies in promoting sustainable development.

Environmental education is part of sustainable development. In this aspect, environmental education (EE) has been introduced into the educational system from primary school to tertiary level. The aim is to produce a society that is sensitive towards the environmental issues and possesses appropriate knowledge, skills and values and able to contribute to the solutions to the environmental problems. EE is not taught as a subject, but the concept and components of EE are integrated across the curriculum at all levels, particularly in subjects,such as Science, Geography, History, Math and languages. The implementation of EE is entirely up to the individual schools. However, no measure has been made so far as to what extent EE is being carried out in schools. For instance, 'Sekolah Lestari Award' is intended to support and enhance the implementation of the National Policy on the Environment. It embraces environmental education through the infusion and incorporation of positive environmental values in school management, curriculum, co-curriculum and 'greening' activities in a continuous manner towards the development of a way of life that is in line with the concept of sustainable development.

Today, efforts to increase environmental awareness are carried out in various programmes and activities, through brochures, pamphlets, TV programmes, advertisements, newspapers, consumer bulletins etc. A number of research have been conducted to evaluate the level of achievement towards sustainable development amongst Malaysian citizen from students at the primary school to public, such as shown in Table 2.2. In spite of the results, it could be concluded that there is a huge gap between knowledge and attitude with respect to environmental concerns of the Malaysian people. EE in Malaysia is still a critical issue to be addressed through action plans for a better environmental society (Zarrintaj *et al*., 2012).

Table 2.2 Some research findings

Researcher	Result
Sharipah*et al.* (2013)	First year engineering students unable to explain what is sustainable development but most of them are involved with some aspects of sustainable lifestyles.
Aminrad*et al*. (2012)	Students would perform an acceptable level of understanding if topics are being actively taught practically via experiential learning than theoretical. Lack of budget, skill and integration to implement EE programmes.
Zubaidah*et al.* (2012)	Social science cluster (UKM) lecturers' understanding of the concept of SD is more about environmental concerns.
Ibrahim (2011)	Difficult to get participation from local communities. Lack of commitment of local people, particularly among tenants and foreigners who have less interest in participating local community activities. Lack of awareness among local people about low carbon initiatives.
Tamby (2010)	Low level of knowledge and attitude among primary and secondary school students.
Hassan *et al*. (2009)	High level of environmental knowledge, awareness and attitudes, but moderate level of practices of UKM students. Pure science students have the highest awareness because they are more interrelated to the environment. Direct contact with the environment would create awareness towards the environment.
Azizan (2008)	High level of awareness, but had no changes in practice.
Shamsulkamal (2008)	Considerably as high level of sustainable environmental understanding and awareness.

Nadeson& Nor Shidawati (2005), and Pauziah (2004)	Low to moderate level of understandings of environmental issues among primary school students.
Wahida*et al.* (2004)	The awareness towards environmental issues and awareness about the need to maintain the environment had increased among the society, but the level of individual involvement in the activities of environmental protection still at low level.

In Malaysia, every higher educational institution needs to fulfil the stakeholders' requirement for programme recognition. Therefore, the Malaysian Engineering Accreditation Council (EAC) under the purview of the Board of Engineers, Malaysia is the quality programme regulation. It is steering the way towards the outcome-based education and under the requirements of the Washington Accord as a member country, produces 12 generic attributes for engineering graduates as stated in the 2012 Engineering Programme Accreditation Manual (2012) as shown in Table 2.3. Besides, the graduates are needed to take up complex engineering problems and activities, environmental and sustainability is also a part of the programme's outcomes.

Table 2.3 Recommended 12 Generic Attributes for Engineering Graduates as recommended in EAC 2012(Source EAC, 2012)

No	Generic Attributes	Descriptions
1	Engineering Knowledge	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
	Problem Analysis	Identify, formulate, research literature and analyze complex engineering problem reaching substantiated conclusions using first principles of mathematics, natural science and engineering sciences.
3	Design/Development of Solutions	Design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.

4	Investigation	Conduct investigation into complex problems using research-based knowledge and research methods, including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.
5	Modern Tool Usage	Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities, with an understanding of the limitations.
6	The Engineer and Society	Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.
7	Environment and Sustainability	Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.
8	Ethics	Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
9	Communication	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
10	Individual and Team Work	Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary setting.
11	Life Long Learning	Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.
12	Project Management and Finance	Demonstrate knowledge and understanding of engineering and management principles and apply these to one’s own work, as amember and leader in a team, to manage projects and in multidisciplinary environment.

Stephen Sterling (1996) argues that education must itself be transformed and suggests that education for sustainability holds the promise of a new transformative paradigm for education (Huckle and Sterling, 1996). Education for change has always been marginal to mainstream thinking and practice. In relation to environmental education in particular, the idea of planning change, rather than merely calling for ‘more and better’ environmental education, has emerged strongly since the beginning of the 1990s and particularly since the publication of ‘Caring for the Earth’ and ‘Agenda 21’. However, environmental and sustainability imperatives are exerting pressure for change in education systems, and this is leading to an emerging international consensus on the need for a strategic response. There is at the same time a need to bring to light underlying tensions resulting from different assumptions and ideas, if real change is to be achieved.

2.9 Theory of Education for Sustainable Development

There are many studies that reveal a lack of a comprehensive theoretical framework for understanding sustainable development and its complexities (Elliott, 2012; Jabareen, 2008;Mat Said *et al.,* 2003; Bossel, 1999; Mebratu, 1998;)A critical review shows that the definitions of sustainable development are vague; there is a lack of operative definitions and disagreement over what should be sustained; the concept is unclear in terms of emotional commitment; and it "remains a confused topic", "fraught with contradictions" (Carew and Mitchell, 2002).

Scott and Gough, (2003) assert that SD presents a complex and challenging learning and raises many questions, such as; what skills are needed to learn effectively across all of the many components of SD and how can learning experiences best be designed. They have proposed a theory of education for SD which consists of three types of approaches on thinking about SD; known as Type 1(the problems are essentially environment), Type 2 (problems are social and/or political and produce environmental issues) and Type 3 (learning must be open-ended). Furthermore, Vare and Scott, (2007) present two complementary approaches as ESD 1 (promoting behaviour change) and ESD 2 (exploring sustainable living) which map onto Scott and Gough's Type 1, 2 and 3, as depicted in Table 2.4.

Table 2.4 Mapping of Scott and Gough, (2003) and Vare and Scott, (2007)

<table>
<tr><th colspan="2">Scott and Gough (2003)</th><th colspan="2">Vare and Scott (2007)</th></tr>
<tr><td>Type 1</td><td>Assume that the problems humanity faces are essentially environmental, and can be understood through science and resolved by appropriate environmental and/or social actions and technologies. It is assumed that learning leads to change once the facts have been established and communicated.</td><td rowspan="2">ESD 1</td><td rowspan="2"><u>Promoting Behaviour Change</u>

(i) Promoting/facilitating changes in what we do
(ii) Promoting (informed, skilled) behaviors and ways of thinking, where the need for this is clearly identified and agreed
(iii)Learning for sustainable development.
(iv)Can be measured through reduced environmental impact.</td></tr>
<tr><td>Type 2</td><td>Assume that our fundamental problems are social and/or political, and that these problems produce environmental symptoms. Such fundamental problems can be understood by means of anything from social-scientific analysis to an appeal to indigenous knowledge.</td></tr>
<tr><td>Type 3</td><td>Assume that what is (and can be) known in the present is not adequate; desired ‘end-states’ cannot be specified. This means that any learning must be open-ended.</td><td>ESD 2</td><td><u>Exploring Sustainable Living</u>
(i) Building capacity to think critically about and beyond what experts say and to test sustainable development ideas
<u>(ii) </u>Exploring the constructions inherent in sustainable living
(iii) Learning as sustainable development.
(iv) Outcomes are the extent to which people have been informed and motivated, and enabled to think critically and feel empowered to take responsibility.</td></tr>
</table>

2.10 Pedagogical Approach towards Inculcating Sustainability

The transformation of conventional learning environment to student-centred learning environment is aligned with the need of outcome-based educational that currently implemented at higher educational institutions, to gain meaningful outcomes (Salih, 2008; Jickling, 2003). Furthermore, student-centred learning environment has been proven to enhance students with higher levels of critical thinking, problem solving, improvement of attitude to learn, as well as an increase in overall attendance (Mohd-Yusof and Hassim, 2004; Umbach and Wawrzynski, 2005; Overby, 2011; Mohd-Yusof *et al*., 2013; Mohd-Yusof *et al.*, 2011). In contrast, traditional approach using lecturing was commonly implemented in current practice of disseminating environmental and sustainability knowledge at all level of education. This is an ineffective approach to educating for sustainable development (Aziz *et al*., 2013; Mamat and Mokhtar, 2012). The teaching and learning approaches have to move beyond the content to help students construct their own self-concept as a lifelong learner and agent of change for sustainable development (Segalàs *et al*. 2008; Shephard, 2008; Sherman, 2008). Learning for sustainable development needs to be more holistic, future-oriented and systemic process ((Tilbury, 2011). According to McMillan *et al*., (2009), the good pedagogical practice is demonstrating to students the connections between theory and practice. Furthermore, this effort should started from an early stage of education (Lukman *et al*., 2013). From this stage, engineering students could build up their sustainable thinking while facing any related sustainable problems. SCL has proven to enhance students with higher levels of critical thinking, problem solving, improvement of attitude to learn, as well as an increase in overall attendance (Overby, 2011). Moreover, reffering to the Final Report submitted by Danish Technology Institute Technopolis in 2008 addresses that education about sustainable development can be delivered through formal, non-formal and informal learning.

A report of the Higher Educational Academy, November 2005 has revealed three prevealing orientations in the teaching of sustainability; 1) educators as role models and learners, 2) experiential learning by reconnecting to real-life situations and 3) holistic thinking (Dawe *et al.* 2005). They have also mentioned that traditional approach is not relevant and easy to teach sustainability. In contrast, some research shows that in most cases, increase in knowledge and awareness do not lead to ecologicalbehavior. These arguments are supported by Jensen (2002) with a finding that knowledge on the environment does not lead to action per se and behavioural change is due to a number of factors, such as traditional knowledge about environment, as what is taught in school is not in essence action oriented and environmental education at school has traditionally focused on passing on knowledge to pupils, but lack of actively appropriating and internalising that knowledge.

Therefore, Jensen (2002) discovered that the main goal in developing students to act and effect change is through action activities. There are four dimensions of environment-related knowledge to be inculcated in the given environmental problem that can be viewed and analysed. Figure 2.4 shows the four dimensions of environment-related knowledge, as (i) knowledge about effects, (ii) knowledge about root causes, (iii) knowledge about strategies for change, and (iv) knowledge about alternatives and visions.

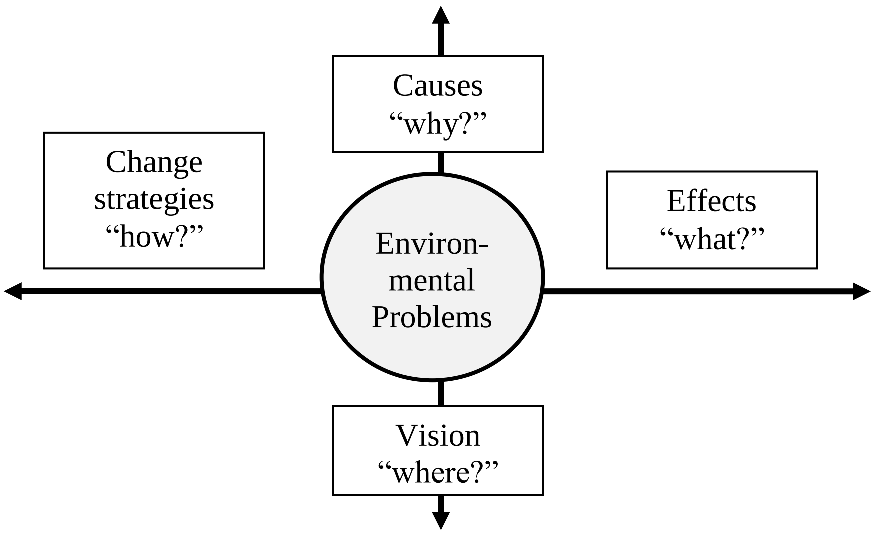


Figure 2.4 Four dimensions of environment-related knowledge (Jensen, 2002)

On the other hand, McMillan *et al.*, (2009), stresses that the good pedagogical practice is demonstrating to students the connections between theory and practice. This effort should start from early stage of education, where engineering students could build up their sustainable thinking while facing any related sustainable problems (Lukman *et al.*, 2013). According to (Pappas, 2012), in teaching sustainability, there are five contexts: social/cultural, economic, environmental, technical, and individual. Individual sustainability (awareness, motivation, and ability to engage in intentional self-development) is the most important factor that influencing the success of activities in the other four contexts. From here, they might well transfer this system knowledge to understanding community and global sustainability. Therefore, learning about sustainability should start with understanding individual sustainability.

2.11 Student-centred Learning (SCL)

SCL is based on learning theories that consider learning as a constructivist, situated and social activity (Smit *et al*., 2013). According to (Attard *et al.*, 2010), in order to learn effectively, learners must construct and reconstruct their own knowledge. They also highlighted four usefulness and impact of SCL approach; (1) conventional pedagogical approaches do not foster the development of critical thinking in students of higher education, (2) elements such as group work, critical analysis and greater interaction among peers positively correlate to students' capacities to accumulate generic competences and soft skills, (3) students who are involved more actively in the teaching and learning process and who receive and give a greater amount of feedback are more secured and assertive in transmitting academic knowledge, and (4) it is necessary to carefully monitor any process of switching to certain modes of SCL, such as group-work, so that no negative effects would occur, such as the monopoly of debate by a vocal minority.

Furthermore, Land and Hannafin (1996) found that the learning environments in SCL are rooted on five foundations; (1) psychological - based on how we think and learn as individuals, (2) pedagogical - focused on methods, activities, and structures of learning environment), (3) technological - used optimized technology to create environments where learning is the desired outcomes , (4) cultural - roles that individuals play in society, and (5) pragmatic foundations - practical constraints of the environment, such as, hardware/software availability, run-time requirement and financial concerns. The integration of those foundations is essential in the effective learning systems design (Nanney, 2004). There are several strategies in SCL,such asactive learning (Bonwell and Eison, 1991;), collaborative learning (Bruffee, 1984), inquiry-based learning, cooperative learning (Johnson *et. al.*, 1991), Problem-based

Learning(Bradford *et al*., 2004), Team-based Learning (Michaelson *et al.*, 2004), and Peer Instruction (Mazur, 1997).

2.11.1 Problem-Based Learning (PBL)

PBL is a student-centred learning strategies that challenges students to learn through engagement in a real problem. The aim of PBL is to help students develop rich cognitive models of the problems to increase knowledge and understanding (Dolmans and Schmidt, 1985), develop students' criticality (Savin-Baden, 2007; Johnson, 1999) enhance enculturation into a community of practice (Bailey *et al*., 2003) etc. According to Savery (2006), PBL empowers students to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem. PBL models start the process with a realistic, if not, real problem. PBL is a philosophy that needs to be adapted to the environment of the institution and the nature of the field in which it is applied. In contrast, most PBL models can be expensive because they require intensive manpower, infrastructure and institutional support. For instance, the medical school model is normally implemented in small group tutorials with one dedicated facilitator that functions as the cognitive coach, while the project organized model that originated from Aalborg University is implemented in an institutional setting with small groups supervised by a dedicated instructor (Barrows, 1996; Graaff and Kolmos, 2003).

Referring to Figure 2.5, (Graaff and Kolmos, 2007) found that there are three approaches as common learning principles across PBL models; (1) *Learning approach* as a problem or project that learning is organised around problems. A problem makes up the starting point for the learning process and places, learning in context and base learning on the learner's experience, (2) *Contents approach* concerns, especially in interdisciplinary learning, which across traditional teacher-centered learning boundaries and theories, and (3) *Social approach* is team-based learning. Learning process is a social act through communication. Students learn,share knowledge and organise the process of collaborative learning.

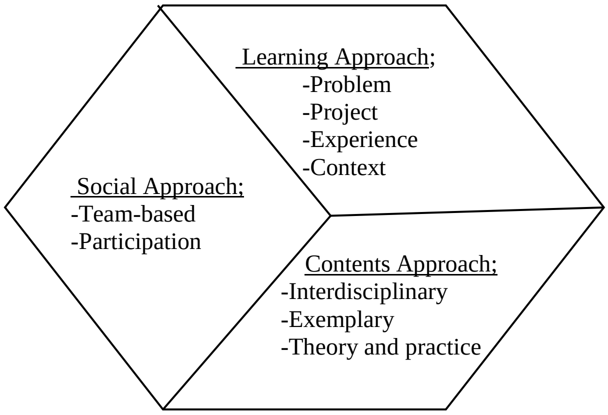


Figure 2.5 PBL learning principles (Graaff and Kolmos, 2003;2007)

As shown in Figure 2.6, PBL model provides a step by step guide and systematical way of learning for students to enhance knowledge. The learning process that develops as a cycle and the cycle is repeated until the problem is fully resolved. PBL typically consists of 3 cycles, which known as;

(i) Phase 1 – problem restatement and identification

(ii) Phase 2 – peer teaching, synthesis of information and solution formulation

(iii) Phase 3 – generalization, closure and reflection

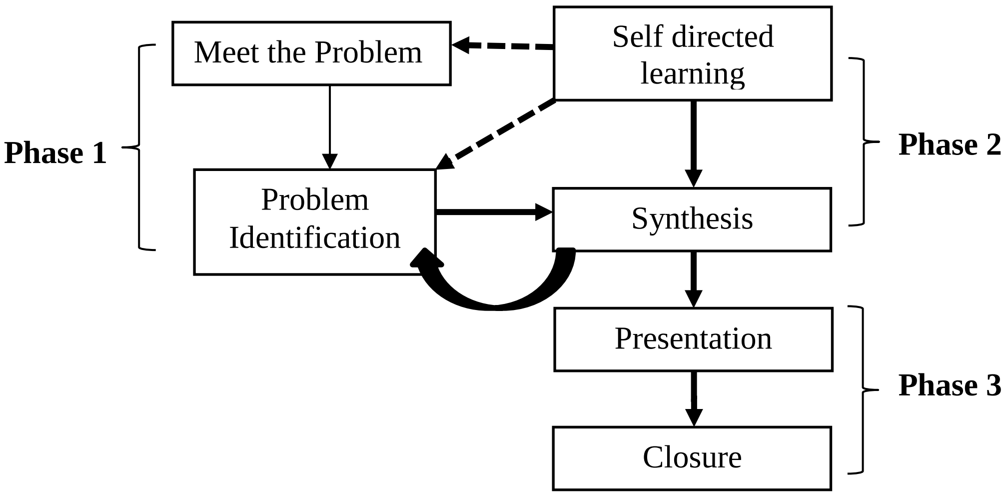


Figure 2.6 Cycle in a Problem-Based Learning Model

2.11.2 Cooperative Learning (CL)

CL is a teaching strategy in which small groups of students use a variety of learning activities to improve their understanding of a subject. CL was known to promote student-centred learning environment (Felder and Rebecca, 2009) with five underpinning principles; positive interdependence, individual accountability, face to face interaction, appropriate interpersonal skills and regular team role assessment (Mohd-Yusof *et al*., 2011). CL has been proven to be effective for all types of students because it promotes learning and fosters respect and friendships among diverse groups of students. In a team, social interaction among students can create collaboration in the learning activities. The positive learning environment would yield strong interaction among learners in a cooperative and supportive environment. Member in a team has a responsibility to support and facilitate each other's effort to reach the goal. Several studies of cooperative learning conducted in Malaysian context, such as Zahariah *et al*., (2005) have found that cooperative learning promote positive relations among students and there was a tendency to be more cooperative among the peer members in discussing and solving problems.

2.11.3 Cooperative Problem-Based Learning (CPBL)

CPBL is a hybrid of two models of student-centred learning methods; i.e. Cooperative Learning (CL) and Problem-Based Learning (PBL). It integrates cooperative learning principles into the PBL cycle (Mohd-Yusof *et al.*, 2012). The CPBL process consists of the same three phases of the PBL process, as shown in Figure 2.6. However, each phase is expanded in order to incorporate CL principles to ensure a functioning cooperative team, which is essential in providing the required support in learning and solving the problem. Students are facilitated by floating facilitators, who goes around from one group to another or conduct the overall class sessions. In a proper CPBL environment, part of the monitoring, support and feedback can be attained from peers, especially team members, instead of solely relying on the facilitator.

The CPBL process consists of three phases, i.e.Phase 1 - the problem identification and analysis; Phase 2 - learning, application and solution formulation; Phase 3 -generalisation, internalization and closure. In each phase, the individual activity is designed to enhance learning and accountability, which will be strengthened with team-based activities, and further supported in the overall class activities to form a learning community. To ensure individual accountability, students are required to submit each of the individual task in the framework for assessment, for which they receive feedback during the overall class discussion. Students have to submit an individual reflective journal to reflect on their learning over the period of time (Zeegers & Clark, 2014).The framework in Figure 2.7 can be used to visualize the CPBL process that support students in grasping the whole learning process, as well as for facilitators explain the significance of each step in terms of the outcomes and activities in each block as they go through each of the three phases in the CPBL cycle (Mohd-Yusof *et al*., 2011).

In a typical engineering class setting with 30 to 60 students, Cooperative Problem-Based Learning (CPBL), which integrates CL principles into the PBL cycle, is shown to be effective in supporting students to attain deep learning in the various learning domains. CPBL can be implemented by dividing students into smaller groups in a medium to large class. CPBL is proven to develop team-based problem solving skills, as well as enhance motivation and learning strategies among undergraduate engineering students (Mohd-Yusof *et al*., 2014; Mohd-Yusof *et al*., 2011; Helmi *et al*.,2011).

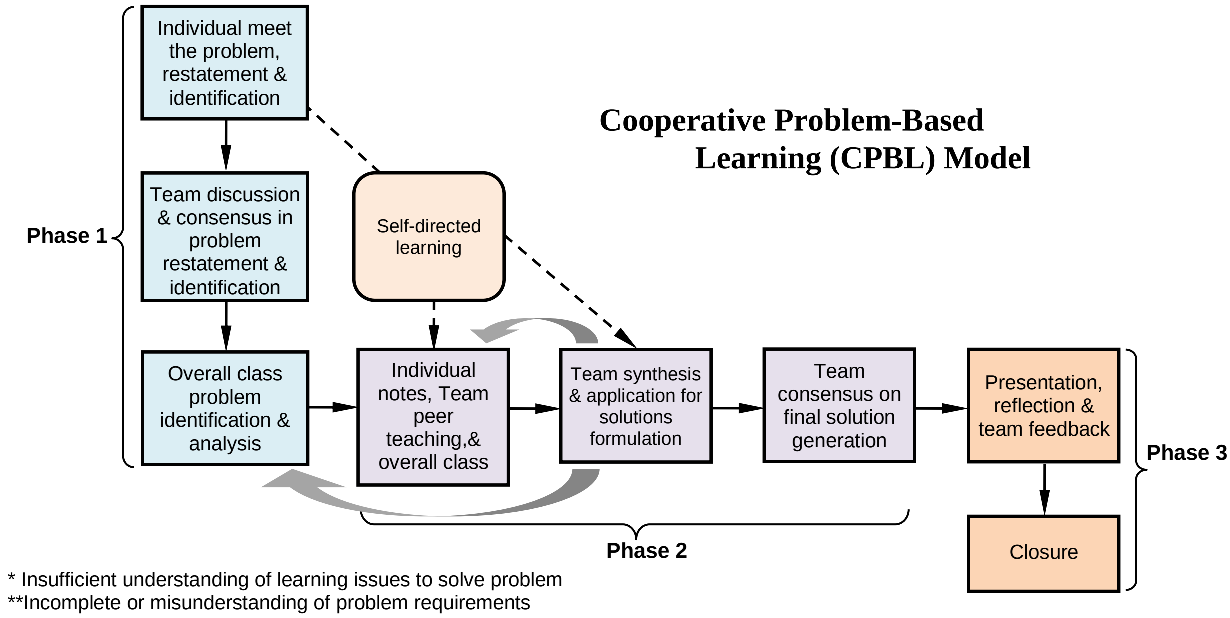


Figure 2.7 Cooperative Problem Based Learning (Source Mohd-Yusuf *et al*, 2011)

2.12 Behavioural Change

Numerous studies have show that environmental problems could be reduced if people were persuaded to change their pro-environmental behaviour (Hargreaves, 2011; Kenis and Mathijs, 2012; Rogerson *et al.*, 2009; Tanenbaum *et al.*,2013; Van der Linden, 2014). However, persuading people to change lifestyles has been proven to be harder than anticipated for several reasons. Without standardized definitions of the techniques included in behavior change interventions, it is difficult to faithfully replicate effective interventions and challenging to identify techniques contributing to effectiveness across interventions.

Harris (2012) found that there are five common reasons, mentioned as follows,

(i) The complexities of environmental problems mean that often members of the general public do not understand the issues.

(ii) Even if people understand the need for change, such change needs to be facilitated. For instant, pro-environmental behaviour such as cycling and reducing use of cars through walking or cycling must be made easier through careful positioning of recycling venues, provision of pavements, cycle paths and affordable public transport schemes.

(iii) Individuals making the changes need to feel that their efforts are not being undermined by others. Those sacrificing their lifestyles are easily undermined by others who embrace a more consumerist lifestyle. This is seen at the local individual level, as people compare themselves with their neighbours.

(iv) The concept of 'common but differentiated responsibilities' is challenging. The 'Rio Declaration, 1987' states that the developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command.

(v) Behaviour change asks us to make immediate sacrifices for the benefit of those far away and for unknown future generations. In both cases, distance (in space or time) and relative anonymity undermine the urge to make personal sacrifices on lifestyle.

Those common reasons significant with social learning theory developed by Albert Bandura(1977, 1986), assumes that whether an individual will engage in or avoid a behaviour is determined by a sequence of factors. Moore and Sugland, (1977) list three factors that may influence human behaviour to change as follows;

(i) The individual must understand the association of behaviour with an outcome.

(ii) The person must believe that he or she is capable of either engaging in or avoiding the behaviour and that the specific strategy chosen can be implemented effectively.

(iii) People must believe that avoiding the outcome is beneficial.

In the same view, Information Deficit model of behaviour change also stresses that unsustainable behaviours occur because people do not know any better. As shown in Figure 2.8, shows the Information Deficit Model that provide information on change values and values changes attitudes andattitudechanges behaviour.

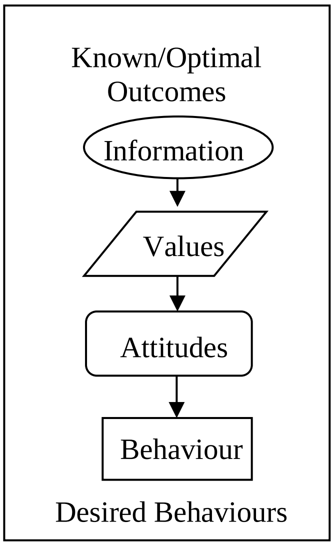


Figure 2.8 Information Deficit Model of Behaviour Change

Tanenbaum *et al.* (2013) mentioned that it is common for local governments, organizations, current curriculum design and pedagogy. For instance, the way how to educate participants about the benefits of recycling, conservation, reuse, or other environmentally friendly practices. A student just need to understand the environment and then they will behave accordingly in a pro-environmental manner.

2.13 Models of Instilling Sustainability in Engineering Education

This section looks at some of the models and framework related to the sustainability in engineering education with different contexts. Rigorous researches are conducted and several models are proposed. This section only focuses on selected models or framework, given as follows;.

2.13.1 'Three-tier' Approach

A 'Three-tier' approach has been developed and implemented in the chemical engineering programme at University of Surrey to teach sustainability (Azapagic *et al*., 2005). Figure 2.9 illustrates the 'three-tier' approach comprising the following elements:

(i) Dedicated lectures and tutorials on sustainable development;
Students are exposed to sustainability concepts as one of the key learning areas through a series of lectures and tutorials

(ii) Specific case studies;
Students are exposed to specific, practical case studies, to enable them to apply the sustainability concepts and identify sustainable solutions. Life cycle approach is carried out to assess economic, environmental and social issues. (Azapagic, 2004; Pardon and Azapagic, 2003)

(iii) Integration of sustainability into the overall curriculum.
Integration of sustainability thinking into the overall curriculum from the fundamental through quantitative methods and tools to the design projects.

According to Azapagic *et al*. (2005), an integrated approach enables a systemic introduction of sustainability criteria into the curriculum, starting with a lower level of complexity and progressing towards more complex considerations at the higher levels of study. This model could promote learning outcomes that enable graduates to establish a clear connection between engineering and sustainable development and helps them in practicing sustainable engineering.

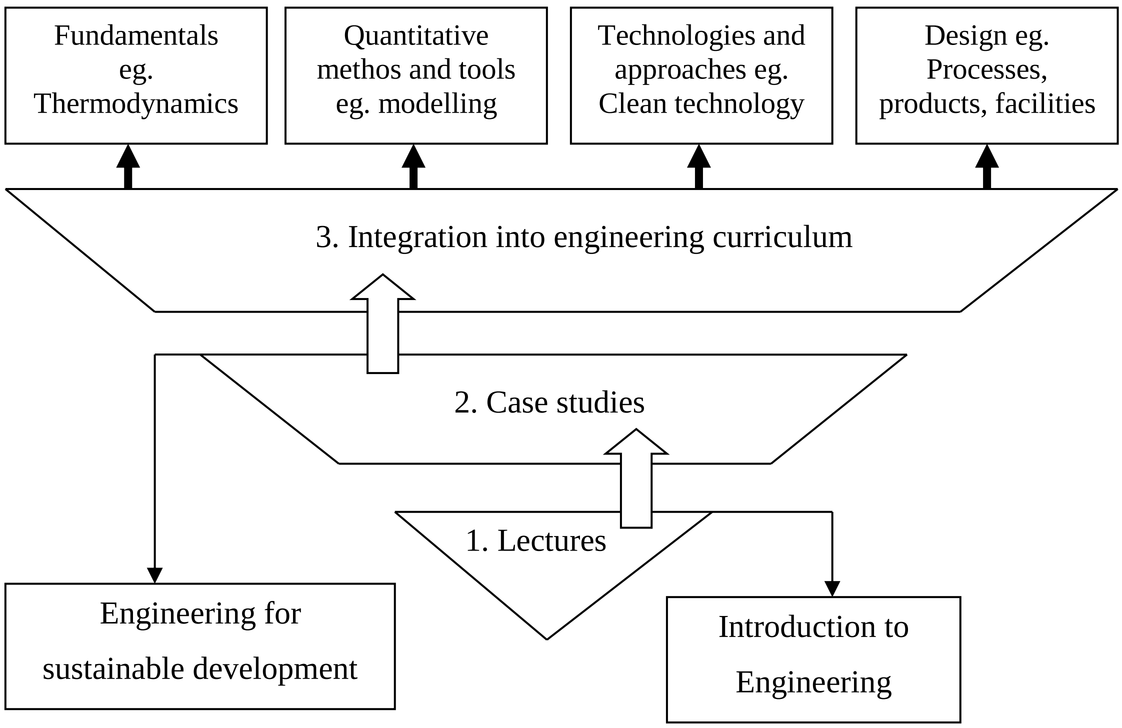


Figure 2.9 The 'Three-tier' approach to teaching sustainability developed by the University of Surrey (adapted from Azapagic, 2001)

2.13.2 Integrated Framework for Communicating Climate Change

Linden (2014) has developed an integrated framework for communication climate change campaign in order to achieve behaviour change as shown in Figure 2.10. It is argued that persuasive communication is only persuasive if it is based on an integrated understanding of the psychological processes that underlie and influence pro-environmental behaviour. There are three criteria condition that need to be met; (1) intervention should design integrative communication messages (interrelation between cognitive, affective and socialdimensions of behaviour change, (2) the context of climate change needs to be made explicit and (3) specific behaviours should be targeted, paying close attention to the psychological determinants of the behaviours that need to be changed. The result shows that creating negative attitudes towards climate change draws on the interaction of both cognitive and affective processes.

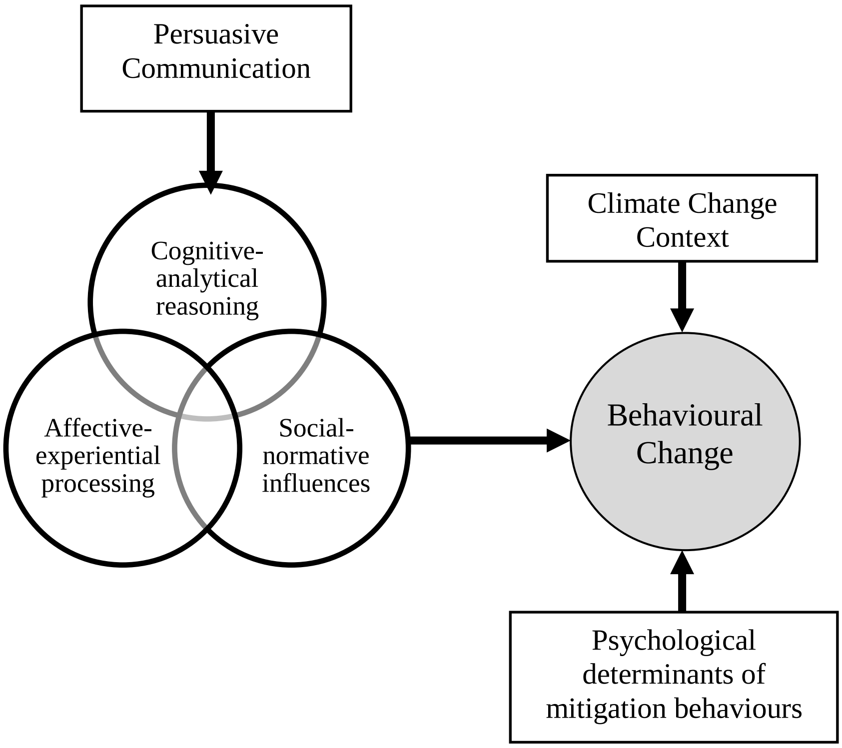


Figure 2.10 An Integrated Framework for Public Communication Interventions (Linden, 2014)

2.13.3 A 'Whole-of-University'

The Australian National University adopts a 'whole-of-university' approach to sustainability which links the principles of sustainability being taught in the classroom with the principles of sustainability being implemented on the campus(McMillin and Dyball, 2009). A good example of linking curriculum, research and campus operations involves the university's 12-month trial of an in-vessel organic waste composting unit.

Figure 2.11 shows the framework of a ‘whole-of-university’ approach to sustainability. This trial seeks to divert 90 percent of the organic waste on campus, including food waste from residence halls and campus cafes, from landfill to composting.

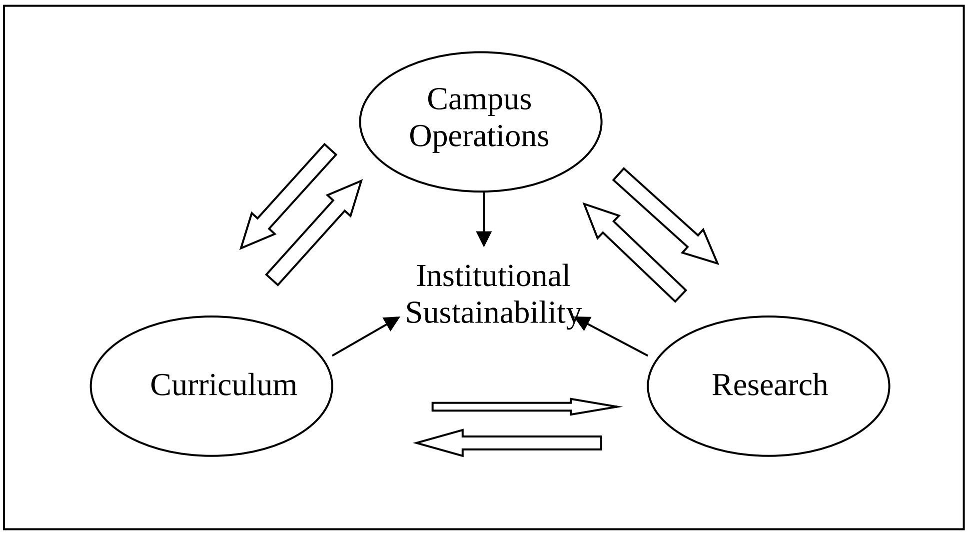


Figure 2.11 A whole-of-university approach to sustainability (Mc Millian and Dyball, 2009)

From the curriculum point of view, students are analysing the emissions offset by diverting the organic waste stream from landfill. In research, both students and academics are looking at the microbial communities in the compost to enhance understanding of the composting process and to improve the process itself. This is an important link between the everyday practice of food consumption and actions that both the individual and the institution can take to achieve positive outcomes.

2.13.4 Three Dimensions of Characterizing Sustainability Course in Engineering Education

Arsat *et al.*, (2011) found that there are three dimensions of characterization on constructing and designing a sustainability course in engineering education, namely models, orientations and approaches, as shown in Figure 2.12. The first dimension to characterize course learning objectives and course contents consists of the two basic models, known as stand-alone model and the integrated model. The stand-alone model means that a course will be designed and constructed to provide an understanding of sustainability with no intention to integrate this knowledge into the existing engineering courses. Meanwhile, the integrated model is a model where sustainability elements are integrated into regular or traditional engineering courses. He also stresses that the sustainability concepts will not only be introduced to engineering fields, but it will purposely be designed for the application, evaluation and synthesis levels.

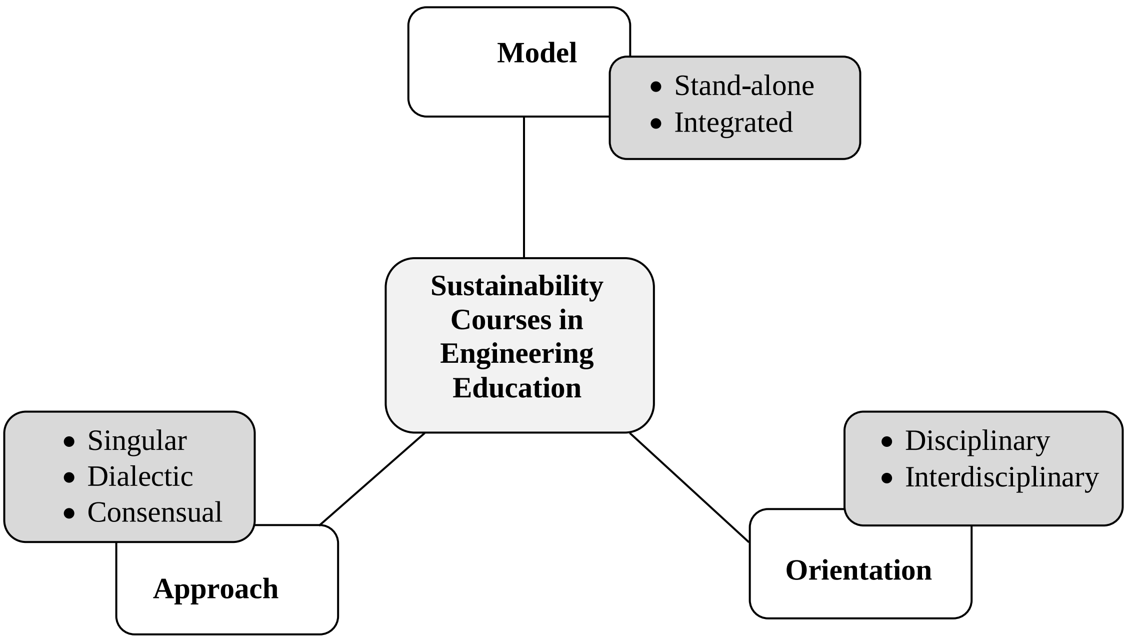


Figure 2.12 Three dimensions of characterizing learning objectives and course contents.(Arsat *et al*., 2011)

The second dimensions of orientation is used to characterize course learning objectives and course contents. It focuses on how learning objectives are formulated and how the choice of content is made from the pool of disciplinary knowledge. This orientations is divided into two types, namely disciplinary and interdisciplinary orientation. The disciplinary orientation only focuses to provide learner with specialized skills and concepts, while integrated orientation purposely brings together the full range of disciplines in the curriculum.

Finally, the third dimension as approaches which is derived from the general model for sustainability and Lourdel's representation of sustainable development, rename as singular, dialectic and consensual. The singular approach is described as sustainability courses that emphasize a specific pillar instead of a holistically blend of the three pillars together in a single course. Furthermore, the dialectic approach is defined as an approach that blends two pillars of sustainability to be the major learning component and the consensual approach is an approach where the learning objectives and course contents for sustainability course are fairly balanced in the integration of three pillars. As a recommendation, Arsat *et al* (2011) proposed that for the demand of the sustainability concepts and the three dimensions, the integrated models, interdisciplinary orientation and consensual approach is the best combination.

2.13.5 Whole Institution EESD Framework

Subarna, (2015) in 'Engineering Education for Sustainable Development (EESD) for Undergraduate Engineering Programmes In Malaysia: A 'Stakeholder Defined Framework' proposed thewhole institution EESD framework which comprises of nine interlinking EESD dimensions which Malaysian universities could use to advance transformative EESD within their institutions; i) advancement of sustainability laden stakeholders values, ii) transdisciplinary stakeholder engagement, iii) ESD centred educational philosophy, iv) transformative learning, v) sustainable academia and institutional operations and practices, vi) sustainability inspired organization culture, vii) sustainable academia and institutional policies, viii) inter, multi and transdisciplinary curriculum and assessment, and ix) inter, multi and transdisciplinary research and teaching approaches. She also proposed six guidelines for the holistic incorporation of sustainable development competencies within an undergraduate engineering programmes, namely programme outcome, modules, language and communication modules, business and management modules, social sciences and humanities modules and university programs. These guidelines are the results of the analysis of the thirty sustainability competences.

2.13.6 University as a Sustainability Campus

University as a higher educational institution has a power in creating knowledge, developing students competencies, and promoting sustainability issues to the society (Larsen *et al*., 2013). In Malaysia, UniversitiTeknologi Malaysia and UniversitiSains Malaysia become example of sustainability campus. UniversitiTeknologi Malaysia (UTM) has been seeking to become a sustainable campus since 2010 and had been formally launched on 16 March 2011 by the Minister of Natural Resources and Environment, Dato' Seri Douglas Embah and Ex-Vice Chancellor UTM, Dato' Seri Prof.Dr. Ir. ZainiUjang (Zen *et al*., 2013). The Sustainable Campus Initiative is an ongoing effort to develop coordinated, long-term and meaningful cross-campus greening. UTM attempts to improve the quality of the campus environment, decrease waste, conserve natural resources and energy, strengthen its commitment to sustainability and integrate these practices into the curriculum to enhance ecological literacy (Zakaria *et al*. 2010). Involvement in campus sustainability initiatives helps students not only to recognise that they are a part of an institution with an ecological impact but also that their individual choices and action do make some difference. Students gain a sense of ownership and connection to the campus. By working with students to foster a more sustainable campus, the university also promotes environmentally responsible citizen by empowering students to become agents of change. For instance, to establish a low carbon campus, various aspects were emphasised, including management of campus solid waste and food waste, recycling, campus transportation, water and energy management. According to Sheau Ting *et al*. (2012), raising energy conservation awareness and developing energy conservation behaviour has been listed as key elements to realising a low carbon campus. In order to reduce dramatically the overall energy consumption on campus, relevant strategies are important to success.

Similarly, Universiti Sains Malaysia (USM) is also promoting the sustainable development agenda since 2000 through its leadership role in the Regional Centre of Expertise (RCE) Penang using an “inside-out approach” (Abidin Sanusi *et al.*, 2008). RCE Penang sees its role as addressing the needs and challenges of the society in relation with sustainable development by developing an educational framework that is capable of ensuring sustainability in the region. Both universities are examples of establishing and promoting education for sustainable development through university research, teaching and learning as well as community engagement.

2.14 Summary

As a summary, the discussion in this chapter can be divided into three parts; 1) environmental knowledge and pro-environmental behaviour, 2) education for sustainable development, 3) pedagogical approaches towards inculcating sustainability and model of instilling sustainability in Engineering Education. Several theories and models related to the study are highlighted. This information will support and provide concrete input for the researcher during the discussion in Chapter 6 and 7.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the flow of the research process, data collection methods, data analysis and ethical considerations used to achieve the research objectives and research questions as mentioned in Chapter 1. A case study with mixed method research methodology has been carried out among the first year chemical engineering students to investigate the impact of implementing CPBL as a teaching and learning approach in instilling sustainability. This chapter outlines the process of data acquisition of Phase I and II. This chapter also discusses the development of the questionnaire used in quantitative study. It discusses in detail the instrumentation, the research population, sampling methods, data collection, data analysis and support tools for data analysis. The research protocol and ethics while conducting the research is also highlighted.

3.2 Research Process

The research process is design to define the research strategy of this study in detail. According to Saunders *et al*. (2000), the research process 'onion' could support the researcher to depict the research interest underlying the choice of data collection methods. Figure 3.1 shows the four layers of research onion which consists of research paradigms, approach, methodology or strategy and data collection methods.

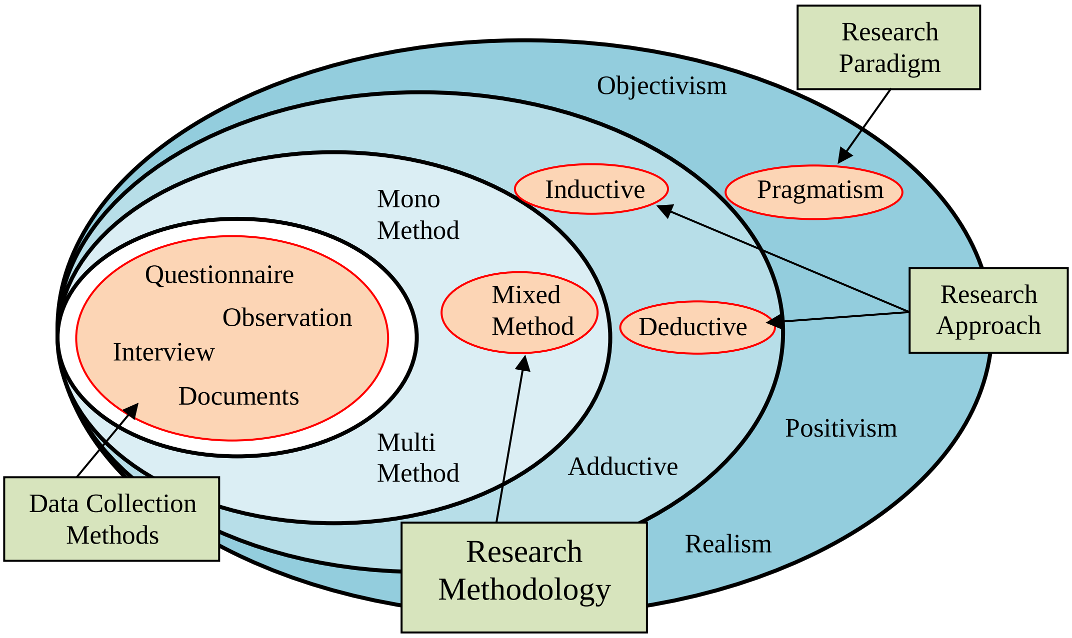


Figure 3.1 Research Process 'Onion'

3.2.1 Research Paradigms

'Paradigm' or 'Philosophy' is referred to the manner in which we view the world. According to Creswell, (2003), there are four paradigms associated with research; postpositivism, constructivism, advocacy and participatory, and pragmatism. Creswell and Clark, (2007) catagories that postpositivism and constructivism as paradigms associated with quantitative and qualitative approaches, respectively. Advocacy and participatory is associated with qualitative approaches rather than quantitative approaches, while pragmatism is associated with a mixed method research and employs multiple data collection methods to achieve the research objectives. In this study, the researcher found that this paradigm of pragmatism is most relevant in order to achieve the research objectives, asa mixed method research methodology has been implemented.

