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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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.

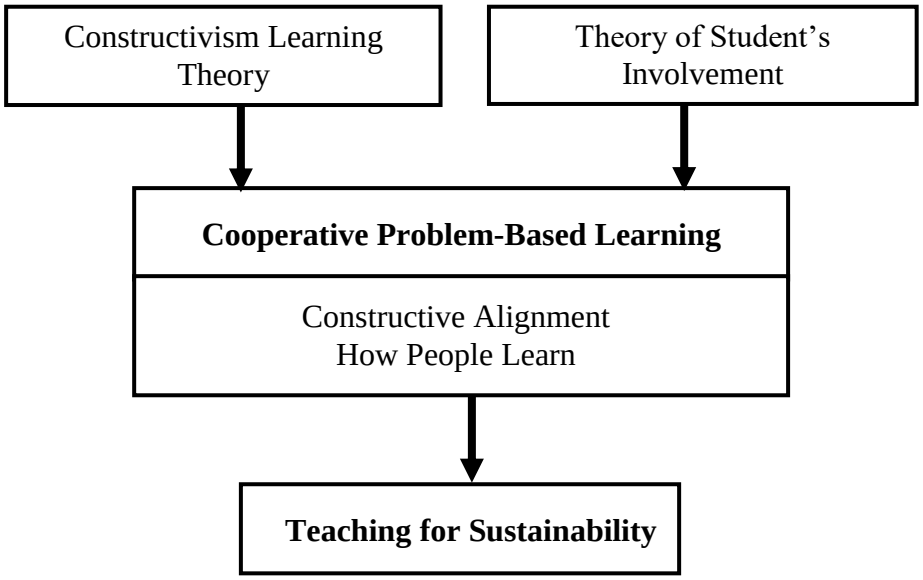


Figure 1.1 Theoretical Framework of Research

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.

