A Longitudinal Study on the Impact of Cooperative Problem-Based Learning in Inculcating Sustainable Development

Azmahani Abdul-Aziz[a]*, Khairiyah Mohd-Yusof[a], Amirmudin Udin [b], Jamaludin Mohamad-Yatim [c]

[a]*Centre of Engineering Eduction, Universiti Teknologi Malaysia, Johor Bahru and 81310, Malaysia*
[b]*Faculty of Education, Universiti Teknologi Malaysia, Johor Bahru and 81310, Malaysia*
[c]*Faculty of Civil Engineering, Universiti Teknologi Malaysia, Johor Bahru and 81310, Malaysia*

Abstract

The purpose of this study was to investigate the impact of Cooperative Problem-Based Learning (CPBL) in inculcating sustainable development amongst first year engineering students. A longitudinal quantitative research methodology was carried out over three semesters to determine the changes. Students were experienced with a real problem related to sustainable issues. Precaution Adoption of Process Model (PAPM) was used as a tool to assess the students' behaviour change which focuses on pro-self and pro-social development towards practicing sustainable lifestyles. Result showed that the implementation of CPBL as a teaching and learning approach has a positive impact on students' development. The findings also found that elements of sustainable development should be embedded into the curriculum on the following semester to gain a continuous impact on students.

Keywords: Teaching and learning approach

1. Introduction

The challenge of 21st century engineering students is to look for the best solution to an engineering problem with sustainable development constraint in mind. However, previous research on first year engineering students in Malaysia [1,2,3] has shown a lack of knowledge about sustainable development and practicing as a lifestyles. Currently, several initiatives have been done by the government and non government organization to promote sustainable development. While at higher educational level, topic on sustainable development becomes an important issue that should be embedded into their academic or non-academic programmes. Therefore, today's engineering educators are facing higher responsibility to educate future engineers with engineering 'habits of mind', which include system thinking, creativity, optimism, collaborative, communication, and attention to ethical considerations [4].

In line with the needs, educators should make a paradigm shift through pedagogical approach from passive learning to active learning. Active learning has been shown to enhance learning [5]. Active learning techniques, especially the Cooperative Learning (CL) and Problem Based Learning (PBL) are currently being promoted across all disciplines as well as levels of studies [6,7,8]. Both are instructional methods where students "learn to learn," working cooperatively in groups to seek solutions to real world problems. PBL prepares students to think critically and analytically, and to find and use appropriate learning resources [9,10].

Thus, the purpose of this study was to investigate the impact of Cooperative Problem-Based Learning (CPBL) in inculcating sustainable development amongst first year engineering students. Sustainable development can be introduced through formal learning and non-formal learning. This study focused on formal learning where topic on sustainable development is a part of course content under 'Introduction to Engineering' course. Longitudinal quantitative research methodology was utilized to observe and assess students' behaviour change associated to sustainable development before and after undergoing the course.

2. Cooperative Problem-based Learning (CPBL)

Cooperative Problem-based Learning (CPBL) is a hybrid of two models of learning methods; Cooperative Learning (CL) and Problem-based Learning (PBL). It integrates cooperative learning principles into the PBL cycle. CL was known to promote five principles; positive interdependence, individual accountability, face to face interaction, appropriate interpersonal skills and regular team role assessment [11,12,13]. In a team, social interaction among students can create collaboration in the learning activities. The positive learning environment would yield strong interaction among learners in a cooperative and supportive environment. Member in a team has a responsibility to support and facilitate each other's effort to reach the goal. Several studies of cooperative learning have been conducted in Malaysian context have found that cooperative learning promoted positive relations among students and there was a tendency to be more cooperative among the peer members in discussing and solving problems such [14,15].

* Corresponding Author name. Tel.: +6-07-553-1605
E-mail address: azmahani@utm.my