Pragmatism was pioneered by the American philosophers, known as Charles Sanders Peirce (1839-1914) and John Dewey (1859-1952). John Dewey believes that learners must adapt to each other and to their environment. He stressed on three major concepts are emphasised of learning; 1) the necessity of physical, manipulative activity to be a part of learning; 2) the creation of a habit of inquiry based on the proven systems in science; and 3) the essential need to see and vitalize the social role of education (Whale, 1968). This research paradigm depends on the way we think about the development of knowledge and apply this knowledge to real situations through experimental inquiry. Johnson and Onwuegbuzie (2004) state that pragmatism is about collecting quantitative and qualitative data and mixing the data to address the research work. According to Lodico *et al*. (2006), most pragmatic researchers use a mixed-methods approach to achieve the best results.

Therefore, in this studythe paradigm of pragmatism is chosen due to the following reasons; (i) as a guidance to use both methods in a single study, (ii) able to employ and mix both qualitative and quantitative data to answer the research objectives, and (iii) able to collect both quantitative and qualitative data concurrently.

3.2.2 Research Approach

In this study, research approachconsists of deductive and inductive. Deductive research is based on deductive thought which transformgeneral theory into specific hypothesis suitable for testing. It works from the more general to the more specific. Conversely, inductive research is based on inductive thought which transform specific observations into a general theory. It works the other way compared to deductive approach, moving from specific observations to broader generalizations and theories. Both research approaches are implemented to gain meaningful findings. In quantitative study, the deductive research approach is adopted, starting with literature review; constructing the instrument, hypothesis, data collection and interpretation. Whilst, in qualitative studies, the inductive research approach is implemented where the several qualitative data collection are conducted to investigate the outcomes, and to align the findings with the literature and theories.

3.2.3 Research Methodology

Research methodology is identified as a generic plan to guide the researcher to answer the specific research questions (Saunders *et*, *al*. 2000). The research methodology used in this study is a mixed-method research. Mixedmethods research is a research which focuses on collecting, analyzing, and mixing both qualitative and quantitative data in a single study or series of studies (Creswell *et al.*, 2003; Onwuegbuzie *et al*., 2006; Greene*et al*.1989; Slavin, 2007 and Johnson *et al*. 2007). According to Marquerite*et al*. (2006), one of the major advantages of mixed method is that it combines the strengths of both qualitative and quantitative research. This research methodology also has several flexibilities,such as in choosing methods of data collection and the strengths of an additional method to overcome the weaknesses in another by using both in a research study. The presentation of results would convince and become powerful when both summaries are integrated. There are several designs of mixed method research which refers to the decision about which type of data is given priority and when each type of data is collected and analyzed, such as sequential, concurrent and embedded mixed-method approach (Creswell *et al.*, 2003 and Marquerite *et al*., 2006).

Research methodology for this study consists of two phases as shown in Table 3.1. Using a case study approach, a group of first year engineering students at the Faculty of Chemical Engineering, Universiti Teknologi Malaysia, enrolled in ‘Introduction to Engineering’ course is identified as the research population. This particular course is selected because it is the only course which include content of sustainability via a case study and it uses student-centered learning as teaching and learning approach. The students need to participate in both quantitative and qualitative studies. Therefore, mixed method research is used to benefit the combination of quantitative and qualitative that data could support each other and present a strong finding. The qualitative analysis also serves as a complement to the quantitative results. Finally, a framework for teaching environmental sustainability is recommended.

Table 3.1 Research Methodology

Phases	Research Method	Purpose
1	Quantitative	To assess the level of students' prior knowledge and pro-environmental behaviour
2	Mixed Methods i) Quantitative (Before-and-after case study design)	To investigate the changes of students' knowledge and pro-environmental behaviour before and after CPBL.
	ii)Qualitative	To investigate the implementation of CPBL approach as teaching and learning approach in developing students' knowledge and behaviour change associated with environmental sustainability.
To recommend suitable framework of teaching environmental sustainability.		

3.2.4 Data Collection Method

Data collection is a process of gathering, measuring information and evidence to provide answersto research questions. There are several types of data collection method based on type of research. During the data collection process, researchers have to follow the ethical procedures.Inthis study, the data collection method consists of quantitative and qualitative study as shown in Figure 3.2. A questionnaire has been used as an instrument in quantitative study. Meanwhile, documents such as course outlines, students' reflection journals, interviews and observationsare, usedas qualitative data. Each instrument must following the research procedures to gain the quality evidence, allowing the building up of convincing and credible answers to questions.

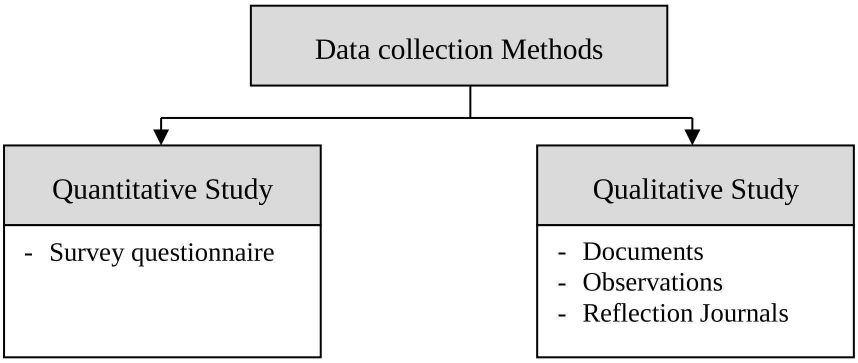


Figure 3.2 Data Collection Methods

3.3 Operational Research Framework

A research framework developed for this study is comprisies of two phases shown in Figure 3.3. In Phase I, a preliminary study via interview is conducted to investigate the students’ prior knowledge and behaviour in relation to environmental sustainability. Respondents areselected randomly from first year engineering students. The purpose of this interview is to investigate the students’ perception of environmental sustainability knowledge and their participation in sustainable behaviour. Outcomes from this phase serve as a guide in determining the research problem and developing the researchinstrument. An instrument is administrated among first year engineering students to determine the most significant items to be considered in order to assess students’ knowledge and behaviour on environmental sustainability.

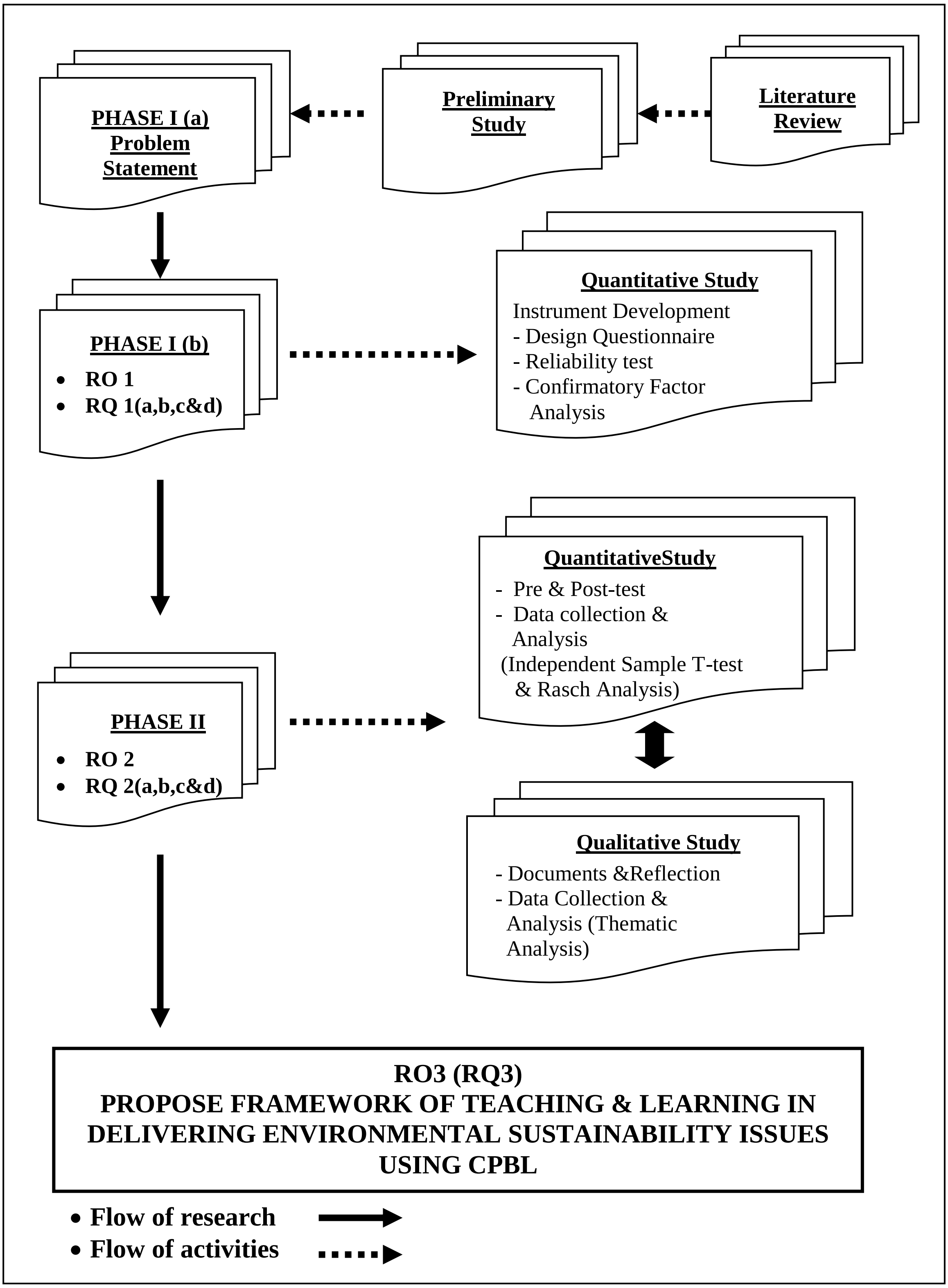


Figure 3.3 Flow of Operational Research Framework

The target population for this research is the first year chemical engineering student enrolled in ‘Introduction to Engineering’ course during semester 1, of 2012/2013 academic session. In Phase I, the instrument is administered to the first year engineering students from selected engineering faculties. Quantitative and qualitative studies are conducted concurrently during the learning process in Phase II. Finally, a framework for teaching environmental sustainability is recommended.

3.3.1 Phase I

Phase I consists of three steps, namely, the preliminary study, instrument development and quantitative study as shown in Figure 3.4. At the beginning, the preliminary study is conducted among randomly selected first year engineering students. This is to get an overview of students’ prior knowledge on environmental issues and to check on their knowledge on sustainable development and to ascertain if they have previously practiced pro-environmentalbehaviour. The purpose of conducting this preliminary study is to have some insights of the issues that are to be investigated. According to Morgan (1998), preliminary study could help researcher to ascertain the possibility of studying the issues, identify the possible respondents and improve the intervention programmes.

A group of 10 students is randomly selected to be interviewed using unstructured questions. The results showed that most students are clueless about sustainable development at the entry level. Most of them did not know how to explain or elaborate the definition on sustainable development because they have not been exposed previously. However, they do involved some aspects oftheir daily activities and are receptive towards sustainable development initiatives such as earth hour, recycling, green technology, climate change and so on. This result was presented in the ‘International Conference on Teaching and Learning in Higher Education (ICTLHE 2012) in conjunction with RCEE & RHED 2012’ (Sharipah *et al.*, 2012).

In the second step of Phase I, a questionnaire is prepared as a tool to assess students' level of knowledge and pro-environmental behaviour in the following questions. The questionnaire is adapted from several environmental attitude inventories such as Behaviour-based Environmental Attitude (Kaiser *et.al,* 2007) and Environmental Attitude Inventory (Milfont & Duckitt, 2010) and it has been modified and tested to suit the Malaysian students' backgrounds. Figure 3.4 shows the detailed of research procedures which include the information on the numberof respondents, data acquisition and findings.

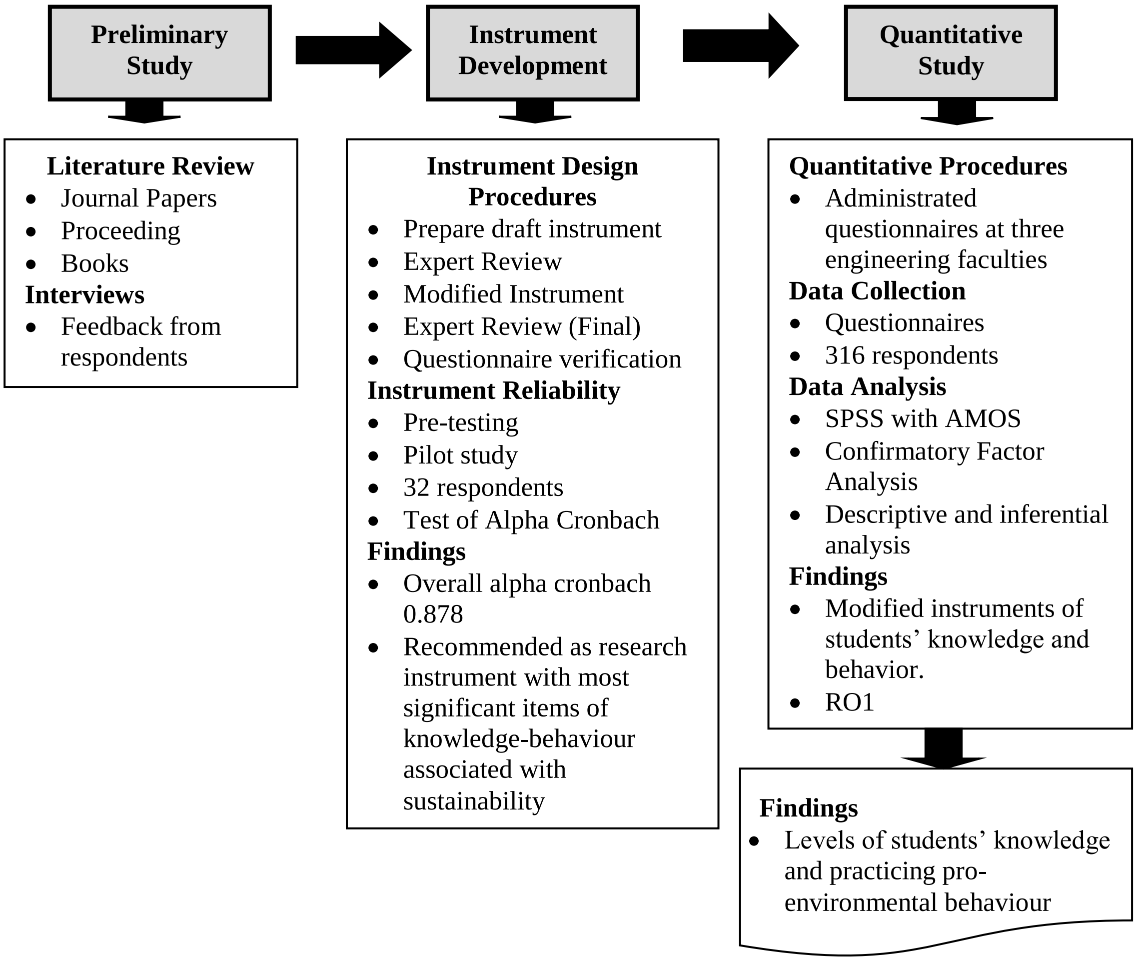


Figure 3.4 Framework of Phase I

In the quantitative study, respondents are randomly selected from three engineering faculties. Confirmatory Factor Analysis (CFA) using 'Analysis Moment of Structure' (AMOS) is performed to determine the most significant item of each construct of knowledge and behaviour. Outcomes from this phase served as a tool to answer the research question RQ1(a – d) and RQ2(a – b).

3.3.2 Phase II

In the second phase, a case study of mixed method research methodologyis carried out to investigate the impact of CPBL on students' knowledge and behaviour.The target group is the first year chemical engineering students enrolled in 'Introduction to Engineering' course. This is a special course which is specifically designed to enhance students' knowledge and understanding about 'what is engineering'. In quantitative study, the respondents have to answer the survey questionnaire before and after the case study. Figure 3.5 shows the flow, data collection and data analysis of the research design. The target group in this phase is classified as purposefully respondent since all students participate in the study. Respondents are exposed to Cooperative Problem-Based Leaning (CPBL) via a problem which is related to sustainability issues. Students are required to follow the CPBL cycles and each stage is closely monitored. Finally, a model of teaching and learning that inculcates sustainable development on pro-environmental behaviour with CPBL as a teaching and learning approach is recommended.

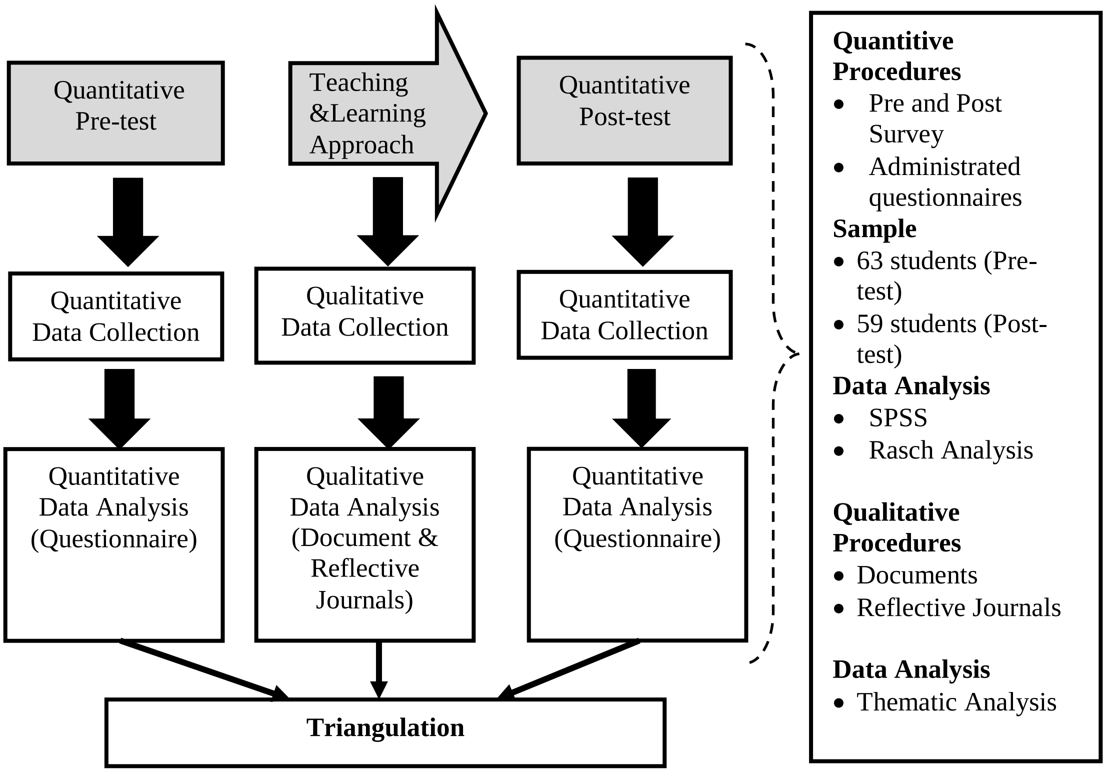


Figure 3.5 Framework of Phase II

3.4 Sample and Population

Research sample and population of this study focuses on first year engineering students.Table 3.2 shows the information on respondents involved in this study. The participants are consisting of two groups of respondents, catagorised according to phase.

Table 3.2 Information on Research Activities and Number of Respondents

<table>
<tr><th>Phase</th><th colspan="2">Research Activities</th><th>Respondent/ Document</th></tr>
<tr><td rowspan="4">Phase I</td><td rowspan="4">Quantitative Study</td><td>Pre-testing</td><td>30</td></tr>
<tr><td>Pilot Study</td><td>36</td></tr>
<tr><td>Real Study</td><td>316</td></tr>
<tr><td>Outlier</td><td>9</td></tr>
<tr><td rowspan="5">Phase II</td><td rowspan="2">Quantitative Study</td><td>Pre-test</td><td>63</td></tr>
<tr><td>Post-test</td><td>59</td></tr>
<tr><td rowspan="3">Qualitative Study</td><td>Reflective Journal</td><td>35</td></tr>
<tr><td>Course Outlines</td><td>1</td></tr>
<tr><td>Problem Used</td><td>3</td></tr>
</table>

3.4.1 Phase I

In this phase, random sampling is conducted in such a way that every student in the population has an equal and independent chance of being selected (Marguereti *et al*. 2006). Simple random sampling is selected among the first year engineering students from three engineering faculties at UniversitiTeknologi Malaysia. The three faculties are Faculty of Civil Engineering, Faculty of Chemical Engineering and Faculty of Electrical Engineering. Prior to data collection, the researcher has obtained approval from the course coordinators to conduct the survey (Appendix A). Referring to Krejcie and Morgan (1970), the sample size of this study is acceptable (307 > 278) as shown in Appendix B. Table 3.2 shows the numbers of respondents involved in this study. In phase 1, three groups of respondents are selected to participate in the research procedures; 30 respondents for pre-testing, 36 respondents for pilot study and 316 respondents for the real study. 9 out of 316 is idenfied as outliers because of missing data.

3.4.1.1Analysis of Demographic Data

A sample of 316 first year engineering students from three engineering faculties at UniversitiTeknologi Malaysia are randomly selected to participate in this study. The three engineering faculties consists of Faculty of Civil Engineering, Faculty of Chemical Engineering and Faculty of Electrical Engineering. Students' demographic data information consists of gender and race. Table 3.3 shows the percentage of gender according to faculties. The descriptive analysis shows thatthe percentage of male (57%) is higher than female (43%) respondents.

Table 3.3 Analysis of Gender across Faculty

		Faculty			Total
		Civil	Electrical	Chemical	
Gender	Male	57	87	43	187
	Female	71	15	43	129
Total		128	102	86	316

Table 3.4 shows thedescriptive analysis of race among the respondents. The respondentsconsist of Malay (79.2 %), Chinese (11.4 %), Indian (2.3 %) and other races (7.2 %). Others means that the respondents are either from Bumiputra Sabah or Sarawak or foreign students. This result shows that majority of respondents are Malay (79.4%). Therefore, in this study, elements of the race is not considered.

Table 3.4 Analysis of Race

Ethnic groups	Frequency	Percentage (%)
Malay	251	79.4
Chinese	36	11.4
Indian	6	1.9
Others	23	7.3
Total	316	100.0

3.4.1.2 Analysis of Students' Educational Background

Figure 3.6 shows the analysis of previous educational background of the respondents. The majority of the respondents' educational background is from matriculation programmes (72.3%). Only a small percentage of the students is from SijilTinggi PelajaranMalaysia (5.5%), collaboration programme between UTM-MARA (5.2%) and others (16.9%).'Others' refers to college 'A' Level or its equivalence. The results show that majority of the respondents in this study has the same educational background.

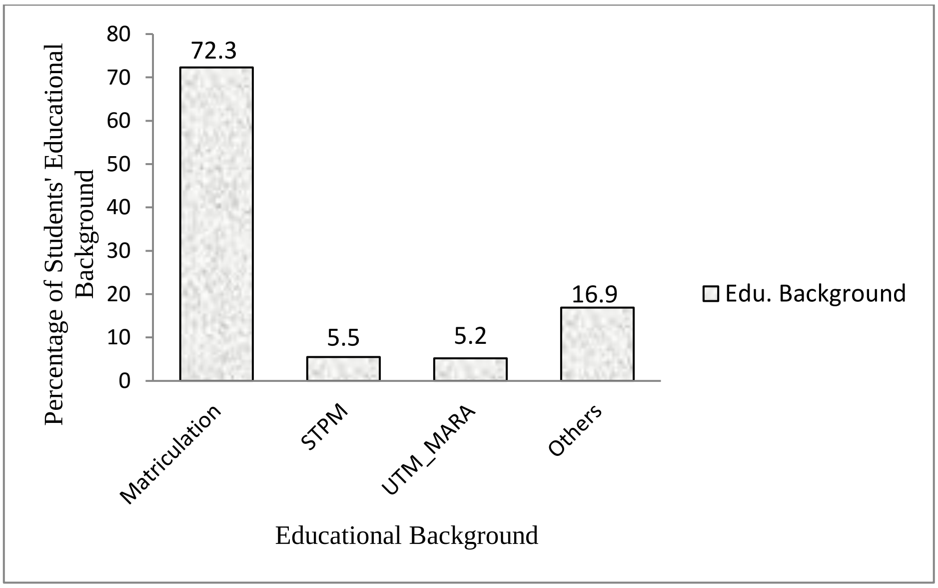


Figure 3.6 Percentage of Students' Previous Educational Background

First of all, in order to understand how students perceive environmental sustainability, they have to understand how they perceive environmental issues because it will influence their understanding of the concept, and how they committed to practice as a sustainable person. Figure 3.7 shows the analysis of students' prior knowledge exposure of basic environmental education. The results show that most of the respondents (73%) agree that they have received the basic environmental education at primary and secondary schools.

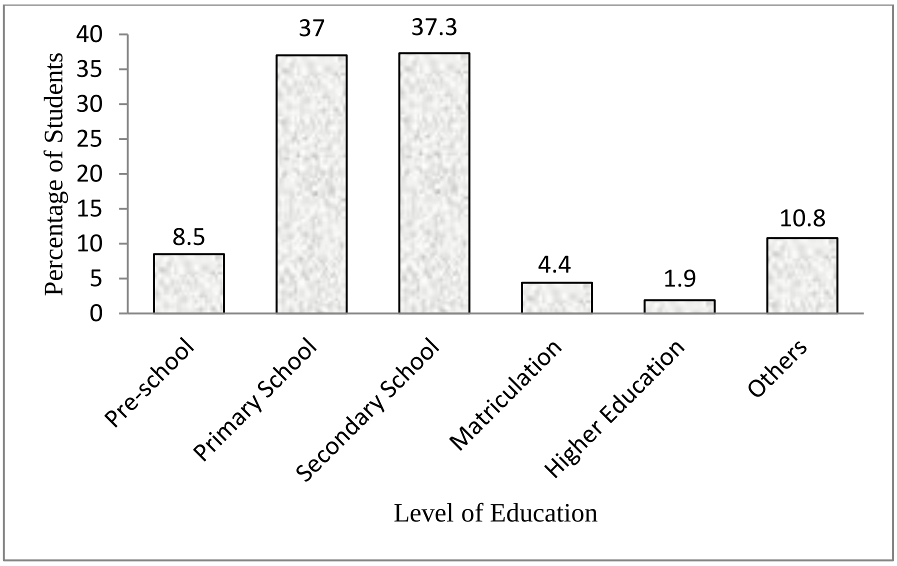


Figure 3.7 Analysis of Students' Prior Knowledge/Exposure to Environmental Education

Figure 3.8 shows the analysis of students' perception on 'previously heard about sustainable development'. They were asked on 'have you ever heard about sustainable development'. 59.3% of the respondents gave response 'Yes' but 27% of the respondents gave response 'No' and 13.7% 'Don't know'. Results show that there is a lack of awareness on sustainable development that should be investigated where only 59.3 % of the respondents agreed that they heard about sustainable development, while nearly 40% of the respondents have no knowledge at all.

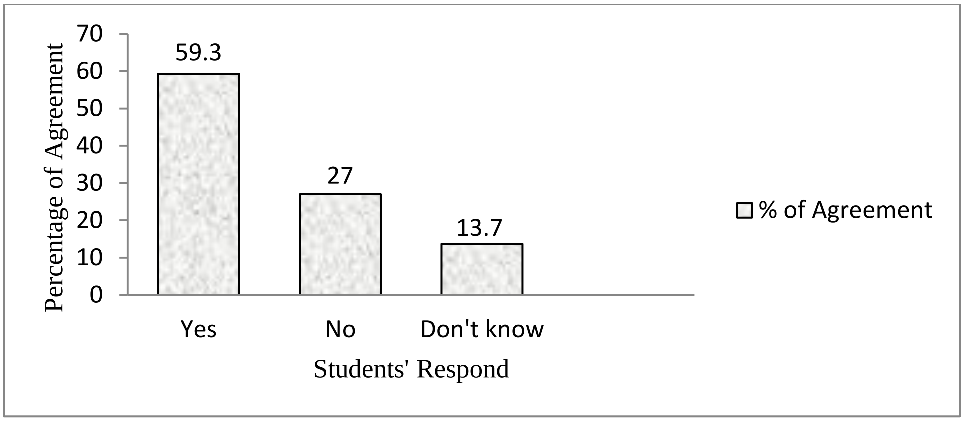


Figure 3.8 Percentage of Students' 'Previously Heard about Sustainable Development'

3.4.2 Phase II

This study is conducted amongst first year engineering students at the Faculty of Chemical Engineering, Universiti Teknologi Malaysia. Respondents are students enrolled in 'Introduction to Engineering' course, where CPBL has been implemented as a teaching and learning approach.Two types of data sampling are carried out, namely, quantitative and qualitative. In the quantitative study, a non-random sample, known as 'purposive sampling' is carried out because all students have to participate in this study. 63 respondents from two of three sections are involved in this study. As mentioned by Marguereti *et al*. (2006), purposive sampling is frequently used by educators who are trying to obtain data on their own school. According to Gall *et al*. (2007), respondents in purposive sampling are selected based on their specific qualities which make them an appropriate choice for the study.

Meanwhile, in qualitative study, two types of data collection are gathered through in-class observations, and document. Document consists of course outline, problems of the case study and students' reflective journals. In-class observations are conducted to observe the CPBL learning environment. Concurrently, the course outline and the problems used in the case study are analysed to determine how the educational principles related to sustainability are integrated in the design of problem.

Futhermore, the students' reflective journals of each stage are analysed to investigate the impact of CPBL on students' knowledge and behaviour change associated with environmental sustainability. Assessment on student's knowledge is based on four domains of knowledge (declarative, procedural, effectiveness and social). Table 3.2 gives information on research activities and numbers of respondents in this study.

3.5 'Introduction to Engineering' Course

Introduction to Engineering (ITE)is a three-credit-hour course taken by first year chemical engineering students at the Faculty of Chemical Engineering in UniversitiTeknologi Malaysia (UTM) since 2005. The duration of this course is fourteen (14) weeks. The objective of this course is to introduce engineering and prepare the students in learning engineering in order to become a professional engineer in the future. This course serves to bridge pre-university education in university life and provide support for adjusting to learning and expectations in tertiary education. This is essential because school systems in Malaysia are highly teacher-centered and exam-oriented. Therefore, the ITE course is designed to have a supportive student-centred learning environment that allows students to explore their mindset in the field of engineering and develop important skills to learn, as well as preparation to be a good engineer in future. CPBL is implemented in this course as the teaching and learning approach. The contents of this course include the overview of engineering, the profession and its requirements in the Malaysian scenario, basic calculations of common process variables and unit conversions, solve simple iterative problems using Excel and graphs, etc. It also includes case study related to sustainability and also an introduction to engineering ethics. In addition to that, soft skills such as communication (oral and written) skills, teamworking skills, learning styles and time management are also part of the course.

This course employs Cooperative Learning (CL) and Problem-Based Learning (PBL) environments to groom students with skills for Cooperative Problem-Based

Learning (CPBL). The course outlines and learning outcomes of this course can be seen in Appendix C. A problem related to sustainability issues is also addressed in ITE as a case study through CPBL learning environment. This study is focused on the CPBL case study on sustainable development and is involved with the programmes in Semester 1of 2012/2013 academic session.In the 2012/13 session, the problem is specifically focussed on low carbon society (LCS) in the Iskandar Region of Johor, Malaysia. The problem is divided into three stages as shown in Appendix D. The detailed design of the problem and learning environment were presented at the '6th Engineering Education for Sustainable Development Conference' at Cambridge University, United Kingdom in September, 2013 (Mohd-Yusof *et al*., 2013).

3.6 Data Collection Methods and Instruments

In this study, the research instrument consists of quantitative and qualitative data. Quantitative instrument is based on a modified questionnaire while qualitative research instrument consists of document and students' reflection journal.

3.6.1 Quantitative Instrument

A questionnaire is developed as a quantitative instrument to assess the current students' level of knowledge and behaviour. The instrument has gone through several processes before being administrated amongst the respondents. According to Barron (2004), there are six phases in the development of an instrument; (i) choosing a domain and indicators; (ii) developing a prototype of an instrument; (iii) piloting prototype instrument and get this feedback; (iv) determining the construct validity of an instrument; (v) determining the validity of the contents of an instrument; and (vi) determining the reliability of the instrument. Figure 3.9 shows the flow of preparing survey instrument before being administrated to the real respondents.

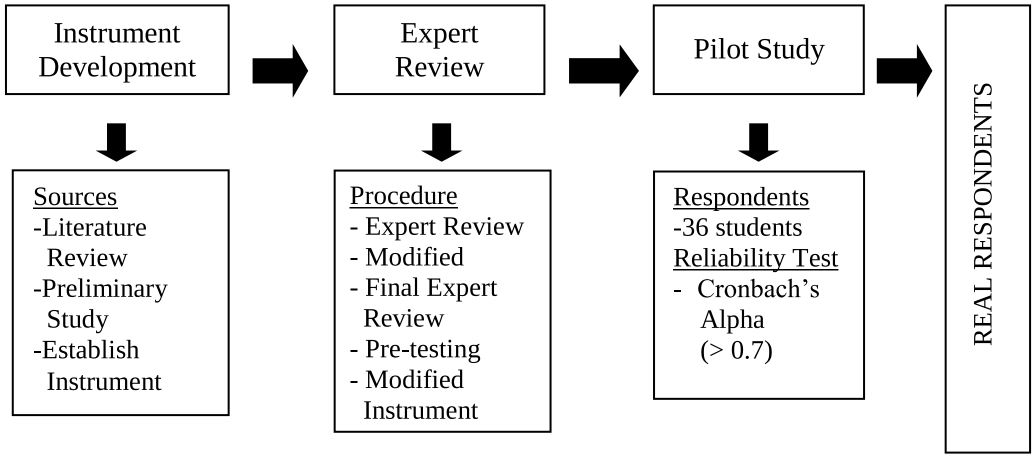


Figure 3.9 Flow of Preparing Research Instrument

3.6.1.1 Research Questionnaire

A questionnaire is adapted from several environmental attitude inventories, such as behaviour-based Environmental Attitude (Kaiser *et al.*, 2007) and Environmental Attitude Inventory (Milfont & Duckitt, 2010). It has been modified to suit the Malaysian students' background. The research questionnaire consists of three sections, namely (i) Demographic & Educational Background; (ii) Knowledge associated with students' knowledgeon environmental issues and sustainable development; and (iii) Students' pro-environmental behavior associated with self and social development. The questionnaire consists of two language;English and Bahasa Malaysia (Appendix E).

a) Part 1: Demographic & Educational Background

This section consists of information such as gender, race, academic background, faculty and year of study. Students are also required to give respond on additional questions such as 'when did you receive prior environmental education' and 'have you ever heard about sustainable development'. Each respondent is required to make response in the checkboxes provided.

b) Part II: Knowledge

This section consists of two scales of knowledge. Knowledge is divided into two sub-constructs, namely environmental issues and sustainable development, as shown in Table 3.5. Knowledge on environmental issues consists of 10 items. These 10 items have been identified from literature reviews, such as ‘Understanding Our Environment’(Hester, 1986), ‘Global Environmental Issues’ (Harris, 2012) and ‘The Ethics of Global Climate Change’ (Arnold, 2011). Knowledge on sustainable development consists of 6 items, which are identified from the results determined from the preliminary study and literature reviews.

Table 3.5 List of Items of Knowledge

Construct	Sub-construct	Code	Items
Content Knowledge	Environmental Issues	KT1	Air pollution
		KT2	Carbon Emission
		KT3	Climate Change
		KT4	Environmental Degradation
		KT5	Global Warming
		KT6	Greenhouse effect
		KT7	Green Technology
		KT8	Ozone layer depletion
		KT9	Waste management
		KT10	Recycle, Reuse & Redo
	Sustainable Development	KBK1	Definition of sustainable development.
		KBK2	Components of sustainable development
		KBK3	Principles of sustainable development.
		KBK4	Impact of un-sustainability.
		KBK5	Renewable and non-renewable resources.
		KBK6	Life Cycle Assessment

b) Part III: Pro-environmental Behaviour

This section consists of two sub-constructs of pro-environmental behavior which are self-development and social development. Items related to pro-environmental behavior are referred to several established instruments, such as New EnvironmentalParadigm by Dunlap & Van Liere (which is accepted by UNESCO), Ecology Scale by Maloney &Ward, Environmental Concern Scale by Weigel & Weigel and Environmental Attitude by Kaiser. Table 3.6 shows the twenty (20) items that are identified to assess students' pro-environmental behaviour.

Table 3.6 Lists of Items of Pro-environmental Behaviour

Constructs	Code	Items
Self-development	BSf1	I watch or listen to media programmes about SD
	BSf5	I separate domestic trash for recycling.
	BSf6	I walk or cycle to attend lecture.
	BSf7	I take a short shower in order to conserve water.
	BSf9	I recycle paper to conserve natural resources.
	BSf10	I pick up litter when I see it in a public area.
	BSf15	I do not let the running water of a faucet when it is not necessary.
	BSf16	I collect and sell recycled items such as papers, bottles and glasses.
	BSf18	I turn lights off when I leave a room
	BSf19	I turn tap off when brushing my teeth.
Social development	BSc2	I discuss with family about sustainability issues.
	BSc3	I discuss with friends about sustainability issues.
	BSc4	I attend meetings or debates about sustainable programmes.
	BSc8	I invite friends to take part in programme in sustainable programmes.
	BSc11	I volunteer to work with sustainability programmes.
	BSc12	I encourage my family to recycle some of the things we use.
	BSc13	I discussed with friends what we can do to help reduce pollution.

	BSc14	I asked my parents not to buy products made from non-renewable resources.
	BSc17	I actively participate in sustainable programmes.
	BSc20	I donate money to support charity programmes.

3.6.1.2 Likert Scale

Likert scale developed by Rensis Likert for his doctoral thesis. The classic use of the Likert scale is to pose questions or items to participants and have them respond using an agreement scale by selecting a number that best represents their response. Likert scales are often called agreement scales because participants are asked whether they agree or disagree with the statement presented (Marguerite *et. al* 2006). In this study, two types of Likert scales are used to guide respondents' evaluations.

(i) Scale of Knowledge

Biggs and Collis (1982) proposed a scheme of conceptual development based on Jean Piaget's work. The scheme is called the Structure of Observed Learning Outcomes (SOLO) taxonomy. It depicts the conceptual development as a series of five successive stages. In this study, this schema is used as an indicator to assess and observe students' knowledge onenvironmental issues and sustainable development. Table 3.7 shows the levels and stages of students' learning in relation to sustainability based on the SOLO taxonomy.

Table 3.7 Stages of SOLO Taxonomy, Indicators of Likert Type Scales and Levels of Learning

Levels	Stages of Solo Taxonomy	Indicators of Likert Type Scales
1	Pre-structured	1.Never heard of
2	Uni-structured	2.Heard of but cannot describe
3	Multi-structured	3.Know and can describe briefly
4	Relational	4.Know and can describe in detail
5	Extended Abstract	5.Expert and confident talk to others

(ii) Scale of Pro-environmental Behaviour

In this study, the range for a 5-point scale is based on the Precaution AdoptionProcess Model (PAPM) of changing individual behaviour, as proposed byWeinstein and Sandman (1991). There are seven stages, and these stages are used as level of agreement in instrument to assess students' behavioural in practicing environmental sustainability. The model asserts that people usually pass through this sequence in order. By implementing this model, the researcher may classify students' behavioural changes into three levels of mode, i.e. low, moderate and high, which corresponds to acting, thinking and feeling (from the theory of behaviourism). Likert type scales are there developed from the seven stages of PAPM and converted into five scales, as shown in Table 3.8.

Table 3.8 Stages and levels of Individual Behaviour Change (Weinstein & Sandman, 1988)

<table>
<tr><th>Stages of PAPM</th><th>Indicators of Likert Type Scales</th></tr>
<tr><td>1.Unaware of the sustainability issues</td><td>1.Unaware on issues</td></tr>
<tr><td>2. Aware but not personally engaged</td><td>2.Aware on issues but not to engage.</td></tr>
<tr><td>3.Engaged and trying to decide what to do</td><td rowspan="2">3.Have an interest to engage but not certain to contribute</td></tr>
<tr><td>4.Decided not to act</td></tr>
<tr><td>5.Decided to act, but not yet having acted</td><td>4.Contribute on issues, but still not to practice</td></tr>
<tr><td>6.Acting</td><td rowspan="2">5. Practice on issues as a part oflifestyle</td></tr>
<tr><td>7.Maintenance</td></tr>
</table>

3.6.1.3 Pre-testing of Questionnaire

Converse & Presser (1986) indicate that the pre-testing questionnaire is part of a pilot study to determine how a questionnaire can be improved to minimize response errors,such as a respondent misinterpreting a question. Producing a good questionnaire will assist the respondent to comprehend the question, retrieve information from memory, weigh the information and form a response. It may contain some element of error if the respondent experiences with cognitive difficulties. They will respond without reading the statement or refuse to answer. Furthermore, Bolton (1993) states that the objectives of the pre-testing questionnaire are, as follows;

(i) To test for an acceptable level of response variation, meaning, task difficulty, and respondent interest/attention.

(ii) To assess the "flow" and reliability of the sections, the order of questions, skip patterns, timing, and respondent interest and attention.

(iii) To identify and change questionnaire design features, such as vocabulary, response alternatives, and skip patterns.

(iii) To minimize response errors and non-response errors.

The questionnaire is pre-tested among thirty (30) offirst year engineering students. However, after analysingthe respondents' feedback, it was found that some modification should be made to the indicators of Likert type scale of pro-environmental behaviour. Students found that the indicators of Likert type scale of pro-environmental behavior, which is identified as 1 – never, 2 – rarely, 3 – sometimes, 4 – often and 5 – always, are quite difficult to identify. Some of the students have refused to read the items and give the same scale for all items. Therefore, instrument modification should be made to change the previous indicator of Likert type scale of pro-environmental behaviour. The Precaution Adoption Process Model (PAPM) of changing individual behaviouris adapted to replace the previous scale. There are seven stages, and used as the level of agreement in instrument to assess the students' pro-environmental behaviour lifestyles as stated in Table 3.8.

3.6.1.4 Pilot Study

The purpose of conducting a pilot study is to detect feasibility and to assess a relevant data related to the study (Puts *et al.* 2011). A pilot study is a process that allows researchers to have a deep understanding of their research through consistency in data collection. In order to achieve an appropriate instrument, the researcher needs to conduct an investigation for an initial finding. The pilot study is conducted with 36 students who are not the actual respondents of the study and randomly selected.

3.6.1.5 Reliability and validity

Reliability and validity are important indicators of quantitative study. According to Bryman (2001), reliability refers to the consistency of a measure of a concept, while validity refers to the 'indicator that is devised to gauge a concept. In this study, Cronbach's Alpha is determined to test the internal consistency amongst the items using the SPSS version 18 software. Table 3.9 indicates the results of Cronbach's Alpha. The values of Cronbach's Alpha for each sub-construct and overall construct are greater than 0.6. According to Croncbach (1951), these results indicate that items are considered as highly achieved to the level of internal consistency. Meanwhile, two types of validity test are conducted. Firstly, face validity via expert review is conducted to give comments on the instrument before it is administred to the real respondents. Secondly, convergent validity test during the confirmatory factor analysis using AMOS.

Table 3.9 Results of Cronbach's Alpha internal reliability test

Indicator	Knowledge		Pro-environmental Behaviour	
	Environmental Issues	Concepts of SD	Self Development	Social Development
Cronbach's Alpha	0.819	0.902	0.750	0.837
Overall Cronbach's Alpha	0.777			

3.6.2 Qualitative Instrument

This section explains the qualitative instruments that answer the second research objective. Qualitative data are obtained by observing the classroom and analyzing data gathered frominterview and documents which consist of reflection journals, course outline and problems used in the case study. The data sources are be triangulated to validate the accuracy of research findings. According to Creswell (2008), triangulation is one of the processes of corroborating evidence from different individuals, types of data or methods of data collection in descriptions and themes in qualitative research.

3.6.2.1 Research Instrument

Purposive sampling of data collection of qualitative study is implemented. In a qualitative study, the data collection methodconsists of course documents, reflection journals and observation as shown in Table 3.10.

Table 3.10 List of Qualitative Instruments

Type of Data	Type of Instrument	Purpose
Document	Course Outline of 'Introduction to Engineering'	To check the course content related to sustainability
	Sustainable Problem Used	To investigate the convergence of four domains of knowledgeof each stages of the problems.
	Students' Reflection Journals	To investigate students' perception on students' learning outcome associated with sustainability of each stages of the problems
Observation	Classroom	To observe the classroom activities of the CPBL learning environment.

The classroom observation, course outline, sustainable problems used and students' reflective journal are determined as data sampling. Respondents are randomly selected and followed the ethical consideration. Students' reflection journals are used to investigate the impact of the CPBL learning environment on students' learning outcomes after undergoing the case study. According to Zeegers and Clark (2014), reflective journal is a metacognitive tool that supports students to reflect on their learning over the period of time. In relation to the sustainable problem used, it is divided into three stages and students have to submit an individual reflective journal at the end of each stage. These reflective journals are collected and analyzed. The students are required to share their experiences, feeling, about what they have learned and their learning process in form of writing and submitted at the end of each CPBL cycle through Moodle e-learning system. Meanwhile, classroom observation is carried out to observe the implementation of student centered learning environment through

CPBL approach. The researcher identified what types of activities that has been conducted in the classroom. The examples of students' reflective journal and classroom observation are attached in Appendix F.

3.6.2.2 Reliability and validity

Golafshani (2003) highlighted that reliability and validity are conceptualized as trustworthiness, rigor and quality in qualitative paradigm. According to Boyatzis (1998) reliability is critical in using thematic analysis. Reliability is consistency of observation, labelling, or interpretation. In this study, documents of course outline, problem used in the case study and students' reflective journals are selected as the qualitative data. In order to ensure the accuracy of this study, member checking is applied. Member checking refers to the act of asking the participants to review theinterview transcripts, field notes or descriptions of the data (Merriam, 1998; Punch, 2009). In this study, three experts are identified as the member checkers.

On the other hand, in mixed method research, Creswell & Clark (2007) defined validity as the ability of the researcher to draw meaningful and accurate conclusions from all of the data in the study. A mixed methods study also warrants a discussion of the overall validity of the design. Validity is an important element within any form of research. Creswell & Plano Clark (2007) also state that mixed methods research validity can take on the types usually related with quantitative and qualitative research. Nevertheless, it is also important to address the validity of the overall mixed methods design.Measures were taken to ensure that threats to research validity had been dealt with accordingly in this study, which are; (a) using the same participants for the quantitative and qualitative data collection, (b) addressing contradictory data through the use of multiple perspectives, (c) ensuring that the quantitative and qualitative approaches address the same question. Through the use of these measures, the potential threats to the validity of the present concurrent design study could be minimised, in addition to enhancing the rigour of the study.

3.7 Data Analysis

This is a case study of mixed method research methodology; hence, there are two types of data analysis. In quantitative study, descriptive and inferential analyses are carried out using SPSS and Rasch Model. Meanwhile, inqualitative studies, a thematic analysis is employed.

3.7.1 Quantitative Data Analysis (Phase I & II)

Quantitative data collection using questionnaire is subject to appropriate quantitative using descriptive and inferential statistics. The data are employed using Statistical Package for the Social Sciences (SPSS) with Analysis of Moment Structure (AMOS) version 18.0 and also Rasch Analysis version 3.62.1.

3.7.1.1 Exploratory Factor Analysis (EFA)

Exploratory Factor Analysis (EFA) is used to uncover the underlying structure of a relatively large set of variables. EFA is aimed at two purposes: 1) to identity which questionnaire items best defined for each variable scale; and 2) to remove any item which does not contribute to a particular variable scale.

