International Journal of Engineering Education Vol. 32, No. 1(B), pp. 333–347, 2016
Printed in Great Britain

0949-149X/91 $3.00+0.00

Instilling Professional Skills and Sustainable Development through Problem-Based Learning (PBL) among First Year Engineering Students*

KHAIRIYAH MOHD YUSOF[1,2], AZIATUL NIZA SADIKIN[1,2], FATIN ALIAH PHANG[1,3] and AZMAHANI ABDUL AZIZ[1,4]
[1] Centre for Engineering Education, Universiti Teknologi Malaysia, 81310 Johor Bahru, Malaysia.
[2] Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, 81310 Johor Bahru, Malaysia.
[3] Faculty of Education, Universiti Teknologi Malaysia, 81310 Johor Bahru, Malaysia.
[4] Faculty of Civil Engineering, Universiti Teknologi Malaysia, 81310 Johor Bahru, Malaysia.
E-mail: khairiyah@utm.my, aziatulniza@utm.my, p-fatin@utm.my, azmahani@utm.my

Developing sustainable development (SD) mindset and professional skills, such as problem solving, team working and communication skills, are crucial for engineering graduates of the 21st Century. Cooperative Problem Based Learning (CPBL), which is the infusion of Cooperative Learning (CL) principles into the Problem-Based Learning (PBL) cycle, had been shown to enhance learning while developing the desired professional skills and positive behavior. This paper describes a mixed method study on the impact of an Introduction to Engineering course on first year students as they go through three cycles of CPBL to solve a sustainability related problem. In the first part of the research, an exploratory study was conducted by analyzing reflective journals submitted by the students at the end of each CPBL cycle using thematic qualitative data analysis technique to determine the major themes in skills developed. The analysis show strong emergence of professional skills and SD. To determine the level of behavior change in SD for students who took the course, a quantitative study was then conducted. Although the students initially faced difficulties in developing the skills, by the end of the third stage, the students realized that they have managed to attain important skills and SD behavior essential as engineers of the future.

Keywords: problem-based learning; professional skills; sustainable development; reflective journals; cooperative learning

1. Introduction

The challenges of the 21st century require engineering graduates who are not only well versed in technical knowledge, but also in professional skills, such as problem solving, team working and communication skills. In addition, understanding of sustainable development (SD), which has been identified as one of the Grand Challenges of the current millennium, is imperative for engineering graduates since they are the innovators and problem solvers of the future. The importance of these requirements has been stated in various engineering education reports from throughout the world [1–3]. It is, therefore, not surprising that the Washington Accord made these professional skills and sustainability to be among engineering program outcomes required for accreditation.

For the member countries of the Washington Accord, the accreditation requirements on professional skills and SD as outcomes force engineering program owners to include them in the curricula.
Professional skills, such as problem solving, team working, communication, time management and leadership can be developed through effective teaching and learning approaches [4, 5].

To develop SD, Fiedler and Deegan [6] indicate that the motivation to change starts from knowledge which is essential for successful action to facilitate behavior change. According to Kaiser and Fuhrer [7], knowledge remains an important and highly significant predictor of environmental behavior. Therefore, incorporating environmental and sustainability issues into the early stage of education plays a key role in facilitating and fostering environmentally responsible behavior, and provides a strong foundation for more sustainable societies [8]. However, numerous studies found that there are deficient knowledge and awareness on sustainable development amongst students [9–13]. The issue is not just a matter of awareness and knowledge; it is about educating students so that SD becomes a habit of the mind that forms the characters of the students. This is crucial when educating future engineers, because as innovators and problem solvers, they are the source of wealth of a nation. Therefore, engineering educators have a great responsibility to educate future engineers from the first year to form these engineering habits of mind, which include systems thinking, creativity, optimism, collaborative, communication, and attention to ethical considerations, as well as sustainability [14].

In line with this current needs, educators have to

* Accepted 11 August 2015.

make a paradigm shift through pedagogical approach from passive to active learning to encourage deep learning. Students can perform an acceptable level of understanding when actively taught via experiential learning [15]. Active learning techniques, such as Cooperative Learning (CL) and Problem Based Learning (PBL), have been shown to enhance learning [16–18]. Both are instructional methods which develop the ability for students to "learn to learn" while working cooperatively in teams. PBL prepares students to think critically and analytically, and to find and use appropriate learning resources while developing the much needed professional skills [19, 20]. Additionally, research shows that PBL has been proven to engage students in deep learning, as well as change attitudes and instill various professional skills [21–26].

For this reason, Cooperative Problem Based Learning (CPBL) was utilized to instill SD among first year undergraduate engineering students while at the same time attain professional skills outcomes in the "Introduction to Engineering" (IE) course taken by Chemical Engineering students in a university in Malaysia. CPBL is the infusion of Cooperative Learning (CL) principles into the Problem-Based Learning (PBL) cycle to provide crucial support for students through the development of team-based learning skills, which will enable them to successfully undergo a PBL learning environment in a typical course setting [23]. CPBL has been shown to enhance motivation in learning and learning strategies, deep learning, as well as develop team based problem solving skills [4, 22, 26, 27].

This paper reports the findings of a mixed-method study on the impact of the "Introduction to Engineering" (IE) course as first year students undergo three cycles of CPBL to solve a sustainability related problem. A qualitative exploratory study was conducted to determine the impact on the development of professional skills and sustainability through a series of reflections written by students throughout the semester on their learning process and attainment of learning using thematic analysis. In addition, since instilling SD is of utmost importance, a quantitative study was conducted to determine the level of behavior change in SD for students who took the course.

2. Effective learning environment through CPBL

Various engineering education reports [1–3] from throughout the world emphasize on the need for graduates who are not only able to apply their technical knowledge, but also possess professional skills that can help them function well at the work place. These skills include problem solving, team working, communication, time management, leadership, etc. While there are possibilities of having additional courses to teach students these skills, the already overloaded engineering curricula leave little space for stand-alone courses to address each professional skill required. In addition, research shows that skills like problem solving must be taught in the context of the profession to be effective [28]. Thus, it is essential for engineering courses to implement effective learning environments that can help students to learn the content, while at the same time develop crucial professional skills.

To attain deep understanding of SD while developing professional skills among first year engineering students, the learning environment for the ITE course is designed based on Constructive Alignment (CA) [29] and the How People Learn Framework (HPL) [30]. Based on constructivist principles, CA asserts that both the teaching and learning activities (TLAs) and the assessment tasks (ATs) should support the development of the intended learning outcomes (ILO) among students, i.e. students form their knowledge, ability or attitude as they go through the activities in a learning environment that provide opportunities for constructing the desired outcomes. The HPL framework consists of four criteria that defines an effective learning environment that is conducive for learning: knowledge, learner, assessment and community centered. Knowledge centered means helping learners understand and learn knowledge that is organized with interconnections to the fundamentals of the discipline, in the context of the application and practice in the area. Learner centered means that learners' background, pre-conceptions, existing knowledge and skills, etc., are taken into account to create meaning and motivate learners. Assessment centered means that learners receive feedback through formative assessment and from peers to help them gauge their current performance and improve. Community centered means that the learning environment promotes a community among students and faculty members, developing a sense of belonging and bonding among them, which in turn creates an environment that is safe to participate, ask questions, venture into new things and make mistakes.