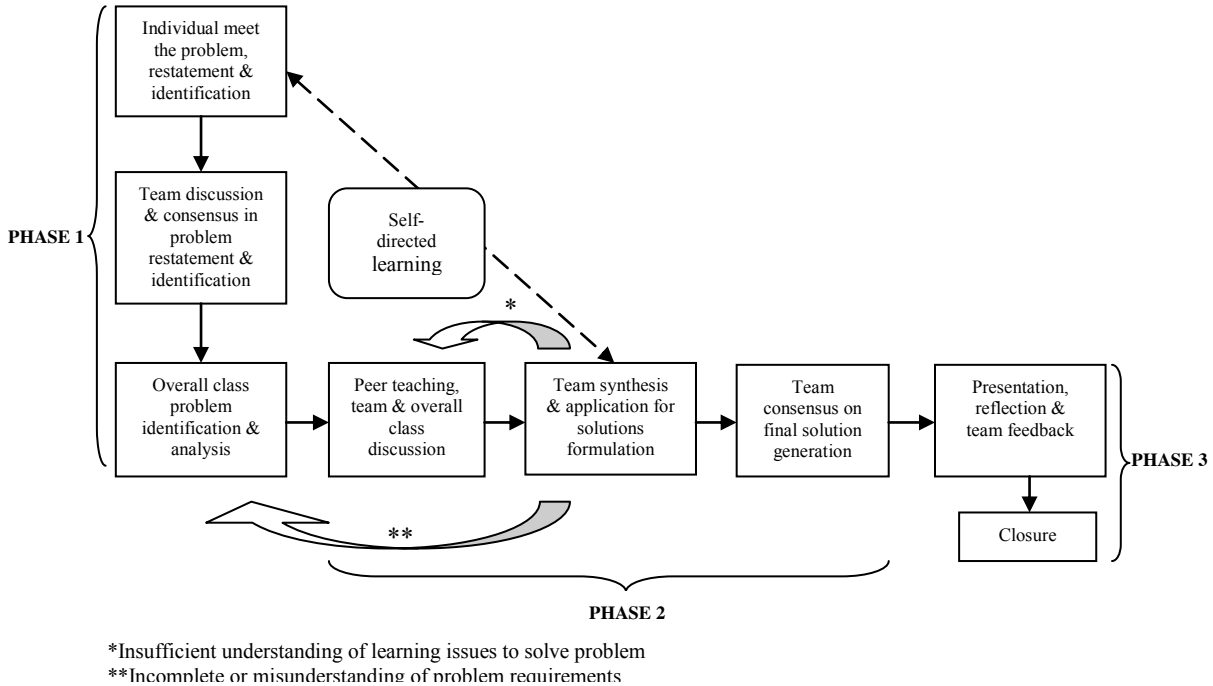

Figure 1: Cooperative Problem-based Learning Framework
(Source : Mohd-Yusof K. et. al. 2012)

Problem-Based Learning (PBL) is an inductive learning approach that has been used successfully for over 30 years [7]. It embeds small groups of students and presents them with a messy, unstructured, realistic (if not real) problem, to solve. The problem should be well crafted to engage and immerse students in learning new issues. Instead, students are guided through a PBL cycle that helps them to identify and construct new knowledge that is synthesized with their existing knowledge to be applied in solving the given problem. Students are guided by cognitive coaches or floating facilitator through the PBL cycle to learn and solve the problem.

Hence, CPBL model is the integration of CL into the PBL cycle as shown in Figure 1. Two premises in constructive alignment are grounded to develop the CPBL model, which are 1) constructivism, where student constructs meaning through his/her learning activities and 2) instructional design that aligns learning outcomes of teaching and learning activities, as well as assessment task [11]. The CPBL learning environment is underpinned by four principles; constructive alignment, PBL as a philosophy, cooperative learning and how people learn (HPL) framework. HPL framework consists of four lenses i.e. knowledge centred, student centred, community centred and assessment centred. This framework was utilized to analyze and design learning environment. The CPBL framework is scaffolding that successfully provides a step by step guide on how to go through each phase of the process. Referring to Figure 1, the typical CPBC cycle consists of:

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

In each phase, the individual activities are designed to enhance learning and accountability, followed by team-based activities and finally in the overall class activities to form a learning community.

3. Research Questions

This study attempted to assess the students' behaviour toward practicing sustainable lifestyles after undergoing cooperative problem-based learning as a teaching and learning approach. This study addressed the research question; to what extend does CPBL could inculcate students' behaviour change associated to pro-self and pro-social development in practicing sustainable lifestyles.

4. Research Methodology

The study was carried out among a group of 120 first years chemical engineering students (45% male and 55 % female) took 'Introduction to Engineering' course. This course embedded knowledge about sustainable development through a problem.

CPBL was implemented as a teaching and learning approach to give guidance and facilitate the students to carry out the problem. The students were selected as a respondent of this study for three semesters. A questionnaire was administrated at three different periods, which were at the beginning of semester 1, end of semester 1 and beginning of semester 3(Year-2). They were given the same questionnaire to determine their levels of knowledge and behaviour change. The instrument consists of 25 items divided into five parts (demographic data, sustainable issues, content knowledge, pro-self and pro-social) has been tested for goodness fit of model through the analysis of structural equation model using AMOS. Table 1 shows the examples of items in the instrument.