3.7.1.2 Confirmatory Factor Analysis (CFA)

Confirmatory Factor Analysis (CFA) is used to analyse the initial measurement model of students' knowledge-behaviour instrument. The primary goal of CFA is to evaluate the factor scale within a measurement model and to determine how well the measurement model fit to the data (Bollen, 1989). The two-step modelling approach suggested by Anderson and Gerbing (1988) is adopted. The first step of a measurement model allows all latent scales to be correlated freely and all non-significant values are removed. There are two types of measurement model: 1) first order measurement model, and 2) second order measurement model. Table 3.11 shows the recommendation of model fit indices that are used in this analysis as indicators to achieve the goodness of model fit. The second step of a structural analysis is designed to test relationships among latent variables.

The Analysis of Moment Structures (AMOS) version 18 is employed in order to answer RQ1(a – d) and RQ2 (a – b). This analysis is conducted to compute the correlations between variables and items using multiple statistical analyses. According to Arbuckle (2007), AMOS is the most powerful and user-friendly structural equation modeling (SEM) software that enables the user to support their research and theories by extending standard multivariate analysis method, factor analysis, regression, correlation, as well as analysis of variance. This is a strong justification to use AMOS in order to identify the items that are not contributing positively and eliminating from the final model. Figure 3.10 shows the three steps that were performed during the stage of analyses.

Table 3.11 Recommended Fit Indices

Fit Indices		Authors	Recommended value
Chi-squared Test	Chi-squared (Cmin)	Tabachnik&Fidell, 1996	Reported if n between 100-200
	Ratio (Cmin/df)	Marsh &Hocevar, 1985	< 5.0
		Bentler, 1990	< 5.0 Reported if n > 200
Test Statistics Using Covariance Matrix	Goodness of Fit Index (GFI)	Chau, 1997	>0.90
		Segars& Grover, 1993	>0.90
Comparisons with Independence Models	Comparative Fit Index (CFI)	Bentler, 1990	>0.90
		Hatcher, 1994	>0.90
	Normed Fit Index (NFI)	Bentler&Bonett, 1980	>0.90
Root mean square error of approximation	Root mean square error of approximation (RMSEA)	Byrne, 2001	<0.08
		Hu &Bentler, 1999	<0.05

3.7.1.3 Structural Equation Modelling (SEM)

Structural Equation Modelling (SEM) is the latest statistical analysis technique used in various studies that are involvedmultifacets of variables across various disciplines. SEM is a second generation data analysis and multiple regressions which enable the results to be represented through a graphical form in a very comprehensive manner. Theoretically, SEM comprises of two types of models: a measurement model and a structural model (Chinda and Mohamed, 2008). There are two types of measurement model: 1) first order measurement model, and 2) or second higher order measurement model. On the other hand, SEM consists of several measurement models in which the main intention is to investigate the relationships between those factors. SEM is applied to investigate the significant influence of knowledge in improving students' behaviour.

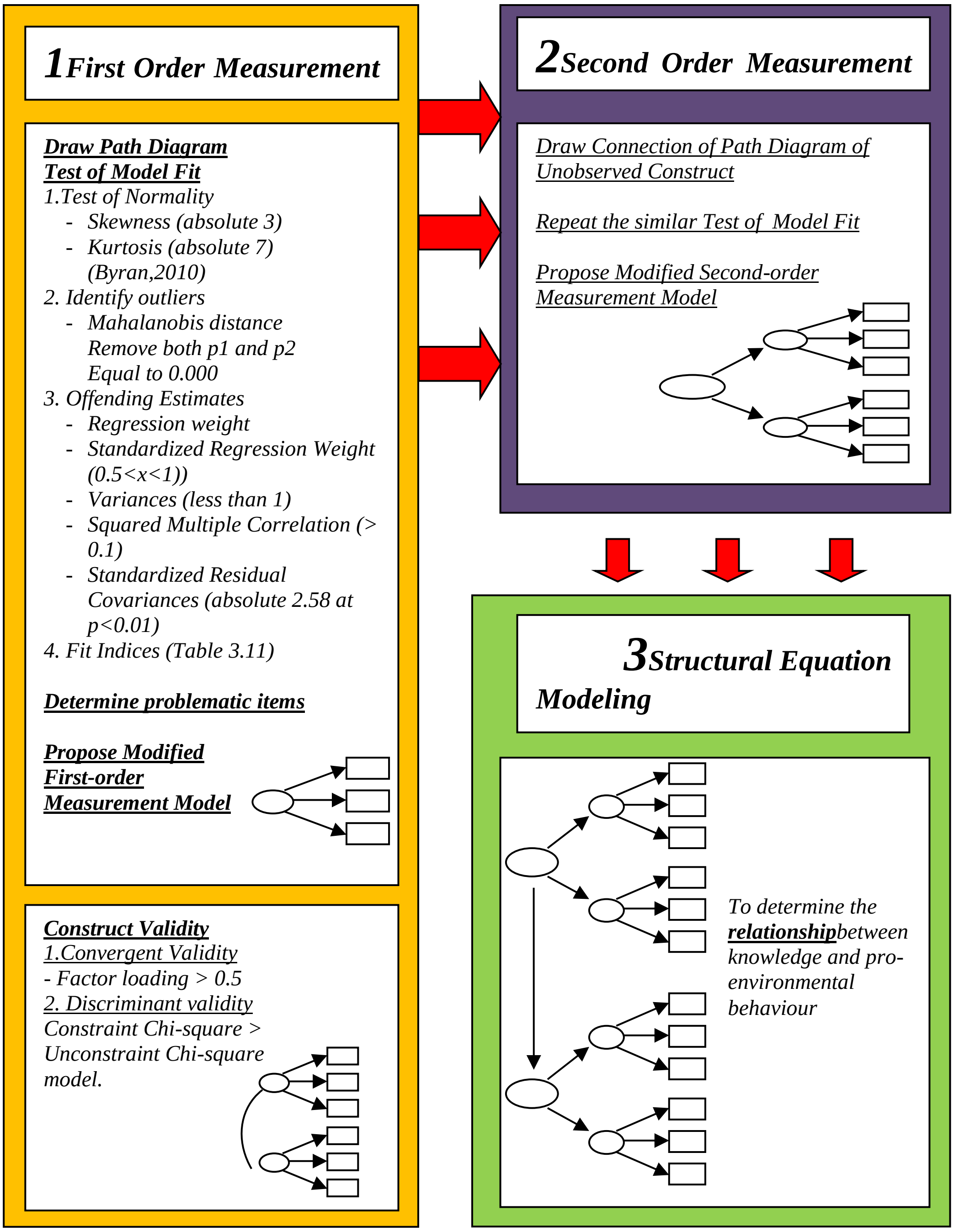


Figure 3.10 Flow of Analysis of Measurement Model

3.7.1.4 Rasch Analysis

The instrument is tested for reliability and unidimensional before further analysis using Rasch Model. Table 3.12 and Table 3.13 shows the statistical results and reliability coefficients of Cronbach Alpha of the subscales using SPSS, and compared with the Rasch Model. According to an analysis using SPSS, the reliability results of each subscale have exceeded 0.6 (George and Mallery, 2003). In Rasch analysis, all the values of items' separation indiceshave exceeded 3.0 and are considered excellent levels of separation. While, the respondents' from the study separation indexes have exceeded 1.5 and considered as acceptable levels of separation. These results indicate that a person reliability is a high consistency to score either lower or higher than expected. While item reliability indicates that the questions are reliable in measuring the proper item. From these statistical perspectives, no items have been deleted due to reliability concerns

Table 3.12 Values of Cronbach Alpha using SPSS and Rasch Model

<table>
<tr><th rowspan="2">Subscales</th><th rowspan="2"></th><th rowspan="2">Person</th><th rowspan="2">Item</th><th colspan="2">INFIT</th><th colspan="2">OUTFIT</th><th rowspan="2">Point Measure Corr. 0.4<x<0.8</th></tr>
<tr><th>MNSQ 0.4<y<1.5</th><th>ZSTD -2<z<2</th><th>MNSQ 0.4<y<1.5</th><th>ZSTD -2<z<2</th></tr>
<tr><td rowspan="5">Knowledge</td><td>Reliability</td><td>0.74</td><td>0.98</td><td rowspan="2">✓</td><td rowspan="2">✓</td><td rowspan="2">✓</td><td rowspan="2">✓</td><td rowspan="2">✓</td></tr>
<tr><td>Separation</td><td>1.67</td><td>6.44</td></tr>
<tr><td>Mean</td><td>0.2</td><td>0.00</td><td rowspan="3" colspan="5">Raw variance explained by measure = 50.3% (> 40%)
Unexplained variance in 1st contrast = 13.4% (< 15 %)</td></tr>
<tr><td>S.D</td><td>0.78</td><td>1.13</td></tr>
<tr><td>Cronbach Alpha</td><td colspan="2">1.00</td></tr>
<tr><td rowspan="5">Behaviour</td><td>Reliability</td><td>0.82</td><td>0.97</td><td rowspan="2">1.67 (BS10A)</td><td rowspan="2">3.5 (BS10A)</td><td rowspan="2">1.66 (BS10A)</td><td rowspan="2">3.4 (BS10A)</td><td rowspan="2">✓</td></tr>
<tr><td>Separation</td><td>2.13</td><td>5.44</td></tr>
<tr><td>Mean</td><td>-0.14</td><td>0.00</td><td rowspan="3" colspan="5">Raw variance explained by measure = 45.5% (> 40%)
Unexplained variance in 1st contrast = 11.7% (< 15%)</td></tr>
<tr><td>S.D</td><td>0.70</td><td>0.76</td></tr>
<tr><td>Cronbach Alpha</td><td colspan="2">0.98</td></tr>
</table>

Table 3.13 Summary of Statistical Results from Rasch Analysis

Subscales	No. of items	Cronbach Alpha using SPSS	Rasch Model			
			Item reliability	Item separation	Respondent reliability	Respondent separation
Environmental Issues	7	0.806	0.98	6.44	0.74	1.67
Concept of Sustainable Development	3	0.725				
Self development of behaviour towards SD	5	0.722	0.97	5.59	0.82	2.12
Social development of behaviour towards SD	5	0.793				

3.7.1.5 Model of Knowledge-Behaviour

The model of knowledge-behaviour is refered to the research findings of Kollmus and Aygemen (2003). They noticed that knowledge has a strong correlation in behaviour. Figure 3.12 shows an initial structural model of assessing students' knowledge-behaviour towards environmental sustainability, developed from two measurement model of knowledge and behaviour. A measurement model of knowledge consists of ten (10) items on environmental issues and six (6) items on sustainable development. Students are required to rate their level of knowledge according to 5 Likert-type scales; 1 – never heard of, 2 – heard of but cannot explain, 3 – know and can explain briefly, 4 – know and can explain in detail, 5 – expert and confidently talk to others. While, a measurement model of behaviour consists of their self- and social development of practicing pro-environmental behaviour. Students are required to indicate their level of agreement on ten (10) items on self-development and ten (10) items on social development, according to 5 Likert-type scales; 1 – unaware on issues, 2 – aware on issues but not to engage, 3 – have an interest to engage but not certain to contribute, 4 – decide to contribute, but still not to practice and 5 – practice as a part of lifestyle.

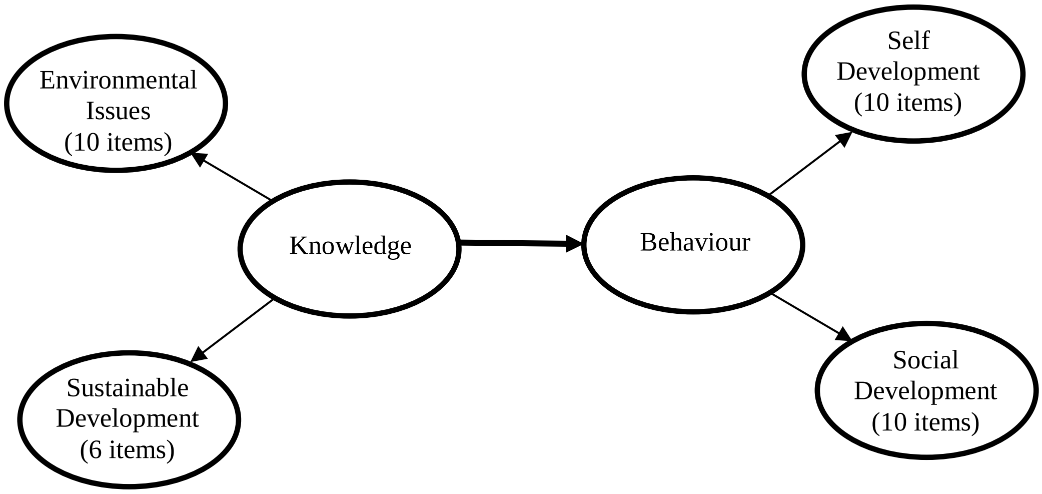


Figure 3.11 Structural Model of Knowledge-Behaviour

3.7.2 Qualitative Data Analysis(Phase II)

According to Thomas (2003), there are three important reasons for using qualitative analysis, which are 1) to condense extensive and varied raw text data into a brief and summary format, 2) to establish clear links between the research objectives and the summary findings derived from the raw data and to ensure these links are both transparent (able to be demonstrated to others), and 3) to develop the model or theory about the underlying structure of experiences of processes which are evident in the raw data. In this study, prior-research-driven code development has been employed. According to Boyatzis (1998), prior-research-driven code development has been the most frequently used approach in social science research. It begins with the theory of what occurs and then formulate the indicators of evidence that would support the theory. In this study, the lists of themes are identified from the literature review.

3.7.2.1 Thematic Analysis

According to Boyatzis (1998), ‘thematic analysis’ is a process for encoding qualitative information. It may be a list of themes; a complex model with themes, indicators, and qualifications that are causally related; or something in between these two forms. Thematic codes are developed using prior-research-driven approach (Boyatzis, 1998; Braun and Clarke, 2006). Prior-research-driven approach is an approach to developing themes systematically from a review of literature. This is a deductive approach. The researcher started with the selected literature and observations are made about the absence of the themes in the raw information. The results of it are either confirmed or refuted. In this study, the worked by Kaiser and Fuhrer (2003) that the joint and convergent of four domains of knowledge, namely declarative, procedural, effectiveness and social knowledge are important in order to effectively educate for environmental sustainability. Therefore, declarative, procedural, effectiveness and social are selected as the the themes. Table 3.14 shows the three stages in using thematic analysis under prior-research-driven approach that are used in this study.

Table 3.14 Summary of Stages and Steps in Using Thematic Analysis

Stage	Step	Prior-Research-Driven Approach
I (Sampling and Design Issues)	1	Deciding on sampling and design issues
II (Developing Themes and a Code)	1	Generating a code from previous research
	2	Reviewing and rewriting the code for applicability of the raw information
	3	Determining the reliability
III (Validating and Using the Code)	1	Applying the code to the raw information
	2	Determining validity
	3	Interpreting results

Mind mapping is utilized as a tool to map the structure of ideas. Allen and Smith (2010) noticed that the approach shares similarities with the hierarchical framework of codes and categories created by qualitative data management software packages such as NVIVO. In this study, the visual of mind mapping approach represents the key themes from the qualitative data analysis, as shown in Figure 3.11. The key themes and codes were validated through member checking (n=3).

3.8 Ethical Considerations

Ethical guidelines and principles for conducting research with human participants are clearly needed. Research ethics are formed to protect those who are being researched and to protect the researcher from topics that may be unsafe or may make either party feel uncomfortable (en.wikipedia.org/wiki/Research_ethics). The researcher has a responsibility to protect the rights of participants in the study, as well as their privacy and sensitivity. In this study, there are several ethical considerations has been made along side the research work, as follows;

1. Researcher or responsible person introduces her/his background and gives an overview about the study before conducting any session of data collection. During quantitative data collection, researcher has identified two classes of three that are selected as research participants. The lecturers, as the responsible person on behalf of the researcher are appointed to conduct the survey. The researcher meets the responsible lecturers, to get permission and cooperation to distribute the questionnaire survey.

2. Respondents are briefed of the overview of the study before they answer any questionnaire survey.

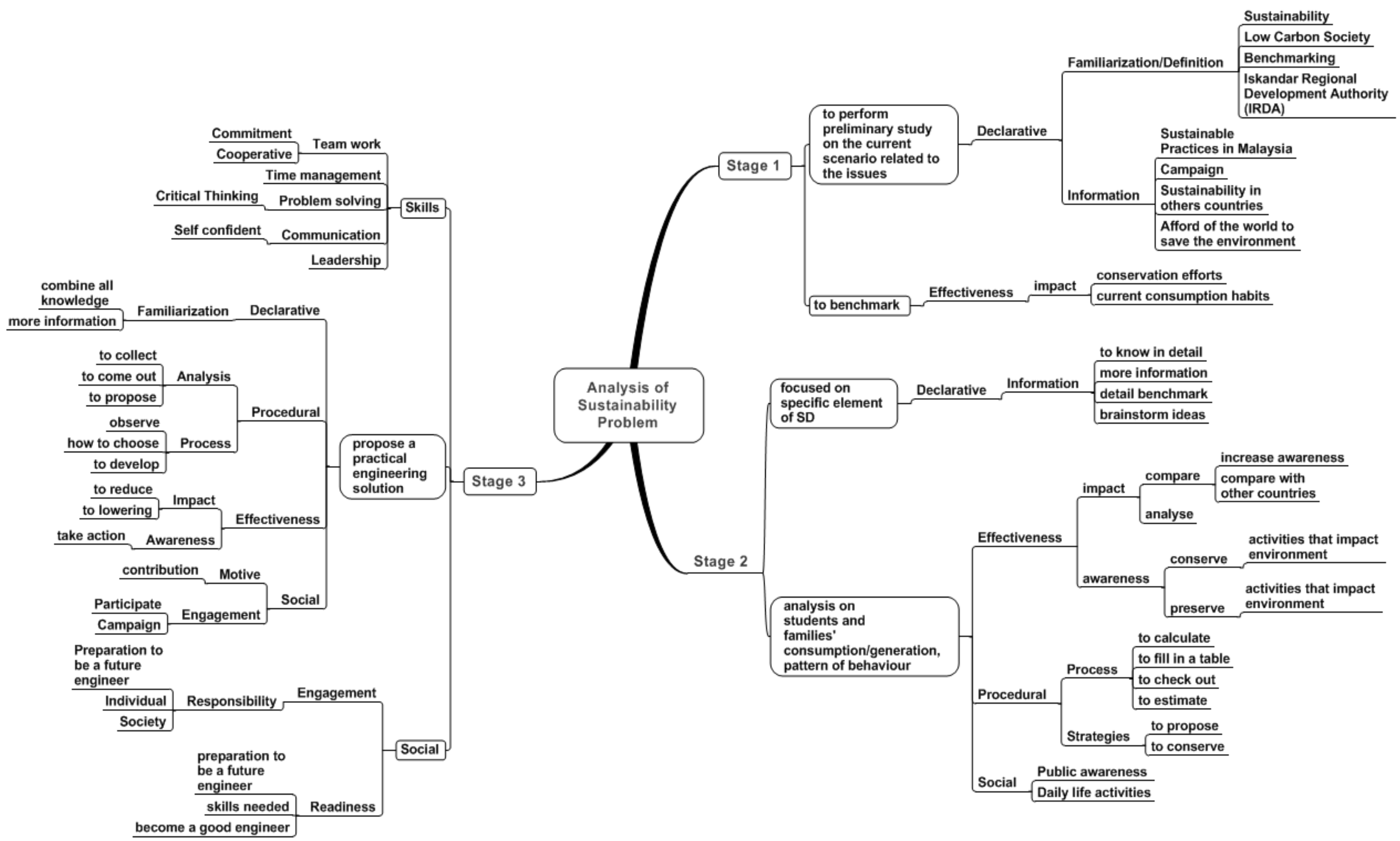


Figure 3.12 Example of Mindmap of Qualitative Data

3. All respondents are required to sign the 'Consent Form' as their willingness to participate in this study before they answer the questionnaire survey. See Appendix A (example of Consent Form).

4. Feedbacks from respondents are confidential. All information are reliable for the research purposes only and belong to the researcher, who holds responsibility throughout the cause of the research

3.9 Summary

This chapter highlights the process of research methodology approach. A case study of mixed method research has been employed to answer the research objectives. This chapter also discusses on research paradigm, methodology, data collection, data analyses, reliability and validity on both research approaches implemented in this study. The results from this studyare discussed in detail in the preceeding chapter.

CHAPTER 4

RESULTS AND ANALYSIS OF PHASE

4.1 Introduction

This chapter describes the analysis of the research data obtained from the Phase I of the study. The research population, methods of data collection and analysis have been defined in Chapter 3. The main purpose of this chapter is to assess the level of first year engineering students' on their (i) prior knowledge on environmental issues, (ii) prior knowledge on sustainable development, and (iii) practicing pro-environmental behaviour associated with self and social development. A quantitative research methodology has been utilized in order to answer the research objectives. There are two types of statistical analysis techniques that are carried out in this study. Firstly, Confirmatory Factor Analysis (CFA) using Analysis of Moment Structures (AMOS) is utilized to analyse the initial measurement model of students' knowledge-behaviour. The objective of using AMOS is to identify the most significant items that are relevant to assess the students' perceptions on each construct. Secondly,descriptive (such as mean and standard deviation) and inferential (such as independent sample t-test and croncbach alpha) analyses using Statistical Package of the Social Science (SPSS) version 18, to answer the following research questions.

4.2 Research Questions of Phase I

Phase I of this research is conducted in order to answer the first research objective; i.e.to investigate the level of first year engineering students' on their (i) prior knowledge on environmental issues, (ii) prior knowledge on sustainable development, and (iii) practicing pro-environmental behaviour associated with self and social development. This research objective consists of four research questions as follows;

RQ1a. What are the most significant items to assess the first year engineering students on; (i) knowledge on environmental issues, (ii) knowledge on sustainable development, and (iii) practicing pro-environmental behaviour associated with self and social development.

RQ1b. What are the levels of perception of the first year engineering students' on (i) prior knowledge on environmental issues, (ii) prior knowledge on sustainable development, and (iii) practicing pro-environmental behaviour associated with self and social development?

RQ1c. Is there any significant difference across gender of students regarding their (i) prior knowledge on environmental issues, (ii) prior knowledge on sustainable development, and (iii) practicing pro-environmental behaviour associated with self and social development?

RQ1d. How significant the relationship between students' knowledge and students' pro-environmental behaviour among the first year engineering students?

4.3 Analysis of Research Question Phase 1

This section presents the first research question of Phase I. The constructs of knowledge and behaviour are analysed using the two types of analyses, which are (i) exploratory factor analysis, and (ii) confirmatory factor analysis. Confirmatory Factor Analysis (CFA) utilises the Analysis of Moment Structures (AMOS) to analyse the initial measurement model of students' knowledge-behaviour. The objective of using AMOS is to identify the most significant items which are relevant to assess the students' perceptions about their knowledge on environmental issues, concepts of sustainable development and how they perceive self-and social development in practicing pro-environmental behaviour.

4.3.1 Exploratory Factor Analysis

Exploratory Factor Analysis (EFA) is carried out to measure the sample adequacy in order to reduce the number of questionnaire items. Descriptive analysis,in terms of correlation matrix using Kaiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity are calculated using SPSS. Table 4.1 shows the homogeneity values of all subscales which more than 0.8,which would be labeled as 'meritorious' and meets the criteria. The significant value for this analysis (sig = 0.000) of all constructs leads us to reject the null hypothesis and conclude that there are correlations in the data set that are appropriate for factor analysis. The results showed that both analyses have met the requirement.

Table 4.1 Kaiser-Meyer-Olkin measure and Bartlett's test of sphericity

Exploratory Factor Analysis (EFA)		Knowledge		Behaviour	
		Env. Issues	Sustainable Development	Self-Development	Social Development
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.877	0.849	0.885	0.892
Bartlett's Test of Sphericity	Approx. Chi-square	1287.733	627.131	803.943	768.531
	df	66	15	45	21
	Sig.	0.000	0.000	0.000	0.000

4.3.2 Confirmatory Factor Analysis for Students' Knowledge

The construct of students' knowledge consists of two latent factors, namely environmental issues (ten items) and sustainable development (six items). Analysis using CFA is carried out to determine the most significant items that are used in answering RQ1(a).

4.3.2.1 First-Order Measurement Model for Students' Knowledge onEnvironmental Issues

Figure 4.1 shows the initial and modified first-order measurement model for students' knowledge on environmental issues. Items which are not significant with the construct, known as 'problematic items', should be removed from the initial measurement model through the use of an iterative sequence. Table 4.2 lists down the ten items of environmental issues used to assess the knowledge of first year engineering students.

Table 4.2 Items for Environmental Issues

Code	Item
KT1	Air Pollution
KT2	Carbon Emission
KT3	Climate Change
KT4	Environmental Degradation
KT5	Global Warming
KT6	Greenhouse Effect
KT7	Green Technology
KT8	Ozone Layer Depletion
KT9	Waste Management
KT10	Reuse, Recycle & Reduce

According to Figure 4.1(i), the result of root mean square error of approximation (RMSEA)of 0.107 does not comply with an acceptable limit of goodness of fit. Therefore, this initial first-order measurement model should be modified for further analysis. All the relevant indicators such as multivariate normality, standardized residual covariances and modification indices are properly treated and investigated, in order to achieve the most significant measurement model.

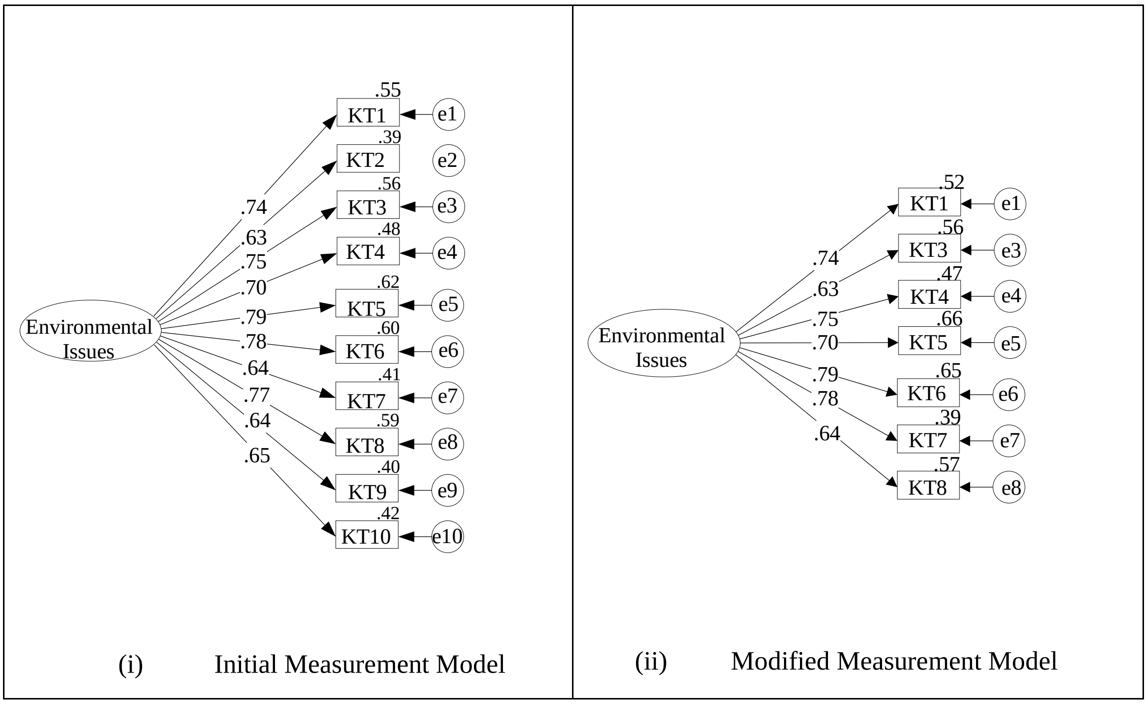


Figure 4.1 Initial and Modified First-Order Measurement Model for Environmental Issues

Table 4.3 shows the result of the assessment of normality. The values of skewness and kurtosis are ranging between -1 and +1. These mean that the univariate normality of individual items in this sub-construct is acceptable.

Table 4.3 Assessment of normality

Variable	min	max	skew	c.r.	kurtosis	c.r.
KT1	2.000	5.000	.185	1.324	-.410	-1.467
KT9	1.000	5.000	.157	1.121	-.225	-.803
KT8	2.000	5.000	-.015	-.106	-.389	-1.392
KT7	1.000	5.000	.375	2.680	-.161	-.576
KT6	2.000	5.000	.043	.310	-.302	-1.079
KT10	2.000	5.000	-.009	-.062	-.611	-2.186
KT5	2.000	5.000	.124	.884	-.444	-1.589
KT4	1.000	5.000	.164	1.175	-.486	-1.738
KT3	1.000	5.000	-.009	-.066	-.081	-.289
KT2	1.000	5.000	.194	1.385	-.093	-.334
Multivariate					11.889	6.723

Table 4.4 Standardized Residual Covariances

	KT1	KT9	KT8	KT7	KT6	KT10	KT5	KT4	KT3	KT2
KT1	000									
KT9	.328	000								
KT8	063	256	000							
KT7	1.017	.677	143	000						
KT6	.260	.755	587	.246	000					
KT10	929	2.423	974	.266	1.092	000				
KT5	.077	-.490	.526	.553	.344	215	000			
KT4	.213	569	.095	546	.869	.692	036	000		
KT3	.037	.598	.899	112	.018	.492	239	613	000	
KT2	.324	1.572	064	667	.110	2.120	1.136	680	.510	000

However, the assessment on standardized residual covariance have two pairs of relationship (KT9-KT10 and KT10-KT2) which are greater than 2.0 in absolute value, as shown in Table 4.4. Referring to Table 4.5, three measurement errors are correlated to others measurement error (e9 is correlated to e7 and e10, e10 is correlated to e9 and e2 and e2 is correlated to e10 and e3). If e9, e10 and e2 are to be considered for deletion from the path diagram, it might improve the goodness of model fit. Therefore KT2 (Carbon Emission), KT9 (Waste Management) and KT10 (Recycle, Reuse and Redo) are identified as the problematic items andare selected to be removed from the initial first-order measurement model.

Table 4.5 Covariances

			M.I.	Par Change
e7	<-->	e9	10.558	.079
e10	<-->	e9	22.271	.103
e5	<-->	e6	21.362	.062
e2	<-->	e10	16.639	-.084
e2	<-->	e3	12.463	.061

As shown in Figure 4.1 (ii), the result of statistical test of modified first-order measurement model of environmental issues after deleting KT2 (*Carbon Emission*), KT9 (*Waste Management*) and KT10 (*Recycle, Reuse and Redo*) complies with the acceptable limits of model fit (RMSEA = 0.075, GFI, NFI & CFI > 0.9 and Ratio = 2.731).Results of assessment of normality, variances, standardized residual covariance and modification indices have also achieved the acceptable limits or ranges. These indicators show that the modified model is satisfactory. All the factors loading of each item is above 0.6. The KT5 (*Global Warming*), KT6 (*Greenhouse Effect*), KT8 (*Ozone Layer Depletion*), KT3 (*Climate change*), KT1 (*Air Pollution*), KT4 (*Environment Degradation*) and KT7 (*Green Technology*)are the variables that appear to be the most significant indicators of Environmental Issues. The factors loading are, 0.81, 0.80, 0.75, 0.75, 0.72, 0.69 and 0.62, respectively. This means that environmental issues explains about 66% of the variance in KT5, 65% of the variance in KT6, 57% of the variance in KT8, 56% of the variance in KT3, 52% of the variance in KT1, 47% of the variance in KT4 and 39% of the variance in KT7.

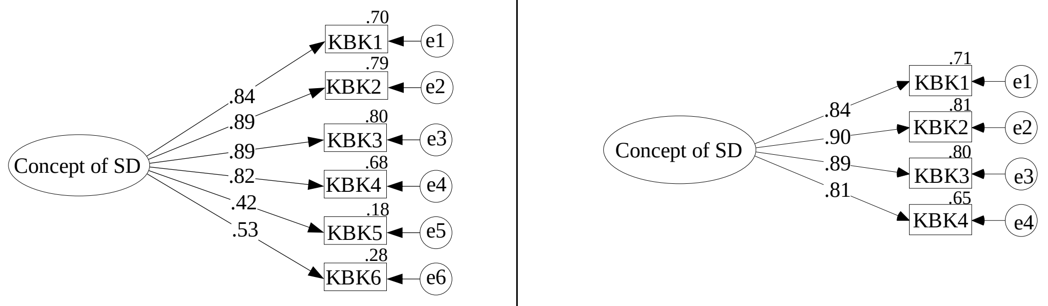
Referring to Table 4.6, the value of Cronbach’s Alpha of these seven items is 0.889. The highest mean score is KT6 (3.66) while KT7 (2.89) is the lowest mean score. According to Cronbach (1951), this result indicates that the items are considered as highly achieved to the level of internal consistency and capable to measure the students' knowledge on environmental issues.

Table 4.6 Content Validity of Modified First-order Measurement Model of Environmental Issues

Code	Items of Environmental Issues	Mean	Std. Deviation	Cronbach's Alpha
KT1	Air Pollution	3.63	.699	
KT3	Climate Change	3.31	.721	
KT4	Environmental Degradation	3.21	.867	
KT5	Global Warming	3.66	.720	0.889
KT6	Greenhouse Effect	3.42	.738	
KT7	Green Technology	2.89	.845	
KT8	Ozone layer Depletion	3.49	.773	

4.3.2.2 First-Order Measurement Model for Knowledge on Sustainable Development

Figure 4.2 shows the initial and modified first-order measurement model for students' knowledge on sustainable development which consists of six items. Referring to Figure 4.2 (i), most of the indicators show the results are below or out of acceptable limits (Ratio = 12.912, GFI = 0.888, RMSEA = 0.197 and NFI = 0.899). Further analyses are needed to identify the problematic items.



(i) Initial Measurement Model

(ii) Modified Measurement Model

Figure 4.2 First-order Measurement Model of Knowledge on Sustainable Development

Result of the assessment of normality in Table 4.7 indicates that all the items have obtained acceptable limits of skewness and kurtosis, meaning that there are no problematic items in this model. However, Table 4.8 and Table 4.9 show that the value of the standardized residual covariance of KBK5 – KBK6 (5.984) is more than absolute 2 and the modification indices of covariances show that the measurement errors of e5 and e6 are correlated to other measurement errors. These indicators indicate that these items are considered as the problematic items and suggested to be deleted from the initial model. As a result, KBK5 (*renewable and non-renewable resources*) and KBK6 (*Life Cycle Assessment*) are identified as the problematic items.

Table 4.7 Assessment of normality

Variable	min	max	skew	c.r.	kurtosis	c.r.
KBK6	1.000	5.000	.280	2.005	-.449	-1.605
KBK5	1.000	5.000	-.194	-1.389	-.237	-.848
KBK4	1.000	5.000	.403	2.881	-.306	-1.094
KBK3	1.000	5.000	.767	5.484	-.011	-.040
KBK2	1.000	5.000	.787	5.628	-.046	-.163
KBK1	1.000	5.000	.616	4.403	.059	.213
Multivariate					6.087	5.443

Table 4.8 Standardized Residual Covariances

	KBK6	KBK5	KBK4	KBK3	KBK2	KBK1
KBK6	.000					
KBK5	5.984	.000				
KBK4	1.209	1.647	.000			
KBK3	.074	-.706	-.100	.000		
KBK2	-.600	-1.117	-.374	.225	.000	
KBK1	-1.346	-.168	.187	-.160	.283	.000

Table 4.9 Covariances

			M.I.	Par Change
e5	<-->	e6	66.233	.348
e4	<-->	e6	8.936	.095
e4	<-->	e5	13.713	.114
e2	<-->	e5	11.376	-.077
e1	<-->	e6	12.300	-.091

Figure 4.2 (ii) shows that the modified first-order measurement model after deleting KBK5 (*renewable and non-renewable resources*) and KBK6 (*Life Cycle Assessment*). The results of model fit indices indicate that this measurement model has achieved the model fit except for RMSEA = 0.081. However these itemsstill remainsto enable AMOS to test latent factors(represent more than three items).

Referring to Table 4.10, the result of Cronbachs' Alpha to measure the internal consistency of overall items is 0.916. As a result, these four items are acceptable to measure students' knowledge on sustainable development. The highest factor loading is KBK2 (*Three elements of sustainable development*, 0.90) followed with KBK3 (*Principles of sustainable development*, 0.89), KBK1 (*Definition of sustainable development*, 0.84) and KBK4 (*Impact of unsustainability*, 0.81)

Table 4.10 Content Validity of Modified First-Order Measurement Model of Knowledge on Sustainable Development

		Mean	Std. Deviation	Cronbach's Alpha
KBK1	Definition of Sustainable Development	2.02	.869	0.916
KBK2	Three elements of sustainable development	1.84	.873	
KBK3	Principles of sustainable development	1.79	.824	
KBK4	Impact of unsustainability	2.33	1.023	

4.3.2.3 Construct Validity of Students' Knowledge

Assessment of construct validity consists of two tests of validity, namely the convergent validity and discriminant validity. Convergent validity refers to a set of variables that presume to measure a construct (Hooper *et al*.,2008). It can be tested using either average variance extracted (AVE)– a high (>0.5) indicates a high convergent validity (FornellandLarcker, 1981) or factor loadings – high factor loadings (> 0.5) on a factor indicate high convergent validity (Hair, et al. 2006). Figure 4.1(ii) and Figure 4.2(ii) shows that the values of the factor loading of each item in both latent factors are above 0.5.

The second test of construct validity is discriminant validity. It is carried out to ensure that all items belong to specific construct. The analysis of discriminant validity is needed to test the required pairs of individual unobserved construct to be correlated or uncorrelated to each others. Table 4.11 indicates that the different of chi-square statistic of the constrained model is larger than 3.84 compare to unconstrained at 1 degree of freedom. It is proven that the constructs of environmental issues and sustainable development are discriminated to each other (Anderson and Gerbing, 1988).

Table 4.11 Discriminant Validity of Students' Knowledge

Pairwise	Unconstrained		Constrained	
	Chi-square	df	Chi-square	df
Environmental Issues - Concept of SD	81.669	43	173.689	44

4.3.2.4 Second Order Measurement Model of Students' Knowledge

Figure 4.3 shows the best results of model fit of second-order measurement model of students' knowledge. All the indicators indicate that this model is satisfied and, within the acceptable limits (Ratio = 1.899, RMSEA = 0.054, GFI, NFI & CFI > 0.9). It shows that students' knowledge consists of seven significant items of environmental issues and four significant items of sustainable development. Students' knowledge on environmental issues represents the highest factor loading (0.85) compared to students' knowledge on sustainable development (0.62). All factors loading of each item is above 0.6.

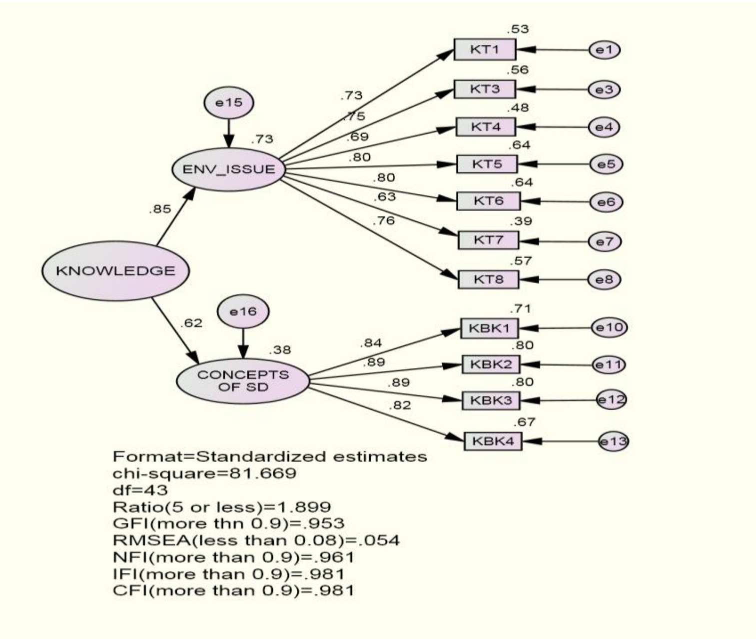


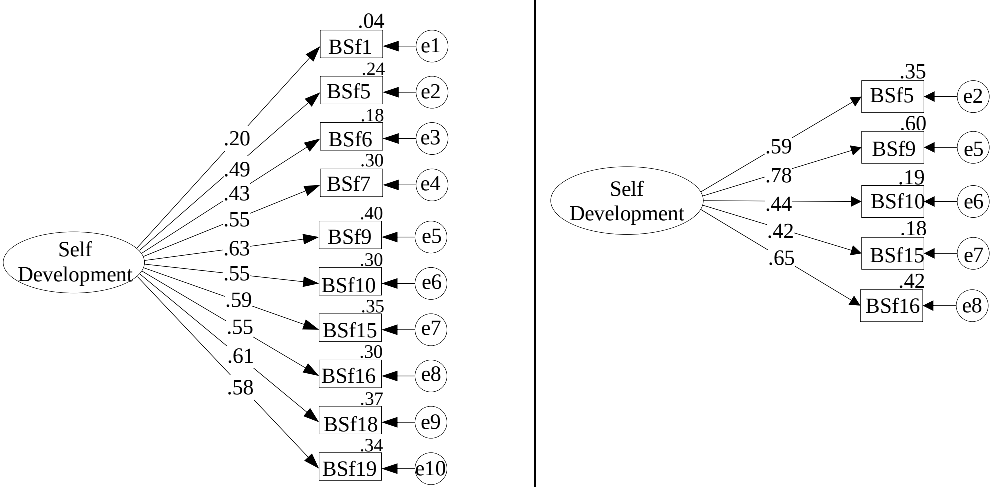
Figure 4.3 Second-order Measurement Model of Students' Knowledge

4.3.3 Confirmatory Factor Analysis of Students' Pro-environmental Behaviour

Confirmatory Factor Analysis of students' pro-environmental behaviour consists of two latent factors, namely self development and social development. Both latent factors of pro-environmental behaviour consists of ten items, respectively. Analysis using CFA is carried out to determine the most significant items used to answer RQ1(a).

4.3.3.1 First-Order Measurement Model of Self Development

Figure 4.4 shows the initial and modified first-order measurement model of students' pro-environmental behaviour on self-development which consists of ten items. Referring to Figure 4.4 (i), most of the indicators show the results are below or out of acceptable limits (CFI = 0.828, RMSEA = 0.101, NFI = 0.789 and IFI = 0.831). Further analyses are needed to identify the problematic items.



(i) Initial Measurement Model

(ii) Modified Measurement Model

Figure 4.4 First-Order Measurement Model of Students' Pro-environmental Behaviour on Self-Development

Result of the assessment of normality in Table 4.12 indicates that BSf6 and BSf18 are located at unacceptable limits of skewness and kurtosis (more than absolute 1). Furthermore, the value of squared multiple correlation of BSf1 (0.04) is very low(less than 0.1). These indicators indicate that BSf1, BSf6 and BSf18 are the first problematic items that need to be deleted from the initial model.

Table 4.12 Assessment of normality

Variable	min	max	skew	c.r.	kurtosis	c.r.
BSf19	1.000	5.000	-.866	-6.194	-.205	-.732
BSf18	1.000	5.000	-1.092	-7.812	.385	1.375
BSf16	1.000	5.000	-.099	-.706	-.983	-3.515
BSf15	1.000	5.000	-.936	-6.699	-.109	-.391
BSf10	1.000	5.000	-.332	-2.371	-.605	-2.165
BSf9	1.000	5.000	-.106	-.759	-.917	-3.279
BSf7	1.000	5.000	-.296	-2.120	-.603	-2.157
BSf6	1.000	5.000	-1.458	-10.429	1.463	5.231
BSf5	1.000	5.000	.123	.883	-.948	-3.391
BSf1	1.000	5.000	.496	3.548	-.054	-.194
Multivariate					22.065	12.478

However, the new statistical test does not achieved the acceptable model fit. Further analysis is carried out to identify the misspecification items. Table 4.13 shows the assessment on standardized residual covariances. There are two pairs of relationship (BSf19 - BSf15 and BSf7 - BSf10) that are greater than the absolute value of two. Therefore, BSf19 and BSf7 are the problematic items that are deleted from the initial model.

Table 4.13 Standardized Residual Covariances

	BSf19	BSf16	BSf15	BSf10	BSf9	BSf7	BSf5
BSf19	.000						
BSf16	-1.007	.000					
BSf15	2.896	-.295	.000				
BSf10	.365	-.741	.416	.000			
BSf9	-.858	.966	-.900	-.484	.000		
BSf7	1.126	-1.330	.749	2.385	-.586	.000	
BSf5	-1.000	1.106	-1.408	-1.054	1.283	-.923	.000

Figure 4.4 (ii) shows the results of the modified of first order measurement model of self- development towards pro-environmental behaviour. Five problematic items (BSf1, BSf6, BSf7, BSf18 and BSf19) are deleted from the initial first-order measurement model of students' pro-environmental behaviour. The statistical results indicate that the new modified model is satisfied with the acceptable limitsof goodness of model fit. Referring to Table 4.14, the result of Cronbachs' Alpha to measure the internal consistency of overall items is 0.714. As a result, these five items are acceptable to measure students' pro-environmental behaviour associated with self development. BSf15 is the highest mean score about 4.08 and the lowest mean score is BSf5 (2.87). The highest factor loading is BSf9(0.78) followed with BSf16 (0.65) and BSf5(0.59).

Table 4.14 Content Validity of Modified Measurement Model of Pro-self Development

Code	Items	Mean	Std. Deviation	Cronbac's Alpha
BSf5	I separate domestic waste for recycling	2.87	1.207	
BSf9	I recycle paper to conserve natural resources	3.25	1.195	
BSf10	I pick up litter when I see it in a public area	3.39	1.107	
BSf15	I do not let the running water of a faucet when it is not necessary	4.08	1.068	0.714
BSf16	I collect and sell recycled items such as papers, bottles and glasses	3.23	1.251	

Descriptive analysis is carried out to analyse the problematic items that are determined using confirmatory factor analysis. Table 4.15 shows the percentage and mean scores of problematic items are more than 4. BSf6(*I walk or cycle to attend lecture*), BSf18(*I turn lights off when I leave a room*) and BSf19(*I turn tap off when brushing my teeth*) are considered as practicing items.

Table 4.15 Percentage of Students' Responses on Problematic Items

ITEMS	Likert type scale (% of Students' Responses)					Mean
	1	2	3	4	5	
BSf 6	3	4.3	11.5	23.9	57.4	4.29
BSf 18	1.6	6.6	15.4	25.6	50.8	4.17
BSf 19	3	9.8	17.4	27.2	42.6	4.00

Referring to the percentage of students' responses, more than 50 % of the respondents have been practicing the items. BSf6(*I walk or cycle to attend lecture*) is the highest item that has been practiced. It is about 57.4 % of the respondents agreed to scale 5 (*practice as a part of the lifestyle*). On the same scale, BSf18(*I turn lights off when I leave a room*) and BSf19(*I turn tap off when brushing my teeth*) are also considered as practicing items, 50.8% and 42.6%, respectively.

4.3.3.2 First-Order Measurement Model of Social Development

Figure 4.5 shows the initial and modified first-order measurement model for students' pro-environmental behavior associated with social development. The results of statistical test show that the initial model did not comply with the acceptable limits of a good model fit (Ratio = 7.883, GFI = 0.83, RMSEA = 0.150, NFI = 0.783, IFI = 0.805 and CFI = 0.803). Therefore, this initial first-order measurement model should be modified for further analysis using the process of iterative sequences. All the relevant indicators such as multivariate normality, standardized residual covariances and modification indices are properly treated and investigated, in order to achieve the most significant measurement model.Table 4.16 shows that the result of the assessment of normality obtained the acceptable limits of skewness and kurtosis except for BSc4. The skewness of BSc4 (1.029) is greater than absolute 1.