Keeping these principles in mind, selecting PBL becomes a natural choice in attaining the desired outcomes for the "Introduction to Engineering" course, given its constructivist underpinnings and its use of realistic (if not real) problems as the starting point of learning. Problems selected serve to connect and integrate the fundamental principles that students learn into something that is meaningful in the context of real world setting that motivates them to learn at a deep level. This is in line with the knowledge and learner centered aspects of the HPL framework. However, small group PBL models (with up to ten students per group), such as the medical school model or the project organized model, can be expensive to implement because of the intensive manpower, infrastructure and institutional support requirements. Small groups are essential because facilitators become the students' cognitive coach to provide support in developing cognitive skills and positive attitudes.

In an effort to support students to allow PBL implementation in a typical medium sized engineering classroom, the principles of CL is integrated into the PBL cycle, resulting in Cooperative Problem Based Learning (CPBL). CPBL was proven to develop team based problem solving skills, and enhance motivation and learning strategies among undergraduate engineering students [4, 21, 22, 26]. In a typical classroom, CPBL can be implemented by dividing students into small groups in a medium to large class; a single instructor, who functions as a floating facilitator, can normally facilitate up to 30 to 60 students. While it is challenging for a floating facilitator to monitor and support all groups closely, in a proper CL environment, part of the monitoring, support and feedback can be attained from peers, especially team members, instead of solely relying on the facilitator. In fact, support can be further enhanced by developing the whole class into a learning community, which is also a criteria of the HPL framework. As part of CL, students form a learning community that support them in learning, including in receiving feedback for improving themselves, which maps to the community and assessment centered criteria of the HPL framework. Although PBL is naturally collaborative in small group settings, implementation in a typical classroom requires explicit structure to guide students to develop into functional learning teams as provided through activities inspired by CL principles. The five CL principles (positive interdependence, individual accountability, face to face interaction, appropriate use of interpersonal skills and regular group function assessment), drive students into functional learning teams which is an important requirement in ensuring an effective and supportive learning environment.

Figure 1 shows the CPBL framework to guide students through the CPBL cycle as they go through the learning process together. The CPBL framework is a scaffolding that successfully provides a step by step guide on how to go through each phase of the process. Referring to Fig. 1, the typical CPBL cycle consists of:

- Phase 1 : Problem restatement and identification
- Phase 2 : Peer teaching, synthesis of information, and solution formulation
- Phase 3 : Presentation, closure and reflection

In each phase, the pattern of activities based on the principles of CL is infused to encourage the formation of a functional learning team. Referring to Fig. 1, in Phase 1 and Phase 2, the individual activities are designed to enhance learning and accountability, followed by team-based activities and finally the

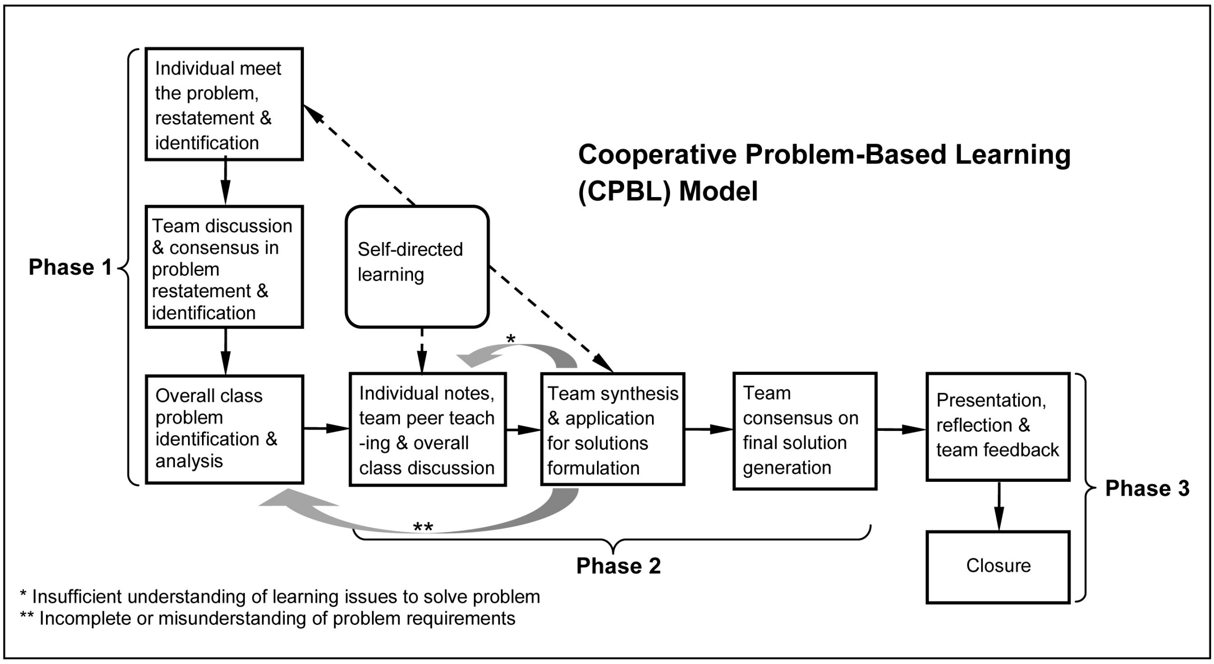

Fig. 1. The Cooperative Problem-Based Learning (CPBL) Framework [31].

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. This is also part of the assessment centered criterion of the HPL framework. More details about the CPBL framework can be seen in [24, 31].

3. "Introduction to Engineering" course

"Introduction to Engineering" (IE) is a three-credit-hour course taken by all first year chemical engineering students in a university in Malaysia. The purpose of the course is to bridge the gap between learning in a school environment and learning to be an engineer in the university. This is essential because students in the school system in Malaysia are used to a highly teacher-centered, examination-oriented environment, where the ability, and thus the available opportunities for students, are determined by the results of standardized examinations. To help students during this transition, the IE course is designed to have a supportive student-centered learning environment that allowed students to develop important skills to learn, as well as understanding and developing abilities required to be good engineers when they graduate [32].

The course is designed based on the How People Learn Framework (HPL) and Constructive Alignment (CA). Therefore, the learning environment is designed based on constructivist approach to fulfill CA and the HPL framework in supporting students to attain the course outcomes. Among the outcomes of the course are for students to work in a team to propose solutions for a SD related complex, open-ended problem. The problem, which is designed to integrate the three pillars of SD (environment, economy and social aspects), is set in a real world setting with the involvement of stakeholders that were involved in a certain type of SD problem, in accordance with the knowledge and learner centered criteria of HPL. For example, one of the problem given was on food waste, with the involvement of a supermarket, wet market and several cafeteria in the university campus, while another problem given was on developing solutions for Low Carbon Society in the Iskandar Region in Johor Bahru, Malaysia, with the involvement of the Iskandar Region Development Authority (IRDA). To support students in team-based problem solving, the problem was divided into three stages, with each stage completed in one CPBL cycle. To provide a complete view, the overall problem is given at the beginning of Stage 1. Subsequently, problems given in Stages 1 and 2 provide details about further requirements, each with increasing expectation. The problem is designed so that with each subsequent cycle and stage, students are supported to develop and enhance their professional skills. Each of the earlier stage of the problem is thus a scaffolding for the subsequent problem. More details on the design of problems for CPBL and for this course can be seen in [25].