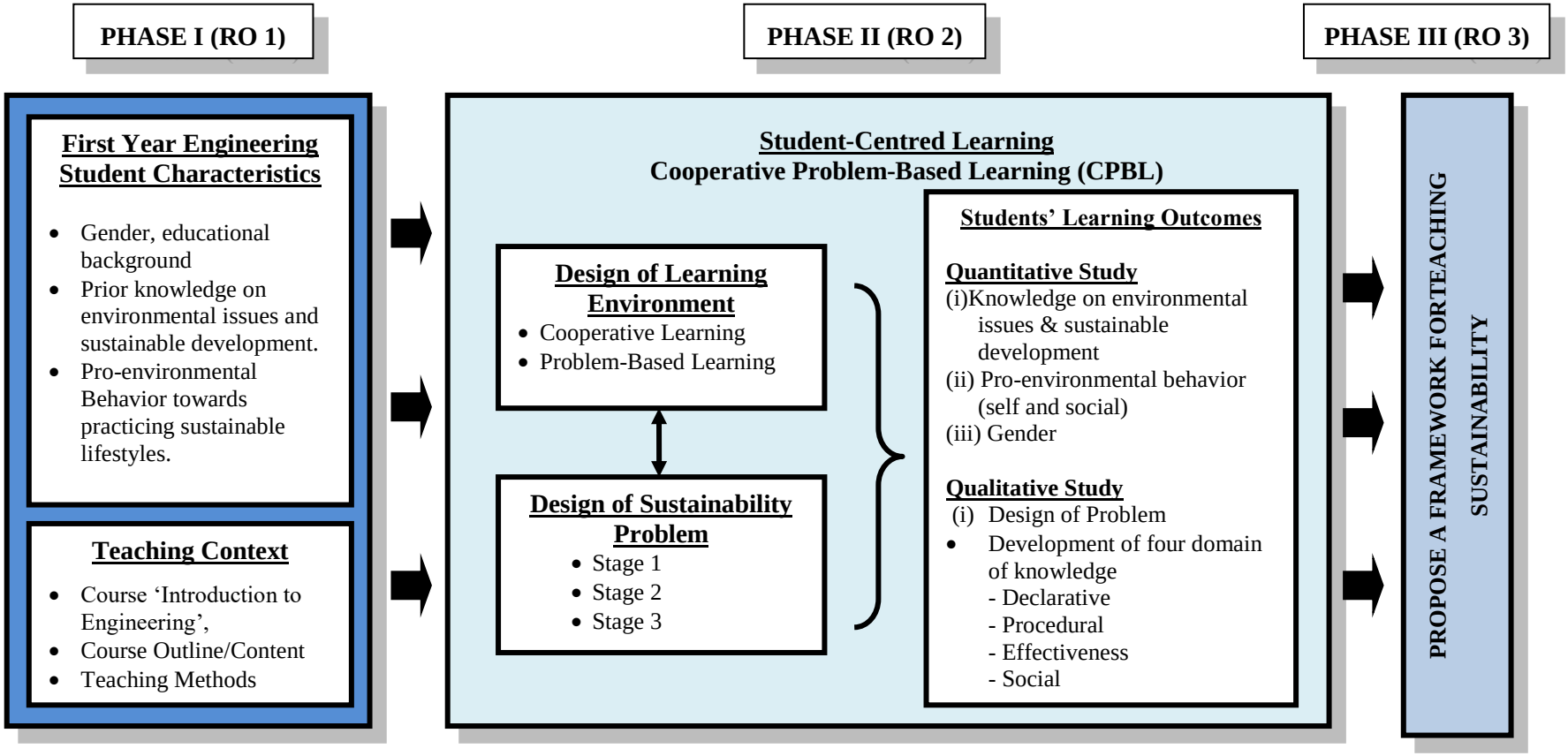
1.7 Conceptual Framework

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.

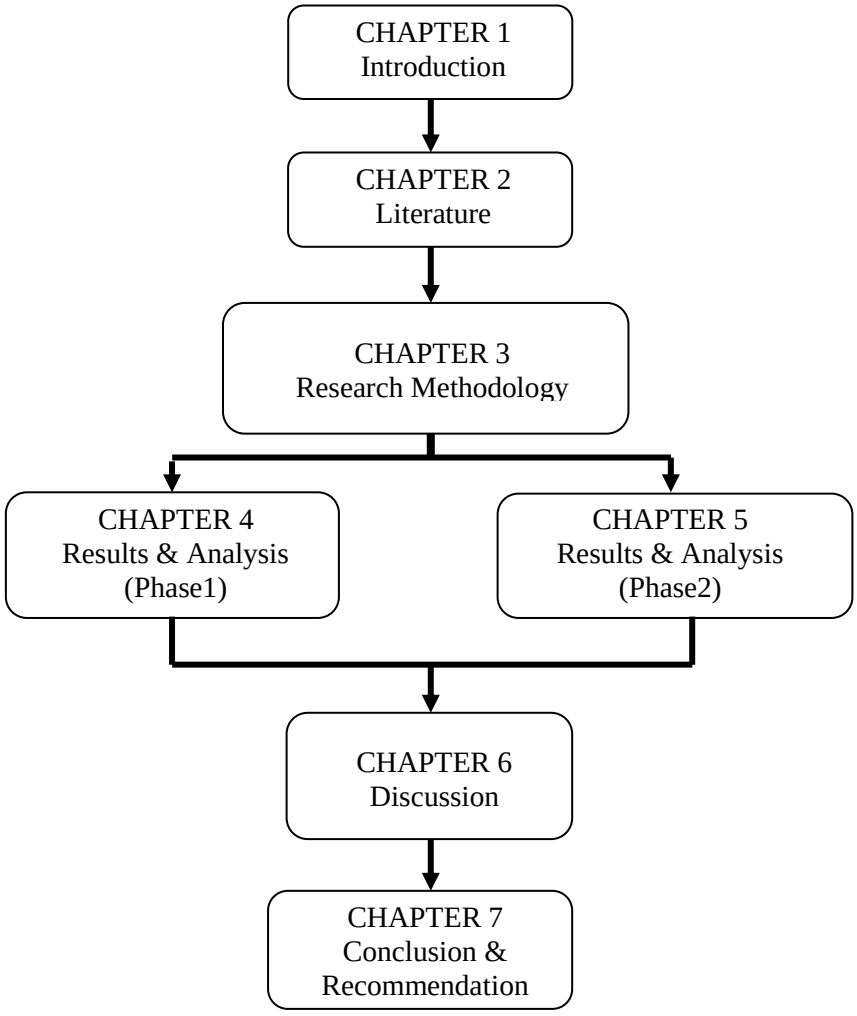


Figure 1.3 Flow of Thesis Organization

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.

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