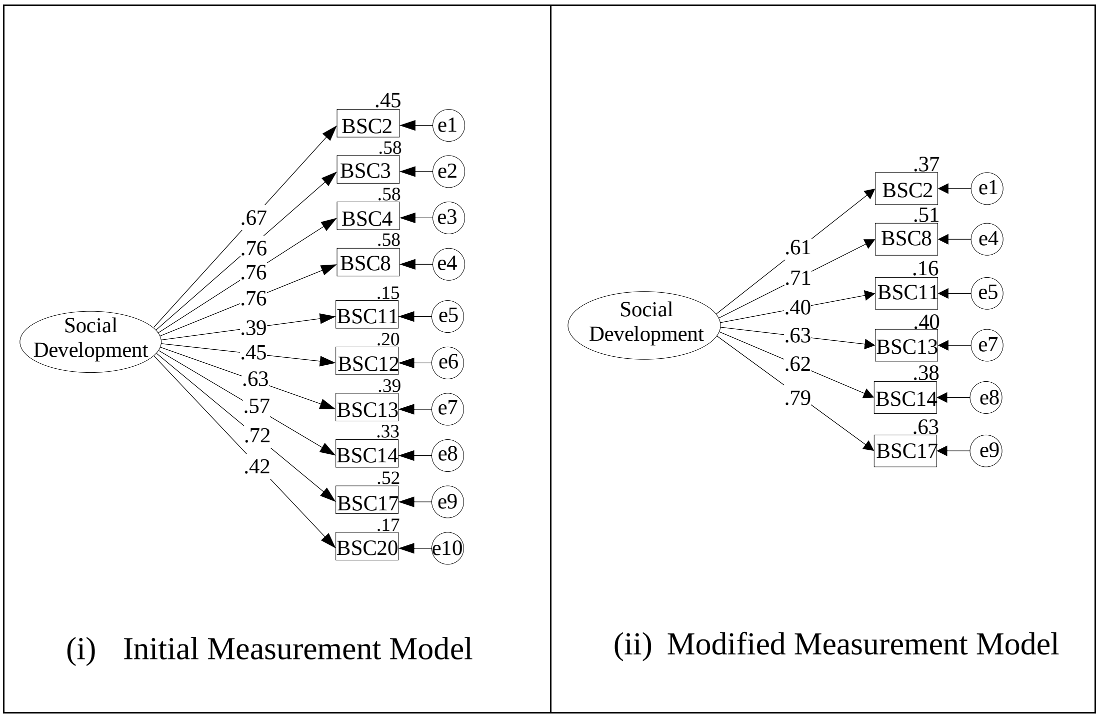


Figure 4.5 First Order Measurement Model of Students'Pro-environmental towards Social Development

Table 4.16 Assessment of normality

Variable	min	max	skew	c.r.	kurtosis	c.r.
BSC20	1.000	5.000	-.021	-.153	-.701	-2.507
BSC17	1.000	5.000	.502	3.594	-.373	-1.332
BSC14	1.000	5.000	.454	3.248	-.429	-1.536
BSC13	1.000	5.000	.162	1.159	-.318	-1.137
BSC12	1.000	5.000	-.109	-.778	-.819	-2.931
BSC11	1.000	5.000	-.227	-1.627	-.528	-1.888
BSC8	1.000	5.000	.610	4.365	-.255	-.910
BSC4	1.000	5.000	1.029	7.363	.770	2.755
BSC3	1.000	5.000	.716	5.122	.181	.647
BSC2	1.000	5.000	.477	3.411	-.320	-1.146
Multivariate					17.652	9.982

Table 4.17 Standardized Residual Covariances

	BSC20	BSC17	BSC14	BSC13	BSC12	BSC11	BSC8	BSC4	BSC3	BSC2
BSC20	000									
BSC17	.021	000								
BSC14	722	.748	000							
BSC13	2.198	146	.671	000						
BSC12	2.100	.108	2.000	2.239	000					
BSC11	2.340	176	.452	.668	2.518	000				
BSC8	.578	264	.776	.635	.220	145	000			
BSC4	1.166	.009	.734	1.639	2.300	1.126	756	000		
BSC3	1.308	1.445	1.166	062	1.805	1.616	.222	.543	000	
BSC2	1.606	085	1.022	.858	2.428	.759	.470	234	2.391	000

Table 4.17 shows the assessment on standardized residual covariance matrix. This model has nine pairs of relationships (BSc20 and BSc13, BSc20 and BSc12, BSc20 and BSc11, BSc12 and BSc14, BSc12 and BSc13, BSc12 and BSc11, BSc12 and BSc4 and BSc3 and BSc2) that are greater than two in absolute value. Therefore, BSc4, BSc12 and BSc20 are the selected items to be deleted from the initial model. After BSc4, BSc12 and BSc20 have been deleted from the initial measurement model, the results of statistical test still did not achieve the acceptable limits of a good model fit. Therefore, further investigation is carried out to identify the problematic items.Table 4.18 shows the assessment on covariances, if e2 is deleted from the initial model, it might increase the chi-square value to the acceptable limit of a good model fit.

Table 4.18 Assessment of Covariances

			M.I.	Par Change
e8	-->	e9	14.620	.143
e2	-->	e9	15.367	-.108
e1	-->	e2	36.671	.166

Figure 4.5 (ii) shows the new measurement model after BSc3, BSc4, BSc12 and BSc20 are deleted from the initial measurement model. The statistical test fits well to an acceptable limits (Ratio = 2.608, RMSEA = 0.072, GFI = 0.976, NFI = 0.953, IFI = 0.971 and CFI = 0.970. BSc17 with the highest factor loading or the most significant indicator for social development. Furthermore, Table 4.19 shows the content validity of each item that has converged to latent factors of social development. The value of Cronbach's Alpha is 0.789 and standard deviations are greater than 0.9. These mean that the latent factors of social development have a strong internal consistency and accurately represent this sub-construct (Hair *et al.*, 1998).

Table 4.19 Content Validity of Modified Measurement Model of Social Development

Code	Items	Mean	Std. Deviation	Cronbach's Alpha
BSc2	I discuss with friends about sustainability issues	2.13	.935	0.789
BSc8	I invite friends to take part in sustainable programme	1.98	.911	
BSc11	I volunteer to work with sustainable programme	3.32	1.076	
BSc13	I discuss with friends what we can do to reduce pollution	2.83	1.028	
BSc14	I asked my parents not to buy products made from non-renewable resources	2.40	1.066	
BSc17	I actively participate in sustainable programme	2.09	.964	

4.3.3.3 Construct Validity of Students' Pro-environmental Behaviour

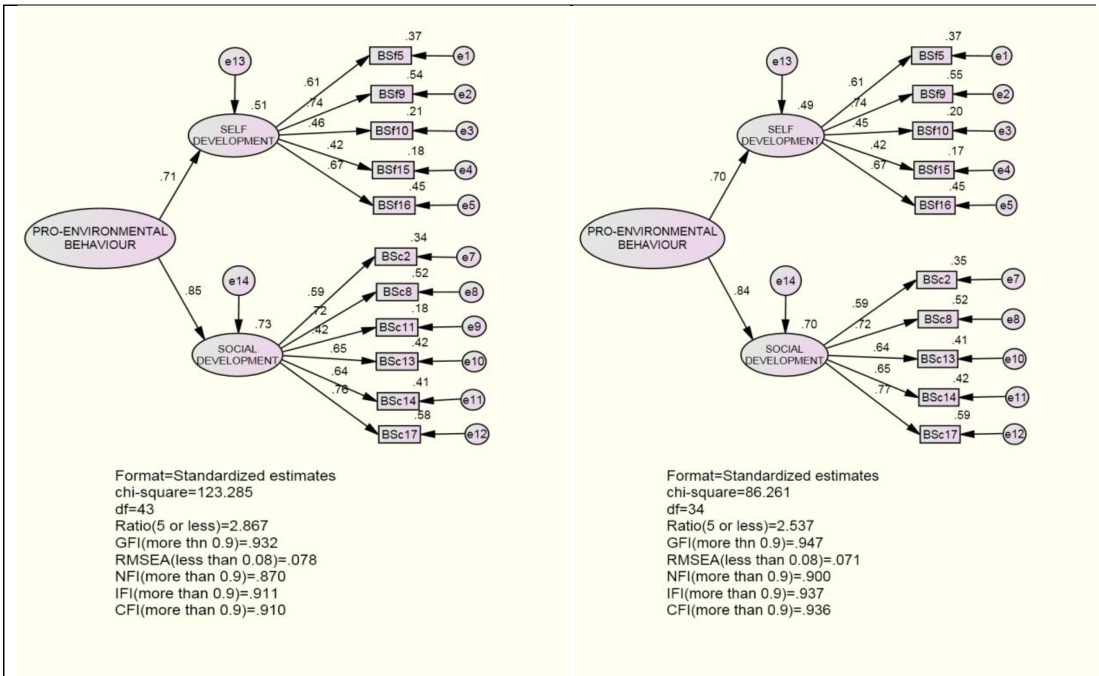
Discriminant validity has been carried out to ensure that all items of pro-environmental behaviour belong to a specific construct. The analysis of discriminant validity is required to test the pairs of individual unobserved construct, to check correlated for correlation between them. Table 4.20 shows that the different of chi-square statistic of the constrained model is larger than 3.84 compare to unconstrained at 1 degree of freedom. It is proven that the construct of self-development and social development in practicing pro-environmental lifestyle is discriminated to each other.

Table 4.20 Discriminant Validity of Students' Knowledge

Pairwise	Unconstrained		Constrained	
	Chi-square	df	Chi-square	df
Pro-self Development – Social Development	123.289	43	170.977	44

4.3.3.4 Second-Order Measurement Model of Pro-environmental Behaviour

Figure 4.6 shows the initial and modified second-order measurement model of student's behaviour related to pro-environmental behaviour. Results of statistical test on initial model indicate that NFI (0.870) does not comply with the acceptable limits of goodness of fit. Further investigation using assessment on standardized residual covariance matrix is then carried out. Table 4.21 shows that there are six pairs of relationship that having more than two in absolute value. BSc11 are covariance with BSf16, BSf15 and BSf10. Therefore, BSf11 is chosen to be deleted from the initial model.



(i) Initial Measurement Model | (ii) Modified Measurement Model

Figure 4.6 Initial and Modified Second-order Measurement Model of Pro-environmental Behaviour

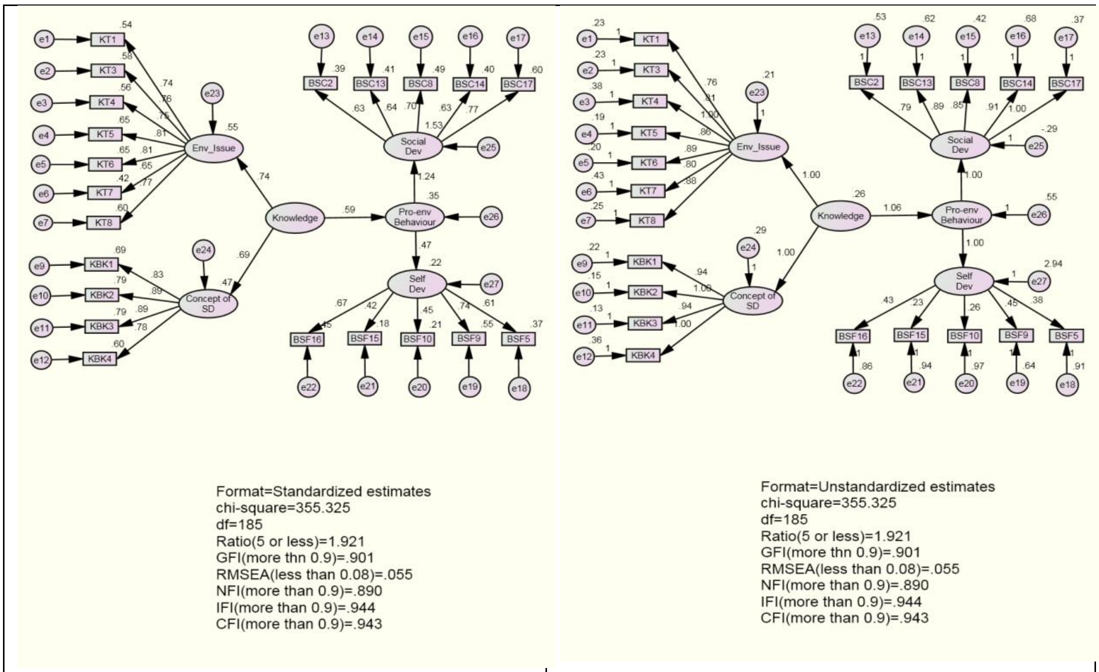
Table 4.21 Standardized Residual Covariances

	BSc17	BSc14	BSc13	BSc11	BSc8	BSc2	BSf16	BSf15	BSf10	BSf9	BSf5
BSc17	.000										
BSc14	.593	.000									
BSc13	-.485	.772	.000								
BSc11	-.478	-1.215	1.165	.000							
BSc8	.293	-1.133	-.482	.024	.000						
BSc2	.704	-.847	-.213	-.520	.924	.000					
BSf16	.208	.716	.723	2.085	.328	-2.061	.000				
BSf15	-1.407	.386	.325	2.466	-.200	-1.601	.189	.000			
BSf10	-.527	.991	1.410	3.987	.915	.223	-.651	1.635	.000		
BSf9	-2.407	1.963	.245	.050	-.052	-2.179	.071	.073	.067	.000	
BSf5	-.093	.707	-.142	.285	1.284	.224	-.102	-.973	-.972	.453	.000

Figure 4.6 (ii) shows the modified second-order measurement model of students' pro-environmental behaviour after discarding the problematic items (BSc3, BSc4, BSc12 and BSc20). The results of statistical test indicate that all indicators have achieved the acceptable limits of a good model fit (Ratio = 2.867, RMSEA = 0.078, GFI = 0.932, IFI = 0.911 and CFI= 0.910). This shows that students' pro-environmental behaviour consists of five significant elements of self-development and five significant elements of social development. Students' pro-environmental behaviour on social developmentrepresents the highest factor loading (0.84) compared to students' knowledge on sustainable development (0.70). Factors loading of each itemis above 0.5 on social development and 0.4 for self-development.

4.3.4 Structural Equation Model of Students' Knowledge-Behaviour

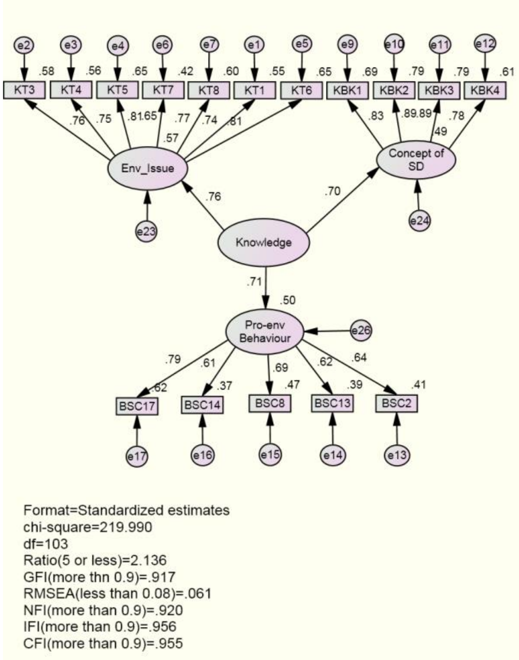
Structural Equation Model (SEM) is employed to investigate the relationship between knowledge and pro-environmental behaviour. Figure 4.7 (i) shows the results of statistical test of the structural modelusing the same procedure as a measurement model. The initial structural results show that GFI (0.897) and NFI (0.886) do not comply with the acceptable limits of a good model fit. The squared multiple correlation and standardized regression weight of latentfactors of social development are more than 1. Furthermore, Figure 4.7 (ii) shows another clue that the variances of latent factors of self-development are more than 0.9 except for BSF9 (0.64).



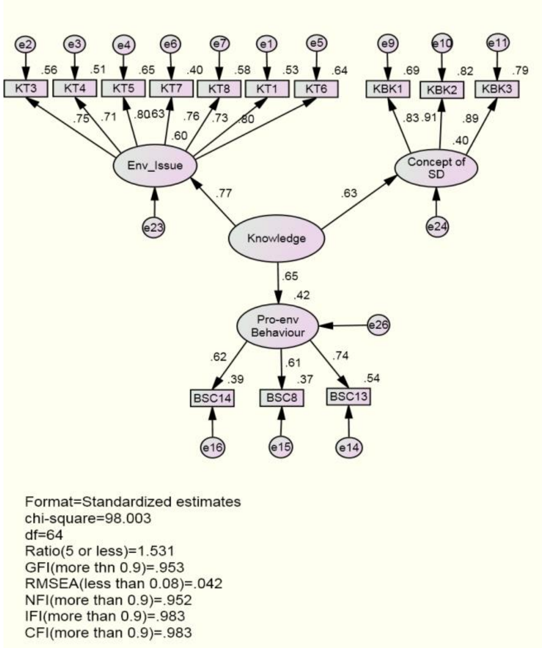
(i) Standardized	(ii) Unstandardized

Figure 4.7 Initial Structural Model of Students' Knowledge-Behaviour

These indicators show that further investigation need to be carried out. After conducting several assessments and analyses, it is found that latent factors of self development should be disregarded from the structural model. Figure 4.8 (i) shows the new structural model for pro-environmental behaviour after deleting latent factors of self-development.



(i) Initial Structural Model



(ii) Modified Structural Model

Figure 4.8 Modified Structural ModelStudents' Knowledge-Behaviour

Figure 4.8 (i) shows the statistical results of the structural modelhas complied with the acceptable limits of a good model fit (Ratio = 2.136, GFI = 0.917, RMSEA = 0.061, NFI = 0.920, IFI = 0.956 and CFI = 0.955). This structural model has achieved several assessment indicators such as assessment of normality (the values of skewness and kurtosis are within absolute one), squared multiple correlation greater than 0.1 and standardized regression weight greater than 0.5. However, the standardized residual covariance matrix in Table 4.22 shows that several pair of relationships, have value greater than absolute two. Therefore BSc2, BSc17 and KBK4 are considered for deletion from the structural model.

Table 4.22 Standardized Residual Covariances

	BSC2	KBK4	KT6	KT1	BSC13	KT3	BSC8	BSC14	BSC17	KBK3	KBK2	KBK1	KT4	KT5	KT7	KT8
BSC2	.097															
KBK4	4.798	1.447														
KT6	-.405	1.488	-.708													
KT1	.270	2.415	-1.034	-.593												
BSC13	-.476	1.427	.050	1.036	.091											
KT3	-.379	1.725	-.968	-.545	.014	-.628										
BSC8	.688	.939	-1.507	-2.554	.225	-1.843	.111									
BSC14	-1.056	-.596	-.722	-1.116	1.443	-1.021	-.395	.087								
BSC17	-.097	1.444	-1.163	-1.360	-.280	-1.187	.591	.880	.326							
KBK3	3.626	1.446	-.859	.673	1.003	-.755	.482	.441	2.336	.833						
KBK2	3.689	1.034	-1.262	.236	.417	-.642	.830	-.267	2.446	1.055	.837					
KBK1	3.631	1.620	-.479	.845	-.470	.243	.449	-.696	1.960	.638	1.005	.734				
KT4	.073	1.833	-2.529	-1.508	.106	-.930	-1.617	-1.021	-1.792	.113	.078	-.129	-1.723			
KT5	-.868	.967	.111	-.744	-.062	-.607	-1.951	-2.081	-2.637	-1.327	-1.382	-.665	-1.630	-.708		
KT7	1.457	1.850	-.986	-1.337	.451	-.393	-1.168	1.152	.377	-.011	-.315	.180	-.733	-1.170	-.456	
KT8	1.126	2.078	-.358	-.402	.773	-1.465	-1.486	-.324	-.452	.074	-.297	-.088	-1.525	-1.277	-.319	-.647

Table 4.23 Standardized Residual Covariances

	KT6	KT1	BSC13	KT3	BSC8	BSC14	KBK3	KBK2	KBK1	KT4	KT5	KT7	KT8
KT6	-.210												
KT1	-.531	-.174											
BSC13	-.297	.736	.033										
KT3	-.436	-.015	-.297	-.184									
BSC8	-.552	-1.695	-.127	-.937	.009								
BSC14	-.443	-.858	.068	-.749	.182	.010							
KBK3	-.313	1.203	.986	-.216	1.744	1.017	.363						
KBK2	-.795	.699	.356	-.169	2.057	.271	.496	.516					
KBK1	.067	1.372	-.441	.787	1.656	-.124	.295	.518	.318				
KT4	-1.568	-.513	.099	.154	-.491	-.519	1.030	.935	.749	-.563			
KT5	.665	-.247	-.421	-.079	-1.019	-1.840	-.799	-.930	-.133	-.606	-.211		
KT7	-.483	-.869	.206	.135	-.359	1.431	.479	.118	.664	.262	-.692	-.131	
KT8	.223	.154	.473	-.931	-.551	-.029	.637	.196	.467	-.469	-.760	.230	-.190

Finally, Figure 4.8 (ii) shows the final modified structural model that complies with the acceptable limits of a good model fit (Ratio = 1.531, GFI = 0.953, RMSEA = 0.042, NFI = 0.952, IFI = 0.983 and CFI = 0.983. Table 4.23 shows that the residual covariances in the standardized residual covariance matrix are less than absolute two. This structural model has satisfied with the assessment of normality, squared multiple correlations, standardized regression weight and variance at significantly difference at the 0.001 level (two-tailed).

4.4 Results of Research Question 1a

RQ1a. What are the most significant items to assess the first year engineering students on; (i) knowledge on environmental issues, (ii) knowledge on sustainable development, and (iii) practicing pro-environmental behaviour associated with self and social development.

(i) Environmental issues

KT5 (*Global Warming*), KT6 (*Greenhouse Effect*), KT8 (*Ozone Layer Depletion*), KT3 (*Climate change*), KT1 (*Air Pollution*), KT4 (*Environmental Degradation*) and KT7 (*Green Technology*) are the variables that appear to be the most significant indicators to assess students' knowledge onenvironmental issues. Their factors loading are 0.80, 0.80, 0.76, 0.75, 0.72, 0.69 and 0.63, respectively. This means that environmental issues explains about 64% of the variance in KT5 (*Global Warming*) and KT6 (*Greenhouse Effect*), 57% of the variance in KT8 (*Ozone Layer Depletion*), 56% of the variance in KT3 (*Climate change*), 53% of the variance in KT1 (*Air Pollution*), 48% of the variance in KT4 (*Environmental Degradation*) and 39% of the variance in KT7 (*Green Technology).*

(ii) Sustainable Development

KBK1 (*Definition of sustainable development*), KBK2 (*Components of sustainable development*), KBK3 (*Principles of sustainable development*) and KBK4 (*Impact of un-sustainability*) are the variables that appear to be the most significant indicators to assess students' knowledge on sustainable development. Their factors loading are0.84, 0.89, 0.

89 and 0.82, respectively. This mean that the knowledge on sustainable development explains about 71% of the variance in KBK1, 80% of the variance in KBK2, 80% of the variance on KBK3 and 67% of the variance in KBK4.

(iii) Self Development

BSf5 (*I separate domestic waste for recycling*), BSf9 (*I recycle paper to conserve natural resources*), BSf10 (*I pick up litter when I see it in a public area*), BSf15 (*I do not let running water of a faucet when it is not necessary*) and BSf16 (*I collect and sell recycled items such as papers, bottles and glasses*) are the variables that appear to be the most significant indicators to assess the students' pro-environmental behaviour on self-development. Their factors loading are0.61, 0.74, 0.45, 0.42 and 0.67, respectively. This means that self development explains about 37% of the variance in BSf5, 55% of the variance in BSf9, 20% of the variance in BSf10, 17% of the variance in BSf15 and 45% of the variance in BSf16.

(iv) Social Development

BSc2 (*I discuss with friends about sustainable issues*), BSc8 (*I invite friends to take part in sustainable programmes*), BSc13 (*I discussed with friends what we can do to reduce pollution*), BSc14 (*I asked my parents not to buy products made from non-renewable resources*) and BSc17 (*I actively participate in sustainable programmes*) are the variables that appear to be the most significant indicators to assess the students' pro-environmental behaviour on social development. Their factors loading are 0.59, 0.72, 0.64, 0.65 and 0.77, respectively. This means that social development explains about 35% of the variance in BSc2, 52% of the variance in BSc8, 41% of the variance on BSc13, 42% of the variance in BSc14 and 59% of the variance in BSc17.

4.5 Results of Research Question 1b

RQ1b. What are the levels of perception of the first year engineering students' on (i) prior knowledge on environmental issues, (ii) prior knowledge on sustainable development, and (iii) practicing pro-environmental behaviour associated with self and social development?

(i) Levels of Students' perception of prior knowledge on environmental issues

Figure 4.9 shows the distribution of the mean scores of students' perception on their prior knowledge on environmental issues. The average mean score is 3.37 (know and can explain briefly). Global Warming (KT5, 3.66), Air Pollution (KT1, 3.63) and Ozone Layer Depletion (KT8, 3.49) have the mean score above the average mean score. Global Warming is the highest mean score of 3.66 and Green Technology is the lowest mean score of 2.89.

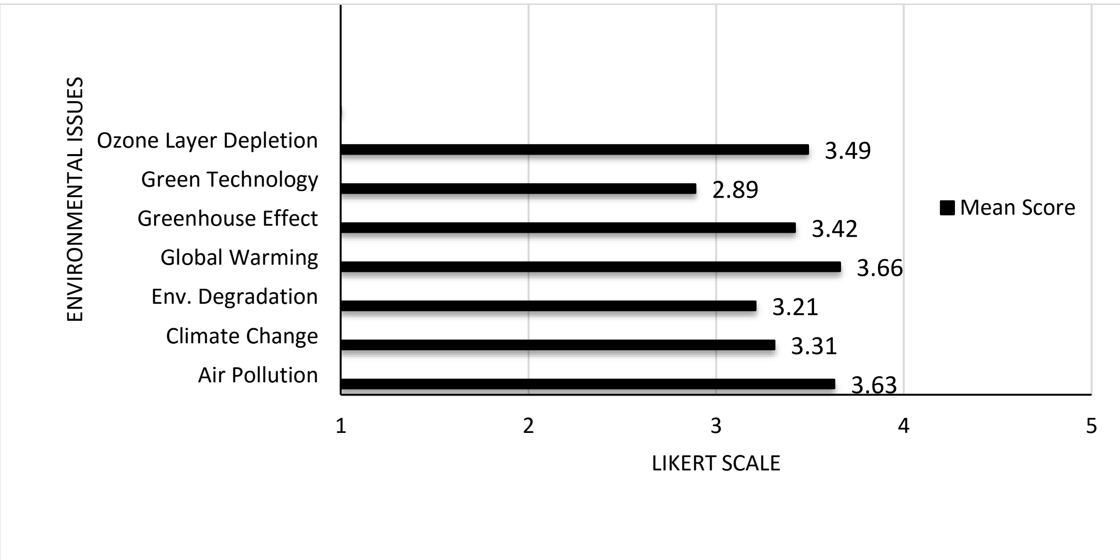


Figure 4.9 Distribution of Means Score of Students' Perception of Prior Knowledge on Environmental Issues

(ii) Levels of Students' perception of prior knowledge on sustainable development

Figure 4.10 shows the distribution of mean score of students' perception on their prior knowledge on sustainable development. All the mean score of each item is below the average. KBK1 (*Definition of Sustainable Development*, 2.02), KBK2 (*Components of Sustainable Development*, 1.84), KBK3 (*Principles of Sustainable Development*, 1.79) and KBK4 (*Impact of un-sustainability*, 2.33) are within the average range of 1.5 to 2.5 (heard and know but cannot describe in detail).

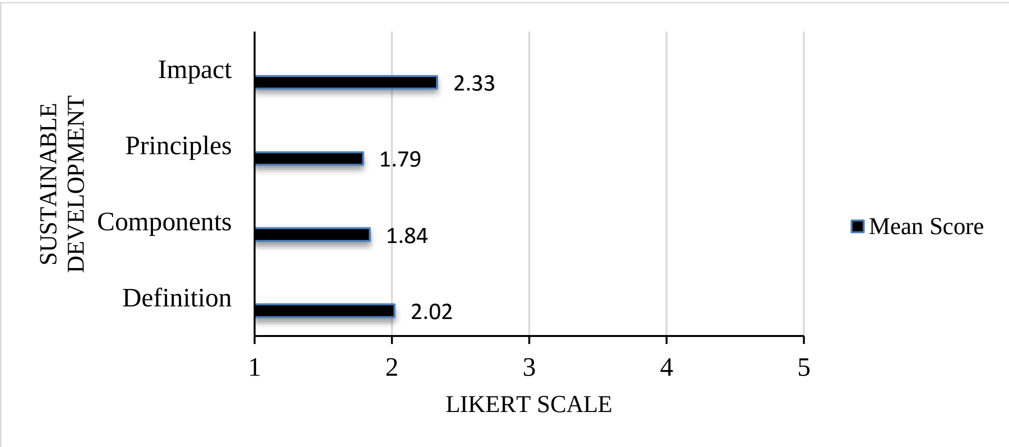


Figure 4.10 Distribution of Mean Score on Students' Perception on Prior Knowledge on Sustainable Development.

(iii) Level of students' perception on self-development

Figure 4.11 shows the distribution of mean scores of students' perception on their pro-environmental behaviour associated to self-development. BSf9 (3.25), BSf10 (3.39), BSf15 (4.08) and BSF16 (3.23) have the mean score above 3 (have an interest to engage on issues but not certain to contribute). BSf15 (*I do not let running water of a faucet when it is not necessary*) has the highest mean score of 4.08 and BSf5 (*I separate domestic waste for recycle*) has the lowest (2.87).

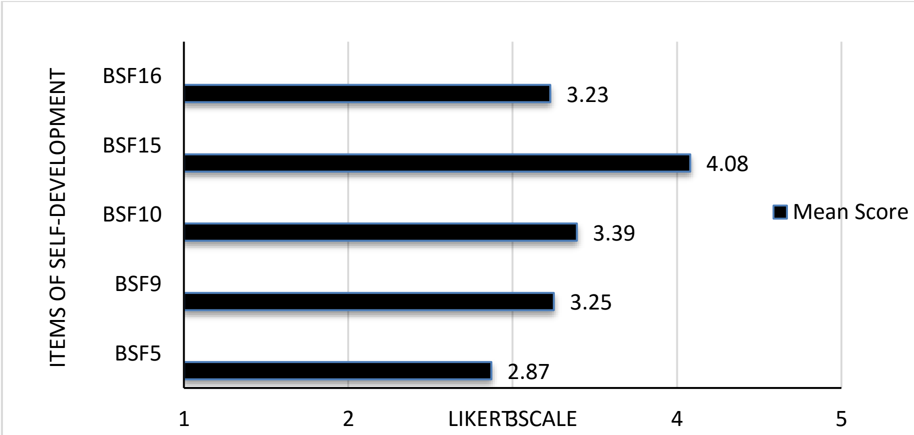


Figure 4.11 Distribution of Mean Score of Students' Pro-environmental Behaviour on Self-Development

(iv) Level of students' perception on self-development

Furthermore, Figure 4.12 shows the distribution of mean score of students' perception of their pro-environmental behaviour associated with social development. All the mean scores of each item are below the average. BSc2 (2.13), BSc13 (2.83), BSc14 (2.40) and BSc17 (2.09) are located between scale 2 (aware of the issues but not to engage) and scale 3 (have an interest to engage on issues but not sure to contribute). BSc13 (2.83) has the highest mean score and BSc8 (1.98) has the lowest mean score.

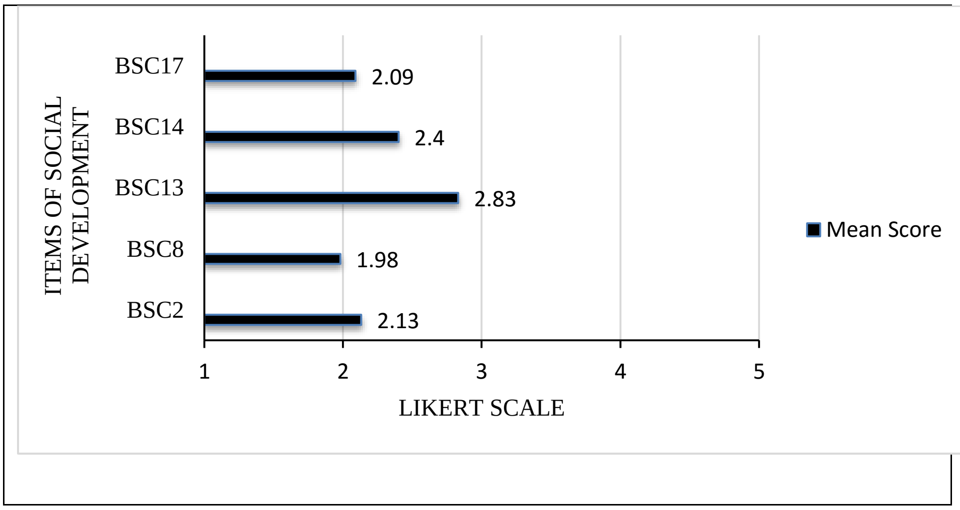


Figure 4.12 Distribution of Means Score of Students' Pro-environmental Behaviour on Social Development

4.6 Results of Research Question 1c

RQ1c. Is there any significant difference across gender of students regarding their (i) prior knowledge on environmental issues, (ii) prior knowledge on sustainable development, and (iii) practicing pro-environmental behaviour associated with self and social development?

(i) Students' Prior Knowledge on Environmental Issues

An independent-samples t-test has been conducted to compare students' prior knowledge on environmental issues between males and females. Table 4.24 shows that the mean score for males (3.422) is higher that the mean score for females (3.297).

The hypothesis of this research question is as follows:

Ho_1 There is no statistical significant difference between males and females in students' prior knowledge about environmental issues.

Table 4.24 Mean scores of Students' Prior Knowledge on Environmental IssuesBetween Gender

	Gender	N	Mean	Std. Deviation
Env. Issues	Male	182	3.4223	.58831
	Female	125	3.2971	.59943

Based on Table 4.25, Levene's test for equality of variances shows that the value of F = 0.163 as the significant value of 0.687.It means that the variances in both groups are similar; hence the 'equal variances assumed' row is used for the t-test. Independent sample t-test result shows that the value of t-test is 1.817 with a degree of freedom of 305 and p = 0.07. Therefore, the null hypothesis is not rejected. Thus, the study shows no significant differences in students' prior knowledge on environmental issues between male and female respondents.

Table 4.25 Independent Samples T-Test for Mean Scores in Students' Prior Knowledge on Environmental IssuesBetween Gender

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Dif.	Std. Error Dif.	Lower	Upper
Env. Issues	Equal variances assumed	.163	.687	1.817	305	.070*	.125	.069	-.010	.261
	Equal variances not assumed			1.811	263.371	.071*	.125	.069	-.011	.261

* $p > 0.05$

(ii) Students' Prior Knowledge on Sustainable Development

An independent-samples t-test is conducted to compare students' prior knowledge on sustainable development between males and females. Table 4.26 shows the mean score for males (2.073) is higher that the mean score for females (1.882).

The hypothesis of this research question is as follows:

Ho_2 There is no statistically significant difference between male and female in students' prior knowledge on sustainable development.

Table 4.26 Mean scores of Students' Prior Knowledge on Sustainable Development

	Gender	N	Mean	Std. Deviation
Concepts of SD	Male	182	2.0728	.82510
	Female	125	1.8820	.76238

Based on Table 4.27, Levene's test for equality of variances shows that the value of F = 0.445 at the significant value of 0.505. It means that the variances in both groups are similar; hence the 'equal variances assumed' row is used for the t-test. Independent sample t-test result shows that the value of t-test is 2.053 with a degree of freedom of 305 and p = 0.041. Therefore, the null hypothesis is rejected. The study shows that there is a significant difference in students' prior knowledge on sustainable development between male and female respondents. The mean score of male is higher than female.

Table 4.27 Independent Samples t-Test for Mean Scores in Students' Prior Knowledge on Sustainable Development

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Dif.	Std. Error Dif.	Lower	Upper
Concepts of SD	Equal variances assumed	.445	.505	2.053	305	.041*	.19080	.09296	.00789	.37372
	Equal variances not assumed			2.083	279.733	.038*	.19080	.09160	.01049	.37111

$*p < 0.05$

(iii) Students' Pro-environmentalBehaviour associated with Self-Development

An independent-samples t-test is conducted to compare students' pro-environmental behavior associated with self-development between males and females.

Table 4.28 shows that the mean scores for females (3.555) is higher that the mean score of for males (3.234).

Table 4.28 Mean scores of Students' Self-Development on Pro-evironmental Behaviour Between Gender

	Gender	N	Mean	Std. Deviation
Self Dev.	Male	182	3.2341	.76581
	Female	125	3.5552	.80797

The hypothesis of this research question is as follows:

Ho_2 There is no statistical significant difference between male and female in students' pro-environmental behaviour associated with self development.

Based on Table 4.29, Levene's test for equality of variances shows that the value of F = 0.673 at the significant value of 0.413.It means that the variances in both groups are similar; hence the 'equal variances assumed' row is used for the t-test. Independent sample t-test result shows that the value of t-test is -3.530 with a degree of freedom of 305 and p = 0.000. Therefore, the null hypothesis is rejected. The study showed that there is a significant difference in students' pro-environmental behavior associated with self-development between male and female respondents.

Table 4.29 Independent Samples t-Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Diff	Std. Error Diff	Lower	Upper
Self Dev.	Equal variances assumed	.673	.413	-3.530	305	.000*	-.321	.091	-.500	-.142
	Equal variances not assumed			-3.495	257.155	.001*	-.321	.092	-.502	-.140

* $p < 0.05$

(iv) Students' Pro-environmental Behaviour associated with Social Development

An independent-sample t-test is conducted to compare students' pro-environmental behavior associated with social development between males and females. Table 4.30 shows the mean scores of males (2.300)which is higher that the mean score for females (2.269).

Table 4.30 Mean scores of Students' Social Development on Pro-environmental Behaviour Between Gender

	Gender	N	Mean	Std. Deviation
Social Dev.	Male	182	2.300	.7480
	Female	125	2.269	.7149

The hypothesis of this research question is as follows:

Ho_2 There is no statistical significant difference between males and females in students' pro-environmental behaviour associated with social development

Based on Table 4.31, Levene's test for equality of variances shows that the value of F = 0.289 as the significant value of 0.592.It means that the variances in both groups are similar; hence the 'equal variances assumed' row is used for the t-test.

Table 4.31 Independent Samples t-Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Diff	Std. Error Diff	Lower	Upper
Social Development	Equal variances assumed	.289	.592	.366	305	.715*	.031	.085	-.137	.199
	Equal variances not assumed			.369	274.323	.713*	.031	.085	-.135	.198

* p> 0.05

Independent sample t-test results show that the value of t-test is 0.366 with a degree of freedom of 305 and p = 0.715. Therefore, the null hypothesis is not rejected. The study shows that there is no significant difference in students' pro-environmental behavior associated with social development between male and female respondents.

4.7 Results of Research Question 1d

RQ1d. How significant is the relationship between students' knowledge and students' pro-environmental behaviour among the first year engineering students?

Referring to Figure 4.8 (ii), the highest factor loading is students' knowledge on environmental issues (0.77) followed by students' knowledge on sustainable development (0.63) and this knowledge influenced students' pro-environmental behaviour at 0.65 of the factor loading. The latent factors of students' knowledge on environmental issues shows that the factor loadings of all items are more than 0.6. KT5 (*Global Warming*) and KT6 (*Greenhouse Effect*) has the highest factor loading at 0.80. Meanwhile, the latent factors of students' knowledge on sustainable development which consists of three out of four, which are KBK1 (*Definition of sustainable development*), KBK2 (*Components of sustainable development*) and KBK3 (*Principles of sustainable development*) have their factor loadings at0.83, 0.91 and 0.89, respectively. However, the latent factors of students' pro-environment behaviour consists of only three items, which are BSc14 (*I asked my parents not to buy products made from non-renewable resources*), BSc8 (*I invite friends to take part in sustainable programmes*) and BSc13 (*I discussed with friends what we can do to help reduce pollution*) have their factor loadings at 0.62, 0.61 and 0.74, respectively.

4.8 Summary

In this chapter, the data analysis has been carried out in order to answer the research objective 1; to assess the level of first year engineering students' on their (i) prior knowledge on environmental issues, (ii) prior knowledge on sustainable development, and (iii) practicing pro-environmental behaviour associated with self and social development. Table 4.32shows the findings of each research question.

Table 4.32 Research Questions and Findings

Research Question	Findings
RQ1a. What are the most significant items to assess the first year engineering students on; (i) knowledge on environmental issues, (ii) knowledge on sustainable development, and (iii) practicing pro-environmental behaviour associated with self and social development.	The most significant items to assess students' knowledge on environmental issues are; (i) Environmental issues KT1-Air Pollution KT3-Climate change KT4-Environmental Degradation KT5-Global Warming, KT6-Greenhouse Effect KT7-Green Technology KT8-Ozone Layer Depletion
	The most significant items to assess students' knowledge on SD are; (ii) Basic understanding about SD KBK1- Definition of sustainable development KBK2- Components of sustainable development KBK3- Principles of sustainable development KBK4- Impact of un-sustainability
	The most significant items to practicing SD for self and social development; (iii) Practicing pro-environmental behaviour Self Development BSf5- I separate domestic waste for recycling BSf9- I recycle paper to conserve natural resources BSf10-I pick up litter when I see it in a public area BSf15-I do not let the running water of a faucet when it is not necessary BSf16-I collect and sell recycled items such as papers, bottles and glasses) Social Development BSc2 -I discuss with friends about sustainability issues BSc8 -I invite friends to take part in sustainable programmes

	BSc13 – I discussed with friends what we can do to help reduce pollution BSc14 – I asked my parents not to buy products made from non-renewable resources BSc17 -I actively participate in sustainable programmes
RQ1b. What are the levels of perception of the first year engineering students' on (i) prior knowledge on environmental issues, (ii) prior knowledge on sustainable development, and (iii) practicing pro-environmental behaviour associated with self and social development?	The levels of students' perception on knowledge and behaviour; (i) Prior knowledge about environmental issues Level 3 (Know and can describe breifly)
	(ii) Basic understanding about sustainable development Level 2 (Heard of but cannot describe)
	(iii) Practicing pro-environmental behaviour Self Development Level 3 (have an interest to engage on issue but not certain to contribute) Social Development Level 2 (aware on issue but not to engage)
RQ1c. Is there any significant difference across gender of students regarding their (i) prior knowledge on environmental issues, (ii) prior knowledge on sustainable development, and (iii) practicing pro-environmental behaviour associated with self and social development?	The results across gender show that; (i) Environmental Issues Statistically no significant difference Male (3,422) higher than female (3.297)
	(ii) Basic understanding about SD Statistically significant difference Male (2.073) higher than female (1.882)
	(iii)Practicing pro-environmental behaviour Self Development Statistically significant difference Female (3.555) higher than male (3.234) Social Development Statistically no significant difference Male(2.3) higher than female(2.269)
RQ1d. How significant the relationship between students' knowledge and students' pro-environmental behaviour among the first year engineering students?	The relationship between students' knowledge on environmental issues and sustainable development are significant on students' pro-envrionmental behaviour of social development. (i) Environmental issues KT1-Air Pollution KT3-Climate change KT4-Environmental Degradation KT5-Global Warming, KT6-Greenhouse Effect KT7-Green Technology KT8-Ozone Layer Depletion

	(ii) Basic understanding about SD KBK1- Definition of sustainable development KBK2- Components of sustainable development KBK3- Principles of sustainable development (iii) Pro-environmental Behaviour BSc8 -I invite friends to take part in sustainable programmes BSc13 – I discussed with friends what we can do to help reduce pollution BSc14 – I asked my parents not to buy products made from non-renewable resource.

CHAPTER 5

RESULTS & ANALYSIS OF PHASE

5.1 Introduction

This chapter provides results and analysis of research questions in Phase II of the research methodology. A case study of mixed method research design has been employed via quantitative and qualitative study in order to answer the second research objective.In the quantitative study, descriptive and inferential statistical analyses are carried out using Statistical Package for Social Science (SPSS) version 18.An independent sample t-test is utilized to compare the differences before and after CPBL approach. Rasch Model framework using WINSTEPS version 3.68.2is used to measure the level of difficulty from response of the respondents. Furthermore,in qualitative studies, the problems used and learning environment are analysed using thematic analysis. The data from course outlines, problems given, in-class observations and students' reflection journals are analyzed. The themes are identified from literature review based on prior-research driven (Boyatzis,1998). Finally, both results are compared and triangulated to see how the effective use of the design problem and learning environment in enhancing students' knowledge and practices. Therefore, the outcomes of this study would lead the researcher to propose a framework for teaching environmental sustainability using CPBL approach for educators and educational programmes.

5.2 Research Questions of Phase II

The phase II of this research has been conducted in order to answer the second research objective(to investigate on the implementation of Cooperative Problem-Based Learning (CPBL) as a student-centered learning environment to instil students' knowledge and behaviour changes associated with environmental sustainability, as in the first-year 'Introduction to Engineering' course syllabus). This research objective involved the use of quantitative and qualitative research methods which consist of 4 research questions as follows;

(i) Quantitative Study

RQ2a. Does CPBL approach impact on students' (i) knowledge on environmental issues, (ii) knowledge on sustainable development, and (iii) students' behaviour in practicing pro-environmental behaviour associated with self and social development before and after CPBL?

RQ2b. Is there any significant difference across gender of students regarding their (i) knowledge on environmental issues, (ii) knowledge on sustainable development, and (iii) practicing pro-environmental behaviour associated with self and social development before and after CPBL?

(ii) Qualitative Study

RQ2c. Are the four domains of knowledge (declarative, procedural, effectiveness and social) inculcated in the design of CPBL problems?

RQ2d. In what ways do the use of problems in CPBL approach give impact to students' knowledge and behaviour change, associated with environmental sustainability?

5.3 Quantitative Data Analysis

A group of first year Chemical engineering students enrolled in 'Introduction to Engineering' course during the first semester of 2012/2013academic session at UniversitiTeknologi Malaysia is selected as respondents. Students enter the university after having completed either matriculation, Sijil Tinggi Pelajaran Malaysia (STPM), UTM-Mara programme or A-level equivalent (for foreign students). In the beginning of the study, 63 out of 65 students have participated in answering the pre-test questionnaire. At the end of semester, 59 out of 65 students are involved themselves in answering the post-test questionnaires as shown in Table 5.1.

Table 5.1 Demographic Data of Respondents

Participant	N	Gender
Before	63	Male = 29/31 Female = 34/34
After	59	Male = 31/31 Female = 28/34

Descriptive analysis, such as mean score, skewness and the effect size are considered in this analysis. In statistical analysis, effect size is referred toas a measure the strength of the relationship between two variables (before and after CPBL) which known as 'Cohen's d'. It is the difference between two means divided by standard deviation. Cohen (1988) proposed rules of thumb for interpreting effect sizes: (i) small effect size is 0.20, (ii) medium effect size is 0.50, and (iii) large effect size is 0.80.153

5.3.1 Impact of CPBL on Students' Knowledge-Behaviour

RQ2a. Does CPBL approach influence students' (i) knowledge on environmental issues, (ii) knowledge on sustainable development, and (iii) students' behaviour in practicing pro-environmental behaviour associated with self and social development before and after CPBL?

Hypothesis of this research question is as follows:

Ho There is no statistically significant difference in students' (i) knowledge on environmental issues, (ii) knowledge on sustainable development, and (iii) students' behaviour in practicing pro-environmental behaviour associated with self- and social development before and after CPBL?

5.3.1.1 Results of Students' Knowledge on Environmental Issues

An independent sample t-test is used to compare students' knowledge onenvironmental issues before and after CPBL. Table 5.2 displays the overall descriptive statistics on the pre-tests and post-tests. Since all values of skewness is within the acceptable limits ranging from 0.131 to 0.495, these data are then considered to be normally distributed. Therefore, the data are analyzed using parametric analysis. Meanwhile, the effect sizes are within the range of 0.38 to 0.63. These indicate that the medium relationships are found before and after CPBL.

As shown in Figure 5.1, at the beginning of the semester, the students' knowledge on environmental issues are lower than the scores after CPBL and the percentages of mean differences of all items are less than 20%. The percentage of improvement shows a small differencebetween 9 to 21. KT7 (*Green Technology*, 21%) has the highest improvement followed by KT4 (*Environmental Degradation*, 18%) and KT3 (*Climate Change*, 14%). Meanwhile, KT5 (*Global Warming*), KT6 (*Greenhouse Effect*) and KT8 (*Ozone Layer Depletion*) have the same increment of 13%. KT1(*Air Pollution*, 9%) and become the least percentage of improvement.