Students were divided into teams of four to five members. Each team was required to complete all the stages, and finally compete with other teams for the grand prize in a final poster competition campaign day. Table 1 shows the stages, duration and the constructively aligned learning environment of the whole problem. In Table 1, S1, S2 and S3 given in column 1 stands for Stage 1, 2 and 3 respectively. The table shows how the teaching and learning activities (TLA) and assessment tasks (AT) are aligned to support students in attaining the outcomes. In each stage, in addition to face to face

Table 1. Constructively aligned learning environment

Stage	Outcomes	TLA	AT
S1 3 weeks	Explain SD, discuss current world scenario, analyze information from to benchmark efforts in Malaysia compared to other nations around the world.	Go through CPBL cycle to find information and learn about SD in the local and global scenario, and present critical analysis of findings.	In-class facilitation during class sessions, peer teaching notes, written report on Stage 1 and presentation, team and individual reflection.
S2 4 weeks, includes 1 week semester break	Data collection of students' and their families' consumption or generation of assigned resource to estimate and determine behaviour pattern, benchmark with local and global information to propose possible solutions.	Go through CPBL cycle to plan and collect required data at residential college and homes, perform data analysis to determine pattern of behaviour for benchmarking. Use data to justify problems to be focused on.	Facilitation during in-class individual group and overall class sessions in CPBL, peer teaching notes, written report on Stage 2 and oral presentation, team and individual reflection.
S3 4 weeks	Propose engineering solutions to a specific problem, get feedback on problem and possible solutions from stakeholders and focus on the best solution.	Go through CPBL cycle to come up with solution, fieldwork to get feedback from stakeholders of the problem, and refine solution based on practicality and cost.	In-class individual group & overall class sessions facilitation, final report and poster presentation, reflection on stage 3 & overall meta-reflection.

guidance during the class times, students were also given the privilege to acquire expert consultation from the lecturers and other experienced professionals working in the field via an online forum or through a first year seminar course taken in the same semester. Depending on the CPBL phase, the lecturers may facilitate students by organizing overall class discussions, small group facilitation (as a floating facilitator), or provide scaffolding activities to support students in acquiring needed skills. At the end of each stage, each team submits their progress report and present their findings to get the feedback on their overall performance in the respective stage, in accordance with the Assessment centered criterion of the HPL framework. In the final stage, the proposed solutions are judged based on creativity and practicality in design, environmental-soundness, and acceptance by society, as well as economic viability.

Referring to Table 1, the problem in each stage became progressively more challenging and demanding as students proceed from Stage 1 to Stage 3. Stage 1 is the initial learning stage for the students, most of whom are hearing about SD for the first time. The students also searched for information to learn what Malaysia and other nations throughout the world are doing regarding SD. The problem in Stage 2 is designed to get the students to discover their own habits, as well as their families' lifestyle by auditing them. The students also learned about data collection and estimation in this stage. Finally, Stage 3 which is the problem solving stage where the students have to find an engineering solution that complies with the three pillars of SD.

4. Research objectives

The initial objective of this research is to identify the development of professional skills and the awareness of sustainable development among the students who went through the IE course using CPBL. The data was collected from reflective journals written by students. As the qualitative data analysis unfold, it showed that there is a change in students' behavior towards sustainable development. To identify the level of behavior change towards sustainable development among the students, a questionnaire was developed to measure the change.

5. Reflective journal as a tool for data collection

According to the constructivist underpinning, knowledge is a compilation of internalised human-made constructions through their experience with the external world [33]. To be able to collect the internalised cognition, the data collection tool must be able to elicit the cognitions of the learners. There are several ways to 'observe' the cognitions of the learners such as self-report, questionnaire, interview and thinking-aloud protocol [34]. Interview and thinking-aloud protocol on how students learn can take a long time for data collection. While both questionnaire and self-report (such as journal, diary and log) are excellent in collecting data from a large sample, questionnaire may not be able to provide in-depth and qualitative data on the cognitions of the students. Moreover, according to [35], it places restriction on students' thinking because of the structuredness of the questionnaire. Therefore, self-report is preferable in this study because it gives the opportunity for the students to report what goes on in their minds [36]. Furthermore, self-report in the form of a reflective journal provides in-depth information on the cognition of students in their learning process.

As explained earlier, CPBL is rooted in the constructivist approach where learning is about actively constructing knowledge and understanding upon the existing knowledge [37]. To achieve this, reflection is a part of the learning process to 'digest' the new information and to integrate the new information to the existing knowledge. Reflection is an important process in learning [38, 39]; especially in professional education that links theories into practice [40]. According to Savin-Baden [38], reflection can be defined as "something that is believed in, not on its own account, but through something else which stands as evidence" (p.8). It is through some evidence that, a learner believes he/she has gained the benefits in a learning process. Therefore, it is utterly convenient to understand the cognitive process of what students have gained by collecting their reflections using reflective journals [36] or diaries [41].

The terms used for this tool to collect students' reflections may include journals, diaries and logs [42]. In the context of this study, reflective journals is defined as a record or log of learning experiences and events [36, 40, 43, 44]. Osterman described reflective journals as notebooks in which students write to their teachers about learning experiences and in which the teachers respond [45]. Reflective journals have been used to assess learning experience among students [36, 40]. They can provide insight into the learning experience of the students which is very difficult to collect through other research instruments [44]. The students are given ample time to reflect and look back into their learning experience and events before providing reports of what they have gained through the learning process [40]. Thus, reflective journals used in this study as a tool for data collection are able to capture the acquisition of professional skills and understanding of SD.

6. Research methodology

A sequential mixed method research design was employed in this study to achieve the research objectives. Qualitative data was collected in the first phase to explore the professional skills and sustainable development awareness using reflective journals. In the second phase, quantitative data was collected using a set of questionnaire to measure the level of behavior change towards sustainable development among students. This study was conducted on 65 first year chemical engineering students in the Introduction to Engineering course during the 2011/12-1 session.

6.1 Exploratory qualitative study

Reflective journals are compulsory as a form of closure in every phase of problem solving framework. The students need to filter, construct, organize, gather, process, and feel the experiences that they have undergone in form of writing. Initially, prompting questions are provided as scaffolding for students to do a good reflection. In submitting individual reflections, students are guided to internalize what they have learned and develop metacognitive skills. Thus, at the end of each CPBL cycle, students were asked to produce reflective journals to think about what they learned and their learning process.

The first reflective journal (RJ1) was written at Week 6 after the first cycle of CPBL. They were briefed the format of a reflective journal for the purpose of reflecting their learning through CPBL. The next reflective journal (RJ2) was collected on Week 10 after the second cycle of CPBL and then in Week 13 (RJ3). At the end of the course, the students were asked to write an overall meta-reflection, to analyze their learning experience from their earlier reflections throughout the whole semester.

The reflective journals were collected through the Moodle e-learning system, an online learning management system which the students have individual access to their own account. Students submitted their reflective journals through e-learning where lecturers can access to the submitted documents. For each submission, lecturers went through the reflective journals to discover students' reflection on the learning process, the significance of content or activities that they went through, as well as problems and issues faced, which was helpful in improving the learning environment. However, in this paper, the use of reflective journals as a tool for teaching and learning will not be discussed. The focus of the paper is to explain what the students gained in CPBL through the analysis of their reflective journals.

To analyze the reflective journal at the end of the semester, a significant amount of time was spent reading and developing coding to assist in the analysis process.

6.2 Quantitative study

Only 63 (46% male and 54% female) out of 65 students participated in the quantitative part of the study. A questionnaire was adapted from several environmental attitude inventories such as Behavior-based Environmental Attitude [46] and Environmental Attitude Inventory [47] and it has been modified to suit with the Malaysian students' background. The questionnaire was administrated at two different periods, which were at the beginning and the end of the course. The instrument consists of three parts; demographic data, self and social development which has been tested for goodness fit of model through the analysis of structural equation model using AMOS. Results from AMOS indicated that only ten items are most significant to measure students' self and social development towards practicing pro-environmental behavior. Table 2 shows the items in the instrument.

Precaution Adoption Process Model (PAPM) of changing individual behavior proposed by Weinstein and Sandman [48], which consists of seven stages, was adopted in the instrument. These stages

Table 2. Items of Pro-environmental behavior

Scale	Subscales	Code	Items
Pro-environmental behavior	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 public area
		BSf15	I do not let running water of a faucet when it is not necessary
		BSf16	I collect and sell recycle items such as papers, bottles and glasses
	Social Development	BSc2	I discuss with friends about sustainable issues
		BSc8	I invite friends to take part in sustainable programme
		BSc13	I discuss with friends what we can do to reduce pollution
		BSc14	I encouraged my parents not to buy products made from non-renewable resources
		BSc17	I actively participate in sustainable programme

were used as the level of agreement in instrument to assess students' behavior in practicing sustainability. The model asserts that people usually pass through this sequence in order. By implementing this model, students' behavioral changes can be classified into three levels: low, moderate and high, which are aligned to behaviorism perspective that acting, thinking and feeling can be regarded as levels of behavior. 'Low level' is identified as a person who is unaware and aware, but does not engage in sustainable lifestyle, categorized as stages 1 and 2. 'Moderate level' is identified as a person who has an interest to engage in sustainable lifestyles but not to contribute, categorized as stages 3, 4 and 5. And 'high level' is identified as a person who contributes and practices sustainable lifestyle, categorized as stages 6 and 7. Likert type scales were developed from stages of PAPM and converted into 5 scales as shown in Table 3. Three levels of behavioral changes were also determined.

7. Results

The results are presented in two parts. The first part consists of the qualitative data analysis, followed by the second part, which consists of the quantitative data analysis.

7.1 Qualitative data analysis

Thematic analysis technique [49, 50] was employed on all the reflection journals written by students at the end of each CPBL cycle to identify the skills attained by the students. There are six phases in thematic analysis [49] as shown in Table 4. The 260 reflective journals of all 65 students were read at least three times each for the researchers to get familiarized with the data before the initial coding. The codes were sorted into themes. Table 5 shows the sample data with codes under the theme of "team working" which are collaboration, tolerance, trust, leadership, unity, motivation, success and attitude. The students mentioned that they learned how to work together as a team (Students B, C, D), tolerating (Student A, D) and motivating each other (Student L), especially at the beginning of the semester when the teams were formed. Table 6 contains the codes for all themes found during the analysis, which are: team working, communication, problem solving, time management and sustainable development.

As the data analysis unfold, a trend of self-improvement is observed among the individual students for each of the professional skills. Referring to Table 7, for team working skills, Student D reflected on team work among his team members in RJ1 as sharing works. Later, in RJ2, Student D mentioned on how to tolerate and help each other. Finally, in RJ3, Student D said that willingness to sacrifice is what he learned through CPBL. Other examples of the development of professional skills can be seen in Table 7.

The analyses of the reflection journals show that

Table 3. Stages and levels of Individual Behavior Change [48]

Stages of PAPM	Indicators of Likert Type Scales	Levels of Behavioral Change
1. Unaware of the sustainable issues 2. Aware but not personally engaged	1. Unaware on issues 2. Aware on issues but not to engaged	Low
3. Engaged and trying to decide what to do 4. Decided not to act 5. Decided to act but not yet having acted	3. Have an interest to engage but not sure to contribute 4. Decide to contribute but still not to practice	Moderate
6. Acting 7. Maintenance	5. Practicing as a part of lifestyles	High

Table 4. Six phases of thematic analysis in analyzing the reflective journals

No	Steps	Actions
1	Get familiarized with the data	All the reflective journals were downloaded from the course e-learning site into printed texts. The reflection journals were read at least three times each to analyze the data.
2	Generate initial codes	The coding was based on the purpose of the research, to identify what professional skills and sustainable development awareness the students gained. Initial codes were generated and later, all the codes were gathered together with the original texts in the reflective journals and arranged in a table (see Table 5 for an example).
3	Search for themes	All the codes were gathered together with the quotations to identify potential themes for all the codes (see Table 6).
4	Review the themes	The themes were reviewed by checking through the data and double checked by two other researchers in the team.
5	Define and name the themes	Names were given to the themes (see Table 6).
6	Produce the report.	A report was produced at the end of the analysis.

Table 5. Example of quotations in the reflective journals that contains code of "team working skills"

Code	Student	Example of quotation
Collaboration	Student C	Team working is indeed very important in our future job as an engineer. Engineers need to work in a team to solve for the problems of the machine or the process. Working in a team is not an easy task also. Everyone has their own weakness and strength. Hence, in the group, all of us need to be tolerance and accept everyone's weakness.
Tolerance	Student A	It was fun doing the projects with my group members even though we did not get along so well at first, but by the end the projects, we work well together, everyone know their own roles and their our responsibilities.
	Student D	The happiness that is generated at the end of the results is invaluable. Apart from team working, I have learnt how to tolerate and help each other like a family to complete a task given on time. As a successful engineer, one should know on how to interact with the people in the surrounding so that the work can be completed smoothly enough.
Trust	Student K	In a team, one needs to acknowledge and understand each other's strength and weaknesses. To utilize those attributes and to improve setbacks is the key to success for a team consisting with members of different personalities and character. Teamwork requires a mutual understanding between each other and this makes things to be done easier and faster.
	Student R	I learnt how to work with others, working with someone I don't familiar with different races. Working in the group teaches me to give and accept others' ideas without condemning it. We will not always have brilliant ideas, so hearing others' opinion can help make us open to different thought and perspective. Other than that, working in a group helps us to be more tolerate with each other.
Leadership	Student B	Working as a team is a good way to share the ideas, to create team work among a group of people and to enhance the quality of the work. I am very sure that my leadership skill has been increased a lot as learned to divide the works among the team members, arrange meetings and talk in front of many audience who may have different ideas on a particular subject.
Unity	Student Y	Our group is actually is a 1 Malaysia group. Why? It is because there are multi races in our group. However this does not avoid us from coming out with good co-operation in within the group mates. We always mange to make discussion by gathering all the group members and we did not discriminate anyone in the group.
Motivation	Student L	I still remember the moment when one of my team mates talked to me in a suddenly serious way, telling me not to stress up myself as I had taken up too much things at once. He offered to help me if I needed any help. I was surprised by his words and was so touched. Sometimes, we might have a little conflicts but I am really happy and grateful to have them as my team mates and hope that I can still work with them as a team in the future.
Success	Student D	We did every part of it with full of focus and concentration. We managed to complete the report successfully. I learned on how to tolerate and help each other like a family to complete the task given on time.
Attitude	Student D	Besides that, what I learnt most is team work and willingness to sacrifice. I had never known that all my group mates will help to do their parts in a very perfect manner which led us to complete the task given on time.
	Student D	What I proud of the most was all my members are so hardworking as even some of them had to do a big part in the report like benchmarking part, but they had completed it and shared with us on that Wednesday night. I was very glad enough with their working progress and their interest on doing the report.