Table 5.2 Descriptive Statistical Results of Students' Knowledge on Environmental Issues (Before and After CPBL)

Items	Test_level	N	Mean	% of Mean Dif	Std. Deviation	Effect Size	Skewness
KT1	Pre-test	63	3.19	9	.780	0.38	0.206
	Post-test	59	3.49		.796		
KT3	Pre-test	63	2.92	14	.747	0.53	0.247
	Post-test	59	3.34		.822		
KT4	Pre-test	63	2.54	18	.839	0.49	0.495
	Post-test	59	3.00		1.034		
KT5	Pre-test	63	3.10	13	.817	0.45	0.376
	Post-test	59	3.49		.898		
KT6	Pre-test	63	2.87	13	.729	0.50	0.443
	Post-test	59	3.25		.779		
KT7	Pre-test	63	2.46	21	.758	0.63	0.131
	Post-test	59	2.98		.900		
KT8	Pre-test	63	2.87	13	.772	0.47	0.475
	Post-test	59	3.24		.817		

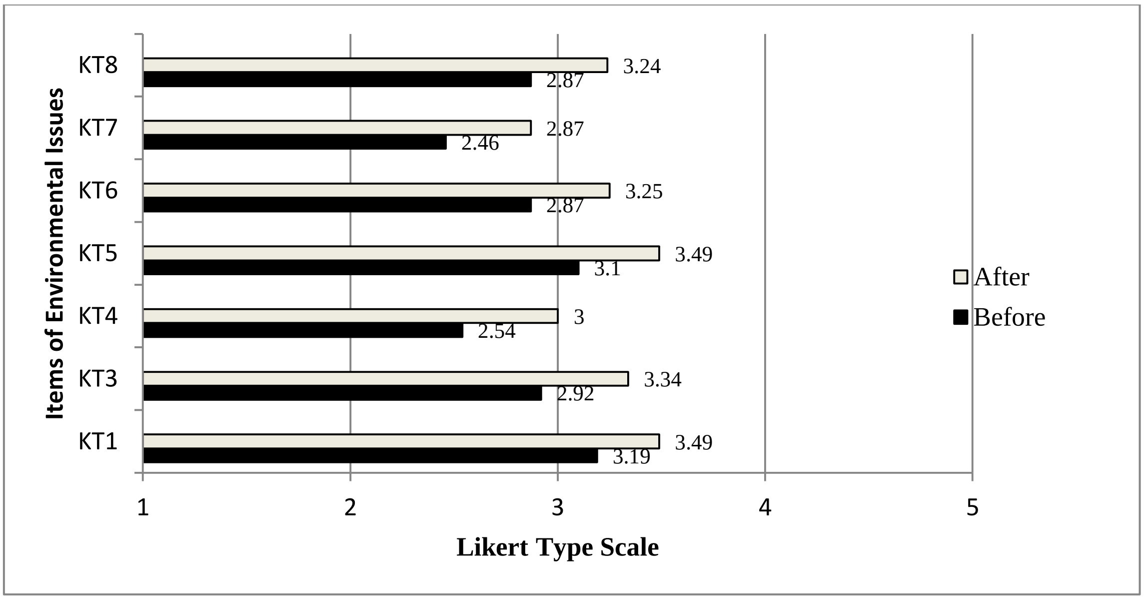


Figure 5.1 Comparing Means of Students' Knowledge on Environmental Issues Before and After CPBL

Table 5.3 shows that the value of Levene's test for equality of variances of all items, except for KT3(*Climate Change*)is at the significant value with *p* greater than 0.05. This means that the variances in both groups are similar; hence the 'equal variances assumed' row is used for the t-test. Meanwhile, the 'equal variances not assumed' row is used for KT3 (*Climate Change*) (p = 0.037).

Table 5.3 Independent T-test of Students' Knowledge on Environmental Issues

		Levene's Test for Equality of Variances		T-test for Equality of Means					
								95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean dif.	Lower	Upper
KT1	Equal variances assumed	1.390	.241	-2.110	120	.037	-.301	-.584	-.018
KT3	Equal variances not assumed	4.430	.037	-2.935	116.950	.004	-.418	-.701	-.136
KT4	Equal variances assumed	.442	.507	-2.708	120	.008	-.460	-.797	-.124
KT5	Equal variances assumed	3.929	.050	-2.552	120	.012	-.396	-.704	-.089
KT6	Equal variances assumed	1.516	.221	-2.792	120	.006	-.381	-.652	-.111
KT7	Equal variances assumed	.049	.825	-3.477	120	.001	-.523	-.820	-.225
KT8	Equal variances assumed	1.658	.200	-2.532	120	.013	-.364	-.649	-.079

Results of independent sample t-test demonstrated its statistical significant. The results show that there are statistically significant differences of all the means in students' knowledge on environmental issues ($p < 0.05$). The values of mean differences are within the range of 0.301 to 0.523. These values indicate that the mean values of all items are significantly higher after CPBL. KT7 (*Green Technology*) is the highest increment of students' knowledge on environmental issues, while KT1 (*Air Pollution*) is the lowest.

5.3.1.2 Results of Students' Knowledge onSustainableDevelopment

An independent samples t-test has beenused to compare students' knowledge on sustainable development before and after CPBL. Table 5.4 displays the overall descriptive statistics on the pre-tests and post-tests results. Since all values of skewness are within acceptable limits ranging from -0.056 to 0.039, data are considered normally distributed. Therefore the data are analyzed using parametric analysis. The effect sizes (*d*) are also greater than 0.8. According to Cohen (1988), effect sizes greater than 0.8 have great effect on the study.

Table 5.4 Descriptive Statistical Results of Students' Knowledgeon Sustainable Development (Before and After CPBL)

	Test_level	N	Mean	Std. Deviation	% of Mean Dif	Effect Size	Skewness
KBK1	Pre-test	63	1.89	.785	95	0.80	0.039
	Post-test	59	3.69	.815			
KBK2	Pre-test	63	1.94	.821	86	0.82	0.005
	Post-test	59	3.61	.810			
KBK3	Pre-test	62	1.81	.807	93	0.81	-0.056
	Post-test	59	3.49	.751			
KBK4	Pre-test	63	2.02	.833	75	0.83	-0.040
	Post-test	59	3.54	.877			

As depicted in Figure 5.2, percentage of improvement after CPBL implementation is higher for all items. KBK1 (*Definition of sustainable development*, 95%) has achieved the highest increment and followed by KBK3 (*Principles of sustainable development*, 93%), KBK2 (*Components of sustainable development*, 86%) and KBK4 (*Impact of un-sustainability*, 75%).

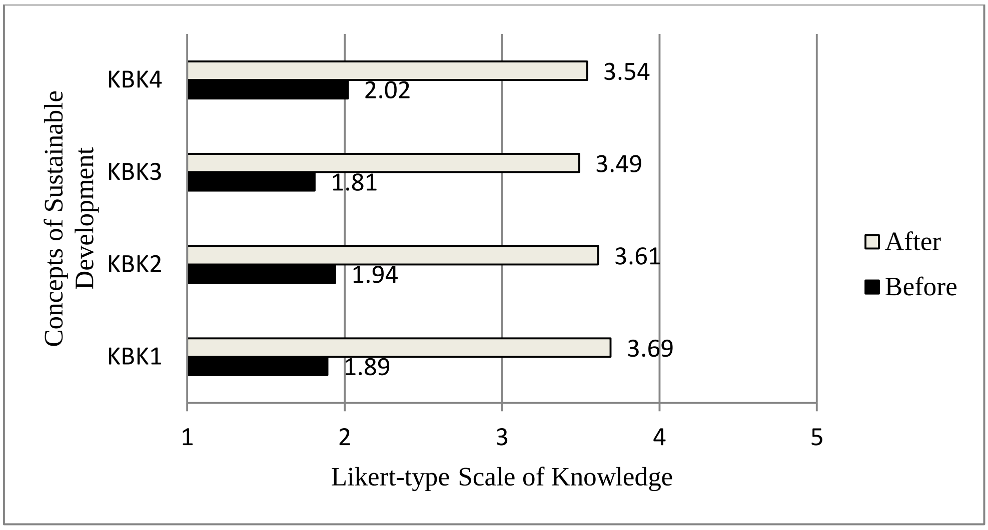


Figure 5.2 Comparing Means of Students' Knowledge onSustainable Development Before and After CPBL

Table 5.5 Independent T-test of Knowledgeon Sustainable Development

		Levene's Test for Equality of Variances		T-test for Equality of Means					
								95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Diff.	Lower	Upper
KBK1	Equal variances assumed	.146	.703	12.467	120	.000	-1.806	-2.093	-1.519
KBK2	Equal variances assumed	.217	.642	11.330	120	.000	-1.674	-1.966	-1.381
KBK3	Equal variances assumed	.283	.596	11.876	120	.000	-1.685	-1.966	-1.404
KBK4	Equal variances assumed	.831	.364	9.860	120	.000	-1.526	-1.833	-1.220

5.3.1.3 Results of Students'Pro-environmental Behavoiur associated with Self-Development

From Table 5.5, the independent sample t-test illustrates that there are significant differences of all means in students' pro-environmental behaviour associated to self-development before and after CPBL implementation (p = 0.000).

Table 5.6 displays the overall descriptive statistics on the pre-test and post-test results. In all cases values of skewness are within acceptable limits ranging from -0.589 to 0.425. After CPBL, the effect sizes for BSf9 (*I recycle paper to conserve natural resources*), BSf15 (*I do not let the running water of a faucet when it is not necessary*)and BSf16 (*I collect and sell recycled items such as papers, bottles and glasses*) are greater than 0.8. According to Cohen (1988), these items have a large effect on students' self-development. However, the effect sizes for BSf5 (*I separate domestic waste for recycling*) and BSf10 (*I pick up litter when I see it in a public area*)remain lower than 0.2. Therefore, these items have little effect on students' self-development.

Table 5.6 Descriptive Statistic on Self Development

	Test_level	N	Mean	% of improvement	Std. Deviation	Effect Size	Skewness
BSf5	Pre-test	63	2.35	6	.953	0.060	0.425
	Post-test	59	2.49		1.180		
BSf9	Pre-test	63	2.84	17	1.110	2.065	0.049
	Post-test	59	3.31		1.087		
BSf10	Pre-test	63	3.06	-12	.998	-1.703	0.100
	Post-test	59	2.69		1.303		
BSf15	Pre-test	63	3.19	31	1.216	4.018	-0.589
	Post-test	59	4.17		.834		
BSf16	Pre-test	63	2.81	23	1.189	2.830	-0.435
	Post-test	59	3.46		.988		

As depicted in Figure 5.3, the percentage of improvement after CPBL are higher for all items except for BSf10 (*I picked up litter when I see it in the park*). Meanwhile, BSf15 (*I do not let the running water of a faucet when it is not necessary*) which is found to have the highest increments after CPBL.

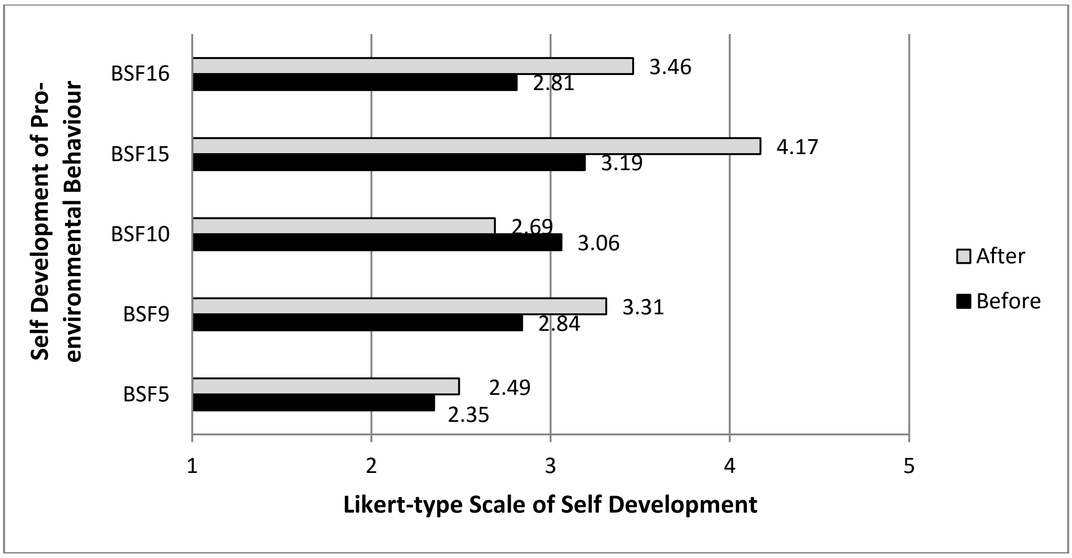


Figure 5.3 Comparing Means of Self-Development Before and After CPBL

An independent t-test is conducted to compare self-development of students' pro-environmental behaviour before and after CPBL. Table 5.7 shows the value of Levene's test for equality of variances at the value of *p*to be greater than 0.05. It indicates that BSf 9 (*I recycle paper to conserve natural resources*), BSf16 (*I collect and sell recycled items such as papers, bottles and glasses*) and BSf 15 (*I do not let the running water of a faucet when it is not necessary*) have significant values greater than 0.05. It means that the variances in these groups are similar;hence the 'equal variances assumed' row is used for the t-test.

On the other hand, BSf5 (*I separate domestic waste for recycling*), BSf10 (*I pick up litter when I see it in a public area*) and BSf15 (*I do not let the running water of a faucet when it is not necessary*) have significant values less than 0.05; therefore 'not equal variances assumed' row is used for the t-test. Results of an independent sample t-test indicate that BSf9 (*I recycle paper to conserve natural resources*), BSf15 (*I do not let the running water of a faucet when it is not necessary*) and BSf16 (*I collect and sell recycled items such as papers, bottles and glasses*) have a significant difference in students' behaviour associated with self development ($p < 0.05$) after CPBL. However, results of BSf5 (*I separate domestic waste for recycling*) and BSf10 (*I pick up litter when I see it in a public area*) show that there are no significant differences after CPBL. Result of BSf10 (*I pick up litter when I see it in a public area*) decreased after the course.

Table 5.7 Independent T-test of Self-Development

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Dif	Std. Error Diff	Lower	Upper
BSf5	Equal variances not assumed	4.233	.042	-.730	111.5	.467	.142	195	-.529	.244
BSf9	Equal variances assumed	.097	.756	-2.330	120	.021	.464	199	-.858	-.070
BSf10	Equal variances not assumed	8.953	.003	1.745	108.5	.084	369	211	-.050	.787
BSf15	Equal variances not assumed	6.656	.011	-5.214	110.2	.000	.979	188	-1.351	-.607
BSf16	Equal variances assumed	.806	.371	-3.262	120	.001	.648	199	-1.042	-.255

5.3.1.4 Results of Students' Behavoiur associated with Social Development

An independent samples t-test has been used to compare social development of students' pro-environmental behavior before and after CPBL. Table 5.8 displays the overall descriptive statistics on the pre-test and post-test results. In all cases,the values of skewness are within acceptable limits ranging from -0.106 to 0.707. The effect sizes of all items are higher than 0.8. According to Cohen (1988), effect sizes greater than 0.8 are considered large.

Table 5.8 Descriptive Statistical on Social Development

	Test_level	N	Mean	% of improvement	Std. Deviation	Skewness	Effect Size
BSc2	Pre-test	63	1.87	85	.793	0.059	5.721
	Post-test	59	3.46		1.006		
BSc8	Pre-test	63	2.03	19	.842	0.434	1.479
	Post-test	59	2.42		1.054		
BSc13	Pre-test	63	2.54	36	.930	-0.106	3.397
	Post-test	59	3.46		.916		
BSc14	Pre-test	63	2.13	50	1.008	0.054	4.582
	Post-test	59	3.24		1.056		
BSc17	Pre-test	63	1.97	17	.933	0.707	1.405
	Post-test	59	2.31		1.133		

As shown in Figure 5.4, percentages of improvement after CPBL implementation are higher for all items. It is found that studentsare responsivemore higher resulting in percentage of behaviour change on BSc2 (*I discuss with friends about sustainable issues*) after CPBL. Meanwhile, BSc17 (*I actively participate in sustainable programmes*) is identified as having least behaviour change in social development after CPBL.

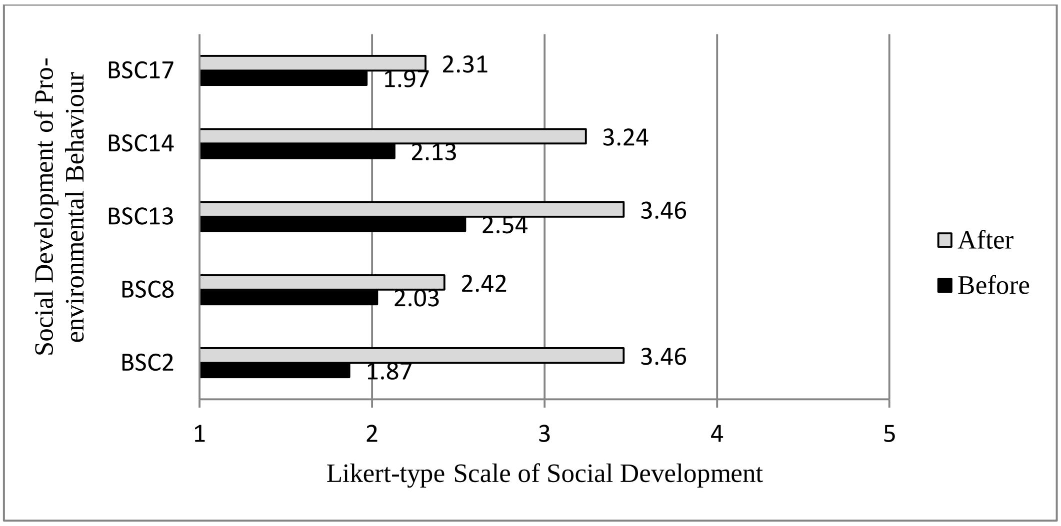


Figure 5.4 Comparing Means of Social Development Before and After CPBL

Table 5.9 shows the values of Levene's test for equality of variances of all items. It indicates that BSc2(*I discuss with friends about sustainability issues*), BSc13(*I discussed with friends what we can do to reduce pollution*), BSc14 (*I asked my parents not to buy products made from non-renewable resources*) and BSc17 (*I actively participate in sustainable programmes*)have significant values greater than 0.05. This means that the variances in these groups are similar; hence the 'equal variances assumed' row is used for the t-test. On the other hand, BSc8(*I invite friends to take part in sustainable programmes*)has a significant value less than 0.05; therefore 'not equal variances assumed' row is used for the t-test.

Table 5.9 Independent t-test on Social Development Before and After CPBL

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Diff	Std. Error Diff	Lower	Upper
BSc2	Equal variances assumed	2.597	.110	-9.697	120	.000	-1.585	.163	-1.908	-1.261
BSc8	Equal variances not assumed	4.497	.036	-2.260	110.966	.026	-.392	.173	-.736	-.048
BSc13	Equal variances assumed	.010	.919	-5.488	120	.000	-.918	.167	-1.249	-.587
BSc14	Equal variances assumed	.005	.942	-5.942	120	.000	-1.110	.187	-1.480	-.740
BSc17	Equal variances assumed	1.867	.174	-1.797	120	.075	-.337	.187	-.708	.034

Results of independent sample t-test show that BSc2(*I discuss with friends about sustainability issues*), BSc8 (*I invite friends to take part in sustainable programmes*), BSc13 (*I discussed with friends what we can do to reduce pollution*) and BSc14 (*I asked my parents not to buy products made from non-renewable resources*) have significant difference in students' pro-environmental behavior on social development (with $p < 0.05$) after CPBL. However, result for BSc17 (*I actively* *participate in sustainable programmes*) shows that there is no significant difference after CPBL.

5.3.1.5 Results of Rasch Analysis

Rasch analysis has been carried out to support the results obtained. The Person-Item Distribution Map (PIDM), shown in Figure 5.5, reveals the spread of students' abilities to responses and spread of items on students' knowledge on environmental issues and sustainable development. The distribution of students' position is on the left side and items on the right side of the vertical broken line. The mean of person is higher than the mean of the items. This typically suggests that the items are easy for the ability of the students. The items are grouped according to the subscales of knowledge.

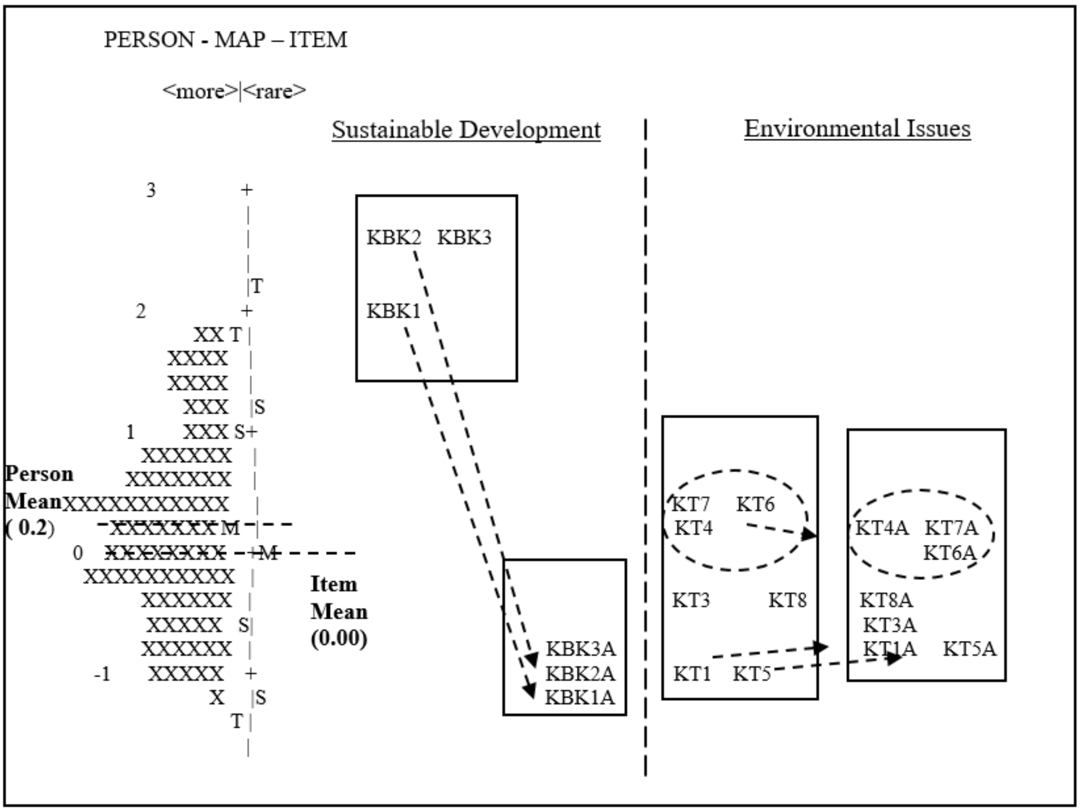


Figure 5.5 Person-Item-Distribution Map (PIDM) of Students' Knowledge before and after CPBL

Referring to Figure 5.5, all items of students' knowledge onenvironmental issues before and after undergoing CPBL spread normally around the mean. Meanwhile, all items of students' knowledge on sustainable development before CPBL indicates that KBK2 (*Components of sustainable development*), KBK3 (*Principles of sustainable development*) and KBK1 (*Definition of sustainable development*) are highly difficult to endorse. However, after completing the problem, all the items are easier to endorse. KBK1 (*Definition of sustainable development*), KBK2 (*Components of sustainable development*) and KBK3 (*Principles of sustainable development*) are moved to the bottom of the map, below the mean.

Figure 5.6 shows the Person-Item Distribution Map (PIDM) of students' pro-environmental behaviour towards practicing sustainable lifestyles on social development and self-development. The scales of items range from '*never aware on issue*' to '*practice on issue as a part of lifestyle*'. According to the distribution of the map, the mean of a person is lower than the mean of the item. This condition indicates that the items are quite difficult for the ability of the students to practice. Before undergoing the CPBL problem, the students have reported social development as a difficult item to practice. Most of the items are located above the mean. Referring to students' behaviour on self-development, 5 out of 6 items are located below the item mean logit 0.00. This shows that the 5 items are easier for the students to practice. BSf15 (*I do not let the water run from a faucet when it is not necessary*) is the easiest item to practice. BSf1 (*I watch or listen to media programmes about sustainable development*) is rarely practiced before CPBL.However, after CPBL, the items are move below the item mean, except for BSf5 (*I separate domestic trash for recycling*) and BSf10(*I pick up litter when I see it in a public area*). Both items change from easy to more difficult to practice.

According to social development, Figure 5.6 shows that at the beginning of the semester, BSc13 (*I discussed with friends what we can do to reduce pollution*) and BSc8 (*I invite my friends to take part in sustainable programmes*) are the most difficult items for the students to practice, in contrast to BSc14 (*I asked my parents not to buy products made from non-renewable resources*). However, after CPBL implementation, BSc13 (*I discussed with friends what we can do to reduce pollution*) and BSc2 (*I discuss with friends about sustainability issues*) become the easier items to practice.

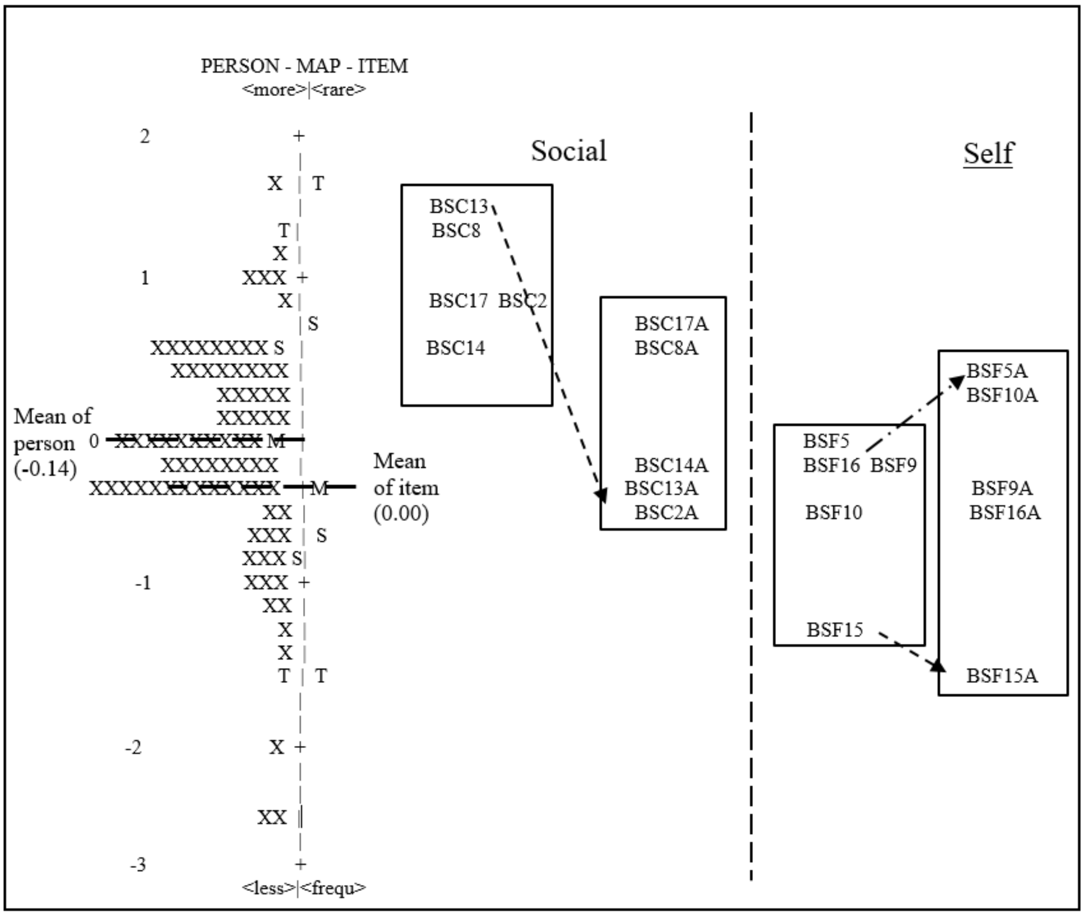


Figure 5.6 Person-Item-Distribution Map (PIDM) of Students' Pro-environmental Behaviour before and after CPBL

5.3.2 Impact of CPBL on Gender

Research Question: Is there any significant difference across gender of students regarding their (i) knowledge on environmental issues, (ii) knowledge on sustainable development, and (iii) practicing pro-environmental behaviour associated with self and social development before and after CPBL?

Hypothesis of this research question is as follows:

Ho There is no statistical significant difference across gender of students regarding their (i) knowledge on environmental issues, (ii) knowledge on sustainable development, and (iii) practicing pro-environmental behaviour associated with self and social development before and after CPBL?

5.3.2.1 Result of Students' Knowledge on Environmental Issues

Table 5.10 displays the overall descriptive statistics on the pre-tests and post-tests results. The effect sizes (*d*) of comparison for allitems are lower than 0.3. According to Cohen (1988), effect sizes lower than 0.3 could have little effect on the study.

Table 5.10 Mean scores of Students' Knowledge on Environmental Issues after CPBL

	Gender	N	Mean	Std. Deviation	Effect Size
KT1	Male	26	3.50	.860	-0.06
	Female	33	3.48	.755	
KT3	Male	26	3.54	.948	-1.17
	Female	33	3.18	.683	
KT4	Male	26	2.96	1.148	0.29
	Female	33	3.03	.951	
KT5	Male	26	3.50	.990	-0.07
	Female	33	3.48	.834	
KT6	Male	26	3.38	.852	-0.72
	Female	33	3.15	.712	
KT7	Male	26	3.12	.993	-0.87
	Female	33	2.88	.820	
KT8	Male	26	3.38	.941	-0.85
	Female	33	3.12	.696	

Based on Table 5.11, Levene's test for equality of variances shows that KT1 (*Air Pollution*), KT4 (*Environmental Degradation*), KT5 (*Global Warming*), KT6 (*Greenhouse Effect*) and KT7 (*Green Technology*) have similar variances in both groups (p> 0.05); hence the 'equal variances assumed' row are used for the t-test. Meanwhile, KT3(*Climate change*) and KT8 (*Ozone Layer Depletion*) are not in similar variances in both groups (*p*<0.05); hence the 'equal variances not assumed' row is used for the t-test. The t-test for equality of mean results show that all items have significant values of p greater than 0.05. Therefore, the null hypothesis is not rejected. The study shows no significant difference in students' knowledge on environmental issues between males and females after CPBL.

Table 5.11 Independent T-test for Means Scores in Students' Knowledge on Environmental Issues after CPBL

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Diff	Std. Error Diff	Lower	Upper
KT1	Equal variances assumed	.583	.448	.072	57	.943	.015	.211	-.406	.437
KT3	Equal variances not assumed	4.854	.032	1.6 17	43.879	.113	.357	.221	-.088	.801
KT4	Equal variances assumed	1.173	.283	-.252	57	.802	-.069	.273	-.616	.479
KT5	Equal variances assumed	1.327	.254	.064	57	.949	.015	.237	-.460	.491
KT6	Equal variances assumed	1.452	.233	1.144	57	.257	.233	.204	-.175	.641
KT7	Equal variances assumed	1.138	.291	1.003	57	.320	.237	.236	-.236	.709
KT8	Equal variances not assumed	5.014	.029	1.193	44.709	.239	.263	.221	-.181	.708

5.3.2.2 Result of Students' Knowledge on Sustainable Development

An independent t-test is conducted to compare students' knowledge on sustainable development after CPBL between males and females respondents. Table 5.12 indicates that the males have higher mean scores on KBK2 (*Components of sustainable development*) and KBK4 (*Impact of un-sustainability*). On the other hand, females have higher mean scores on KBK1 (*Definition of sustainable development*) and KBK3 (*Principles of sustainable development*). However, both groups have slight differences of mean scores on each item.

Table 5.12 Mean Scores of Students' Knowledge on Sustainable Development after CPBL

	Gender	N	Mean	Std. Deviation	Effect Size
KBK1	Male	26	3.65	.936	0.26
	Female	33	3.73	.719	
KBK2	Male	26	3.65	.936	-0.23
	Female	33	3.58	.708	
KBK3	Male	26	3.46	.859	0.18
	Female	33	3.52	.667	
KBK4	Male	26	3.65	.936	-0.71
	Female	33	3.45	.833	

Based on Table 5.13, Levene's test for equality of variances shows that all items have similar variances in both groups ($p > 0.05$); hence the 'equal variances assumed' row is used for the t-test. The t-test for equality of mean results shows that all items have significant values of p greater than 0.05. Therefore, the null hypothesis is not rejected. The study shows no significant differences in students' knowledge on sustainable development between males and females after CPBL.

Table 5.13 Independent Samples Test for Mean Scores in Students' Knowledge on Sustainable Development after CPBL

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
			Sig.	t	df	Sig. (2-tailed)	Mean Diff.	Std. Error Diff	Lower	Upper
KBK1	Equal variances assumed	.418	.126	-.341	57	.734	-.073	.215	.505	.358
KBK2	Equal variances assumed	.091	.301	-.365	57	.716	.078	.214	.350	.507
KBK3	Equal variances assumed	.026	.315	-.270	57	.788	-.054	.199	.451	.344
KBK4	Equal variances assumed	.117	.734	-.864	57	.391	.199	.231	.262	.661

5.3.2.3 Result of Students' Behaviour associated with Self-Development

An independent t-test has been conducted to compare self-development of students' pro-environmental behaviorafter CPBL between males and females. Table 5.14 indicates that the males have higher mean scores in all items.

Table 5.14 Mean Scores of Students' Pro-environmental Behaviour associated to Self Development after CPBL

	Gender	N	Mean	Std. Deviation	Effect Size
BSf5	Male	26	2.58	1.102	-0.75
	Female	33	2.42	1.251	
BSf9	Male	26	3.35	1.093	-0.35
	Female	33	3.27	1.098	
BSf10	Male	26	2.77	1.210	-0.68
	Female	33	2.64	1.388	
BSf15	Male	26	4.35	.745	-1.04
	Female	33	4.03	.883	
BSf16	Male	26	3.54	1.104	-0.60
	Female	33	3.39	.899	

However, both groups have small differences of mean scores on each item. The effect sizes of all items are less than 0. According to Cohen (1988), effect sizes less than 0 are considered small.Based on Table 5.15, Levene's test for equality of variances shows that all items have similar variances in both groups (*p*> 0.05); hence the 'equal variances assumed' rows are used for the t-test. The t-test for equality of mean results show that all items have significant values of *p* greater than 0.05. Therefore, the null hypothesis is not rejected. The study shows no significant differences in students' pro-environmental behavior associated with self-development between male and female after CPBL.

Table 5.15 Independent Samples T-test for Mean Scores on Students' Pro-environmental Behaviour associated with Self-Development after CPBL

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
BSf5	Equal variances assumed	.153	.697	.490	57	.626	.153	.311	-.471	.776
BSf9	Equal variances assumed	.157	.694	.256	57	.799	.073	.287	-.502	.649
BSf10	Equal variances assumed	1.619	.208	.386	57	.701	.133	.344	-.557	.822
BSf15	Equal variances assumed	.003	.955	1.459	57	.150	.316	.217	-.118	.749
BSf16	Equal variances assumed	1.371	.247	.554	57	.582	.145	.261	-.378	.667

5.3.2.4 Result of Students' Behaviour associated with Social Development

An independent t-test has been conducted to compare social development ofstudents' pro-environmental behaviorafter CPBL between male and female. Table 5.16 indicates that males have higher mean scores for items BSc2, BSc8 and BSc14 than females. However, both groups have small differences of mean scores on all items.

Table 5.16 Mean Scores of Students' Pro-environmental Behaviour associated to Self-Development after CPBL

	Gender	N	Mean	Std. Deviation	Effect Size
BSc2	Male	26	3.46	1.104	-0.04
	Female	33	3.45	.938	
BSc8	Male	26	2.50	1.068	-0.59
	Female	33	2.36	1.055	
BSc13	Male	26	3.46	1.140	-0.04
	Female	33	3.45	.711	
BSc14	Male	26	3.23	1.210	0.04
	Female	33	3.24	.936	
BSc17	Male	26	2.27	1.002	0.27
	Female	33	2.33	1.242	

Based on Table 5.17, Levene's test for equality of variances shows that all items have similar variances in both groups ($p > 0.05$) excluding BSc13; hence the 'equal variances assumed' rows are used for the t-test. The t-test for equality of means results shows that all items have significant values of *p* greater than 0.05. Therefore, the null hypothesis is not rejected. The study shows no significant difference in students' pro-environmental behavior associated with social development between male and female after CPBL.

Table 5.17 Independent Samples T-test for Mean Scores in Students' Pro-environmental Behaviour associated with Self Development after CPBL

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
BSc2	Equal variances assumed	1.087	.302	.026	57	.979	.007	.266	-.526	.540
BSc8	Equal variances assumed	.017	.898	.490	57	.626	.136	.278	-.421	.693
BSc13	Equal variances not assumed	8.822	.004	.027	39.770	.978	.007	.255	-.509	.523
BSc14	Equal variances assumed	2.017	.161	-.042	57	.967	-.012	.279	-.571	.548
BSc17	Equal variances assumed	1.601	.211	-.214	57	.831	-.064	.300	-.664	.536

5.4 Qualitative Data Analysis

In this section, qualitative research methodology is utilized in the case study of mixed method to support quantitative results. Theclassroom observation, sustainable problems given and students' reflective journal are selected as the data sampling. The thematic codes are developed using prior-research-driven approach (Boyatzis, 1998). Excerpts from the three stages of the case study are integrated to draw and support the findings.The analysis of this qualitative study are focused on;

(i) Analysis of ProblemsUsed in CPBL

(ii) Analysis of Students' Reflective Journal after CPBL

5.4.1 Analysis of the ProblemsUsed in CPBL

RQ2c. Are the four domains of knowledge (declarative, procedural, effectiveness and social) inculcated in the design of CPBL problems?

RQ2d. In what ways do the use of problems in CPBL approach give impact to students' knowledge and behaviour change, associated with environmental sustainability?

The use of problems in the case study served as a backbone of learning, and provides a context that students have to learn to solve them. The problem is set as a competition to find engineering solutions for issues related to SD that is practical, cost effective for the society and integrate the three pillars of sustainable development. The problem is divided into three stages to gradually challenge students with increasing difficulty (Appendix D). Related industries and agencies are solicited and included in the problem to make it realistic. In the 2012/2013 session, the problem is focused on low carbon society (LCS) in the Iskandar Region of Johor, Malaysia. The details of the problem crafting has been presented at 'International Conference on Engineering Education for Sustainable Development', Universiti of Cambridge, Uniter Kingdom, 2013 (Mohd-Yusof *et al.*, 2013). Figure 5.7 shows the three stages of the problems with learning outcomes.

In this study, the researcher has analysed the problem to determine 'Are the four domains of knowledge (declarative, procedural, effectiveness and social) inculcated in the design of CPBL problems?'. Table 5.18 shows the mapping of learning outcomes of each stage with the four domain of knowledge (declarative, procedural, effectiveness and social). It has been found that the four domains of knowledge are being included in the problems given. In stage 1, the first objective is to perform preliminary study on the current states related to sustainability issues about Low Carbon Society clearly construct students with declarative knowledge. The students do some observation through literature about the definition and current information. In the second learning objective; to benchmark current efforts in

Malaysia and compare to other nations around the world, has led the students to develop their effectiveness knowledge through the process of benchmarking locally and abroad.

As seen in Table 5.18, learning outcomes of Stage 2 prepare the students to focus on specific element of SD and measurement, data collection and analysis of the students' and their families' consumption or generation, and pattern of behaviour, as well as proposing various possible solution. In this stage, studentsareguided to deepen their declarative knowledge about the issues. Student are also asked to audit their own use of specific element of SD in their residential colleges and their family's consumption when they go back during the semester break. It is found that Stage 2 has exposed the students in building their procedural, effectiveness and social knowledge on SD.

Table 5.18 Mapping of Learning Outcomes and Four Domains of Knowledge of Each Stage

Stage	Learning Outcomes	Four Domains of knowledge			
		Declarative	Procedural	Effectiveness	Social
1	Explain SD and discuss the current world scenario	✓			
	Analyze information from to benchmark efforts in Malaysia compared to other nations around the world			✓	
2	Focused on specific elements of SD	✓			
	Data collection of students' and their families' consumption or generation of an assigned resource to estimate and determine behaviour pattern,		✓	✓	✓
	Benchmark with local and global information to propose possible solutions.	✓		✓	
3	Propose engineering solutions to a specific problem, get feedback on problems and possible solutions from stakeholders and focus on the best solution	✓	✓	✓	✓

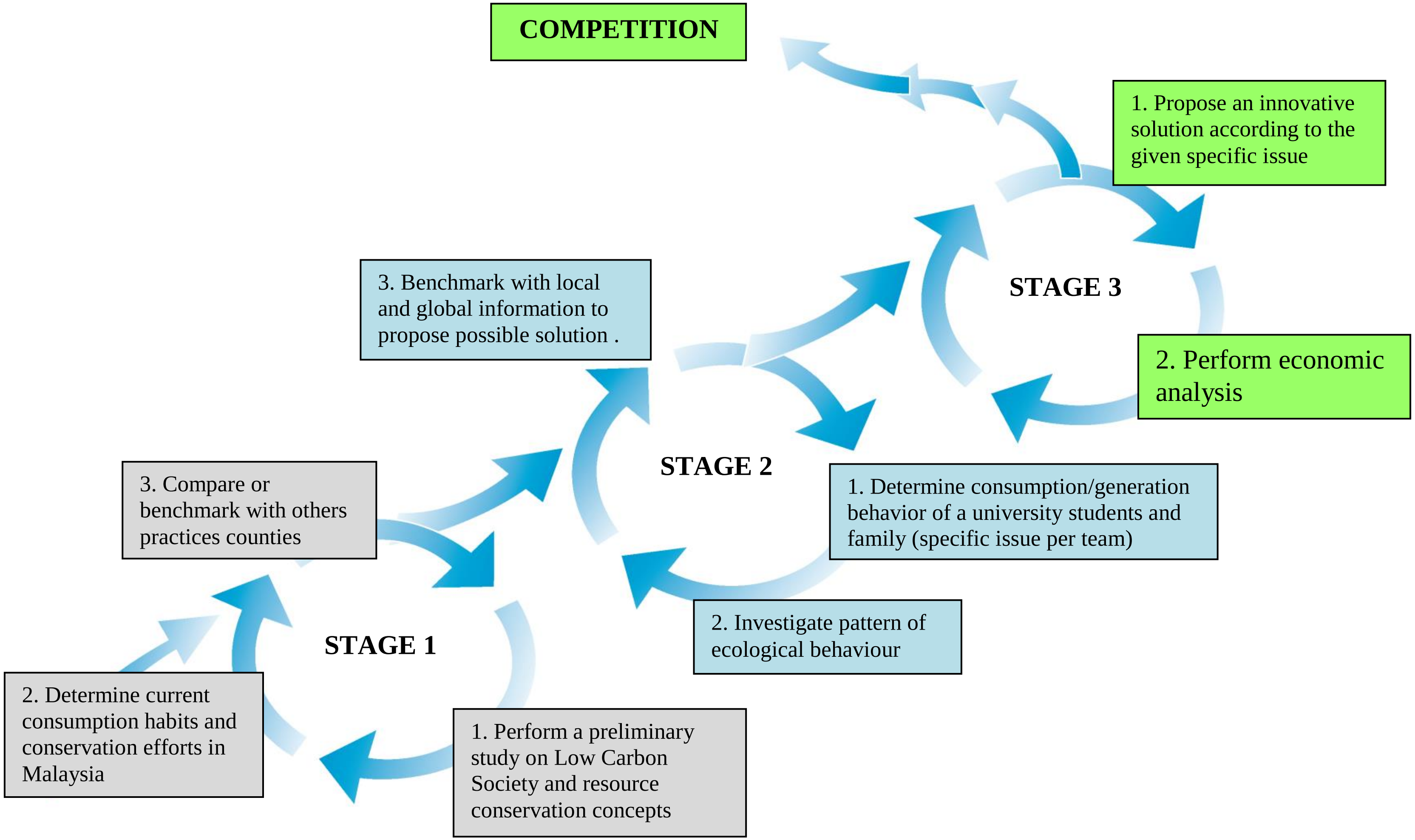


Figure 5.7 Three Stages of the Case Study of 'Low Carbon Society'

In Stage 3, the student would propose engineering solutions that they can justify with the proper technology and cost analysis. Stage 3 is the most challenging stage and students are able to propose the best engineering solution, justifying their choice based on the three pillars of SD, which force them to consider environment, economic, and societal needs and requirements. In this stage, as a team, students would combine all the knowledge and information gathered from Stage 1 and 2 to propose an innovative engineering solutions.As a conclusion, Stage 3 has assisted the students to integrate all domains of knowledge.

5.4.2 Analysis of Student's Reflective Journal

Students' reflection journals are used to investigate the impact of problem used and the learning environment on students' learning outcomes after undergoing the case study. According to Zeegers and Clark (2014), reflective journal is a metacognitive tool that supports students to reflect on their learning over a period of time. The design of problem is divided into three stages and students have to submit an individual reflective journal at the end of each stage. These reflective journals are collected and analysed using thematic analysis and mind mapping approach. The example of analysis of student's reflective journal can be seen in Appendix G.

5.4.2.1 Students' Perceptions on Knowledge on Environmental Issues and Sustainable Development

A thematic analysis is performed on the qualitative data using the reflection journals(stage 1, 2 and 3) and open ended questionnaire. According to the students' feedback, it is found that the level of students' knowledge on environmental issues and sustainabilitygradually increase as they go through the case study. Most ofthe respondents (n = 7) appeared to have no knowledge on environmental issues and 'what is sustainable development' before undergoing stage 1. As excerpts from their reflection journals in Stage 1, the level of students' knowledge on environmental issues and understanding the meaning of sustainable development is very low.

RJ1S1; To be honest, I had never heard of the concept of sustainable development before and I thought that it is not my matter...

RJ3S1; Firstly, before I continued my study, I have never heard about Low Carbon Society and Iskandar Malaysia.

However, after completion of Stage 1, it appears that the students' level of knowledge has increased. The problem and learning environment have exposed the students with deeper understanding about the issues. As excerpts from the reflective journal Stage 1, students noticed that;

RJ1S1; In completing Stage 1 of Low Carbon Society, I have learnt many things about our current environmental condition and also about myself, my team even the preparation to be an engineer in the near future...I become familiar with Low Carbon Society concept.

RJ3S1; ..During doing the research, I have known many things in the real meaning. I knew what Low Carbon Society is in the real meaning...

In Stage 3, students are able to talk and discuss the issues with their colleagues, as mentioned by respondent RJ8S3;

RJ8S3;After more than 2 months, many things I understand in deeper meaning, such as sustainability, energy conservation, and carbon emission. This term I have heard before, but didn't know how to explain it in my words. However, after had learned new knowledge from this semester, I'm able to discuss it with my friend. This knowledge has changed me to become more open-minded and realise what actually happened in the world.

5.4.2.2 Students' Perceptionon Awareness aboutEnvironmental sustainability

Results from the students' reflective journal has revealed that most of the students agree that before undergoing the problem given they are unaware about the environment (level 1, refer to PAPM model of behaviour change). In an excerpt from RJ4S2, he mentioned that;

RJ4S2; I really not care about environment before this, but now I realize about our role as a community.... As one of the main contributors of carbon emission to the atmosphere.

Moreover, students have realized that as one of a develop countries, the level of awareness among Malaysian citizens onenvironmental sustainabilityis still low. In an excerpt from RJ6S2, she noticed that our Malaysian daily life activities are the main contributor to the unsustainable environment. Most of the students have also agreed that they have a responsibility to protect the environment for the future generation.

RJ6S2; ..Every day we use the electricity and sometimes we wasting the energy or use the electricity in wrong manner. These may lead to higher carbon emission because energy production will produce carbon.