Table 6. Themes and codes

Theme	Codes
Team working skills	Collaboration, tolerance, trust, leadership, unity, motivation, success, attitude
Communication skills	Connection, affection, convey messages, listen, ask questions, presenting, giving & accepting critics
Problem solving	Identifying, gather information, generate hypothesis, analyze facts, craft creative solution
Time management	Planning & organizing, prioritize, set goals, be flexible, conquer procrastination
Sustainability development	Awareness, responsibility, future direction, future generations, global environment

CPBL is an effective and efficient means for learning and developing professional skills. CPBL not only offer the opportunity to learn knowledge contents, but it also creates leadership, inspires teamwork and promote problem solving skill. However, the students also expressed the concern that CPBL increased the workload and was more time consuming than conventional approaches, but the workload forced them to develop time management skills, as seen in Table 7, even though they initially had difficulties. Despite initial negative reactions, the majority of the students stated that the CPBL favored the acquisition of the knowledge on SD. Moreover, the students regarded CPBL as an

Table 7. Example of quotations for skills found at the end of each stage

Professional skills	Reflective journal	Example of quotations from the reflective journals
Team working skills	RJ1 (Student D)	What I proud of the most was all my members are so hardworking as even some of them had to do a big part in the report like benchmarking part, but they had completed it and shared with us on that Wednesday night. I was very glad enough with their working progress and their interest on doing the report.
	RJ2 (Student D)	We did every part of it with full of focus and concentration. We managed to complete the report successfully. I learned on how to tolerate and help each other like a family to complete the task given on time.
	RJ3 (Student D)	Besides that, what I learnt most is team work and willingness to sacrifice. I had never known that all my group mates will help to do their parts in a very perfect manner which led us to complete the task given on time.
Communication skills	RJ1 (Student E)	Unexpectedly, I am bravely volunteer myself to explain about food waste. I am shocked with my improvement on my soft skills. Before this, I will make sure that I will be the one that can escape from explaining section. I had improved my leadership skills. I am proud with my new attitude and I will make sure that I will not change to my old self.
	RJ2 (Student E)	I feel really satisfied with my presentation performance. My friend told me that I was courage to talk in front of others and good enough to explain my point. I did not expect that impression but I feel really grateful with the entire compliment.
	RJ3 (Student E)	During my presentation, I become more confident and excited on presenting my part. I succeed to attract the attention of the people by my body language, loudness of voice plus the picture of ticklish larvae. I am proud by myself but I am still need to improve my skills.
Problem solving skills	RJ1 (Student B)	I started to prepare myself with my group members for the next level which is overall class discussion by making sticky notes. I find making sticky notes is one of the good method of transferring data and information because the points are easily understood. I also think that way because sticky note is colorful and attract people to read it.
	RJ2 (Student B)	I started to feel exhausted and disappointed because of no progress on my task. I used different method which is by thinking logically about my task. I learned that I should not only depend on Internet but should try to think by using logical thinking to solve a problem.
	RJ3 (Student B)	I faced difficulty in interpreting and list down these information because I found the question of stage 3 as a complicated task. However, I managed to write it within the allocated time after think sharply for few minutes and after read the instructions few times. I highlighted the important points in the instruction sheet in order to make me understand the problem very well.
Time management skills	RJ1 (Student J)	It was quite challenging on finishing the report because it's holiday, other people enjoy their holiday but we have to complete our assignment. So it's quite hard to balance between fun and work.
	RJ2 (Student J)	I don't have much time to attend group discussion or even calling my mom. Even its only for a week, I think I'm still lack in time management. I can't really balance between studies and other activities.
	RJ3 (Student J)	That's a lot of thing to do at once. It's quite hectic for all of us. From there, we learn on how to manage our time well and not to procrastinate our work.
Sustainable Development	RJ1 (Student H)	The whole process was a new experience and it was worth the time and effort we put into it. I learned that food waste was a problem to human being in term of environmental hazard and economic cost. Before this, I never even care about the leftovers and did not know much on it, but now I know that it can even be turn into a sellable products.
	RJ2 (Student H)	I can see what is going on with food waste in Malaysia and other countries. Malaysia does not have proper food waste management and it could be problematic if no solution that need to be taken seriously. So from here, I learned that if I not start to life in sustainability from now, it could affect country because the country only can be changed with the citizens' behaviors.
	RJ3 (Student H)	Before this assignment, I never realised that the amount of food waste that us as humankind produced is in so enormous amount about 670 million tonnes of food wasted annually. This shows that we didn't really appreciate the value of food and the importance of food. The current food waste generation habits that include over-buying and don't use up the leftovers mainly contribute to this problem worldwide.

effective way to learn about sustainability and appreciated the opportunity to work on a real sustainability problem. In turn, the project provides students with both fundamental knowledge about sustainability, and experience with implementing sustainability. Thus, CPBL helps students develop professional skills, such as team working, communication, problem solving and time management. Experiential learning of CPBL would provide the community with successful, well-equipped students that competent in the skills, knowledge, and wisdom.

7.2 Quantitative data analysis

The quantitative study was carried out to investigate the impact of CPBL on students' pro-environmental behavior associated to self and social development. Table 8 shows the content validity calculated, where the Cronbach's Alpha is 0.714. Therefore, these five items are acceptable to measure students' pro-environmental behavior associated to self- development.

Table 9 displays the overall descriptive statistics on the pre-tests and post-tests results of self development. In all cases, skewness was within acceptable limits ranging from –0.589 to 0.425. An independent samples t-test was used to compare self-development on students' pro-environmental behavior before and after CPBL. The effect sizes for BSF9 (I recycle paper to conserve natural resources), BSF15 (I do not let water run from a faucet when it is not necessary) and BSF16 (I collect and sell recycle items such as papers, bottles and glasses) are greater than 0.8. According to Cohen [51], an effect size that is greater than 0.8 shows that the difference between before and after undergoing CPBL is highly significant. However, the effect sizes for BSF5 (I separate domestic waste for recycle) and BSF10 (I pick up litter when I see it in the park) are lower than 0.2. These items have small effect in students' self development after CPBL. Comparing all the items, BSF15 was found to be the highest increments after CPBL, increasing from scale 3 (have an interest to engage but not sure to contribute) to scale 4 (decide to contribute but still not to practice), which is at the 'moderate' level of behavioral change.

Table 10 shows the content validity of each item that converged to construct of social development, where the value of Cronbach's Alpha is 0.789. These results showed that the sub-construct of social development has a strong internal consistency and accurately represents this construct [52].

In all cases skewness was within acceptable limits ranging from –0.106 to 0.707. The effect sizes of all items are higher than 0.8. Comparing all the items, BSC2 (I discuss with friends about sustainability issues) was found to be the highest increments after CPBL with 85% of improvement and followed by BSC14 (I encourage my parents not to buy product made from non-renewable resources) with 50% improvement. It shows that students' behavior increase from scale 1 (unaware on issues) to scale 3

Table 8. Content Validity of Self Development Construct

No.	Item	Mean	Std. Deviation	Cronbach's Alpha
BSf5	I separate domestic waste for recycling	2.87	1.207	0.714
BSf9	I recycle paper to conserve natural resources	3.25	1.195	
BSf10	I pick up litter when I see it in public area	3.39	1.107	
BSf15	I do not let water run from a faucet when it is not necessary	4.08	1.068	
BSf16	I collect and sell recycle items such as papers, bottles and glasses	3.23	1.251	

Table 9. Descriptive Statistic on Self Development

	Test_level	N	Mean	Std. Deviation	% of improvement	t	Effect Size	Skewness
BSF5	Pre-test	63	2.35	0.953	6	–0.730	0.060	0.425
	Post-test	59	2.49	1.180				
BSF9	Pre-test	63	2.84	1.110	17	–2.330	2.065	0.049
	Post-test	59	3.31	1.087				
BSF10	Pre-test	63	3.06	0.998	–12	1.745	–1.703	0.100
	Post-test	59	2.69	1.303				
BSF15	Pre-test	63	3.19	1.216	31	–5.214	4.018	–0.589
	Post-test	59	4.17	0.834				
BSF16	Pre-test	63	2.81	1.189	23	–3.262	2.830	–0.435
	Post-test	59	3.46	0.988				

Table 10. Content Validity of Social Development Construct

No.	Item	Mean	Std. Deviation	Cronbach's Alpha
BSC2	I discuss with friends about sustainability issues	2.13	0.935	0.789
BSC8	I invite friends to take part in sustainable programme	1.98	0.911	
BSC13	I discuss with friends what we can do to reduce pollution	2.83	1.028	
BSC14	I encouraged my parents not to buy products made from non-renewable resources	2.40	1.066	
BSC17	I actively participate in sustainable programme	2.09	0.964	

Table 11. Descriptive Statistical on Social Development

	Test_level	N	Mean	% of improvement	Std. Deviation	t	Effect Size	Skewness
BSC2	Pre-test	63	1.87	85	0.793	–9.697	5.721	0.059
	Post-test	59	3.46		1.006			
BSC8	Pre-test	63	2.03	19	0.842	–2.260	1.479	0.434
	Post-test	59	2.42		1.054			
BSC13	Pre-test	63	2.54	36	0.930	–5.488	3.397	–0.106
	Post-test	59	3.46		0.916			
BSC14	Pre-test	63	2.13	50	1.008	–5.942	4.582	0.054
	Post-test	59	3.24		1.056			
BSC17	Pre-test	63	1.97	17	0.933	–1.797	1.405	0.707
	Post-test	59	2.31		1.133			

(have an interest to engage but not sure to contribute), resulting in the level of behavioral change from 'low' to 'moderate'.

The results from both analyses showed that after undergoing CPBL, students' pro-environmental behaviour change on social development is higher than self development. CPBL is effective in enhancing students' behavior in all aspects of social development construct. This shows that the activities in the CPBL cycle developed students' communication and team working skills. Nevertheless, in self development, CPBL shows positive outcomes in enhancing students' behavior to conserve natural resources, prevent wastage of water and effort to recycle. However undergoing CPBL did not enhance students' behavior to separate waste and action towards cleanliness of environment. This is because, from an interview conducted, students reported that the change of living environment from home to dormitory changes their way to manage waste.

8. Discussion

From the first part of this research, the exploratory qualitative study, five themes emerged after analyzing the data from the reflection journals. Four of them are professional skills (team working, communication, problem solving and time management skills), while the fifth theme is sustainable development (SD). The themes that emerged actually fits the design of the course through the problem given and the CPBL cycles that the students went through to solve the three stages of the problem. The main thrust of the problem is on SD, and thus having the theme emerged in the students' reflections shows that they were indeed immersed in the problem, and learning and solving it instilled the concept of SD in them. The main thrust of the skills developed through CPBL cycles are the four themes that emerged on the professional skills, and thus shows that the students were indeed developing the skills which were purposefully intended through the design of the CPBL model.

The four professional skills developed through CPBL by the first year students, which are team working, communication, problem solving and time management skills, are similar to the findings of earlier studies conducted on third year students who had undergone CPBL for one semester [21, 22, 24–27]. The skills developed are also consistent with other studies on students who had undergone PBL (for developing problem solving skills) and CL (for developing team working skills) [20, 21, 53, 54, 55]. From the reflective journals that have been analyzed (see Table 7), it can be observed that the students showed efforts on how they tried to rationalize their situations to cope with new learning style and to make proper planning in solving the problem. The students also showed strong commitment to be effective team members, developed leadership characteristics and the behavioral aspects of effective team working.

Nevertheless, the development of these skills and inculcation of SD did not occur instantaneously. Initial gradual development was initiated in Stage 1 of the problem and facing the CPBL cycle for the first time. This is understandable, considering that the students had gone through a highly "spoon-fed" examination oriented culture throughout their school years, and were suddenly faced with a highly student-centered, constructivist learning environment. What the students felt at the end of Stage 1 of the problem, after undergoing the first CPBL cycle is also expected because as explained by Woods [20], students who are new to PBL undergo an emotional cycle that is similar to those facing trauma. In the initial stage of the "trauma cycle", most students would be shocked and faced difficulties in trying to cope with a new learning method that required them to use skills that they did not have. Nevertheless, as they try to cope and accept that what they have to do is a necessity, they begin to develop the necessary skills as they improve themselves when they go through the CPBL cycle in Stage

2. This is reflected in the more positive outlook in the second reflective journal, as shown in the remarks in Table 7. At this stage, although they were still struggling, the students could see the fruits of their labor and began to appreciate the skills that they are developing through the learning process. Finally, similar to Woods' description for the end of the "trauma cycle", students reached a higher level of performance when they were able to integrate the new skills that they have developed or enhanced. Referring to Table 7, this pattern can be discerned in all the 5 themes identified from the qualitative analysis.

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 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 could 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 'action'. The finding reveals that the students gained deep learning from CPBL activities and increased their awareness on self and social development towards sustainable development. 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 were able to function as it was 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 (e.g. *'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 [56]. Nevertheless, it was also identified that the only activity that decreased between pre and post-test was '*I pick up litter when I see it in public area*'. The result indicated that the students' behavior 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 [8] and [57] that students act according to the rules, norms and conditions of the society or community where they live.

This study proposes that educators are the key players in delivering the concept of SD through effective teaching and learning approach and to ensure that the needs of present and future generations are better understood and addressed. Educators can make effective interventions and support students 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 insight into the benefits and gives suggestions that could be placed into the classrooms.

The findings of this research shows that the first year students who went through the CPBL cycles in their IE course gained both professional skills development as well as self and social development enhancement in sustainability. 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 Grand Challenges in Engineering of the 21st Century through CPBL.

The use of mixed-method design in this research provides some insights on what motivated the individual behavioral change on sustainable development among students. Item BSC2 (*'I discuss with friends about sustainable issues')* gained the highest increment between the pre- and post-tests could also be explained using the qualitative data. Referring to Table 7, Student H mentioned how she gained new experiences through the learning process in RJ1. With this learning experience comes the awareness and sense of responsibility to make a change in behavior in self and all citizen as mentioned in RJ2. Finally, in RJ3, she reflected on the global environmental issues that needs to be tackled to create a more sustainable future. All these were captured in the qualitative data analysis and are the codes for Sustainable Development theme in Table 6.

The need to discuss with friends about sustainable issues are an important step after the development of awareness and sense of responsibility. This is as mentioned by Student H in her reflective journal that there is a need to change the behavior of the citizens. 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. However, to be able to explain in detail the development of the behavioral change, in depth qualitative data need to be collected using other research methods such as interview or focused group discussion.