RJ9S1;This assignment has taught me the importance of keeping the environment, how to manage a resource wisely..

RJ3S2;..Our environment has been polluted... we are responsible to clean our environment... everyone is needed to contribute and work together.

RJ3S1; I never realized that it is my role as a chemical engineering student to accomplish this mission to increase the awareness among the citizen about the serious condition of our mother nature.

5.4.2.3 Students' Perceptions on Problem Used in CPBL Learning Environment

Feedbacks gathered from the students' reflective journals (n=35) have showthat after completing the case study, the students have successfully converged the four domains of knowledge: (i) declarative (familiarization/information), (ii) procedural (process/strategies), (iii) effectiveness (impact/awareness) and (iv) social (motives/engagement). Kaiser and Fuhrer (2003) stressed that these types of knowledgeshould be considered in designing problems related to environmental sustainability in order to gain meaningful learning outcomes.

(i) Stage 1

In stage 1, each team has to perform a preliminary study on LCS and resources conservation concepts to benchmark practices in Malaysia compared to the international level, with particular emphasize on the current community practices such as residential areas and schools. They are also required to determine current consumption habits and conservation efforts that can be used for benchmarking. The aim of stage 1 is to gather information and initiate students into the current concept of SD. Duration of this stageis 3 weeks and at the end of this stage, each student submitted the first reflection journal. During Stage 1, class times are spent on each CPBL phase closely facilitated by the lecturer, also provides guidance on the process rather than content. In particular, the facilitators provide scaffolding to help students learn and accomplish the required tasks, since they are new to CPBL and open-ended problems. From this stage, students develop the skills for information mining and self-directed learning. Students go through required CPBL processes by working collaboratively with their team members, which offers a learning environment that is motivating.

Table 5.19 shows examples of statements from students' reflection in Stage 1. In this stage, It was found that students have developed more on declarative knowledge. As excerpts from the reflective journals, students gained deep understanding about LCS, definition and information about SD and benchmarking. Students also perform their own literature to determine the current status of sustainability issues in Malaysia and other nations throughout the world (declarative knowledge). For instance, they benchmarked several countries that are committed and teaches their citizen to become more sustainable and care about the environment (effectiveness knowledge).After completing the first stage, most of the students felt that they are responsible to change their attitude in order to save the environment.

Table 5.19 Example of students' reflection in Stage 1

Themes	Codes	Example of quotation
Declarative	Definition	*I knew about what is LCS in the real meaning. LCS is the society that emits greenhouse gases only in certain amount, which can be absorbed by nature since there is too much carbon dioxide in our environment that can lead to the global warming and climate change. (RJ3S1)*
		Benchmarking is a process to identify the best practices in the certain countries where similar processes exist and then compares the result with what we are studying. (RJ5S1)
	Information	*Malaysia's government has launched several campaigns to increase the awareness among citizen and teach the new generation to care about the environment.(RJ2S1)*
		Many countries include our country normally practice land filling method to deal with food waste which is not more environmental friendly manner. In fact, when the food wastes dispose in landfill sites, they will release methane gas, which is 21 times more harmful than carbon dioxide which can lead to global warming. (RJ7S1)
Effectiveness	Awareness	*After completing Stage 1, I have learned many things about our current environment, our own responsibility and the preparation to be an engineer in the near future. (RJ1S1)*
		Firstly, before I continue my study, I never heard about Low Carbon Society and Iskandar Malaysia. I never realized that it is my role as a chemical engineering student to accomplish this mission to increase the awareness among the citizen. (RJ3S1)

(ii) Stage 2

In Stage 2, each team is required to establish carbon emission benchmarking for Iskandar Malaysia (IM) as opposed to Malaysia and global practices. In view of IM's aspiration to become low carbon society in 2025, students are required to propose several possible practical and effective efforts to reduce carbon intensity for residential sector that contains the usual public facilities and infrastructure such as schools, community halls, playgrounds, roads, shop houses, etc. The objectives of this stage are to focus on the specific element of SD and the measurement, data collection and analysis of the students' and their families' consumption or generation, and pattern ofbehavior, as well as proposing various possible solutions. The aim of this stage is to get students to scrutinize their own actions and behavior in their life as university students, and their families' habits when they collect the required data associated with the problem. Duration on this stage is 4 weeks and at the end of this stage, each student would submit the second reflective journal. In this stage, four specific elements of SD have been identified, namely, water, energy, eco-living and solid waste. Each group has focused on one of the specific elements.

Referring to Table 5.20, most of the students agreed that they have enriched the understanding on the given problem, such as, familiarization on definition, terminology, concepts and factual knowledge and added further information about current issues, ecological, bench marking and capable to create more ideas (declarative knowledge). Students noticed that they have gained a lot of information about the issues. Students have also developed procedural knowledge, where they are able to design and plan the data gathering activities, estimation and analysis as well as presenting data to form a conclusion. On the other hand, students are able to write on the impact of unsustainablebehavior after doing the benchmarking between their country and other developed countries (effectiveness knowledge). Students also noticed their responsibility to protect the environment and engagement in sustainable lifestyles (social knowledge).

Table 5.20 Example of students' reflection in Stage 2

Themes	Code	Example of students' reflections
Declarative	Information	*I have been learning of new thing in this stage. I know how much solid waste generated per person in Malaysia and worldwide. (RJ26S2)*
		From the literature, I noticed that the electric power per capital in Malaysia increased year after year but different in Japan, it decreased from year 2007 to 2009... Malaysian people still ignore about conservation of energy. (RJ16S2)
Procedural	Process	*...we need to estimate the water consumption per day for each student, we need to analyze the data and propose way to reduce water usage effectively in the specific area that has been given. RJ15S2*
		In this stage, I learned many useful things such as how solid waste is related to carbon emission, the efforts that had been done in order to reduce and conserve solid waste, and estimate the average quantity of solid waste disposed by Malaysian people. (RJ26S2)
	Strategies	*We proposed five ideas, decrease waste through behavior change, establish new plans and policies that promote waste reduction, implement recycling and composting practices, reduce waste through green procurement and provide recycle bin that consists of two types of solid waste (biodegradable and non-biodegradable). (RJ10S2)*
Effectiveness	Impact	*…. to compare the solid waste consumption between our country and selected benchmark country...we realize that Malaysian were unaware about Solid Waste Management (SWM). They know about SWM but do not practice it in their daily lifestyles. (RJ8S2)*
		...I have learned the effect of our daily life activities to the environment...For example, every day we use the electricity in wrong manner. These may lead to high carbon emission because carbon products were released during energy production. (RJ21S2)
Social	Engagement	*.. we have to play our role in order to reduce waste to save our earth. I hope this case study will make us aware of the importance of a low carbon society. (RJ16S2)*
		I get to know in details about other countries effort to reduce the carbon emission whether by developing new technology or increase the awareness of the public. Based on the information, I can conclude that everyone need to support the government or non-government efforts, policies and programs that being implemented to achieve low carbon emission. Without the public awareness to reduce carbon emission it might be impossible to do so because the one that release carbon is the public itself. (RJ9S2)
	Responsibility	*..Every day we use the electricity and sometimes we wasting the energy or use the electricity in wrong manner. These may*

		lead to increase carbon emission as energy production will produce carbon. RJ6S2
		This assignment has taught me the importance of keeping the environment, how to manage a resource wisely.. (RJ9S2)
		Our environment has been polluted... we are responsible to clean our environment... everyone is needed to contribute and work together. (RJ3S2)

(iii) Stage 3

In Stage 3, students are required to propose a practical engineering solution that they can justify with the proper technology and cost analysis. The aim of this stage is to use all the knowledge and information gathered from stages 1 and 2 to focus on a specific problem which they can propose an innovative engineering solution that complies with the three pillars of SD.The duration on this stage is 4 weeks and students submit the last reflective journal at the end of this stage. At this stage, students would have integrated the three elements of sustainability (environment, economic and social) in proposing a product. By Stage 3, students are now familiar with the CPBL cycle, and can basically go through each step without prompting from the facilitators. However, Stage 3 is the most challenging stage, since the teams now have to be creative in coming up with a suitable engineering solution.

From the reflection journals' excerpts, as shown in Table 5.21, students critically explained how they select the type and cost of material to be used in the designed product (procedural knowledge). As an example, student RJ8S3 mentioned that his team decided to come out a solution based on the concept of rainwater harvesting and proposed a systematic system to collect rainwater.

Table 5.21 Example of students' reflections in Stage 3

Themes	Codes	Example of quotations
Declarative	Information	*In this stage, we combine all knowledge, effort and work from earlier stage to carry out the effective solution... To get more information, we having a site visit to residential area which is Taman Pulai Indah...to get response from the residents about the solution that we will propose. (RJ16S3)*
		After more than 2 months, many things I understand in deeper meaning, such as sustainability, energy conservation, and carbon emission. This term I have heard before, but didn't know how to explain it in my own words. However, after had learned new knowledge from this semester, I'm able to discuss it with my friend. This knowledge has changed me to become more open-minded and realize what actually happened in the world. (RJ8S3)
Procedural	Strategies	*.....our team decided to come out with a solution based on the concept of rainwater harvesting... we proposed to use a systematic system which includes gutters to collect rainwater and a system of pipe with will automatically channel the collected rainwater into the flushing tanks at public toilets. (RJ11S3)*
	Process	*In this stage, we focused on economic analysis...what type of material used and cost of the material...I have learnt about how to choose the right and suitable materials to construct the 'post-bin'. (RJ8S3)*
Effectiveness	Impact	*We produce Smart Rainwater Harvesting (SmaRH) system. This idea is actually come after analysing the problem in the school. We compare the cost for installation and the economic analysis either it brings positive impact or not. This stage is the most challenging part because it is closer to final examination.(RJ1S3)*
		For the silver conductive plate, the reasons we choose silver as a metal to conduct the electricity are because it is very ductile, malleable, and its has the highest electrical conductivity, even higher than copper, meaning that it can transfer electricity efficiently. Among metals, pure silver has the highest thermal conductivity. Silver plated has the best conductivity, can be resistant to EMP impact can be used as connector pads. Moreover, silver metal also have low resistance. Furthermore, silver plate is also difficult to corrode. This metal is used to construct the conductivity plate. From this task, I have learnt about how to choose the right and suitable materials to construct the 'Post-bin'.(RJ4S3)
	Awareness	*There are a lot of things that I have learned especially the effect of our daily life activities to the environment. Every day we over use the electricity which lead to produce high carbon emission.(RJ6S3)*
Social	Responsibility	*After four months, ITE course has finally ended...I have learnt a lot as a student, as a human and about the world. This course has taught me the true meaning of becoming an engineer as there are other things that are more important apart from excellent in academic. (RJ32S3)*

Furthermore, while completing the case study, students have realized their responsibility on environmental sustainability (social knowledge), such as in the following excerpts from their reflection journals;

RJ32S3: The most importance thing of all that I learnt from this PBL is the knowledge and experience. I learnt the states of the world's carbon emission and their ways to reduce it especially Malaysia. Malaysia is a developing country and lacks of technologies compare to other developed countries such as Japan and the United State. Malaysian also lacks the awareness of LCS. Due to this, I think we need to find the best way to promote LCS to Malaysian citizen and the government should be more assertive on conserving our natural resources.

RJ28S3: LCS competition is the best ever. And I hope, we not just take it as a competition but really do our best towards LCS because we already have the awareness. We must save the world thatwe are living in.

On the other hand, students noticed that on undergoing the learning activities, they have developed several skills such as team work, time management, commitment, communication, critical thinking, and self-confidence that are essential as a preparation to be a future engineer. As excerpt,

RJ6S3: As my conclusion, this course has taught me a lot..teach me in enhancing my presentation skills, generic skills, such as time management, team working and problem solving in order to get me ready for my future especially in job market.

5.5 Summary

This chapterpresents the results and analysis of research objective 2. In the quantitative study, it has been found that after undergoing the case study using CPBL approach, students' knowledge about environmental issues, concepts of sustainable development and pro-environmental behaviour have improved. It is interesting to find that there exists no differences across gender; both have the same level of knowledge about environmental issues, concepts of sustainable development and pro-environmental behavior associated with self and social development after CPBL. While, in the qualitative study, results have show that the use of problems and learning environment in CPBL approach have significantly caused impact on students' knowledge and pro-environmental behaviour. Analysis using problem used in the case study and student's reflective journal has found that the four domains of knowledge (declarative, procedural, effectiveness and social) are successfully integrated in the teaching and learning process. Students not only have enhanced the knowledge on environment issues and sustainable behaviour but also on skills and motivation to be a better person as engineer of the future. Table 5.22 shows the findings of each research question.

Table 5.22 Results and Findings of Research Objective 2

Research Objective 2		
To investigate on the implementation of Cooperative Problem-Based Learning (CPBL) as a student-centered learning environment to instil students' knowledge and behaviour changes associated with environmental sustainability, as in the first-year 'Introduction to Engineering' course syllabus.		
Quantitative Study		Findings
RQ2a	Does CPBL approach influences students; (i) Knowledge on environmental issues, (ii) knowledge on sustainable development, and (iii) students' behaviour in practicing pro-environmental behaviour associated with self and social development before and after CPBL?	**(i) Environmental Issues** Statistically significant difference of all items **(ii) Sustainable Development** Statistically significant difference of all items **(iii) Self development** (a) Statistically significant difference; BSf9 (I recycle paper to conserve natural resources)

		BSf15(I do not let the running water of a faucet when it is not necessary) BSf16 (I collect and sell recycled items such as papers, bottles and glasses) (b) No statistically significant difference; BSf5 (I separate domestic waste for recycling) BSf10(I pick up litter when I see it in a park area) **(iv) Social Development** (a) Statistically significant difference; BSc2(I discuss with friends about sustainability issues) BSc8 (I invite friends to take part in sustainable programmes) BSc13(I discussed with my friends what we can do to reduce pollution) BSc14(I asked my parents not to buy products made from non-renewable resources) (b) No statistically significant difference; BSc17(I actively participate in sustainable programmes)
RQ2b	Is there any significant difference between male and female in students'; (i) knowledge about environmental issues, (ii) knowledge about sustainable development, and (iii) practicingpro-environmental behaviour associated with self and social development before and after CPBL?	Statistically no significant difference of all sub-construct. Null hypothesis is not rejected.
Qualitative Study		Findings
RQ2c	Are the four domains of knowledge (declarative, procedural, effectiveness and social) are inculcated in the design of CPBL problems?	It was found that the four domains of knowledge were successfully integrated in the design of problem.
RQ2d	In what ways does the use of problems in CPBL approach impact students' knowledge and behaviour change associated with environmental sustainability?	The learning process in each stages were systematically enhanced students to develop and deepen their four domains of knowledge associated with environmental sustainability. The CPBL learning environment also have increased their motivation to be a better person as well as future engineer.

CHAPTER 6

DISCUSSION

6.1 Introduction

This chapter presents the discussion of the findings of this study. The findings of this study are discussed according to the research objectives. Research objective 1 identifies the levels of students' prior knowledge and behaviour using the tested questionnaire. In research objective 2, the impact of the implementation of CPBL in instilling environmental sustainability knowledge and behaviour are investigated. Finally in research objective 3, a framework of teaching environmental sustainability is recommended.

6.2 Summary of the Research Study

This section summarises the findings of the study.This study is divided into three parts. Firstly, the discussion of quantitative results in Phase 1 to assess first year engineering students' prior knowledge on environmental issues, sustainable development and students' behaviour in practicing pro-environmental activities associated with self- and social development, as well as across gender. Secondly, in Phase II the discussion of quantitative and qualitative results are to investigate the implementation of CPBL learning environment to instil students' knowledge and behaviour change associated with environmental sustainability. In qualitative study, the problems and students' reflective journal are used to investigate the convergence of four domains of knowledge. A mixed method design is adopted to gather data from the first year Chemical engineering students at the Faculty of Chemical Engineering enrolled in 'Introduction to Engineering' course in Semester 1, 2012/2013 session. This group has been selected as research participants because of the course content with the sustainability issues included and student-centred learning is implemented as a teaching and learning approach. In this phase, quantitative study is conducted to investigate the impact of CPBL in developing students' knowledge and promoting students' behaviour in practicing sustainable lifestyles. Furthermore, qualitative study is performed to investigate how the use of problem and learning environment in CPBL would enhance students' knowledge and behaviour. Finally, a framework for teaching environmental sustainability is recommended.

This study proposes that educators be the key players in delivering the concept of SD through effective teaching and learning approach, to ensure that the needs of present and future generations are better understood and addressed. Educators can make effective interventions and support that the students require in adopting sustainable behavior. Using effective problems related to sustainability issues in CPBL as an instructional approach can promote students' engagement in pro-environmental behavior change. This study provides an insight into the benefits and gives suggestions that could be placed into the classrooms.

6.2.1 Research Objective 1

The first part of this objective is to determine the most significant items that are suitable to measure each construct. In order to answer the question, a set of questionnaire is developed. It is thentested and modified to suit the Malaysian students' background. The respondents in this study consist of first year engineering students where most of them have the same educational background (majority of 72.3% from matriculation programme). The results reveal thatthe most significant indicators to assess students' knowledge and behaviour consist of seven items of students' knowledge on environmental issues, four items on students' knowledge on sustainable development, both five items on students' practicing pro-environmental behaviour associated with self- and social development. The findings are as follows;

(i) Environmental issues: Air Pollution (KT1), Climate Change (KT3), Environmental Degradation (KT4), Global Warming (KT5), Greenhouse Effect (KT6), Green Technology (KT7) and Ozone Layer Depletion (KT8).

(ii) Sustainable Development: 'Definition of sustainable development' (KBK1), 'Components of sustainable development' (KBK2), 'Principles of sustainable development' (KBK3) and 'Impact of un-sustainability' (KBK4).

(iii) Selfdevelopment consists of BSf5 (*I separate domestic waste for recycling*), BSf9 (*I recycle paper to conserve natural resources*), BSf10 (*I pick up litter when I see it in a public area*), BSf15 (*I do not let running water of a faucet when it is not necessary*) and BSf16 (*I collect and sell recycled items such as papers, bottles and glasses*)

(iv) Social development consists of BSC2 (*I discuss with friends about sustainable issues*), BSC8 (*I invite friends to take part in sustainable programmes*), BSC13 (*I discussed with friends what we can do to reduce pollution*), BSC14 (*I asked my parents not to buy products made from non-renewable resources*) and BSC17 (*I actively participate in sustainable programmes*).

Furthermore, the levels of perception of the first year engineering students' on (i) prior knowledge on environmental issues, (ii) prior knowledge on sustainable development, and (iii) practicing pro-environmental behaviour associated with self- and social development are identified in the second research question (RQ1b). After the analysis, it is found that the levels of first year engineering students are as follows;

(i) Students' prior knowledge on environmental issues is at level 3 (know and can describe briefly).

(ii) Students' knowledge on sustainable development is at level 2 (heard of but cannot describe).

(iii) Students' self-development of pro-environmental behaviour is at level 3 (have an interest to engage but not certain to contribute).

(iv) Students' social development of pro-environmental behaviour is at level 2 (aware on issue but not to engage).

As a conclusion from the above results, before entering the university, the students already have the prior knowledge on environmental issues but can only describe briefly. These finding indicate that environmental issues related to climate change (3.66), air pollution (3.63) and ozone layer depletion (3.49) have the highest score. Students also agree that they have already received the environmental education since primary and secondary school. Furthermore, results of students' knowledge on sustainable development show that most of the students have no knowledge where the average mean score is 1.995. This finding is significant with the results from preliminary study where most of the students are unable to give the definition of 'what is sustainable development?'. Meanwhile, they also have an awareness on pro-environmental behaviour associated with self-development but not certain to contribute (level 3 – have an interest to engage but not certain to contribute). In contrast, students' social development associated to practicing pro-environmental behaviour is very low (level 2 - aware on issue but not to engage). These findings are similar with the research conducted by Nadeson and Nor Shidawati (2005), Pauziah (2004) and Tamby (2010). They found that the level of students' understanding on environmental issues and attitude towards environmental sustainability among primary and secondary school students are low to moderate. On the other hand, Wahida *et al.* (2004) indicate that the awareness towards environmental issues and the need to maintain the environment had increased among the society, but the level of individual involvement in the activities of environmental protection is still at a low level.

The third research question (RQ1c) is focused on gender. Results of students' prior knowledge on environmental issues show that there are no significant differences across gender. This findings indicates that the students have received the same level of environmental education before entering the university. However, according to the score of mean value, students' knowledge on environmental issues, for male (3.422) is higher than female (3.297) and this finding is also endorsed by Diamantopoulos et al. (2003). In contrast, there is a significant differences between male and female students associated with their prior knowledge on sustainable development. The mean score for male (2.073) is higher than female (1.882) at the low level (less than 2). Referring to students' pro-environmental behaviour, result shows that there is a significant differences with self-development. The mean score for female (3.555) is higher than male (3.234). This finding is similar with Davidson and Freudenburg (1996), Zelezny (2000), Tikka *et al.* (2000), Keles (2011) and Lukman*et al.* (2013) that female participated more in pro-environmental behaviour. However, there is no significant differences on social development across gender. It indicates that male (2.30) and female(2.269) have the same level of behaviour (aware of the issue, but no to engage) on social development.

Furthermore, in forth research question (RQ1d) it has been found that the relationship between knowledge and students' pro-environmental behaviour is specifically concerned with social development. BSC8 (*I invite friends to take part in sustainable programme*), BSC13 (*I discussed with friends what we can do to reduce environmental problems*) and BSC14 (*I asked my parents not to buy products made from non-renewable resources*) are the significant items to assess students' behaviour associated with social development. Their factor loadings are, 0.61, 0.74 and 0.62,respectively. Results on self development show that most of the students are already aware of and contribute in self-development items, but somehow still lacking on social development.

This finding is also supported with the qualitative study. Students notice that they have no knowledge on sustainable development and no concern with the environment before entering to the university. These results that show the significant gap between knowledge and practices among the students reflected back on the educational background of the students.

As a conclusion, the results reveal that students' prior knowledge on environmental issues and self developmentis at level 3. While, students' prior knowledge on sustainable development and social development is at the level 2. Therefore, the following study is conducted to investigate whether implementation of CPBL could impact students' knowledge on both construct and promote behaviour change specifically on social development. Concurrently, the problem used and its design is also investigated. Does the four domains of knowledge converged in the problems? And what is the impact on students' learning outcomes?

6.2.2 Research Objective 2

A case study of mixed method research design is employed via quantitative and qualitative study in order to answer the second research objective. A group of first year engineering students who enrolled in 'Introduction to Engineering' course at Faculty of Chemical Engineering, UniversitiTeknologi Malaysia are selected as research population. 'Introduction to Engineering' course is selected as the research interest area because of; (i) issues on sustainability via a case study is included in the course content and (ii) student-centered learning using CPBL approach is implemented as teaching and learning approach. CPBL, which integrates cooperative learning principles into the PBL cycle, is shown to be effective in supporting students to attain deep learning in the various learning domains.

In quantitative study, results of students' knowledge on environmental issues and sustainable development are significantly different before and after CPBL. These findings are supported with the result from Rasch analysis that all items of students' knowledge on environmental issues before and after undergoing CPBL spread normally around the mean. Students have the prior knowledge about environmental issues and could discuss briefly with friends. KT7 (*Green Technology*), KT9 (*Waste Management*) and KT4 (*Environmental Degradation*) are found difficult to endorse. Nevertheless, at the end of the semester, these items are found to be much easier to understand. While, KT1 (*Air Pollution*) and KT5 (*Global Warming*) are the easier items to understand. At the end of the semester, after learning through CPBL, the students realized that they have actually lacked knowledge about environmental issues since they found that they have a lot more to find out. This is why students endorse quite higher difficulty on easier items after CPBL such as KT1A (*Air Pollution*) and KT5A (*Global Warming*). Students increase their knowledge on environmental issues from level 2 (heard of but cannot describe) to level 3 (know and can describe briefly). Global warming (3.49) and Air Polution (3.49) are the highest score endorse by the students.

All items of students' knowledge on sustainable development before CPBL are highly difficult to endorse. The means score of all items are significantly higher after CPBL. It shows that the students' knowledge on sustainable development drastically increased from level 1 (never heard of, 1.92) to level 3 (know and can describe briefly, 3.58). KBK1 (*Definition of sustainable development*) has the highest increment from level 1 (never heard of) to level 3 (know and can describe briefly). These finding indicate that after CPBL, most of the students 'know what is sustainable development'.

Referring to students' behaviour of self development, results show that the students' behaviour change from level 2 (*aware on issue, but not to engage*, 3.30) to level 3 (*have an interest to engage on issue but not certain to contribute*, 2.33). BSf15 (*I do not let the running water of a faucet when it is not necessary*) was found to be the highest increments after CPBL. Referring to Rasch Analysis, students' behaviour on self-development, 5 out of 6 items are located below the item mean logit 0.00. This shows that the 5 items become easier for the students to practice. BSf15 (*I do not let the water run from a faucet when it is not necessary*) is the easiest item to practice. Students reported that they have been practicing this as a part of their lifestyle. BSf1

(*I watch or listen to media programmes about sustainable development*) is rarely practiced before CPBL. Students are either never aware or aware on issues but not to practice. This means that they are not interested to know and learn about SD. However, after CPBL, the items moved below the item mean, except for BSF5 (*I separate domestic trash for recycling*) and BSF10 (*I pick up litter when I see it in a public area*). Both items change from easily to more difficult to practice. As reported, this is due to change of living environment from home to dormitory that have changed their way to manage waste.

While, results of social development show that the students behaviour change from level 2 (aware on issue, but not to engage, 2.11) to level 3 (have an interest to engage on issue but not certain to contribute, 3.00). BSc2 (*I discuss with friends about sustainable issues*, 3.46) and BSc13 (*I discussed with friends what we can do to reduce pollution*) have the highest percentage of behaviour change. According to Rasch Analysis, before CPBL, the students endorsed that social development are the most difficult for the ability of the students to practice. Most of the items are located above the mean. However, after CPBL, BSc2 (*I discuss with friends about sustainable issues*) and BSc13(*I discussed with friends what we can do to reduce pollution*) are the easier items to practice.

At the beginning of the semester, BSc4 (*I attend public talk about sustainable issues*) and BSc8 (*I invite my friends to take part in sustainable programmes*) are the most difficult items for the students to practice. While, BSc14 (*I asked my parents not to buy products made from non-renewable resources*)is the easier item to practice. Students have an interest to engage and contribute, but still not to practice. However, after CPBL, BSc13 (*I discussed with friends what we can do to reduce pollution*) and BSc2 (*I discuss with friends about sustainable issues*)are the easier items to practice. Under the activities inside the CPBL cycle, students developed communication and team working skills. Therefore, it is not surprising to see results that showed students improving their social skills with parents, friends and society.

The study found that the students developed their social development behavior higher than self-development behavior. This means that the systematic cycles in CPBL activities; individual construction, construction and interaction with team member and overall class interaction have effectively developed social development behavior amongst the students. The social development shows that the cooperative learning elements in CPBL are able to function as earlier intended in the design of CPBL. This learning environment becomes a platform to enhance students' social skills such as communication, team working and leadership. For instance, students improved their skill in social network (eg. *'I discuss with friends about sustainable issues'*). Students are more likely to engage if they in turn are supported by teaching staff who engage with students, with the course, and with the teaching process. Nevertheless, it has been identified that the only activity that decrease between pre and post-test is '*I pick up litter when I see it in public area*'. The result indicates that the students' behaviorhave changed from 'have an interest to engage' to 'aware but not to engage'. Upon closer scrutiny, this made sense because of the cleanliness in the campus. Thus, it is difficult to find litter to be picked up. This finding is aligned with the arguments of Lukman*et al*. (2013) and Chapman and Sharma (2001) that students act according to the rules, norms and conditions of the society or community where they live in.

On the other hand, analysis of gender has found that there are no significant difference between gender after CPBL of all constructs. These findings indicate that male and female have the same level of knowledge and behaviour change after CPBL. As a conclusion, referring to quantitative results and analysis, CPBL has successfully developed students' knowledge and behaviour change associated with environmental sustainability.

Concurrently, a qualitative study is employed to observe the implementation of CPBL as teaching and learning approach. In this phase, problem used in the case study, and students' reflection journals written at the end of each stage of the problem are analyzed using thematic analysis.The problem is set in a real world setting to integrate the three pillars of sustainable development (environment, economy and social aspects). According to the design of problems, it shows that all four domains of knowledge (declarative, procedural, effectiveness and social) are systematically crafted and embedded into the problem at each stage. At each stage students have to deepen their knowledge on the issues and applied in the proposed innovative product at Stage 3. This problem also need the students to get information outside the classroom where, this is the way the students have developed their social skills.

In Stage 1, ithas been found that students have developed more on declarative knowledge. Students have gained deep understanding about LCS, definition and information about SD and benchmarking. They also reviewed the literature to determine the current status of environmental sustainability issues in Malaysia and other nations throughout the world. For instance, they benchmarked several countries that are committed and teach their citizen to become more sustainable and care about the environment. After completing the first stage, most of the students felt that they are responsible to change their attitude in order to save the environment. They have also realized that the initial information on the LCS problem have opened their eyes to be a better person in the future.

In Stage 2, students develop their ability to design and plan the data gathering activities, estimation and accuracy in data gathering, and analyzingand presenting data to form a conclusion. For this stage, students are facilitated through crucial CPBL phases, with more tasks being completed out of the class. At the beginning of this stage, the facilitators would closely guide students toward self-direction, and gradually reduce the facilitation and scaffolding as students become more and more familiar with the CPBL cycle. Most of the students agreed that they have enriched their understanding on declarative knowledge, such as familiarization on definition, terminology, concepts and factual knowledge and added further information about current issues, ecological requirements, bench marking and generation on ideas. Students noticed that in this stage they have gained a lot of information on the issues. After undergoing the experiential learning in this stage, it is found that three domains of knowledge (procedural, effectiveness and social) have merged. When conducting the data collections students have realized that factors which contribute tonegative ecological behaviorare lack of public awareness and daily life activities. Students started talking about the need of self- and community engagement. In addition, they realized that the level of awareness among Malaysian citizens on sustainability is still low. Students also agreed that they have the responsibility to protect the environment for future generation.

In Stage 3, results from the analysis showed that convergence of the four domains of knowledge in the design of the problem and the CPBL environment has enhanced students' knowledge on environmental issues, behaviour changes and skills, which is essential for future engineers.

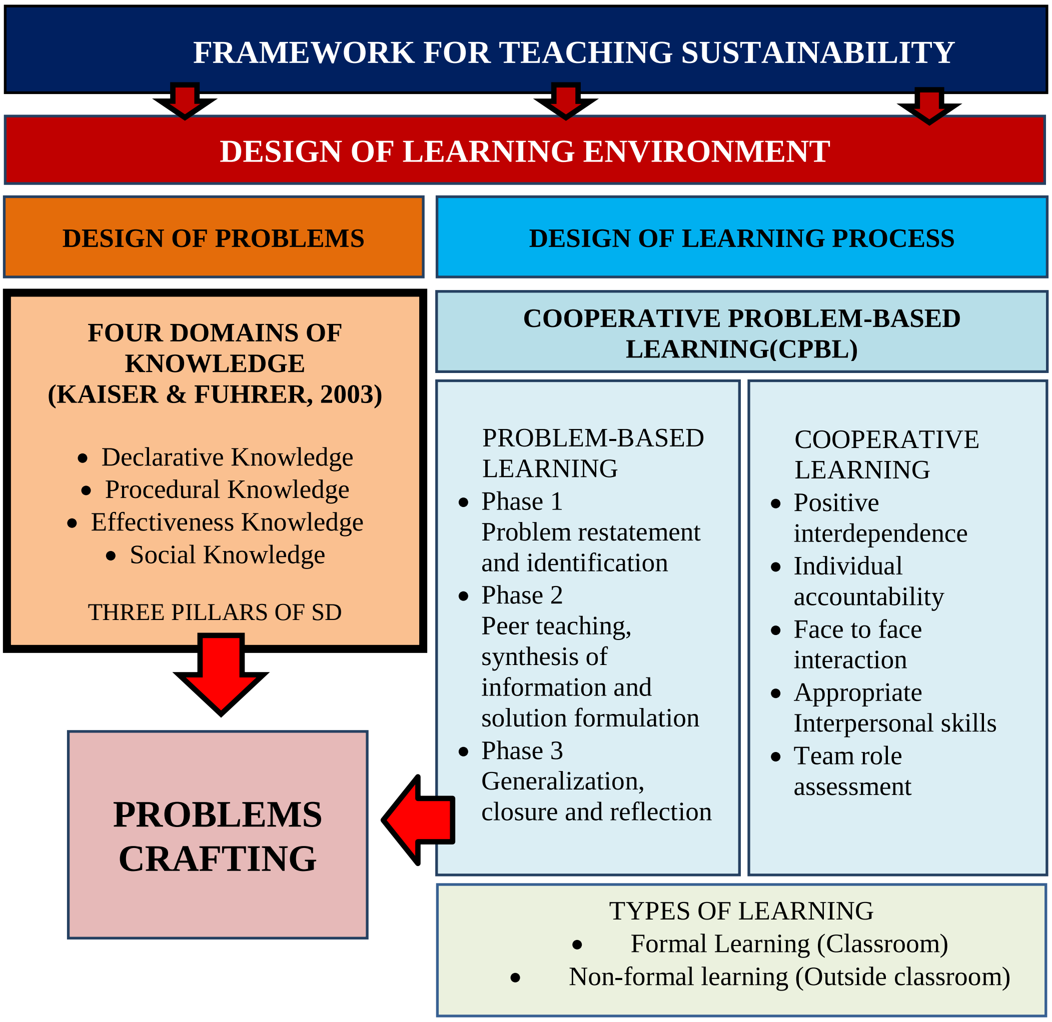
As a conclusion, after discovering that CPBL is capable of enhancing sustainable development among the first year students, further study using quantitative study reveals that there is also a significant behavior change towards environmental sustainability after undergoing activities to solve the problem given. The quantitative study shows that the combination of CPBL as an instructional approach and a problem related to sustainable issue would promote students' engagement in behavior change on sustainable development and development of professional skills. The CPBL learning environment has positively filled in the gap between 'knowledge' and 'practice'. This finding reveals that the students gained deep learning from CPBL activities and their awareness on self- and social development towards sustainable development is enhanced. The need to discuss with friends about sustainable issues is an important step after the development of awareness, and sense of responsibility. By communicating on environmental issues and thus creating awareness among friends, a wider scale of behavioral change can be obtained and SD can be achieved. Therefore, the use of mixed-method design in this study can offer deeper understanding on the behavioral change.

The findings of this research show that the first year students who went through the CPBL cycles in the case studyhave developed both cognitive and affective domains. This is in parallel with the theory of constructivism and students involvement, that the active learning environment could enhance student's knowledge, participation, and this happens across gender.The students went through several cycles of constructively aligned CPBL learning environment to attain the desired level of learning outcomes. Therefore, it is possible to prepare the attributes of engineers needed to face the greater Challenges in Engineering of the 21st Century through CPBL.

6.2.3 Research Objective 3

In summary, the finding of the study can be represented, as shown in Figure 6.1. The results of this study reveal that the design of learning environment is the important element in attaining sustainability outcomes. The design of learning environment consists of the design of problems and learning process. The uniqueness of this model is the way how the problem has been designed. The problem has been designed based on four domains of knowledge. CPBL learning process has already proven through research as a systematic way of learning which involved participation among the students via team membersand also as an experiential learning where each team has to conduct research outside the classroom such as interviewing peopleon sustainability issues. This study has found that students not only develop knowledge, increase awareness about environmental sustainability and skills development, but also the readiness to be a future engineer.

The teaching and learning approaches have to move beyond the content to help students construct their own self-concept as a lifelong learner and agent of change for sustainable development (Segalàs *et al*., 2008, Shephard, 2008, Sherman, 2008). Learning for sustainable development needs to be more holistic, future-oriented and systemic process ((Tilbury, 2011). According to McMillan *et al*., (2009), the good pedagogical practice is demonstrating to students the connections between theory and practice. Figure 6.1 shows the proposed framework of teaching environmental sustainabilitythat could instil students’ knowledge and pro-environmental behaviour associated with environmental sustainability.



***The thick box is the research contribution.**

Figure 6.1 Proposed Framework for Teaching Environmental sustainability using CPBL approach

(i) Design of Problems

The problems serves as the backbone of learning environmental sustainability issues that include acquisition of knowledge through deep learning, and development of skills through participation in learning activities. Hence, researcher found that the inculcation of four domains of knowledge are very crucial in designing the problems associated with environmental sustainability issues.

Four Domains of Knowledge. Kaiser and Fuhrer, (2003) highlighted that the joint and convergent of four domains of knowledge are important in order to effectively promoteenvironmental sustainability.Figure 6.2 depicts a proposed model that could assist in designing the sustainability problems. Declarative knowledge enable students to familiarize on several new terms or terminology, definition and information to making decisions for a sustainable future, such as 'what is sustainable development'. Procedural knowledge equips students with know-how-to process and strategies that allow them to act within the issues such as ' how is solid waste generated to enable carbon emission?'.

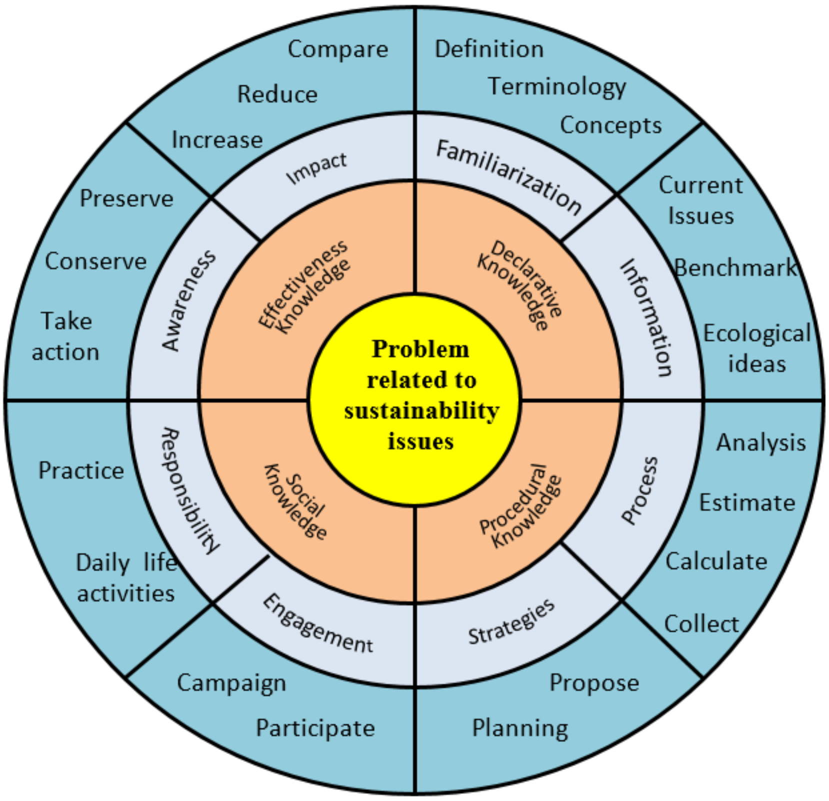


Figure 6.2 Proposed Model of Design Sustainability Problem

The development of effectiveness knowledge incorporates the impact of the individual thinking into the broader picture, meaning that students need to consider the individual and collective effects of their own and others' action over time, such as 'what are the effect of our daily life activities to the environment'. Lastly, social knowledge is needed to establish the motives and engagement in promoting sustainable actions, such as ‘what is their responsibility to protect the environment’.

(ii) Design of Learning Process

CPBL provides an active learning environment (Mohd-Yusof*et al*., 2011). The hybrid of problem-based learning and cooperative learning in CPBL framework provide a systematic way to explore learning, as illustrated in Figure 6.3.

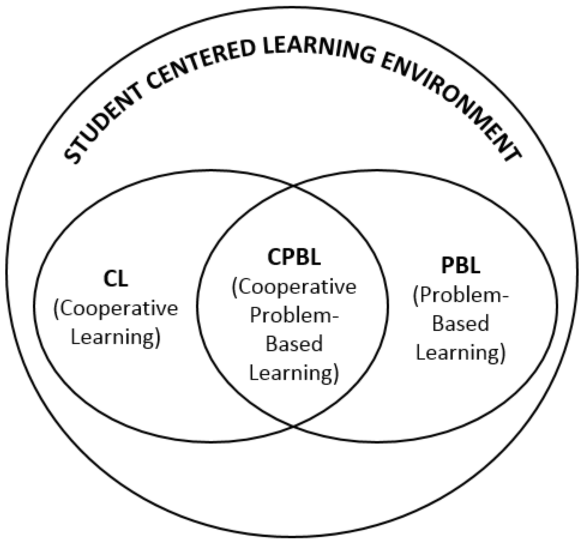


Figure 6.3 Cooperative Problem-Based Learning as Student-Centered Learning Environment

The CPBL process consists of three phases (refer Figure 6.3 and Figure 2.7). Phase 1 consists of the problem identification and analysis. Phase 2 consists of learning, application and solution formulation. Phase 3 is a generalisation, internalization and closure. In each phase, the individual activity is designed to enhance learning and accountability, which would be strengthened by team-based activities, and further supported in the overall class activities to form a learning community (Mohd-Yusof *et al*., 2011).

(iii) Problem Crafting

A problem is crafted to immerse students into going through engineering process and is set as a competition to find engineering solutions for SD-based issue that is practical and cost effective. The problem is designed in three stages with increasing the degree of difficulties as shown in Figure 6.4. To make it more realistic, the related industries and stakeholders are solicited and included in the problem. The problem is designed towards ensuring a learning environment that develops the four domains of environmental sustainability knowledge ininfluencing behaviour change.

The design of problem is aligned with the three components in constructive alignment (Biggs, 1996); i) Learning outcomes, ii) Teaching and Learning activities and iii) Assessment task, as shown in Figure 6.4. Results from the research finding suggest several sustainability issues in crafting the problems such as air pollution, climate change, environmental degradation, global warming, green technology and ozone layer depletion. Teaching and learning activities in each stage will go through the three phases in the CPBL framework. However, in this study, assessment task is not been considered but it is a part of effective teaching and learning that should be assessed. Therefore, assessment task also included in the proposed design of sustainablility problem as shown in Figure 6.4.

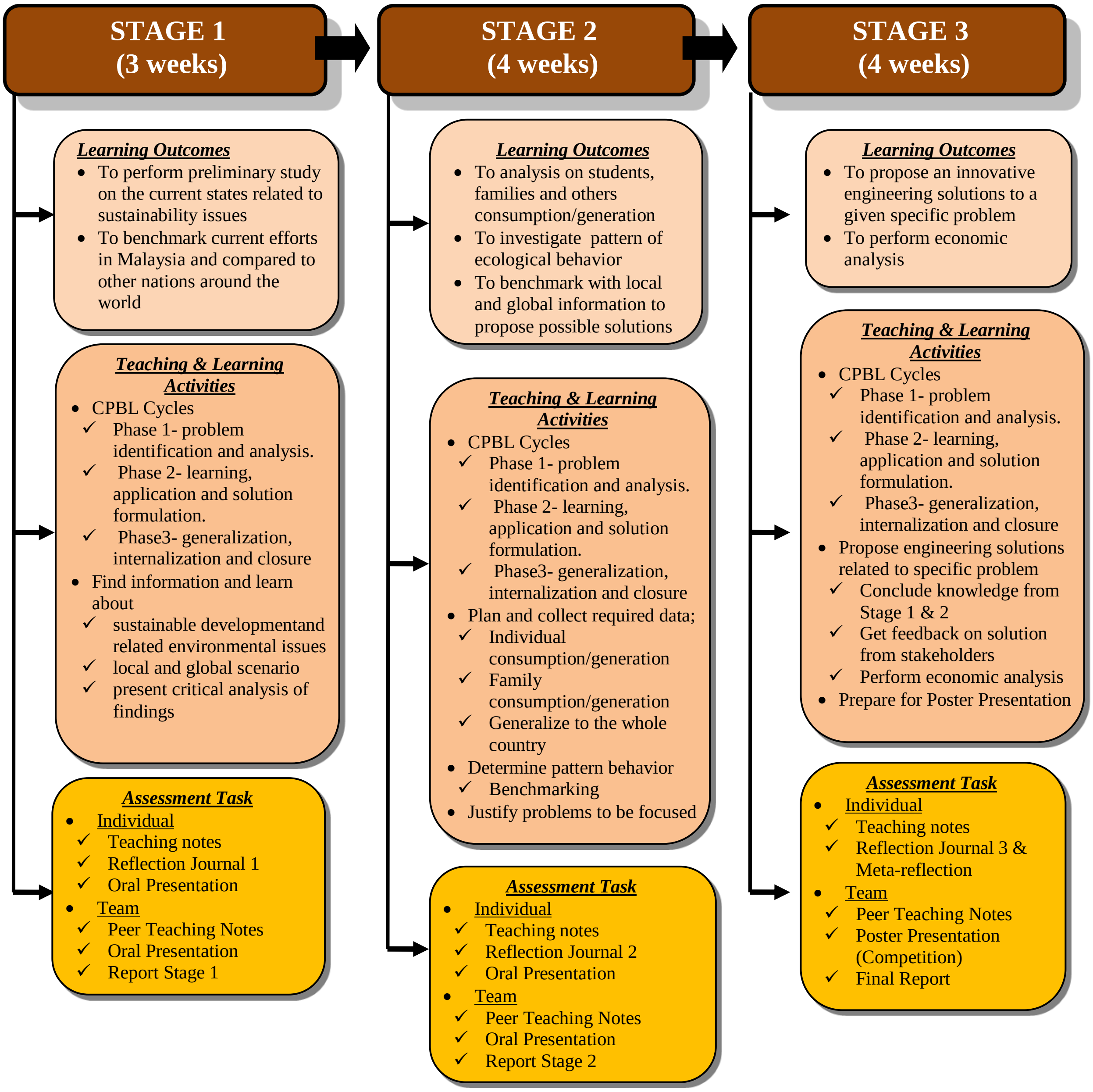


Figure 6.4 Proposed Design of Sustainability Problem and CPBL Learning Environment

6.3 Summary

This chapter presents the disccusions of the finding in Phase I and Phase II. Phase I has been performedto assess the students' level of knowledge onenvironmental issues and sustainable development, and students' pro-environmental behaviour associated with self and social development. Phase II discusses the findings of research objective 2,in which a case study of mixed method research is carried out. The problems used in the case study and students' reflective journal are analysed to investigate the implementation of CPBL in enhancing cognitive and affective domains of environmental sustainability outcomes. Chapter 7 presents the conclusion as well as the recommendations for future research in teaching environmental sustainability, and engineering education, in general.

CHAPTER 7

CONCLUSION AND RECOMMENDATION

7.1 Introduction

This chapter provides the conclusions for the findings of the study, future research, recommendations for practices and the implication of future research work in engineering education.

7.2 Conclusions

As a conclusion, this study is important to instil the knowledge and understanding towards the awareness of sustainable development among the first-year engineering students, which will be built upon and strongly embeded in their cognitive and affective outcomes as a future sustainability engineer. Results from the research objectives reveal that most of the engineering students in Malaysia have low to moderate level of knowledge on environment and sustainable development and effort to practice sustainable lifestyles. This problem is not only faced by our students but also in other countries. Azapagic*et al*. (2005) reported that outcome on a world-wide survey of undergraduate engineering students on how they know about sustainable development was not satisfactory.

This study has found thatthe design of learning environment of CPBL which consists of design of problems and design of learning processare the key elements to achieve meaningful outcomes. Through Cooperative Problem-based Learning (CPBL) as a teaching and learning approach, the students would be exposed to understand the interdependency of all fields and are capable of working within a team (Helmi*et al*., 2011). This findingis also supported by Mohd Nor *et al*. (2009), they suggest that course content and teaching and learning activities should be well structured and designed.