9. Conclusion

This study shows that first year engineering students who went through CPBL in the "Introduction to Engineering" course were able to develop problem solving, team working, communication and time management skills as well as behavior change in sustainable development. This is in accordance with previous studies [55] which also showed that there was enhancement of professional skills after going through CPBL. This study also showed that there was a gradual development of the skills as the students go through three cycles of CPBL, which started off with difficulties in facing a new learning environment and negative perception before finally gaining acceptance and attaining success.

Reflective journals have been used as an integral part of assessment to measure the students' ability to demonstrate an increasing awareness of their own learning towards a sustainable development concept. The quantitative results show that the students are able to demonstrate their own learning ability toward 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 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 surfaces out through the reflective journal is on professional skills. The results show that CPBL was able to meet specific goals for student learning and measure their achievement that demonstrates how well these professional skills were developed. Thus, the approach provides an opportunity to increase understanding of social and global issues, to apply engineering skills and to appreciate ethical and professional issues which are attributes future engineers need to be successful in a competitive, challenging and global marketplace.

References

1. J. J. Duderstadt, *Engineering for a Changing World: A Roadmap to the Future of Engineering Practice, Research and Education,* The Millennium Project, University of Michigan, 2008.
2. The Royal Academy of Engineering, *Educating Engineers for the 21st Century*. London, the Royal Academy of Engineering, 2007.
3. National Academy of Engineering, *The Engineer of 2020: Visions of engineering in the new century*. Washington, Academic Press, 2005.
4. K. Mohd-Yusof, S. A. Helmi, J. Mohammad-Zamry and H. Nor-Farida, Motivation and engagement of learning in cooperative problem-based learning (CPBL) framework, paper AC 2011-2721, *ASEE Annual Conference*, Vancouver, Canada, June 2011.
5. D. R. Woods, R. M. Felder, A. Rugarcia and J. M. Stice, The Future of Engineering Education: III. Developing Critical Skills, *Chemical Engineering Education*, **34**(2), 2000, pp. 108–117.
6. T. Fiedler and C. Deegan, Motivations for environmental collaboration within the building and construction industry, *Managerial Auditing Journal*, **22**(4), 2007, pp. 410–441.
7. F. G. Kaiser and U. Fuhrer, Ecoligical Behaviour's Dependency on Different Forms of Knowledge, *Applied Psychology: An International Review*, **52**, 2003, pp. 598–613.
8. R. Lukman, R. Lozano, T. Vamberger and M. Krajnc, Addressing the attitudinal gap towards improving the environment: a case study from a primary school in Slovenia, *Journal of Cleaner Production*, **48**, 2013, pp. 93–100.
9. N. S. S. Sharipah, K. Mohd-Yusof and A. Abdul-Aziz, Perception on Sustainable Development among new first year engineering students, *Procedia—Social and Behavioral Sciences*, **56**, 2012, pp. 530–536.
10. T. S. Mohd-Meereh, L. Halim and T. Nadeson, Environmental citizenship: What level of knowledge, attitude, skill and participation the student own? *Procedia—Social and Behavioral Sciences*, **2**, 2010, pp. 5715–5719.
11. N. Ibrahim and B. T. Teh, *Low Carbon Lifestyle: A Key in Moving Iskandar Malaysia Towards Low Carbon Region*, ISSM 2011, Kora Kinabalu, Sabah, Malaysia, 2011.
12. R. Clugston, Earth Charter Education for Sustainable Ways of Living, *Journal of Education for Sustainable Development*, **4**, 2010, p. 157.
13. D. Tilbury, Are we learning to change? Mapping global progress in education for sustainable development in the lead up to 'Rio Plus 20', *Global Environmental Research*, 2010, pp. 101–107.
14. N. R. Weber, M. Dyehouse, C. A. Harris, R. David, J. Fang, I. Hua and J. Strobel, First-year Engineering Students' Environmental Awareness and Conceptual Understanding Through A Pilot Sustainable Development Module, *American Society for Engineering Education*, 2011.
15. Z. Aminrad, S. Z. Sayed-Zakariya, A. S. Hadi and M. Sakari, Environmental Education in Malaysia, Progresses and Challenges Ahead (Review), *Life Science Journal*, **9**(2), 2012, pp. 1149–1154.
16. R. M. Felder and R. Brent, *Cooperative Learning in Technical Courses: Procedures, Pitfalls, and Payoffs*, ERIC Document Reproduction Service, ED 377038, 1994.
17. B. J. Duch, S. E. Groh and D. E. Allen, *The Power of Problem-based Learning*, Stylus Publishing, Virginia, USA, 2001.
18. D. Boud and G. Feletti, *The Challenge of Problem-Based Learning*, New York, St. Martins' Press, 1997.
19. J. R. Savery, Overview of Problem-based Learning: Definition and Distinction, *The Interdisciplinary Journal of Problem-based Learning*, **1**(1), 2006, pp. 9–20.
20. D. R. Woods, *Problem-Based Learning: How to Gain the Most from PBL*, Waterdown, Donald Woods Publishers, 1994.
21. Syed Ahmad Helmi Syed Hassan, K. Mohd-Yusof, Mohd Salleh Abu and Shahrin Mohammed, An Instrument to Asses Students' Engineering Problem Solving Ability in Cooperative Problem-Based Learning (CPBL), *Proceedings for the 2011 ASEE Annual Conference and Exposition on Engineering Education*, Vancouver, Canada, June 26–30, 2011.
22. Syed Ahmad Helmi, K. Mohd-Yusof, F. A. Phang, Shahrin Mohammad and Mohd Salleh Abu, Inculcating Team-based Problem Solving Skills, Part 1: Enhancing Problem Solving

Elements. *Research in Engineering Education Symposium (REES 2013)*, Putrajaya, Malaysia on 4–6 July 2013.
23. J. Strobel and A. van Barneveld, When is PBL more effective? A meta-synthesis of meta-analyses comparing PBL to conventional classrooms, *The Interdisciplinary Journal of Problem-based Learning*, **3**(1), 2009, pp. 44–58.
24. K. Mohd-Yusof, S. A. Helmi, J. Mohammad-Zamry and H. Nor-Farida, Cooperative Problem Based Learning: A Practical Model for a Typical Course, *International Journal Emerging Technologies*, **6**(3), 2011, pp. 12–20.
25. J. Mohammad-Zamry, K. Mohd-Yusof, N. F. Harun and S. A. Helmi, A Guide to the Art of Crafting Engineering Problems for Problem Based Learning (PBL). In: K. Mohd-Yusof, N. A. Azli, A. M. Kosnin, S. K. Yusof and Y. M. Yusof (eds), *Outcome-Based Science, Technology, Engineering, and Mathematics Education: Innovative Practices*, IGI Global, Hershey, Pensylvania, USA, pp. 62–84, 2012.
26. K. Mohd-Yusof, Syed Ahmad Helmi and F. A. Phang, Inculcating Team-based Problem Solving Skills, Part 2: Enhancing Team Working Skills. *Research in Engineering Education Symposium (REES 2013)*, Putrajaya, Malaysia on 4–6 July 2013.
27. F. A. Phang, K. Mohd-Yusof, Fatimah Mohamad Adi and Syed Ahmad Helmi Syed Hassan, Engineering Students' Perception on Learning through Cooperative Problem-Based Learning (CPBL) for the First Time, *Proceedings of the 2012 ASEE Annual Conference*, San Antonio, Texas, USA, 11–13, June, 2012.
28. D. Jonassen, J. Strobel and C. B. Lee, Everyday Problem Solving in Engineering: Lessons for Engineering Educators, *Journal of Engineering Education*, **95**(2), 2006, pp. 139–151.
29. J. Biggs and C. Tang, *Teaching for Quality Learning at University*, 3rd Ed., Open University Press, London, 2007.
30. J. Bransford, N. Vye and H. Bateman, *Creating High-Quality Learning Environments: Guidelines from Research on How People Learn*, National Academy of Sciences, 2004, pp. 159–197.
31. K. Mohd-Yusof, Syed Ahmad Helmi Syed Hassan and F. A. Phang, Creating a Constructively Aligned Learning Environment using Cooperative Problem-based Learning (CPBL) for a Typical Course, *Procedia—Social and Behavioral Sciences*, **56**, 2012, pp. 747–757.
32. M. H. Hassim, M. J. Kamaruddin, J. Jamaluddin, N. Othman, A. N. Sadikin, H. Hashim, H. Hassan and K. Mohd-Yusof, An Introductory Course for Instilling Sustainability Awareness: Design and Implementation, *PSE Asia 2013*, Kuala Lumpur, June 2013.
33. J. D. Raskin, Constructivism in psychology: Personal construct psychology, radical constructivism, and social constructionism. In J. D. Raskin & S. K. Bridges (Eds.), *Studies in meaning: Exploring constructivist psychology* (pp. 1–25). New York: Pace University Press, 2002.
34. H. A. H. Rowe, Observing' thinking and learning processes. In E. Glen (Eds.), *Learning and teaching cognitive skills* (pp. 9–26). Melbourne: The Australian Council for Education Research, 1991.
35. T. A. Thorkildsen, *Fundamentals of measurement in applied research*, Boston: Pearson, 2005.
36. A. M. Faizah, The use of reflective journals in outcome-based education during the teaching practicum, *Malaysian Journal Of ELT Research*, **4**, 2008, pp. 32–42.
37. M. Savin-Baden, *Problem-based Learning in Higher Education: Untold Stories*, UK: The Society for Research into Higher Education and Open University Press, 2000.
38. J. Dewey, *How We Think: A Restatement of the Relation of Reflective Thinking to the Educative Process*, Boston, MA: D.C., Heath and Company, 1933.
39. D. A. Schon, *Educating the reflective practitioner*, San Francisco: Jossey-Bass, 1987.
40. K. D. Chirema, *The use of reflective journals in the promotion of reflection and learning in post registration nursing students*, Doctoral thesis, University of Huddersfield, 2003.
41. C. S. Joselon and K. Imperio, Participant Diaries as a Source of Data in Research With Older Adults, *Qualitative Health Research*, **15**(7), 2005, pp. 991–997.
42. J. Moon, Learning journals and logs, reflective diaries. In Centre for Teaching and Learning (Ed.) *Good Practice in Teaching and Learning*, Dublin: UCD Dublin, 2003.
43. J. Wellington, *Educational research: Contemporary issues and practical approaches*, London: Continuum, 2000.
44. R. Phelps, The Potential of Reflective Journals in Studying Complexity 'In Action', *Complicity: An International Journal of Complexity and Education*, **2**(1), 2005, pp. 37–54.
45. K. E. Osterman, Reflective practice. A new agenda for education, *Education and Urban Society*, **22**(2), 1990, pp. 133–152.
46. F. G. Kaiser, B. Oerke and F. X. Bogner, Behavior-based environmental attitude: Development of an instrument for adolescents, *Journal of Environmental Psychology*, **27**, 2007, pp. 242–251.
47. T. L. Milfont and J. Duckitt, The Environmental Attitudes Inventory: A valid and reliable measure to assess the structure of environmental attitudes, *Journal of Environmental Psychology*, **30**(1), 2010, pp. 80–94.
48. N. D. Weinstein and P. M. Sandman, A model of the precaution adoption process: Evidence from home radon testing, *Health Psychology*, **11**, 1992, pp. 170–180.
49. V. Braun and V. Clarke, Using Thematic Analysis in Psychology, *Qualitative Research in Psychology*, **3**(2), 2006, pp. 77–101.
50. D. Howitt and C. Duncan, *Introduction to Research Methods in Psychology* (2nd ed.), US: Prentice Hall, 2007.
51. J. Cohen, A power primer, *Psychological Bulletin*, **112**(1), 1992, pp. 155–159.
52. L. J. Cronbach, Coefficient Alpha and the Internal Structure of Tests, *Psychometrika*, **16**(3), 1951, pp. 297–334.
53. M. J. Prince, Does Active Learning Work? A Review of the Research, *Journal of Engineering Education*, **93**(3), 2004, pp. 223–231.
54. D. W. Johnson, R. T. Johnson and K. A. Smith, *Active Learning: Cooperation in the College Classroom*, Edina, Minnesota, Interact Book Company, 2006.
55. K. Mohd-Yusof, A. N. Sadikin and F. A. Phang, Determining the effect of an engineering overview assignment on first year students, *Proceedings of the 2014 ASEE Annual Conference*, Indianapolis, Indiana, USA, 15–18 June, 2014.
56. C. Bryson and L. Hand, The Role of engagement in inspiring teaching and learning, *Innovations in Education and Teaching International*, **44**(4), 2007, pp. 349–363.
57. D. Chapman and K. Sharma, Environmental Attitudes and Behaviour of Primary and Secondary Students in Asian Cities: An Overview Strategy for Implementing an Eco-School Programme, *The Environmentalist*, **21**, 2001, pp. 265–272.

Khairiyah Mohd-Yusof is the Director of the Centre for Engineering Education, Universiti Teknologi Malaysia. She is currently the Vice President for Asia and Oceania for the International Federation of Engineering Education Societies (IFEES), the Secretary for the Society of Engineering Education Malaysia (SEEM), and board member for the International Research in Engineering Education Network (REEN). Her engineering education research focuses on innovative curriculum and teaching and learning practices, faculty development, talent pipeline and Engineering Education for Sustainable Development.

Aziatul Niza Sadikin is a lecturer at the Department of Chemical Engineering, Faculty of Chemical Engineering, Universiti Teknologi Malaysia (UTM), since 2001. Her main research interest areas are Separation Processes and Engineering Education. She is one of the class facilitators for a first year chemical engineering course, Introduction to Engineering, which employs Cooperative Problem-Based Learning (CPBL) as the teaching and learning methodology. She is an active member of an engineering research team in UTM.

Fatin Aliah Phang completed her PhD at University of Cambridge, UK in 2009 and appointed as a lecturer at the Faculty of Education, Universiti Teknologi Malaysia (UTM). She was the Academic Manager of the Centre for Engineering Education (CEE), UTM and now one of the Academic Fellows at the centre. She is actively involved in research and training in Engineering Education as well as other research areas such as Science Education and Environmental Education.

Azmahani Abdul-Aziz is a Senior Lecturer at Department of Hydraulics and Hydrology, Faculty of Civil Engineering and also as a Fellow at Centre of Engineering Education at Universiti Teknologi Malaysia. Her disciplinary background is water engineering and engineering education. Currently, she is pursuing her PhD in Engineering Education. Her doctoral research focuses on the impact of student centred learning environment in instilling sustainable development among engineering students.