The qualitative resultsshow that the students are able to demonstrate their own learning ability towards a sustainability concept at a deeper and more complex level using CPBL. This is because the students are forced to think critically and creatively when exploring new ideas on sustainable development and integrating them with existing knowledge. The results also show that CPBL can be used to embed sustainable development systematically in the engineering curricula. Thus, the CPBL approach in this introductory course would also serve to elicit greater levels of self-awareness and motivation with respect to sustainability among future graduates and also provide opportunities for deeper reflection of the roles and responsibilities of engineers. Another aspect that surface out through the reflective journal is on motivation to be afuture engineer. The results have shown that CPBL is able to meet beyond the specific goals for student learning. Thus, the approach provides an opportunity to increase understanding of social and global issues, to apply engineering skills and to appreciate ethics and professional issues which are attributes of future engineers who need to be successful in a competitive, challenging and global marketplace.

The integration of problems and learning processare crucial for attaining environmental sustainability outcomes, described as follows;

Knowledge development. The effective use of problems and systematic way of learning process have been proven to enhance students' knowledge on environmental and sustainability issues, and promote behaviour change. The problem serves as the backbone of learning sustainability issues that include acquisition of knowledge through deep learning, and development of skills through participation in learning activities. It has been found that the four domains of knowledge (declarative, procedural, effectiveness and social) have successfully been integrated in the problem, and are supported by CPBL cycles to scaffold students' team-based learning and problem skills. The problem is designed in three stages to gradually challenge students with increasing difficulty. The involvements of related industries and agencies in the problem have made it realistic.In completing the problems, students have not only increased their knowledge on environmental issues but also involved in economic and social aspects. The design of problems provides them the importance of the three pillars of sustainability. Environmental issues bring about the students mindset to appreciate and perceive the environment. The implementation of CPBL as student-centered learning environment could help students to explore and propose possible solutions of the problems. Moreover, engaging students in active learning would not only increase their understanding of the content, but will instil the importance of action and engagement throughout their lives. Student-centered learning is found to be an effective teaching and learning approach to facilitate students' development on cognitive and affective domains (Frisk and Larson, 2011; Segalas*et al*., 2010).

Pro-environmental behaviour. The effective use of problems and systematic way of learning process have been proven to promote students' pro-environmental behaviour change. The most effective part of the learning activities that impact on students' awareness where they are required to evaluate their own, family and community waste consumption or generation. Students then realized that they are the main contributors in unsustainable lifestyles. Frisk and Larson (2011) also agreed that knowledge of sustainability is essential for successful action to facilitate behaviour change. Additionnally, Fiedler and Deagon (2007) indicate that people's motivation to behaviour change has indeed come from knowledge. These findings are also supported by Jensen (2002) on the discovery that students participation through action is the main goal in developing students to act and effect change.

Skills development. The effective use of problems and systematic way of learning process have been proven to develop students' skills associated with education for environmental sustainability. At the end of the course, researcher has noticed that students have acquired some skills, associated with environmental sustainability, such as,(i) enable students to seek solutions for highly complex real life problems, (ii) enable students to think critically about the mature knowledge, and about the ways in which knowledge is produced and validated, (iii) enable students to develop social and environmental responsibility, and (iv) enable students to bridge the gap between theory and practice.The findings also found that students agree to a higher level of engagement in the problems and learning environment after attending the course.This is supported with Helmi*et al*. (2011)thatCPBL learning environment has enabled students to participate creatively in teams and contribute co-operatively to achieve meaningful outcomes.

Motivation to be future engineer. The effective use of problems and systematic way of learning process have been proven to motivate students' readiness and preparedness to be a better engineer in future. Students have realized their responsibility to protect and preserve the Mother Earth. During the process of benchmarking in Stage 1 and 2, students make a comparison between their own country and other selected countries (which have already achieved sustainable countries),such as Japan and Sweden. They have also realized their responsibility as a future engineer to protect and care about their own country. Therefore, these findings also have the same view with Weber *et al.* (2014) that incorporating environmental sustainability in to engineering education is vital to both individual engineering students' success and to the profession as a whole.

Gender. The effective use of problems and systematic way of learning process have been proven to show that there are no variation between male and female in achieving learning outcomes. Before attending the course, the quantitative results show the variation between male and female in term of knowledge and practicing pro-environmental behaviour. Through CPBL, it has proven that students who undergo the same learning environment could achieve the same knowledge and values. However, there are very limited research findings on gender regarding the impact of student-centered learning in relation to environmental sustainability.

Finally, it has also been experimentally verified that students achieve better cognitive and affective learning outcomes when more community-oriented and constructive learning approaches are applied. Additionnally, Tilbury (2011) stresses that learning for sustainability needs to be more holistic, future-oriented and systemic process. This is supported with Segalas *et al.* (2010) that multi-methodological experiential active learning education increases cognitive learning on sustainability. Specifically, most students emphasized that the learning environment after completing the problem, have made them reflect on their own responsibility is required of them to become a good engineer and good citizen in future.

7.3 Future Research

The research presented in this thesis has opened a field of systematic teaching and learning approach using CPBL to introduce environmental sustainability among the first year chemical engineering students. It has shown that the combination of the systematic design of problems related to environmental sustainability and the learning environment are the important elements to be considered. Findings of this research, indicate that Cooperative Problem-Based Learning has a large impact on students' knowledge and behaviour change associated with environmental sustainability. In addition, this approach is also successful in developing students' skills, such as teamwork, problem solving, critical thinking, time management and leadership. Nevertheless, there is a need to explore the following suggestions;

(i) With respect to teaching and learning approaches to environmental sustainability, further research is required to focus on evaluating the students' learning outcomes using different teaching and learning approaches.

(ii) The instrument used in the quantitative study could be improved. The construct of knowledge and behaviour should evaluate the students' perception based on the four domains of knowledge; declarative, procedural, effectiveness and social.

(iii) To determine the effectiveness of the proposed framework, it is recommended that a study on the impact of using the proposed framework at other engineering faculties and evaluate the students' learning outcomes be conducted.

(iv) Gender variation is needed to be further research. This is a very interesting issue to explore because the quantitative findings show that there are no significant differences in gender for students who have attended the CPBL learning environment.

(ii) It would be very interesting to conduct a continuous evaluation using longitudinal study on students' behaviour change after the course. The research could evaluate how the knowledge of environmental sustainability gained at the university could influence their professional lives after graduation.

7.4 Recommendations for Practices

Several recommendations are made for practices as follows;

(i) Educators

This study has a significant benefit to educators because it will help them to identify several issues that they can adopt on their teaching and learning activities. The findings that will be collated from this study may also help them improve their teaching skills by knowing which areas of learning are essential for students. It also illustrates an approach to teaching and learning about sustainable development that could help to stimulate students' interests in this course during their studies and to ensure their commitment to practicing sustainable engineering later as professionals.

(ii) Students

The study is significant to develop students' content knowledge and behaviour changes associated with sustainable development from the earlier year of study. Hence, with the knowledge and deep understanding about sustainable development, students will be more prepared to engage, manage and solve critical problems or issues.This learning environment has provided the students with a deeper understanding about sustainable development through teaching and learning approach, asrequired by Malaysian Quality Assurance (MQA) and Engineering Accreditation Council(EAC).

(iii) Educational Institution

This study is significant in order to produce good quality graduates, with the ability to integrate knowledge, skills and attitudes in relation to sustainable development as a future engineer. CPBL has been proven in developing students' knowledge, and enhance several other positive skills, such as team working, communication, problem solving and leadership. Through this course, students would acquire the knowledge, ability and predisposition to integrate economic, environmental and societal sustainability in defining and solving engineering problems.Educational institutions where faculty create a learning environment that emphasizes effective educational practices have students who are active participants in learning and engagement (Umbach and Wawrzynski, 2005).

(iv) Society

This study has significantly promoted behaviour change after students have gone through the process of learning. The three stages of learning process could enhance students' experience on unsustainable environment. Research findings have found that proper delivery of content knowledge could affect behaviour change (Kollmuss and Agyeman, 2002). The design of problems and learning environment are able to fostering a feeling of responsibility and willingness to actively contribute to the development of a sustainable society after completing their education. Nevertheless, the knowledge and understanding on sustainable development are an important catalysts for the long-term benefit of changing attitudes, behaviours, and lifestyles towards having a more sustainable living and be more responsible as future engineers. SD may also help them reflect on their social relationships and deepened their sense of responsibility towards others.

7.5 Implication for Engineering Education

The researcher identifies the following recommendations for future work on sustainable development course;

(i) An increased use of Cooperative Problem-Based Learning to expose students to deep understanding the concept of sustainable development. During the completion of the case study, students havedeveloped extra knowledge on sustainable development.

(ii) When students are posed with a case study, they would have an opportunity to work in groups, it encourages them to stay on task and face a new experience of learning.

(iii) The CPBL phases and scaffolding teaching strategy have developed the students to become more independent and self-regulating learners and problem solvers. Students are not only exploring their own knowledge and deep understanding about the environment and economic aspects but also about the social commitments.

(iv) These findings also indicated that through experience of learning activities, students move to be a better citizen in a sustainable society.

7.6 Summary

As a summary,this study is a case study which utilised mixed-method research methodology. It was conducted among a group of engineering students with limited sample size and it could not be generalised. However, this study is important to instil the knowledge and understanding towards the awareness of sustainable development of the first-year engineering students. This awareness would embedded in their cognitive and affective outcomes in the way for them to be a sustainability engineer in future. Through Cooperative Problem-based Learning (CPBL) as a teaching and learning approach, the studentswould be exposed to understand the interdependency of all fields, and would be capable of working as a team member. The design of problems and systematic way of learning environment have been proven to enhance students' knowledge and promote pro-environmental behaviour. Hence, combination of successful teaching and learning approach through specific course would influence positive students' attitudes change, while making the transition towards sustainable thinking and living. In experimenting and implementing alternative teaching methods to attain sustainable development, it is important to rigorously determine the students' actual level of attainment for the purpose of continuous improvement and to encourage the use of relevant techniques. This study could provide as a guide for other educational institution, not only limited to higher education, but also relevant to be implemented at school levels. The educators could differentiate the degree of difficulties of the problems and follow the same learning environment. As a conclusion, it is hoped that this study will serve not only as a research outcomes but as a valuable input to help our educators to educate our future generation.

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APPENDIX A

CONSENT FORM

(i) Permission to do research and conduct survey

(ii) Agreement to participate in the research as a respondent

(iii) Validation from expert

Daripada;
Azmahani Abdul Aziz
Sekolah Pengajian Siswazah,
Universiti Teknologi Malaysia,
81310, UTM, Skudai,
Johor

21HB SEPTEMBER 2012

Kepada;
Fakulti Kejuruteraan Awam,
Universiti Teknologi Malaysia,
81310, UTM, Skudai,
Johor
(U/P : Dr. Roslli bin Noor Mohamed)

Assalamualaikum wrth..

Saudara,

Memohon Kebenaran Menjalankan Kerja-Kerja Pemungutan Data

Adalah saya dengan hormatnya, merujuk perkara di atas.

2. Untuk makluman saudara, saya sedang menyiapkan pengajian saya di peringkat PhD bertajuk 'The Effect of Teaching and Learning Approach in Developing First-year Engineering Students' Knowledge-Behaviour in Relation to Sustainability'. Oleh yang demikian, saya memohon kebenaran dan membantu saya untuk melakukan kerja-kerja pemungutan data seperti berikut;

- i) Mengedarkan borang soal selidik
- ii) Menemu bual pelajar
- iii) Mengikuti aktiviti pengajaran yang berkaitan dengan penyelidikan
- iv) Memperolehi bahan-bahan yang berkaitan dengan penyelidikan

3. Kerjasama dan perhatian dari pihak saudara amatlah saya hargai dan diucapkan ribuan terima kasih.

Sekian Terima Kasih.

Yang Benar,

(AZMAHANI ABDUL AZIZ)

Diluluskan utk tujuan kajian PhD

21/9/12

Penyelia,
PM DR. KHAIRIYAH MOHD YUSOF
PENGARAH,
PUSAT PENDIDIKAN KEJURUTERAAN,
UTM, SKUDAI,
JOHOR

CONSENT FORM

By signing this consent form, with full knowledge of all foregoing, I agree,

(i) I am aware that I have the option of allowing my interview to be audio recorded to ensure an accurate recording of my responses.
☑ Yes ☐ No

(ii) I am also aware that excerpts from the survey and/or interview may be included in the thesis and/or publications to come from the research, with the understanding that quotations will be either anonymous or attributed to me only with my review and approval.
☑ Yes ☐ No

(iii) I was informed that I may withdraw my consent at any time without penalty by advising the researcher.
☑ Yes ☐ No

Participant Name: N. SYAFA 'IZZATIE BT MAT POZI

Participant Signature: [signature]

Contact Number: 014-8230221

Witness Name: [illegible]

Witness Signature: [signature]

Date: 20/9/2012.

Validation by Expert

I hereby acknowledged that the analysis of qualitative data used in this study has been read and check based on my knowledge and expertise.

Name : AZIATUL NIZA SADIKIN

Signature:

DR. AZIATUL NIZA SADIKIN
Lecturer
Faculty of Chemical Engineering
Universiti Teknologi Malaysia
81310 Johor Bahru, Johor

Designation/Expertise:

Experience(years): 14 YEARS

Validation by Expert

I hereby acknowledged that the survey instrument used in this study has been read and check based on my knowledge and expertise.

Name : ROZANA BINTI ZAKARIA

Signature: ______________

Designation/Expertise: DR. ROZANA ZAKARIA
Associate Professor
Department of Structural & Materials
Faculty of Civil Engineering
Universiti Teknologi Malaysia
81310 UTM Johor Bahru, Johor

Experience(years): 15 years.

Validation by Expert

I hereby acknowledged that the analysis of qualitative data used in this study has been read and check based on my knowledge and expertise.

Name : Dr Hadijah Jaffri

Signature: [signature]

Designation/Expertise: Senior lecturer (Educational Psychology)

Experience (years): 11 years

APPENDIX B

Table for Determining Sample (Krejric & Morgan,1970)

TABLE 1

Table for Determining Sample Size from a Given Population

N	*S*	*N*	*S*	*N*	*S*
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

Note.—*N* is population size.
S is sample size.

APPENDIX C

COURSE OUTLINE

‘INTRODUCTION TO ENGINEERING’ COURSE

APPENDIX C

COURSE OUTLINE

Department & Faculty: Department of Chemical Engineering Faculty of Chemical Engineering UTM	**Page 1 of 6**
Subject & Code: Introduction to Engineering (SKKK 1023) **Total Lecture Hours: 3 hours x 14 weeks**	**Semester: 1** **Academic Session: 2013/2014**

Lecturers	:	**Associate Prof. Dr. Khairiyah Mohd Yusof & Dr . Aziatul Niza Sadikin**
Room No.	:	Centre for Engineering Education, F54 / N01-212, Faculty of Chemical Engineering
Tel. No.	:	07-5537776 / 07-5535526
E-mail	:	khairiyah@cheme.utm.my / aziatulniza@cheme.utm.my
Section	:	05
Meeting Time	:	Tuesdays (9 - 11 am) and Thursdays (8 – 9 am)
Venue	:	N 02 1-11
Prerequisite	:	Positive attitude and outlook

Synopsis : The objective of this course is to introduce engineering and prepare the students in learning engineering in order to become a professional engineer in the future. This course serves to bridge pre-university education to university life and provide support for adjusting to learning and expectations in tertiary education. The contents of this course include the overview of engineering, the profession and its requirements in the Malaysian scenario, basic calculations of common process variables and unit conversions, create an engineering graph and solve simple iterative problems using Excel and also an introduction to engineering ethics. In addition to that, soft skills such as communication (oral and written) skills, teamworking skills, learning styles and time management are also included in the course. This course employs Cooperative Learning (CL) and grooms students with skills for Cooperative Problem-based Learning (CPBL). Throughout the course, students will work on a CPBL case study on sustainable development.

Course Outcomes : By the end of the course, students will be able to:

1) **Define** engineering and the roles and responsibilities of an engineer in various aspects, including professional ethics as defined by the Board of Engineers Malaysia (BEM) and the Institution of Engineers Malaysia (IEM).
2) **Perform** unit conversions for basic dimensions and derive simple calculations for commonly used dimensions and process variables in the chemical industry.
3) Explain conservation and sustainability of resources and **recommend** effective measures to overcome the problem.
4) Effectively **participate** in cooperative learning activities, which includes team-working, managing time and interpersonal skills according to the according to the standard rubrics for this course using systematic techniques of prioritization utilizing Covey's 4 quadrants, time management, and managing meetings.
5) Effectively **communicate** in oral and written modes to convey ideas to experts, peers and community.
6) Effectively **participate** in cooperative problem-based learning which includes problem identification and solving, peer teaching, meta-cognition and self-directed (life-long) learning skills according to the standard PBL process for this course, using essential study skills such as technical reading and effective note making.

Department & Faculty: Department of Chemical Engineering Faculty of Chemical Engineering UTM	**Page 1 of 6**
Subject & Code: Introduction to Engineering (SKKK 1023) Total Lecture Hours: 3 hours x 14 weeks	**Semester: 1 Academic Session: 2013/2014** **2 of 6**
Prepared by: Name: Khairiyah Mohd. Yusof Signature: Date:	**Certified by: (Head of Department) Name: Signature: Date:**

Course Mapping on Bloom Taxonomy and Key Performance Index (KPI) of Course Outcome

No	Course Outcome	University Criteria/PO Mapping	Bloom's Taxonomy	Active Verb	Level	Assessment	KPI
1	Define engineering and the roles and responsibilities of an engineer in various aspects, including professional ethics as defined by the Board of Engineers Malaysia (BEM) and the Institution of Engineers Malaysia (IEM).	Technical Skill/ PO1	Cognitive	Define	Comprehension (C2)	Report, Presentation Reflection	0.65
2.	Perform unit conversions for basic dimensions and derive simple calculations for commonly used dimensions and process variables in the chemical industry.	Technical Skill/ PO1	Cognitive	Perform	Application (C3)	Quiz, Test	0.65
3.	Explain conservation and sustainability of resources and recommend effective measures to overcome the problem.	Sustainability/ PO6	Cognitive	Recommend	Evaluate (C6)	PBL Report & Presentation, Reflection	0.65
4.	Effectively participate in cooperative learning activities, which includes team-working, managing time and interpersonal skills according to the according to the standard rubrics for this course using systematic techniques of prioritization utilizing Covey's 4 quadrants, time management, and managing meetings.	Team Working/ PO8,	Affective	Participate	Set (P2) Value (A3)	PBL (Peer Rating), Reflection	0.80
5.	Effectively communicate in oral and written modes to convey ideas to experts, peers and community.	Communication/ PO9	Psychomotor	Communicate	Set (P2)	PBL (Report, Presentation, e-Forum	0.70
6	Effectively participate in cooperative problem-based learning which includes problem identification and solving, peer teaching, meta-cognition and self-directed (life-long) learning skills according to the standard PBL process for this course, using essential study skills such as technical reading and effective note making.	Problem Solving, PO2, PO3	Cognitive	Solve Participate	Synthesis (C5) Evaluation (C6)	PBL (Report, Presentation, e-Forum, Reflection	0.70

Department & Faculty: Department of Chemical Engineering Faculty of Chemical Engineering UTM	Page 3 of 6
Subject & Code: Introduction to Engineering (SKKK 1023) Total Lecture Hours: 3 hours x 14 weeks	Semester: 1 Academic Session: 2013/2014

Student Learning Time

Teaching and Learning Activities	Student Learning Time (hours)
1. In-class facilitation & activities • Problem identification • Overall class peer-teaching • Quiz • Mini lectures • Tutorial discussion • Individual team consultation and monitoring • Seminars	42
2. Independent Study • Self-directed learning • Peer-teaching • Team discussions • Virtual discussions • Reflection • Assignments	52
3. PBL case studies report writing	24
4. Test	2
Total	**120 hours**

Teaching Methodology

This course will utilize cooperative learning (CL) and cooperative problem-based learning (CPBL) techniques. At the beginning of the semester students will be divided into groups of three or four and are assigned to sit together in their respective teams. Team members will work together during the in and out of class CPBL process.

In order to enhance the team working, life-long learning and problem solving ability, a PBL case study divided into several parts will be given. Students are expected to assign and rotate roles while working together to solve the case study. Cooperation, interpersonal skills and learning and assisting peers will be evaluated by using peer-rating evaluation based from the teamworking rubrics. Individual auto-rating factors will be calculated based on the peer-rating, and will be multiplied to the team marks to yield individual marks. Electronic forums and in-class discussions will be held on cooperation and managing conflicts to enhance team working.

Presentations, electronic discussions and reports are used to assess the achievement of communication and topic outcomes, whereas a test is used to evaluate the attainment of the intended course outcome in terms of the technical skill.

Department & Faculty: Department of Chemical Engineering Faculty of Chemical Engineering UTM	**Page 4 of 6**
Subject & Code: Introduction to Engineering (SKKK 1023) **Total Lecture Hours: 3 hours x 14 weeks**	**Semester: 1** **Academic Session: 2013/2014**

Course Weekly Schedule

Week	Topic	Topic Outcomes
Week 1 10/9/13 (Tuesday) 12/9/13 (Thursday) (Active Learning & Cooperative Learning)	1. The Semester System 2. Syllabus Overview & Expectations 3. Team Development ▪ Team division ▪ Team name, rule, motto and logo ▪ Ice breaking	*Students will be able to:* • Explain the concept of credit hours in semester system used in UTM • Undergo the first stage of team development
Week 2 – 3 17/9/13 (Tuesday) 19/9/13 (Thursday) 24/9/13 (Tuesday) 26/9/13 (Thursday) (Cooperative Learning)	1. Cooperative Learning (CL) Skills • What and why of CL • Team-working ▪ Team-building ▪ People/ Interpersonal skills ▪ Learning Styles (ILS) & human intelligences ▪ Human interaction ▪ Role-play 2. Engineering Overview (CL Project) • Roles of an engineer and what's in store for the future? • Possible Careers for chemical engineers • Role of engineers in realizing sustainable development • Factors & preparation required in university to be a successful engineer • Being a professional engineer – the roles of BEM and IEM • What is engineering thinking and problem solving? • Engineering Ethics – why is it necessary? • Team Communication – listening skills, JOHARI Window • Planning &Time Management – setting priorities, Covey's 4 quadrants & Gantt Chart • Chemical Engineering Overview (Lecture) • What is chemical engineering? • 5M concept in chemical engineering	*Students will be able to:* • Explain traits that are required to learn and perform effectively as a responsible member of a team according to the principles of cooperative learning. • Describe the 5 stages that is common in transforming a group to a team. • explain the 5 principles of cooperative learning • Identify the four types of human intelligences, which are IQ, EQ, SQ and CQ. • Explain and classify the type of learning styles using the ILS and how to optimise learning according to given guidelines. • Use mind maps as a tool for learning and thinking • Describe the 4 quadrants according to Covey of classifying and prioritising tasks • Plan projects using a Gantt Chart • explain the roles of an engineer • Identify the main branches of engineering • Explain what is chemical engineering based on the basic 5M concept • Explain OBE and its implications in engineering education and future prospects • Identify the type of learning team they are working in

Department & Faculty: Department of Chemical Engineering Faculty of Chemical Engineering UTM	Page 5 of 6
Subject & Code: Introduction to Engineering (SKKK 1023) Total Lecture Hours: 3 hours x 14 weeks	Semester: 1 Academic Session: 2013/2014

Course Weekly Schedule (continued)

Week	Topic	Topic Outcomes
Week 4 – 6 1/10/13 (Tuesday) 3/10/13 (Thursday) 8/10/13 (Tuesday) 10/10/13 (Thursday) **15/10/13 (Tuesday)** 17/10/13 (Thursday) (Cooperative Learning & Problem Based Learning)	1. Introduction to PBL • Problem identification & analysis • Research and self-directed learning • Synthesis and problem solving • Project planning 2. PBL Case Study – Part 1 3. Introduction to Engineering Calculations (Chapter 2) • Units and Dimensions • Conversion of Units • System of Units • Force and Weight • Scientific Notation, Significant Figures and Precision • Dimensional Homogeneity • Dimensionless Quantities	*Students will be able to:* • describe PBL and explain its importance • perform the 3 phases of the PBL cycle to solve a problem • identify data and learning issues of a problem with guidance • Identify and analyse the problem given • Perform self-directed learning and peer-teaching • Synthesize information to solve the problem • Write and present the report for the case study • plan a project timeline using a Gantt chart • Perform unit conversions across commonly used units in chemical industries, such as SI, Engineering and cgs. • plan a project timeline using a Gantt chart
Week 7 – 9 22/10/13 (Tuesday) 24/10/13 (Thursday) 29/10/13 (Tuesday) 31/10/13 (Thursday) 12/11/13 (Tuesday) 14/11/13 (Thursday) (Cooperative Learning & Problem Based Learning)	1. Introduction to Engineering Calculations (Chapter 3) 2. Process and Process Variables • Mass and Volumes • Flow Rate • Chemical Composition • Pressure • Temperature 3. PBL Case Study – Part 2 4. Sustainable Development	*Students will be able to:* • Perform calculations using commonly used basic and derived dimensions in chemical industries. • Explain the importance of sustainable development in solving engineering problems • Calculate carbon and water footprints • Describe common process variables in the process industries • Perform process and process variables calculations in various units.

Department & Faculty: Department of Chemical Engineering Faculty of Chemical Engineering UTM	Page 6 of 6
Subject & Code: Introduction to Engineering (SKKK 1023) **Total Lecture Hours: 3 hours x 14 weeks**	**Semester: 1** **Academic Session: 2013/2014**

Course Weekly Schedule (continued)

Week	Topic	Topic Outcomes
Week 10 – 14 19/11/13 (Tuesday) 21/11/13 (Thursday) 26/11/13 (Tuesday) 28/11/13 (Thursday) 3/12/13 (Tuesday) 5/12/13 (Thursday) 10/12/13 (Tuesday) 12/12/13 (Thursday) 17/12/13 (Tuesday) 19/12/13 (Thursday) (Cooperative Learning & Problem Based Learning)	1. PBL Case Study on Sustainable Development – Final Solution, Report and Campaign 2. Basic Calculations Tournament 3. Engineering Ethics – Case Study 4. Basic Calculations Test	*Students will be able to:* • Identify and analyse the problem given • Perform self-directed learning and peer-teaching • Synthesize information to solve the problem • Write and present the report for the case study • Explain the importance of sustainable development in solving engineering problem. • Use basic interpolation and iterative computations using manual calculations and Microsoft Excel.

References :

1) "Studying Engineering: A Road Map to a Rewarding Career" by Landis & Steyn
2) "Elementary Principles of Chemical Engineering" by Felder & Rousseau
3) "Engineering Fundamentals and Problem-Solving" by Eide, Jenison, Mashaw & Northup

Assessment :

The breakdown for grading is as follows:

Evaluation	***Percentage (%)***
Basic Calculations Test & Quizzes:	30
PBL Case Study:	40
Assignments:	10
Reflections & e-Learning Participation:	20
TOTAL	***100***

The total points obtained by each team on the CL and PBL assignments and projects will be multiplied with a **grade adjustment factor** from **peer and lecturer rating**.

The breakdown for the PBL case study grading (40 %) is as follows:

Problem identification & Peer teaching notes	5
Presentations	5
Progress reports/progress checks	10
Final CPBL (report + presentation + solution)	20

APPENDIX D

Design Problems of the Case Study

Three Stages of Problem on Low Carbon Society

(i) Stage 1

(ii) Stage 2

(iii) Stage 3

PROBLEM OF STAGE 1

LOW CARBON SOCIETY (LCS) 2012

Introduction

In line with the region's vision of "a sustainable metropolis of international standing", Iskandar Malaysia (IM) hopes to become a low carbon-emission society by 2025. As such, Low Carbon Society Competition (LCS 2012) is organised. Iskandar Regional Development Authority (IRDA) in collaboration with Universiti Teknologi Malaysia (UTM) would like to solicit ideas from all levels of its community to proposed an innovative sustainable solutions for resource conservation in creating low carbon society (LCS). The propose innovations will help to reduce the amount of carbon-dioxide emissions at a national level and create a road map towards a low carbon society at either a regional or city level. The propose innovations in Iskandar Malaysia (IM) is expected to be a showcase of the best practice not only for this region and this country but also for Asian regions. In order to ensure the practicability of the recommended solutions, benchmarking with world-wide and Malaysia practices should be conducted.

Objectives

The objectives of this competition are;

- To familiarize with the concept of Low Carbon Society and eco-community.
- To differentiate different types of resource conservation efforts to reduce carbon (world-wide and Malaysia scenario).
- To establish current carbon intensity in IM.
- To propose cost competitive resource conservation strategy to reduce carbon intensity in IM.
- To promote awareness in developing LCS to residential community in IM.

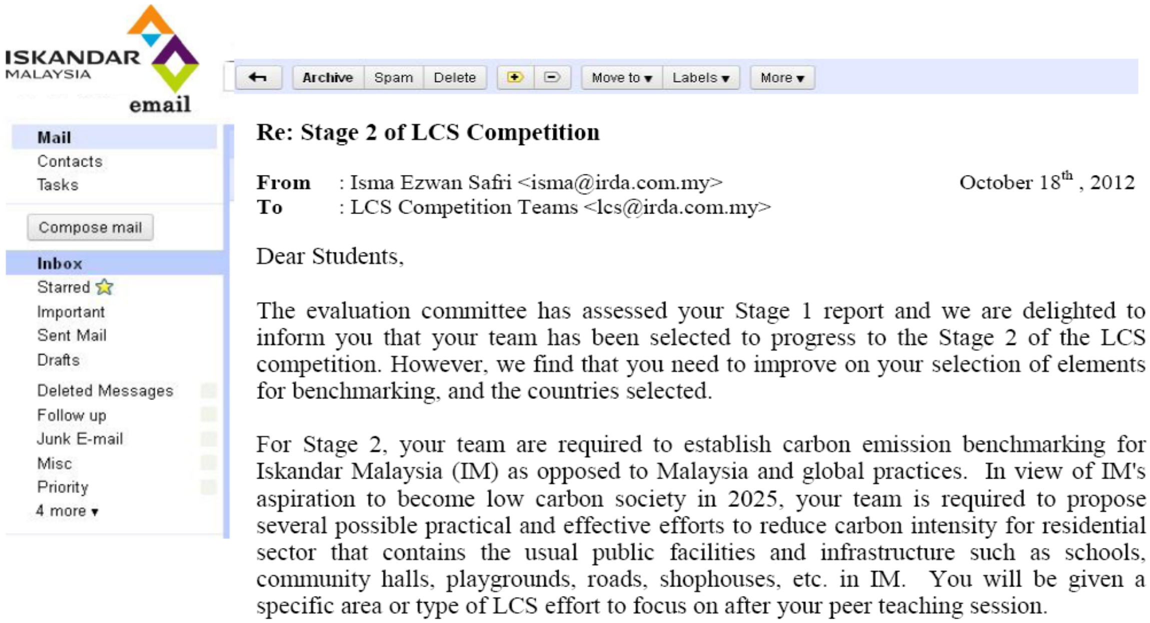
Rules and Regulations

- The number of students in a group must not be more than five.
- This project should propose engineering solution for resource conservation efforts to reduce carbon intensity in IM
- Participants are required to choose the one particular resource conservation area (e.g. water, energy, solid waste).
- Participants are given **two months** to come out with the completed proposal.
- Throughout the two months period, participants are given the privilege to acquire expert consultation from an experienced researcher working in the field via online forum. In addition, participants are also encouraged to seek other expert consultations such as from academicians, environmental consultants, etc.
- The organizer will also appoint advisors whom will guide the participating teams

throughout the competition.

- Each team should submit their staggered progress report (which will contain part of the information required) at the end of every phase (which will be explained in detailed) to the advisors to be edited.
- Besides written final proposal, every team is also expected to do an oral presentation in front of the panel of judges for ten minutes.
- Entries not complying the rules and regulations of the competition will be disqualified.
- Decisions by the judges are final

PROBLEM STAGE 2



Re: Stage 2 of LCS Competition

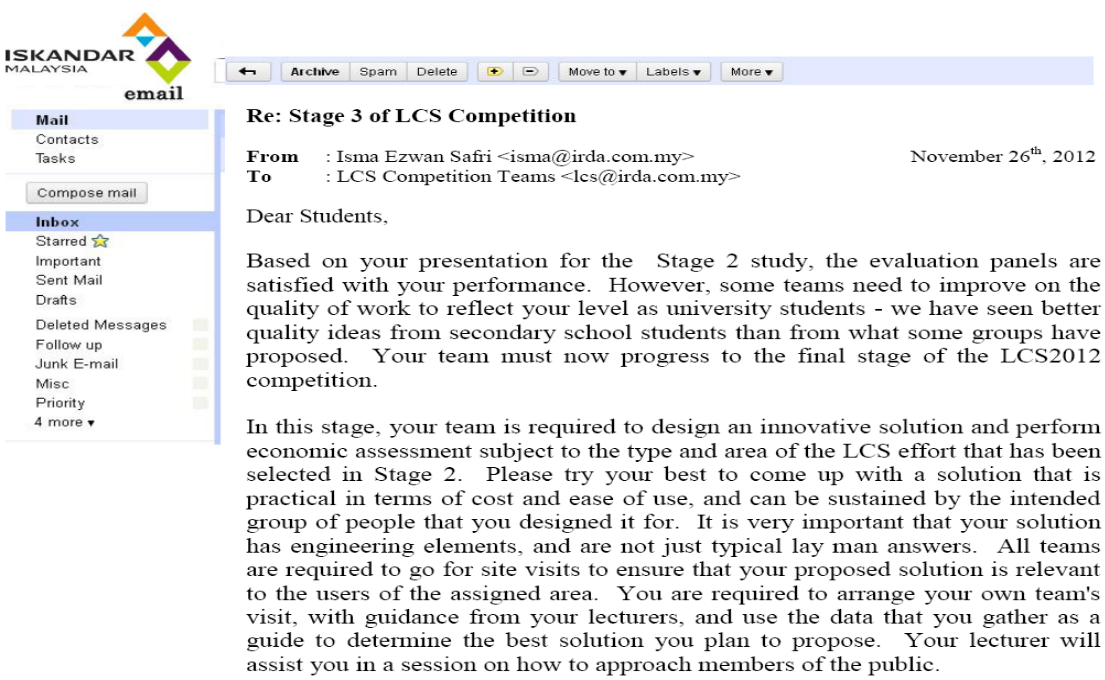
From : Isma Ezwan Safri <isma@irda.com.my> October 18th , 2012
To : LCS Competition Teams <lcs@irda.com.my>

Dear Students,

The evaluation committee has assessed your Stage 1 report and we are delighted to inform you that your team has been selected to progress to the Stage 2 of the LCS competition. However, we find that you need to improve on your selection of elements for benchmarking, and the countries selected.

For Stage 2, your team are required to establish carbon emission benchmarking for Iskandar Malaysia (IM) as opposed to Malaysia and global practices. In view of IM's aspiration to become low carbon society in 2025, your team is required to propose several possible practical and effective efforts to reduce carbon intensity for residential sector that contains the usual public facilities and infrastructure such as schools, community halls, playgrounds, roads, shophouses, etc. in IM. You will be given a specific area or type of LCS effort to focus on after your peer teaching session.

PROBLEM STAGE 3



Re: Stage 3 of LCS Competition

From : Isma Ezwan Safri <isma@irda.com.my> November 26th, 2012
To : LCS Competition Teams <lcs@irda.com.my>

Dear Students,

Based on your presentation for the Stage 2 study, the evaluation panels are satisfied with your performance. However, some teams need to improve on the quality of work to reflect your level as university students - we have seen better quality ideas from secondary school students than from what some groups have proposed. Your team must now progress to the final stage of the LCS2012 competition.

In this stage, your team is required to design an innovative solution and perform economic assessment subject to the type and area of the LCS effort that has been selected in Stage 2. Please try your best to come up with a solution that is practical in terms of cost and ease of use, and can be sustained by the intended group of people that you designed it for. It is very important that your solution has engineering elements, and are not just typical lay man answers. All teams are required to go for site visits to ensure that your proposed solution is relevant to the users of the assigned area. You are required to arrange your own team's visit, with guidance from your lecturers, and use the data that you gather as a guide to determine the best solution you plan to propose. Your lecturer will assist you in a session on how to approach members of the public.

APPENDIX E

UNIVERSITI TEKNOLOGI MALAYSIA

QUESTIONNAIRE

FIRST-YEAR ENGINEERING STUDENTS' KNOWLEDGE-BEHAVIOUR IN RELATION TO SUSTAINABILITY

Instruction:

This questionnaire consists of statements about your prior knowledge-behaviour in relation to sustainability. There are no correct or incorrect responses. Read each item carefully. Please think about how you would rate your knowledge, opinion and/or agreement for each item. This survey consists of two phases; **Phase 1** – beginning of semester and **Phase 2** – end of semester. Each phase has two parts; **Part 1** on knowledge and **Part 2** on behaviour, which will be administrated separately. **Thank you very much for your willingness and cooperation**.

CONSENT FORM

By signing this consent form, I agree,

(i) To be one of respondents.

❑ Yes ❑ No

(ii) I am also aware that results from this survey may be included in the thesis and/or publications to come from the research.

❑ Yes ❑No

Signature of Approval: ________________________________

Date:_____________________________

PERSONAL INFORMATION

Instruction: Please answer the following questions by ticking (/) in the appropriate box.

A1. Gender ☐ Male ☐ Female

A2. Race ☐ Malay ☐ Indian

☐ Chinese ☐ Others ____________________

A3. Academic background before entering UTM ☐ Matriculation ☐ STPM ☐ UTM-Mara Express

☐ Others ________________________

A4. English proficiency SPM - __________ (Grade)

MUET - __________ (Band)

A5. Faculty ☐ Civil ☐ Mechanical ☐ Electrical ☐ Chemical

A6. Year of study ☐ Year 1 ☐ Year 2 ☐ Year 3 ☐ Year 4

A7. Latest CGPA ☐ 2.00 - 2.49 ☐ 2.50 - 2.99 ☐ 3.00 - 3.49

☐ 3.50 - 4.00

PART 1

KNOWLEDGE ON ENVIRONMENTAL (PENGETAHUAN TENTANG ALAM SEKITAR)

1. Have you previously received environmental education?
   Pernahkah anda menerima pendidikan tentang kelestarian sebelum ini?

   - ☐ Yes *(Ya)*
   - ☐ No *(Tidak)*
   - ☐ Don't know *(Tidak tahu)*

2. Please indicate at which level you have received earlier environmental education?
   Sila nyatakan di peringkat mana anda mula menerima pendidikan awal tentang kelestarian?

   - ☐ Preschool *(Pra-sekolah)*
   - ☐ Primary school *(Sekolah Rendah)*
   - ☐ Secondary school *(Sekolah Menengah)*
   - ☐ Matriculation/Foundation *(Matrikulasi/Asasi)*
   - ☐ Higher education *(Pendidikan Tinggi)*
   - ☐ Others *(Lain-lain)*

3. Which of the following influenced your knowledge in relation to environmental education? Please tick only the three most significant.
   Manakah antara berikut mempengaruhi pengetahuan anda tentang pendidikan persekitaran? Sila tandakan tiga (3) sahaja yang paling ketara.

   - ☐ **Family** *(Keluarga)*
   - ☐ **Peers** *(Rakan-rakan)*
   - ☐ **Myself** *(Diri sendiri)*
   - ☐ **Teachers** *(Guru)*
   - ☐ **Involvement in sustainable programmes** *(Penglibatan dalam program kelestarian)*
   - ☐ **Information Technology** *(Teknologi Maklumat)*
   - ☐ **None of the above** *(Tiada yang di atas)*

4. How do you rate level of awareness on environmental education among Malaysian citizen?
   Bagaimana anda menilai tahap kesedaran keatas pendidikan alam sekitar dikalangan rakyat Malaysia?

   - ☐ Very low
   - ☐ Low
   - ☐ Moderate
   - ☐ High

5. How do you rate your knowledge of the following topics? Please **CIRCLE/TICK** the Likert type scales that appropriate on you with the following description.
*Bagaimanakah anda menilai pengetahuan anda tentang topik berikut? Sila **BULAT** Likert jenis skala yang sesuai berdasarkan huraian berikut.*

1 **Never heard of**
(*Tidak pernah dengar)*

2 **Heard of but cannot describe**
(*Pernah dengar tetapi tidak boleh huraikan*)

3 **Know and can describe briefly**
(*Tahu dan boleh huraikan secara ringkas*)

4 **Know and can describe in detail**
(*Tahu dan boleh huraikan dengan lengkap***)**

5 **Expert and confident talk to others**
(*Mahir dan yakin bercakap dengan orang lain*)

A	Topic					
1	Air pollution (*Pencemaran udara)*	1	2	3	4	5
2	Carbon Emission *(Pelepasan karbon)*	1	2	3	4	5
3	Climate Change (*Perubahan iklim)*	1	2	3	4	5
4	Environmental Degradation (*Kemerosotan Alam Sekitar)*	1	2	3	4	5
5	Global Warming (*Pemanasan Global)*	1	2	3	4	5
6	Greenhouse effect *(Kesan ruman hijau)*	1	2	3	4	5
7	Green technology *(Teknologi hijau)*	1	2	3	4	5
8	Ozone layer depletion *(Penipisan lapisan ozone)*	1	2	3	4	5
9	Waste management *(Pengurusan Sisa)*	1	2	3	4	5
10	Recycle, Reuse & Redo (Kitar semula, guna semula & buat semula)	1	2	3	4	5

6. Have you ever heard about sustainable development?
Pernahkah anda dengar tentang pembangunan lestari?

- ☐ Yes (*Ya*)
- ☐ No (*Tidak*)
- ☐ Don’t know (*Tidak tahu*)

7. Please rate your prior knowledge of sustainable development based on the following Likert type scales?
Sila nilai pengetahuan asas anda tentang pembangunan lestari merujuk kepada skala jenis Likert berikut?

1 Never heard of
(*Tidak pernah dengar)*

2 Heard of but cannot describe
(*Pernah dengar tetapi tidak boleh huraikan*)

3 Know and can describe briefly
(*Tahu dan boleh huraikan secara ringkas*)

4 Know and can describe in detail
(*Tahu dan boleh huraikan dengan lengkap***)**

5 Expert and confident talk to others
(*Mahir dan yakin bercakap dengan orang lain*)

B	Statement					
1	Definition of sustainable development. *(Definisi pembangunan lestari)*	1	2	3	4	5
2	Components of sustainable development *(Komponen-komponen dalam pembangunan lestari)*	1	2	3	4	5
3	Principles of sustainable development. (*Prinsip-prinsip dalam pembangunan lestari)*	1	2	3	4	5
4	Impact of un-sustainability. *(Kesan keatas ketaklestarian)*	1	2	3	4	5
5	Renewable and non-renewable resources. *(Sumber-sumber yang boleh diperbaharui dan tidak boleh diperbaharui.)*	1	2	3	4	5
6	Life Cycle Assessment *(Penilaian Kitaran Hayat)*	1	2	3	4	5

PART 2

BEHAVIOUR

1. Please **CIRCLE** your level of agreement on the following statement based on the given Likert type scale.
*Sila **BULATKAN** tahap persetujuan anda tentang perkara-perkara berikut berdasarkan skala jenis Likert yang diberikan.*

1 Unaware on issue
(Tidak sedar dengan isu)

2 **Aware on issue but not to engage**
(Sedar dengan isu tetapi tidak terlibat)

3 Have an interest to engage on issue but not certain to contribute
(Berminat untuk terlibat dengan isu tetapi tidak pasti untuk turut serta)

4 Contribute on issue but still not to practice
(Turut serta dengan isu tetapi bukan sebagai amalan)

5 Practice on issue as a part of lifestyles
(Mengamalkan isu sebagai sebahagian daripada amalan hidup)

	Statement	Liker Scale				
1	I watch or listen to media programmes about SD *Saya menonton atau mendengar melalui media program tentang SD*	1	2	3	4	5
2	I discuss with friends about sustainable issues. *Saya berbincang dengan rakan-rakan tentang isu-isu kelestarian.*	1	2	3	4	5
3	I discuss with family about sustainable issues. *Saya berbincang dengan keluarga tentang isu –isu kelestarian.*	1	2	3	4	5
4	I unplug appliances or switch them off at the wall when they're not in use *Saya tanggalkan soket atau memadamkannya pada dinding bila ia tidak digunakan.*	1	2	3	4	5
5	I separate domestic trash for recycling. *Saya mengasingkan sampah domestik untuk kitar semula.*	1	2	3	4	5
6	I walk or cycle to attend lecture. *Saya berjalan atau berbasikal untuk menghadiri kuliah*	1	2	3	4	5
7	I take a short shower in order to conserve water. *Saya menggunakan air secara berhemah semasa mandi*	1	2	3	4	5
8	I invite friends to take part in sustainable programme *Saya mengajak rakan-rakan untuk sertai program kelestarian.*	1	2	3	4	5
9	I recycle paper to conserve natural resources. *Saya kitar semula kertas untuk memulihara sumber semulajadi.*	1	2	3	4	5

	Statement	Beginning of semester				
10	I pick up litter when I see it in public area. *Saya mengutip sampah bila ternampak di kawasan umum.*	1	2	3	4	5
11	I reduce the amount of food waste . *Saya kurangkan jumlah sisa makanan*	1	2	3	4	5
12	I encourage my parents to recycle some of the things we use. *Saya menggalakkan keluarga menguna semula barang yang telah digunakan.*	1	2	3	4	5
13	I discussed with friends what we can do to help reduce pollution. *Saya berbincang dengan rakan apa yang boleh dilakukan untuk mengurangkan pencemaran.*	1	2	3	4	5
14	I asked my parents not to buy goods that are not environmentally friendly *Saya melarang keluarga saya daripada membeli barangan yang tidak mesra alam.*	1	2	3	4	5
15	I do not let running water of a faucet when it is not necessary. *Saya tidak akan membazirkan air mengalir dari pili jika tidak digunakan/diperlukan.*	1	2	3	4	5
16	I collect and sell recycle items such as papers, bottles and glasses. *Saya mengumpul dan menjual barangan kitar semula seperti kertas, botol dan kaca.*	1	2	3	4	5
17	I actively participate in sustainable programmes. *Saya bergiat aktif dalam program kelestarian,*	1	2	3	4	5
18	I turn lights off when I leave a room Saya memadamkan lampu apabila meninggalkan bilik.	1	2	3	4	5
19	I turn tap off when brushing my teeth. Saya tutup air bila memberus gigi.	1	2	3	4	5
20	I donate money to support sustainable programmes. Saya menyumbangkan wang untuk menyokong program kebajikan.	1	2	3	4	5

THANK YOU VERY MUCH FOR YOUR WILLINGNESS AND PARTICIPATION

APPENDIX F

REFLECTIVE JOURNAL

(i) Example of Students’ Reflective Journal

(iii) Example of Classroom Observation

Respondent : RJ1
Stage 1

In completing stage 1 of low carbon society, I have learnt many things about our current environment condition and also about myself, my team even the preparation to be an engineer in the near future. Needless to say, nowadays people are less aware about our Mother Nature, making the environment continuously threaten by dangerous effect such as global warming, climate change due to the increase in greenhouse gases (GHG) and others serious matters. Someone should overcome this problem as soon as possible before it going into more nasty condition. One of the communities that should take responsibility is engineer. Engineers have their own roles on how to solve this problem actually such as by inventing something which can reduce carbon emission. So, as the alternative, Iskandar Malaysia, as one of the economic growth centre in Malaysia grabs this chance to establish low carbon society in the region and complete the mission by 2025. As the opening, they proposed their plan to us as the first year chemical engineering students in UTM by organizing low carbon society competition. For sure, it brings highly positive effects to us as the engineers to be soon. Seriously, I got many things on what I have done with stage 1.

In this reflection journal, I will divide into two parts basically. Firstly, I will explain what I have got from the research about low carbon society. The second part is what I have learnt through preparation for stage 1 of low carbon society. Let straight to the main point.

First of all, I become familiar with low carbon society concept. To be honest, I had never heard of the concept before and at the same time I didn’t find any information about it. This is because I thought that it was not my matter. Since that, I just let it go until I further my study in chemical engineering course. I feel so thankful to God because my way here is trying to conserve the nature. Now, I deeply understand what is meant by low carbon society. Roughly, this concept is one the solution to create awareness among the citizens by lowering carbon emission in all matters. Automatically, it will involve all groups of people such as at home, schools, government and non-government sector and so on. In our routine days, we will use less energy fewer and renewable resources such as wind, solar panel and wave. It is a society that is ready and able to realize the economic opportunity that come from producing fewer carbon emissions, from improved energy and resource efficiency and from reducing the level of reliance on carbon-based fuel. In order to achieve low carbon society, everyone should provide compatible and equitable contribution towards lowering the intensity of carbon at the atmosphere even the children at kindergartens.

Understanding our current Earth condition makes my team members more aware what we should we do now and after wards. This is because at first, all of us were sighed and take the matter for granted. After we completed stage 1, we aware what are our roles. In achieving the mission, all of us need to cooperate together indeed. Engineers are only problem solver and all kind of communities should take the possible actions. That is called citizenships where all of us help each other. Other than that, low carbon society is much related to the sustainable development. What is sustainability? This is the first question play in my mind. Actually, it means that the development which take impact on the environment and take the opportunity to minimize environmental deterioration. So, in a simple nutshell, sustainability must be considered seriously in order to create low carbon society. We must sustain our natural resources for the next generation and to be mindful, we need to take the actions now. We must avoid littering into the rivers, reduce the cutting down of trees activity, apply 3R concept (reduce, reuse, recycle) seriously and so on. As for the government, they should enforce laws to instill awareness among the illegal loggers. These are simple solutions on how we can create sustainability in our routine days. If everyone gives positive contribution, it might help our Earth keep green all the time.

In Iskandar Malaysia’s low carbon society, it is more focused on the residential areas and school because these communities are quite effective to convey the awareness. Teachers and parents especially must play their role and try to be as a good role model to the children. Perhaps, they will follow on what they do in creating sustainability.

Malaysia Productivity Corporation (MPC) has respective ways to achieve the mission. They cooperate with several companies like Toyota Malaysia, Panasonic Malaysia, Malaysia Green Technology Corporation and so on.

Now, I understand how sustainable development related to the carbon emission which can produce low carbon society soon.

Other than that, I also learnt about the process of benchmarking. In general, benchmarking is defined as continuous process to find and implement best practices that will lead to superior performance. It is our reference and role model to get better for our organization through making comparison with others. As the definition implies, benchmarking is a process that will make an improvement regarding quality and productivity in an organisation. It involves a few steps in order to make benchmarking. They are planning, analysing, integration and action. We benchmark Japan and Scotland. This is because Japan is a country where there are many great technologies and one of the top developed countries that can be proud of. So, we conclude that surely they also play role in conserving the nature from corrosion. They plan low carbon society last 10 years ago. We choose Scotland because they are many well educated citizens, in addition their technologies are quite good. From benchmarking, I learnt that we must choose good elements to benchmark. As example, we can compare about their population, lifestyle, public transportation and so on. It learnt the flow of benchmarking indeed.

During learning process, I got many positive effects to improve myself and team. At first of stage 1, we are required to identify the problem restatement of LCS and prepare KNL table which stand for know, need to know and the last is learning issues. From this task, we learn on how to identify the main problem in a certain case and find the criteria that should be considered. At first glimpse, most of the students give the solution to the low carbon society as the problem restatement. Unfortunately, it is totally wrong. In learning process, firstly, we must identify the problem, proceeding with analysis and the last is solution. But, we directly jump into the solution. After getting rough explanation from the lecturer, all of us understand what we need to do. Actually, this is the main skill that we need to have as engineer which is problem solver. It reflects our thinking on how we discuss to get closer with the problem. Obviously, it gives a skill for us as the engineering students. Other than that, it taught us to be more creative and innovative to discover issues that we need to learn in order to get the settlement.

In addition, during the learning process, I learnt to be cooperative with the teammates. This is very important to make all of us to work well. Everyone should generate ideas to develop a discussion. It is fine actually for me if other members contribute something ridiculous and do not make sense. From my perspective, it is better to share anything with other members rather than waiting ideas from someone. When this situation happens during our discussion, we will accept and analyse the idea. First of all, everyone will listen and lastly give some comments toward the point of view. Actually, it can make the discussion develop into interesting and avoid boring. This is how we work together. But, in my team, we still have a sceptic and this duty rotates for every discussion. One cannot lead the entire discourse because it makes others feel uneasy and unneeded to speak. Supposedly, we must get together. In order to realize cooperation, someone will ask all the team members if have anything to convey. Indirectly, it gives chance for all of us to participate in the confabulation. Besides that, in order to make us to work well, everyone will encourage each other. Someone will challenge to make better in certain work. It prepares us to be more alert and stay strong to get through obstacles now and in the future. Then, I learnt about time management. We must prepare earlier to avoid last minute work. It gives a bad and low quality of work. One should give priority in academic first and then followed by curriculum.

In a nutshell, stage 1 of low carbon society taught me a lot of thing as a university student. One should alert and care our environment indeed. Currently, our Mother Earth is threatened with deterioration. Everyone should take part and show some efforts in conserving our nature.

Simple actions likes avoid littering and open burning, car pooling and support green campaign must be followed.

From other part of stage 1 feedback, I aware that time management should be excellent. A team must have a table such as Gantt Chart which emphasize how we work in well timed. Working in a team is also need a lot of sacrifices. I believe that this is the preparation and training for us to be a good engineer in the future. Engineer must be strong, smart and think critically. Currently, my goal is learning to be a good engineer soon. So, this is my first milestone to measure my ability in chemical engineering prospect. A quote said that start by doing what is necessary, then what is possible, and suddenly you are doing the impossible• . We need to learn from the basic, enhancing our knowledge to be a better person in the future.

RJ1S1

Stage 2

In completing stage 2 of Low Carbon Society, I have learnt many things about our current environment condition and also about myself, my team even the preparation to be an engineer in the near future. Needless to say, nowadays people are less aware about our Mother Nature, making the environment continuously threaten by dangerous effect such as global warming, climate change due to the increase in greenhouse gases (GHG) and others serious matters. Someone should overcome this problem as soon as possible before it going into more nasty condition. So, the objective of stage 2 of Low Carbon Society is providing the effective and possible solutions in order to reduce carbon intensity. Then, it also followed by investigation on the average consumption.

My journal basically divides into two parts, which are the things I got through stage 2 and what I learnt during completing all the assignment in stage 2. There are many new things I learn. From the average consumption, I learnt how to calculate it. For my team, we estimated the average consumption of electricity. The methods are quite easy but before, I had never to care about all these things. For the family, we just take reading of power meter at our home everyday start from 7.00 am and continuously in the next morning in one week. So, in a day we got to know the average electricity consumption. After completing all the data, the result is 9.1kWh per day. I think it is quite high. A family should consume the home appliances wisely to reduce energy which create abundant of carbon release. Besides that, I also know the average electricity consumption for a UTM student. We analysed the bill for Kolej Tun Dr. Ismail for three year. After getting through some calculation, the average is 1.7kWh which I think it is very high. Students need to be aware that the more energy we released, the higher the tendency for our Earth get threaten with global warming.

In addition, I also familiarized with effective solutions in order to reduce the carbon emission to the atmosphere. The solutions basically divided into two categories. They are solution about awareness of people and solution about the appliances. Awareness solutions are improving the style of awareness campaign, exploringÂ â€˜A Student's Guide to Global Climate Change , Siteâ€™ and usingÂ EPA's Climate Change Emission Calculator Kit (Climate CHECK) to learn about climate change. For the appliances, surely we need to use high efficiency electrical appliances to reduce greenhouse gases (GHG). The ways to realize this statement is by using fluorescent lights in fixtures that stay on more than two hours per day and replacing â€˜Heating, Ventilation and Air-Conditioning (HVAC)â€™ systems with efficient systems and controls the use of heat pumps and thermal mass. Therefore, all these solution had implied I our routine days in reducing the carbon. People should take care about their surroundings. Make sure we use 5 Stars Labelling products to help our Earth to stay green.

Along completing the stage 2 report, I can absorb and learn new things which provide me about maturity in thinking and also learn to be flexible person. Honestly, stage 2 asks the students to think critically. To come out with the result of average consumption, we need to be smart in choosing the ways to calculate it. We need to consider several things such as frequent appliances we used, the power for each item, the usage duration and so on. After that, we can estimate the average consumption per day in kWh unit. Then, I also I learnt to be cooperative with the teammates. This is very important to make all of us to work well. Everyone should generate ideas to develop a discussion. It is fine actually for me if other members contribute something ridiculous and do not make sense. From my perspective, it is better to share anything with other members rather than waiting ideas from someone. When this situation happens during our discussion, we will accept and analyse the idea. First of all, everyone will listen and lastly give some comments toward the point of view. Actually, it can make the discussion develop into interesting and avoid boring. This is how we work together.

During the learning process, the important thing that I got is the spirits among the team members. All of us want to make an excellent report and result. To make it realized, a well spirit must be inculcated before starting with the working process. Everyone should aware that we must be prepared earlier become things come to worst. A well spirit can hinder any matters which can ruin our goals. This is because our mind had set to certain things. Every member should support each other and it is seemed vital for each of us care other problems. That is what I learnt along the learning process. Other than that, I want also to highlight about time contribution. So far, we received an improvement where everyone committed with their time division. This matter had been mentioned since engineering overview assignment. Glad to hear, now, we can see the progression in our team. That shows we are not selfish.

In a nutshell, stage 2 of low carbon society taught me a lot of thing as a university student. One should alert and care our environment indeed. Currently, our Mother Earth is threatened with deterioration. Everyone should take part and show some efforts in conserving our nature. Simple actions likes avoid littering and open burning, car-pooling and support green campaign must be followed. Other than that we must reduce the consumption on electrical appliances. To be smarter, use things where 5 star labelling stated on it. At least, you have provided a solution to help our Earth. Then, in our team, we must be critical thinker, producing high level opinion. Everything we wish to accomplish can be done easily if we work hard for it. Just followed our Gant Chart and it will give us a big impact towards our works.

RJ1S2

Stage 3

In completing stage 3 of Low Carbon Society, I have learnt many things about our current environment condition and also about myself, my team even the preparation to be an engineer in the near future. Needless to say, nowadays people are less aware about our Mother Nature, making the environment continuously threaten by dangerous effect such as global warming, climate change due to the increase in greenhouse gases (GHG) and others serious matters. Therefore, in this stage 3, students need to propose an engineering solution in order to achieve Iskandar Malaysia mission to be a Low Carbon Society in the near future. It is very hard actually to find a compatible solution which can be applied at school.

After discussing for many hours with team mates, we come out with some ideas. The first idea is we want to make a set of table and chair from palm oil. From there, we discuss about economic analysis and think about the most important engineering element which can be applied to the solution. After a few hours, we get nothing. It is very hard actually to find that element. We need to consume many days to get overall information. The other idea about the solution is producing rainwater harvesting system. We did the same thing. We spent a few hours on the internet to get the information. Finally, we choose rainwater harvesting as our solution to be implemented in Low Carbon Society Competition. This is because, the data collected from site visit at Sekolah Menengah Kebangsaan Aminuddin Baki stated that, the most terrible problem is water crisis than electricity problems. This is because there are so many leakages and students are not use water consumption wisely. Therefore, our solution is much compatible and suitable to be applied at school in Iskandar Malaysia region.

Through finding and proposing a solution, I have learnt many things about elements that need to be fill in so that our solution is making sense and not a Doraemon solution. It means that we give a solution without any explanation and suddenly a device can be produced instantly. For sure, we must include engineering elements to make our solution is reliable. In our solution, we include about neutralization process and pressure about water that needs to be flowed to main tank at the school. Other than that, I also learnt about economic analysis. It means that in producing a solution, we must calculate about the cost so that it is reasonable and give a high impact feedback now and in the future. As we use rainwater instead of usual water, it can cut down the cost for water consumption bill monthly at the school. During Low Carbon Society Competition, our team was announced as third place winner for eco living category. This is most valuable part for us as it worth for our sacrifices throughout 1 semester.

For improving myself and team mates during stage 3, it is same like others stages before. I want to highlight that we need to sacrifice our times during study week to prepare final report of Low Carbon Society. This condition makes us to manage our time wisely so that we do not come to stress at last. Other than that, we also need to prepare poster as our aid during the presentation. It is quite challenging actually because we are never prepare poster with A0 dimension before. We are also quite choosy in order to choose a design. In conclusion, stage 3 teaches me time management during peak period and teaches me doing economic analysis with current condition.

RJ1S3

OVERALL

This is overall semester reflection journal. I will tell everything what I have been through for Introduction to Engineering subject for 1 semester. Our task was started with engineering overview assignment. This is our first milestone actually. This assignment is all about engineering element such as engineering ethics and sustainable development. As I said at the beginning of semester 1, the journey of a thousand miles begins with a single step. It is really shows that our action and the ways we handle assignment at first experience is very important. In this assignment, we also learn about team working, well time management and so on. Now, we are able to define the meaning of engineering. Basically, it is a skill and profession which apply science knowledge and mathematical methods in order to create and innovate something new for people where there is a combination of physics, chemistry, mathematics and biology.

Actually, in simple term, engineer is a problem solver. Engineer should think critically to solve problems. Problems in engineering are divided into two which are simple and compound problem. In order to solve it, engineers are often to apply analogical reasoning as the first step. For simple problem, engineers will discuss among themselves about the best two solutions and finally, the best one will be taken. Every decision that they have made must justify with compelling evidences. Simple problems actually can be settled internally without involving upper level employees or manager. But, it is very differ with compound problems. Compound problems include simple problems and their solution is therefore partly deductive. It involves all departments in a company because it might relate to financial, condition of products and etc. Engineering needs teamwork. This is one of vivid example where engineers brainstormed themselves finding the best way to solve problem. However, understanding engineering thinking leads to better training of engineers as society's servants. I tell about problems in engineering because this is our task where exploring the problems engineers face in their jobs.

Basically, what I have got is assignment 1 taught me a lot of thing as a university student. One should be able to work in a team because almost the assignments need everyone contribution to make it success. Besides that, time management should be excellent. A team must have a table such as Gantt Chart which emphasize how we work in well timed. Working in a team is also need a lot of sacrifices. Sometimes, we must leave our leisure time, contribute some money and so on. All these are called sacrifices. I believe that this is the preparation and training for us to be a good engineer in the future. Engineer must be strong, smart and think critically. Currently, my goal is learning to be a good engineer soon. So, this is my first milestone to measure my ability in engineering. Surely, I must transform myself to achieve my goal. Our attitude pictures how we plan our future. Guys, when we think something, we must solve it however.

Then, we proceed with Low Carbon Society. Generally, LCS is divided into 3 stages named Stage 1, Stage 2 and Stage 3. I will tell for all stages. In the first stages, we are approached with the concept of LCS and about benchmarking. We can define easily now what is LCS meant. LCS is concept where we want to minimise the intensity of carbon emission in a sustainable development. How about sustainable development? It means that the development which take impact on the environment and take the opportunity to minimize environmental deterioration.

So, in a simple nutshell, sustainability must be considered seriously in order to create low carbon society. We must sustain our natural resources for the next generation and to be mindful, we need to take the actions now. We must avoid littering into the rivers, reduce the cutting down of trees activity, apply 3R concept (reduce, reuse, recycle) seriously and so on. It is vital to implement sustainable development in every single town planning and whatever. I also know the benchmarking process and how we want to conduct with this matter.

Basically, in stage 1 of LCS, I learnt about cooperation. During the learning process, I learnt to be cooperative with the teammates. This is very important to make all of us to work well. Everyone should generate ideas to develop a discussion. Then, In order to realize cooperation, someone will ask all the team members if have anything to convey. Indirectly, it gives chance for all of us to participate in the confabulation. Besides that, in order to make us to work well, everyone will encourage each other. Someone will challenge to make better in certain work. It prepares us to be more alert and stay strong to get through obstacles now and in the future.

We proceed with stage 2 of LCS. Basically, in stage 2, we making observation about electricity consumption and finding possible efforts in order to reduce carbon emission. About electricity consumption, we take average electricity consumption. We plan a method in order to find the average. The methods are quite easy but before, I had never to care about all these things. For the family, we just take reading of power meter at our home everyday start from 7.00 am and continuously in the next morning in one week. So, in a day we got to know the average electricity consumption. After completing all the data, the result is 9.1kWh per day. I think it is quite high. A family should consume the home appliances wisely to reduce energy which create abundant of carbon release. Other than that, I also know about methods have been used to approach with LCS mission. For overall conclusion in stage 2, l learnt about how to calculate average consumption. Along completing the stage 2 report, I can absorb and learn new things which provide me about maturity in thinking and also learn to be flexible person. Honestly, stage 2 asks the students to think critically. To come out with the result of average consumption, we need to be smart in choosing the ways to calculate it.

For stage 3, it this is our final LCS part where we produce a solution to achieve Low Carbon Society mission. We produce Smart Rainwater Harvesting (SmaRH) system. This idea is actually come after analysing the problem in the school. We consider all the cost for installation and the economic analysis either it brings positive impact or not. This stage is the most challenging part because it is closer to final examination. Other than that, in this subject, we also learn some basic calculation. Chapter 2 is quite easy for me but chapter 3 was terrible especially discussing about pressure. This calculation is fundamental knowledge for chemical engineering students actually. All of us need to master it before entering into second year and above. In conclusion, for the entire subject, I was really happy and feel good after taking this subject. It teaches me about team working through CPBL project. I feel great taking this subject because it taught me about well time management.

RJ1M1

Lecture : 27/11/2012	CLASSROOM OBSERVATION	
<u>Closure for stage 2</u> Introduction to stage 3 Propose the solution. What is SD? What is carbon footprint? What is Kyoto Protocol? As chemical engineer, your contribution is higher How you measure, how your react when your face with a problem? What is your strength and weaknesses? Discover yourself	Motivation The Johari Window (Joe Ingham and Harry Luft) How to manage stress? How you develop your intellectual development? 1.Coping with change Determine level of performance. 2. Performance Level of a team -rotate the roll that everyone will experience as a leader. -get to know one and other. -how to handle teamwork -How to deliver a job **Blake and Mouton Conflict Model (Model of relationship & Goal)** Which is more important, relationship or goal in team working? -Confront -Force -Withdraw -Smooth	Skills Team working Leadership
<u>Stage 3-</u> Problem restatement and problem identification.	**<u>Lecturer</u>** What is the problem all about? What are the expectations? engineering element Cost effective User friendly Practical Thing solution from other places and suited with your problem that suitable with our culture and country How you know that your solution is practical? Go to the site and talk to the people	**<u>Activities</u>** Team PR & PI (3 minutes discussion) Preparing KNL table <u>Learning issue</u> How to estimate the budget? - Cost effective - Don't consider any Sit in a team mate and discuss about what question you want to ask?

APPENDIX G

ANALISIS OF STUDENTS' REFLECTIVE JOURNAL

(i) Thematic Analysis (Validation by Expert)
(ii) Example of Mind Map

VALIDATION BY EXPERT

1. Students' Knowledge Development

Construct of Knowledge	Excerption	Yes	No	Remarks
Declarative Knowledge	1. Definition			
	Actually, sustainable development means that the development which make an impact on the environment and take the opportunity to minimize environmental deterioration. *(RJ1S1)*	✓		
	In the simple words, Low Carbon Society is the society that emits greenhouse gases only in an amount which can be absorbed by nature since there is too much carbon dioxide in our environment that can lead to the global warming and climate change. *To minimize the intensity of carbon emission in a sustainable development..* *(RJ3S1, RJ1S1)*	✓		
	What is FWRC? FWRC is the process that converts food waste into value added products... can reduce negative effects to the environment, preserve energy and resources. *(RJ7S1)*	✓		
	Bench marking is a process to find the best practices to have a great performance. *(RJ3S2)*	✓		
	I also know about the real meaning of eco-living. Eco-living is the sustainable use of natural resources....the principles of eco-living are conserve resources, conserve energy, reduce waste, reduce pollution and release of harmful substances into the environment and protect the earth's ecological balance with other living things. *(RJ3S3)*	✓		
	2. Information			
	Before this, I'm not aware about Iskandar Malaysia but now I know about it. With the rapid development of Iskandar Malaysia, IRDA as the authority that responsible to look upon the progress development of Iskandar Malysia to become a LCS region in order to save the environment despite of the rapid development. *(RJ2S1)*	✓		
	Japan is one of the clean countries in the world and has many advance technologies *(RJ4S1,RJ3S1)*	✓		

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	In Scotland, the used of insulator house to replace air conditioning. The purpose of insulator houses is to reflect the heat by changing its glass color to white and absorb during the days by changing its glass color to black. (RJ6S3)	✓		
	In Japan, introduce hybrid car which eco-friendly and use of hydrogen gas for electricity…to replace or minimize the use of energy. (RJ6S3)	✓		
	…There are so many efforts being done by other countries to become low-carbon society and implement sustainable development concept. (RJ2S1)		✓	Very general
	I also learnt about resource conservation area to find out which particular area that we should focus on, such as water, solid waste and energy. (RJ3S1)		✓	This is student perception/ reflection.
	From the survey, we found that plastic bottles are the highest solid waste that is thrown by the people. (RJ5S3)	✓		
	After benchmarking between those countries, I gain extra information and knowledge		✓	
	From the questionnaire…, we found that the average of water consumption at recreational park is low as compared to school and kindergarten (RJ4S3)	✓		
	I found that only small percentage of Malaysian people that really care about our environment. (RJ4S1)	✓		
	Many countries include our country normally practice land filling method to deal with food waste which is not the most environmental friendly manner. In fact, when food waste disposes in landfill sites, they will release methane gas which is 21 times more harmful than carbon dioxide which can lead to global warming. (RJ7S1)	✓		
	Actually, carbon nanotubes have high tensile strength which is stronger than steel an also can produce electricity very well…have multiple advantages…can be mixed into polymer to manufacture components of cars and also in making of paper batteries. (RJ7S1)	✓		

	Before this assignment, I never realize that the amounts of food waste that we produce are about 670 million tonnes per annual. (RJ7S2)	✓		
	There are many type of energy such as fossil fuels, electricity and others. (RJ6S2)	✓		
	In this stage, I know how solid waste is related to carbon emission, effort that have been done in order to reduce and conserve solid waste, and estimate the average quantity of solid waste disposal per person. (RJ17S2)		✓	
	Fossil fuels are non-renewable resources and also contribute in producing carbon (Carbon Monoxide) during the process of combustion. (RJ6S3)	✓		
	I learnt a lot about low carbon society.... I realize Malaysians are actually one of the countries that waste more water than the amount we need... I myself actually reflect what I did in the past few years which are not helping the country in its development of a sustainable region and there are lots of small matters which we overlooked that can deteriorate the environment. I realize my roles in sustainable development of the country and not only in this project or Iskandar Malaysia (RJ22S3)		✓	Reflection
	I discovered that different waste product has its own ways to be managed. There also has bad effect if the resources do not manage properly. (RJ18S2)		✓	
	I can conclude that Malaysian is far worse in water management.. I have learnt many new things such as the water resource situation of the world and Malaysia itself. Malaysia is still creating framework, policies and regulations to manage water resources. The Malaysian also is not very aware about the rising water demand situations in Malaysia. (RJ12S2		✓	
Procedural Knowledge	1.Processes *This product involves the Chemoluminescence Reaction and Photochemmistry Reaction. The material use in this product is the baking powder, mountain dew, hydrogen peroxide and glass tube of glow stick.* *Then, we make costing analysis....The other prices involve costing for installation and profit.* (RJ5S3)	✓ ✓		

	Basically, the system is just about collecting rainwater and channel them directly to flushing tanks in the toilets. (RJ4S3)	✓		
	We need to learn about the process in turning waste cooking in to carbon nanotubes… to make sure that our solution is sustainable and economical. (RJ7S3)	✓		
	A lot of things that I and my group have learned such as how to reduce carbon emissions into the atmosphere… (RJ6S2)		✓	
	To develop electricity system using waste water and be used as supportive system. (RJ2S3)		✓	
	We have learnt many things in this school because they very concern about environment and green living…they plant trees and every class also decorated using the concept of green living. (RJ3S3)	✓		
	…we calculate the average of how much solid waste produce per person and compare with the standard world record. (RJ28S2)	✓		
	2.Strategies			
	The main function for gloomy bottle is to make aglow in the dark. We know that most of light is produce by device that uses electrical energy or kinetic energy. But in this project, we use chemical reaction to produce the light. (RJ5S3)	✓		
	The rainwater…mixed together and consequently conserves the water and lowering the carbon emission. (RJ4S3)	✓		
	…we have chosen the solution which can turn waste cooking oil into carbon nanotubes. (RJ7S1)		✓	
	Actually our concept is to make the society recognize that they should not just rely on the electricity supply from the power grid (TNB) but find other alternative to make their own electricity supply…Propose an alternative solution for power supply at home…'Waste Water Hydroelectric Generator' (RJ2S3)	✓		
	One of the task is we need to estimate the water consumption per day for every student in UTM, each member of our family per day. After that we analysed the data and propose way to reduce	✓		

	water usage effectively in the given specific area that have been given, (RJ15S2)			
	We plan to look at the water meter for each block but it too dangerous. Therefore, we make a survey and get feedback from 40 students in Kolej Tun Dr. Ismail. From the collected data, we managed to estimate the water consumption per day for each student. (RJ15S2)	✓		
	We propose a solution using the concept of rainwater harvesting tank to reduce carbon emission in recreational area. A systematic system which includes gutters to collect rainwater and a system of pipes that will automatically channel the rainwater into the flushing tanks in the public toilet. (RJ11S3)	✓		
	We propose an auto-sort machine to transform plastic bottle to make a shirt. From the literature, a plastic called 'polyethylene terephthalate' or "PET" can be transform into t-shirt after undergoes some processes. (RJ28S3)	✓		
	Denmark local authorities are responsible for the treatment of household, commercial and hazardous waste. About 65% wastes are being recycling. (RJ28S3)		✓	
Effectiveness Knowledge	1.Impact			
	The importance to conserve nature as our main living things. Because the ill effects of carbon will make our life miserable in the future. (RJ4S3)	✓		
	The current food waste generation habits that include over-buying and don't use up the leftovers mainly contribute to the negative impact to the environment. (RJ7S1)	✓		
	During Stage 2, a lot of things that I have learned especially the effect of our daily life activities to the environment. There are many things that could affect the amount of carbon emissions...eg. Every day we use the electricity in wrong manner. (RJ6S2)	✓		
	There are a lot of things that I have learned especially the effect of our daily life activities to the environment. Every day we over use the electricity which lead to produce high carbon emission. (RJ6S3)	✓		

	water usage effectively in the given specific area that have been given. (RJ15S2)			
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	We propose a solution using the concept of rainwater harvesting tank to reduce carbon emission in recreational area. A systematic system which includes gutters to collect rainwater and a system of pipes that will automatically channel the rainwater into the flushing tanks in the public toilet. (RJ11S3)	✓		
	We propose an auto-sort machine to transform plastic bottle to make a shirt. From the literature, a plastic called 'polyethylene terephthalate' or "PET" can be transform into t-shirt after undergoes some processes. (RJ28S3)	✓		
	Denmark local authorities are responsible for the treatment of household, commercial and hazardous waste. About 65% wastes are being recycling. (RJ28S3)		✓	
Effectiveness Knowledge	1.Impact *The importance to conserve nature as our main living things. Because the ill effects of carbon will make our life miserable in the future.* (RJ4S3)	✓		
	The current food waste generation habits that include over-buying and don't use up the leftovers mainly contribute to the negative impact to the environment. (RJ7S1)	✓		
	During Stage 2, a lot of things that I have learned especially the effect of our daily life activities to the environment. There are many things that could affect the amount of carbon emissions...eg. Every day we use the electricity in wrong manner. (RJ6S2)	✓		
	There are a lot of things that I have learned especially the effect of our daily life activities to the environment. Every day we over use the electricity which lead to produce high carbon emission. (RJ6S3)	✓		

	We did an interview by asking about living green…most of them said that electricity bill is higher compared to water billing due to the installation of air conditioner at their home. (RJ2S2)		✓	
	This assignment truly has given some lessons to me which I don't realize during my lifetime. When the technology seems have controlling our routine life, we forgot about the nature itself. We emit carbon without we realized that its affect environment. There-s a lot of consequences we might face such as greenhouse effect, global warming and a lot more. That's realized me to always be alert to our nature itself and for our next generation in years to come. (RJ33S2)	✓		
	In our daily life, we often forgot the fact how wasteful we have done. We never did take note of managing the usage of water and energy in a sustainable way. We open the tap and let the water flow while brushing our teeth. We did not switch off the fan when we were not in the room. (RJ29S3)	✓		
	I found that the electrical power per capita in Malaysia always increased from year to year… meant that we did not found yet the ways to conserve energy especially electric energy and Malaysian people still did not care about conservation of energy…. I hope after this Malaysian people will concern about conservation of energy (RJ24S2)	✓		
	2.Benefit *Our product is useful and practical for various places and everyone can use it as it is very easy to use, cheap and environmental product. Eg. The product can replace the function of torchlight, emergency lamp and also can be used as bedside lamps…save and conserve the energy.'* (RJ5S3)	✓		
	I learnt others countries such as Japan and Europe…most of the countries teach their citizen to become a society that has sustainable mentality and care about the environment…They develop system to manage their resources to avoid waste. (RJ2S1)		✓	
	This assignment has taught me the importance of keeping our environment from destroyed by irresponsible parties. (RJ6S2)		✓	
	This assignment taught me a lot about how to manage a resource wisely so that this resource can remain in use for the community, our children and grandchildren in the future. (RJ6S3)		✓	

	Scotland also has good technologies and their citizens also practice a good healthy lifestyle such as cycling, walking and others. *(RJ3S1)*	✓		
	They also very committed with water conservation in order to educate the student to take care their environment. *(RJ3S3)*		✓	
	it taught me a lot about how to manage a resource wisely so that this resource can remain in use for the community and our children and grandchildren in the future. *(RJ21S3)*	✓		
	I did not know anything about low carbon society but then after completed this task I realized there are so many effort being done ... I realize about the current environmental condition and what will happen if there is no effort to save it for our future generation. *To make IM a LCS we ourselves need to change attitude in our daily life. Citizen need t o have sustainable mentality and care about the environment condition.* *(RJ2S1)* *)*	✓		
	I know the effort that has been done by Malaysia in order to reduce carbon emission and still in progress to find the most effective way to reduce carbon emission. *(RJ16S2)*	✓		
	Awareness *I also get to know how Malaysia managed the resources and the effort to conserve the environment through campaign...to increase the awareness among citizen and teach the new generation to care about environment.* *(RJ2S1)*	✓		
Social Knowledge	1. Engagement			
	There are simple solutions on how we can create sustainability in our routine days. If everyone gives positive contribution, it might help our Earth keep green all the time. *(RJ1S1)*	✓		
	From the site visit and interview session with the local community, we know the actual problem in solid waste management in the residential area. *(RJ6S3)*	✓		
	We are responsible to clean our environment since we have polluted it. In order to make this happen, everyone is needed to	✓		

	contribute and work together. (RJ3S1)			
	Parents, teachers, government should play their role to increase the awareness about our current condition of the environment to the society so that we can live in a clean and comfortable environment. (RJ3S2)	✓		
	The most important part is I know a lot more about carbon. I have study about carbon dioxide before but not in detail like right now. I really not care about environment before this but now I realize about our role as community as one of the main contributor of carbon emission to the atmosphere (RJ33S1	✓		
	I do hope that one day all Malaysian citizen can come to their concerned and that everybody can play their role in creating a low carbon society in the future... As for myself, I'll always try to use paper at a minimal level and use electricity and water wisely. In addition, I'll use public transportation and car-pool whenever I have to travel. (RJ11S3)	✓		
	From the data collection, we realize that Malaysian people unaware about solid waste management, They know about SWM but do not practice it in their daily life. (RJ82S2)	✓		
	we all gain more information about this problem and it increase our awareness on this matter. What I hope, we can practice it.... (RJ8S3)		✓	
	I had learn new thing in this stage. I know how much solid waste has been generated per person in Malaysia and world-wide. It is a large amount of solid waste, so we have to play our role in order to reduce it to save our earth. I hope that this research will make us aware of the importance of a low carbon society. (RJ16S2)	✓		
	I realize that Japanese is very good because they not only aware with their environment but they practicing eco-living lifestyle. However, Malaysian people are only aware with the environment but do not really care on how they can do to save the environment. (RJ18S2)	✓		
	We must save the world we are living in. Even a little we can do to realize LCS, the result might be boom to the world. (RJ28S3)	✓		
	2. Soft skill			

	By completing this project, critical thinking is very important to come out with the effective solution to help our society and our environment. *(RJ3S3,RJ1S2)*	✓		
	During completing STAGE 2, I can absorb and learn new things which provide me about maturity in thinking and also learn to be flexible person *(RJ1S2)*	✓		
	I feel great taking this subject because it taught me the skill of time management. *(RJ1S3, RJ3S1)*	✓		
	...I plan and manage my activities. Besides, my life also systematic and organize. *(RJ5S3)*	✓		
	In conclusion, for the entire subject, I was really happy and feel good after taking this subject. It teaches me about team working through CPBL. *(RJ1S3)*	✓		
	I leant how to deal with people and work in a team...for me I have improved my soft skill. *(RJ2S3)*	✓		
	3. Networking			
	This is a new experience for us to deal with the school office management. *(RJ3S3)*	✓		
	This project also help me to be confident to communicate to other people, how to approach them and make them comfortable during the interview session. *(RJ5S3)*	✓		
	My team mates also help me to improve my communication with other people. *(RJ5S3)*	✓		
	Overall what I gained from this stage is... to be confident when dealing with other people. *(RJ4S3)*	✓		
	In the LCS task, we interview the local community	✓		
	4. Collaboration/Networking			
	Work in a team makes us stronger and we can learn from each other.	✓		

	(RJ3S3)			
	Learnt how to deal with people and work in a team. *(RJ2S3)*	✓		
	Teachers and parents especially must play their role and try to be as a good role model to the children in creating sustainable lifestyles. *(RJ1S1)*	✓		
	We make discussion among our team and we choose to generate electricity from the waste water at home. *(RJ2S3)*	✓		

2. Students' Perception on Level of Sustainable Knowledge and Awareness towards Sustainability

Construct	Excerption	Yes	No	Remarks
Sustainable Knowledge	*I never heard about FWRC (Food Waste Reuse Concept) before in my life....After done the assignment; I have much understanding on sustainability and the impact of FWRC on society, economic and the natural environment.* *(RJ7S1)*	✓		
	To be honest, I had never heard of the concept before and I thought that it is not my matter...I feel thankful to God because my way here is trying to conserve the nature. *(RJ1S1)*	✓		
	After completing Stage 1, I have learnt many things about our current environment, myself, my team even the preparation to be an engineer in the near future. *(RJ1S2)*	✓		
	First of all, what I get from Stage 1, I know a lot of new terms that I never heard before, for example bench marking and sustainable. *(RJ4S2)*	✓		
	During Stage 2, I have learnt a lot especially on the effect of our daily life activities on the environment. *(RJ6S2)*	✓		
	I've never heard about LCS and Iskandar Malaysia. *(RJ4S1)*		✓	

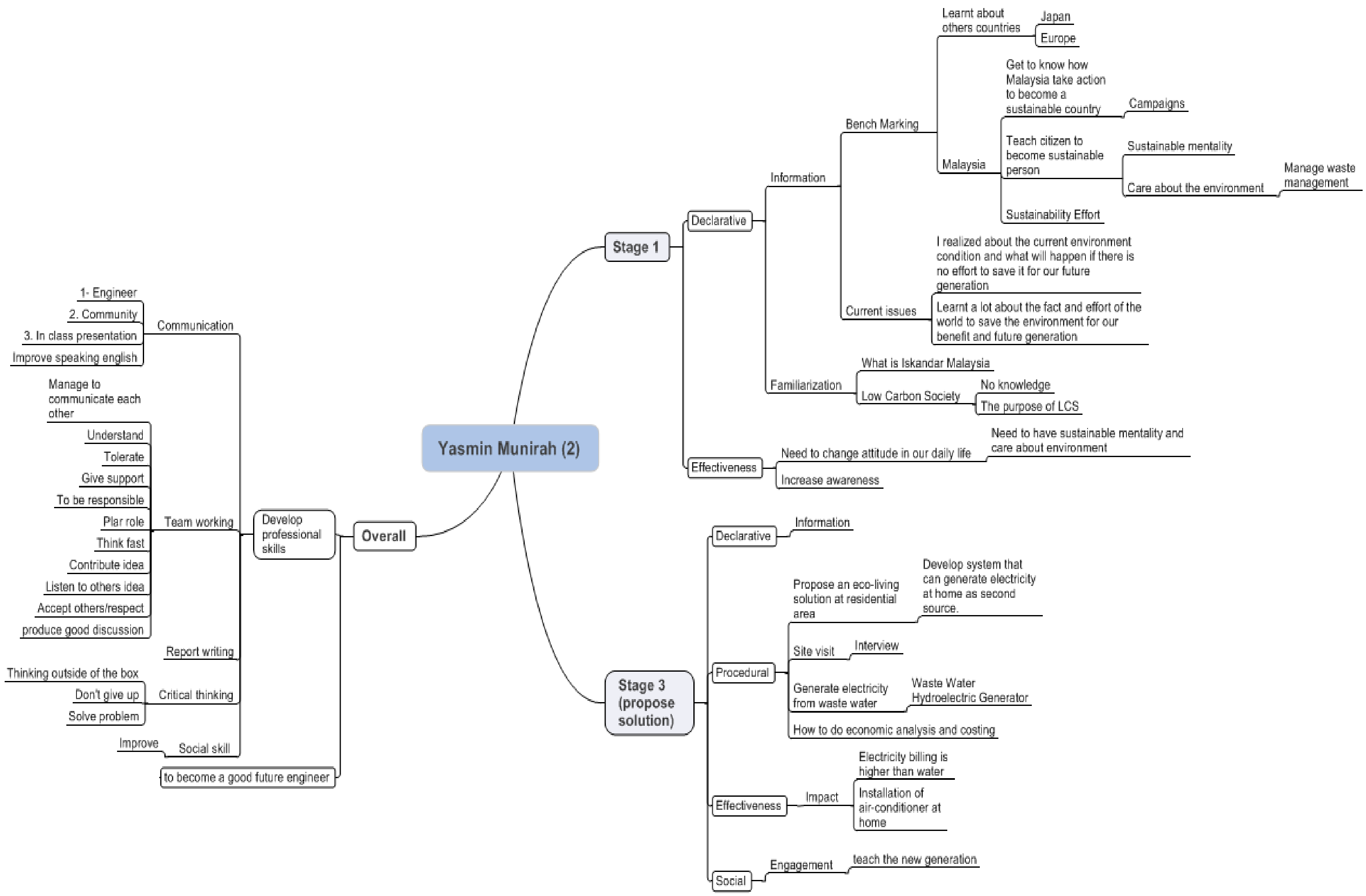
	During completing Stage 1, I have learnt many things about our current environment and about myself. (RJ4S2)	✓		
Pro-environmental behaviour	*I really not care about environment before this but now I realize about our role as community as one of the main contributor of carbon emission to the atmosphere.* (RJ4S2)	✓		
	I never realize that the amount of food waste that produced by human kind is about 670 million tones /annual…we really didn't appreciate the value and importance of food. (RJ7S1)	✓		
	We must sustain our natural resources for the next generation and to be mindful, we need to take action now. We must avoid littering into the rivers, reduce cutting down of trees, apply 3R concept seriously and so on. (RJ1S1)	✓		
	I also realize that we are one of the main contributors on climate change, so that we must keep our awareness and take action on it. (RJ6S3, RJ3S2)	✓		
	In Malaysia, we are still lacking on environmental awareness, some of them realized but did not care at all. (RJ2S2)	✓		
	Try to appreciate our Mother Earth while they are still exists. (RJ4S3)	✓		

3. Students' Perception on Motivation

Construct	Excerption	Yes	No	Remarks
Motivation	1. Preparation to be a future engineer			
	After completing Stage 1, I have learnt many things about our current environment, myself, my team even the preparation to be an engineer in the near future. (RJ1S2)	✓		
	Actually, it is a competition that improves our soft skill as a future engineer. (RJ3S3)	✓		
	This subject has been really a great opportunity for me to brush up my potential and soft skill to become a good engineer	✓		

	in the future. (RJ2S3)			
	I hope I will learn more to be a good engineer in the future that can contribute to the society and our life...take care for the next generation. (RJ3S3)	✓		
	As a future chemical engineer, of course we had to practice doing research and make a solution that relate to our course. (RJ5S3)	✓		
	This subject truly can help me to have better understanding on what engineers do in their works and how to become a better engineer in the future. (RJ7S3)	✓		
	I do realize I need to be a person that think fast (decision making), aware of the situation and have critical thinking and always be positive...think out of box.. (RJ2S3)	✓		
	In addition, in order to be a good engineer, we need to follow the code of ethics and never break the laws for own benefits. (RJ7S3)	✓		
	Finally, I like to express that this course has help me and guide me how to become a better student and more than that is human being. (RJ5S3)	✓		
	She advice that....the real situation as an engineer is totally different from our imagination and challenging. After I heard that, I change my attitude and try to do more action than complain. (RJ5S3)	✓		
	Emotionally part, stage1 really taught me a lot. This CPBL really taught me to be very independent and not too rely on other people. (RJ5S1)	✓		
	Develop Skills			
	We have to improve our communication skills because as an engineer we have to deal or face with a lot of people with different styles and background. (RJ4S3)	✓		
	I found that team working skill is tremendously important to accomplish task. (RJ7S3)	✓		

	Critical thinking and problem solving skills are the most vital elements to become successful engineer in the future. *(RJ7S3)* *This assignment enhance my presentation skills, time management skills, team working skills and problem solving skills in order to get me ready for my future especially in job market.* *(RJ6S3)*	✓ ✓		
	Student Satisfaction *In conclusion, this assignment has a lot of value added. It is great and memorable experience.* *(RJ2S3)* *WE have gone through many new experiences in order to complete this project...it is very fun and fantastic...I'm very thankful because we have given a chance to do the project.* *(RJ3S3)* *Finally, I like to say that this course has help me and show me how to become the better student and more than that is as human being.* *(RJ5S3)* *What skill that I leant most through this course is to improve my communication skills.* *(RJ4S3)* *I am really happy and feel good after taking this course. It teaches me about team working through CPBL...I feel great taking this course it taught me about well time management.* *(RJ1S3)* *As my conclusion, this course has taught me a lot...teach me in enhancing my presentation skills, generic skills, time management skills, team working skills and problem solving skills in order to get me ready for my future especially in job market.* *(RJ6S3)*	✓ ✓ ✓ ✓ ✓ ✓		



Example of Analysis Students' Reflection using Mindmap

APPENDIX H

LIST OF PUBLICATIONS & AWARDS

Journal and Conference Papers

1 Khairiyah Mohd Yusof, Aziatul Niza Sadikin, Fatin Aliah Phang and Azmahani Abdul Aziz1, Instilling Professional Skills And Sustainable Development Through Problem-Based Learning (PBL) Among First Year Engineering Students* *International Journal Of Engineering Education* Vol. 32, No. 1(B), Pp. 333–347, 2016

2. Azmahani Abdul-Aziz & Khairiyah Mohd-Yusof ;Effective use of Problems in Instilling Sustainability knowledge and Behavior among First Year Engineering Students, *International Conference on Sustainability Initiatives (ICSI) 2015 in conjunction with 8th ASEAN Environmental Engineering Conference (AEEC),* Kuala Lumpur, Malaysia, 24-25 August 2015

3. Khairiyah Mohd-Yusof, Fatin Aliah Phang, Azmahani Abdul Aziz, Mohd Johari Kamaruddin, Mimi Haryani Hassim, Haslenda Hashim, Aziatul Niza Sadikin, Jamarosliza Jamaluddin, Norhayani Othman, Hashim Hassan, Syed Ahmad Helmi & Zaini Ujang; Inculcating Sustainable Development among Engineering Students, Part 1: Designing Problems and Learning Environments with Impact,*International Conference on Enginering Education for Sustainable Development*, Cambridge University, United Kingdom, 2013

4. Azmahani Abdul-Aziz , Khairiyah Mohd-Yusof, Amirmudin Udin, Adibah Abdul-Latif & Jamaludin Mohamed-Yatim; Inculcating Sustainable Development among Engineering Students, Part 2: Assessing the Impact on Knowledge and Behaviour Change, *International Conference on Enginering Education for Sustainable Development,* Cambridge University, United Kingdom, 2013

5. Azmahani Abdul-Aziz, Khairiyah Mohd-Yusof, Amirmudin Udin, Jamaludin Mohamad-Yatim, Wan-Haslina Hassan, "Inculcating Awareness of Sustainable Development in First Year Engineering Students - A Comparative Study of Pedagogical Approaches", *Proceedings of the Research in Engineering Education Symposium* 2013, Julai 2013, Putrajaya, Kuala Lumpur.

6. Azmahani Abdul-Aziz, Khairiyah Mohd-Yusof, Amirmudin Udin, Jamaludin Mohamad-Yatim, "A Longitudinal Study on the Impact of Cooperative Problem-Based Learning in Inculcating Sustainable Development", *The 4th International Research Symposium on Problem-Based Learning (IRSPBL)* 2013, Julai 2013, Putrajaya, Kuala Lumpur.

7. Azmahani Abdul Aziz, Khairiyah Mohd Yusof, Amirmudin Udin, Jamaludin Mohamad Yatim, "Development of Students' Knowledge-Behavioural Changes in Relation to Sustainability through a Case Study", *Journal of Procedia – Social and Behavioral Sciences*, Elsevier Publisher, Vol 102, pp 568 – 576, 2013.

8. Azmahani Abdul Aziz, Sharipah Norbaini Syed Sheikh, Khairiyah Mohd Yusof, Amirmudin Udin, Jamaludin Mohamad Yatim, 2012***;*** Development a Structural Model of Assessing Students' Knowledge-Attitudes towards Sustainability, *Journal of Procedia- Social and Behavioral Sciences.* Elsevier Publisher, Vol. 56 , 513-522

9. Azmahani Abdul Aziz, Sharipah Norbaini Syed Sheikh, Khairiyah Mohd Yusof, 2012***;*** Perception on Sustainable Development among New First Year Engineering Undergraduates, *Procedia in Social and Behavioral Sciences*, Elsevier Publisher, Vol. 56 , 530 -536

10. Azmahani Abdul Aziz, Khairiyah Mohd Yusof, Amirmudin Udin, Jamaludin Mohamad Yatim, "Development of Students' Knowledge-Behavioural Changes in Relation to Sustainability through a Case Study", *Proceeding of 6th International Forum on Engineering Education*, Kuala Lumpur, 2012.

Book of Chapter

1. K.Mohd-Yusof, S.R. Wan Alwi, A.N. Sadikin, A. Abdul-Aziz, "Inculcating Sustainability Among First-year Engineering Students Using Cooperative Problem-based Learning", *Chapter in Book, Sustainability in Higher Education*, Chandos Publishing, 2015

2. Azmahani Abdul-Aziz, Khairiyah Mohd-Yusof, Amirmudin Udin, Jamaludin Mohamad Yatim**,** "A Longitudinal Study on the Impact of Cooperative Problem-Based Learning in Inculcating Sustainable Development", *Chapter in Book, PBL Across Cultures*, Aalborg University Press, Denmark, 2013.

LIST OF AWARDS

1. Khairiyah Mohd Yusof, Azmahani Abdul Aziz, Fatin Aliah Phang Abdullah, Aziatul Niza Sadikin, Mimi Haryani Hassim, Zaki Yamani Zakaria, Azizul Azri Mustaffa, Mohd. Kamaruddin Abd. Hamid, ***Effective use of Problems in Instilling Sustainability Awareness and Behavior among First Year Engineering Students,***Innovative Practices in Higher Education Expo, I-PHEX 2014. (Best of The Best Award)

2. Khairiyah Mohd Yusof, Azmahani Abdul Aziz, Aziatul Niza Sadikin, Mimi Haryani Hassim, Norhayani Othman, Jamarosliza Jamaluddin, Mohd. Johari Kamaruddin***, Innovative Approach for Inculcation of Sustainable Development among Future Chemical Engineers,*** IChem Malaysia Awards for Innovation and Excellence, 2013, (Education and Training Award)