Table 1. Example of Items in Instrument

Scales	Subscales	Code	Items
Knowledge	Environmental issues	KT1	Air Pollution
		KT2	Climate Change
	Concept of SD	KBK1	Definition of SD
		KBK2	Three components of SD
Pro-environmental behaviour	Self Development	BSf18	I turn lights off when I leave a room
		BSf19	I turn tap off when brushing my teeth
	Social Development	BSc17	I actively participate in SD programmes
		BSc20	I donate money to support SD programmes

4.1.Description of a Problem and Procedure

Students were divided into teams of five. Each team is required to fulfill all the stages, rules, regulations and finally competed with other teams for the grand prize in a solid waste management campaign day. The project was designed to integrate the three pillars of sustainable development along with the students completed all the stages as showed in Table 2.

Table 2. Stages of Project

Stages	Title	Duration
1	Waste Characterization and Benchmarking	2 weeks
2	Life Cycle Assessment (LCA)	4 weeks
3	Propose Engineering Solution Based on 3R Concept	4 weeks
4	Campaign Day	1 day

Each team is required to propose engineering solution to reduce, reuse and recycle (3Rs) of waste and to choose the area of study where they currently live (e.g. their campus area). Throughout the period, they are given the privilege to acquire expert consultation from an experienced researcher working in the field via online forum. In addition, they are also encouraged to consult other experts such as academicians, environmental consultants, etc. At the end of each stage, they should submit their staggered progress report and mini presentation will be held for the selected team. Advisers will be appointed to guide the participating teams throughout the competition.

Finally, they are required to submit a comprehensive final written proposal that followed the proposal specifications guidelines. In addition, they are encouraged to consider several sources such as latest technologies as well as applied research, designed to provide benefits to people who generate waste and to public and private entities responsible for reducing, reusing and recycling of waste. The proposal should call for an increase in the ratio of recyclable materials, further reusing of raw materials and manufacturing waste, and overall reduction resources and energy used. Nonetheless, all materials used in the proposal should be clearly and properly cited. The winning proposals are viewed to be most environmentally-sound as well as economical viable based on 3R concept. Through the CPBL learning environment, students will develop and understand the principles of sustainable development and how it applies over the whole life of a product from raw material through design, manufacture, use and final disposal.

4.2 Teaching and Learning Activities

During completing the problem, students were exposed to CPBL model as their teaching and learning approach. Figure 1, Table 2 and Table 3 show the connection among CPBL phases, sustainable problem and learning activities. The activities for each stage were designed to be aligned with CPBL phases. Since this learning environment is very new to the students, a dedicated tutor or floating facilitator will be around to facilitate during class time. A series of discussion will be held outside the classroom in order to produce a final report and presentation. In all activities (individual, team and class), CL principles were integrated into PBL cycle to form a successful team. Therefore, students must be in functional teams so that they can harmoniously cooperate and support one another.

Table 3. Summary of CPBL Phases and Learning Activities

Stages	CPBL Cycle	Learning Activities
1,2 & 3	Phase 1 : Problem restatement (PR) and identification (PI)	Individual PR and PI Team PR and PI Class Discussion
	Phase 2 : Peer teaching (PT), synthesis of information, and solution formulation	Individual PT notes Team PT notes Class PT (selected team)
	Phase 3 : generalization, reflection and closure	Individual Reflection Peer and self –rating, Final report

4.3. Assessment Tool of Behaviour Change

Weinstein and Sandman (1991) proposed the Precaution Adoption Process Model (PAPM) of changing individual behaviour which consists of seven stages. These stages were used as level of agreement in instrument to assess students' behavioural in practicing sustainability. The model asserts that people usually pass through this sequence in order. By implementing this model, researcher has classified students' behavioural changes into three levels of mode as low, moderate and high which aligned with theory of behaviourism that acting, thinking and feeling can be regarded as level of behaviour. 'Low level' is identified as feeling of a person who is unaware and aware but does not engaged in sustainable lifestyles, stage 1 and 2. While, 'moderate level' is identified as thinking of a person who has an interest to engage in sustainable lifestyles but still not to contribute, stage 3,4 and 5. And 'high level' is identified as acting of a person who has contributing and practicing sustainable lifestyles as a part of their life, stage 6 and 7. Likert type scales were developed from stages of PAPM and converted into 5 scales as shown in Table 4. Three levels of behavioural changes were also determined.

Table 4, Stages and levels of Individual Behaviour Change (Weinstein & Sandman, 1988)

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

5. Data Analysis and Results

5.1 Descriptive Analysis

Descriptive results of the survey questions are presented in Table 4. This quantitative study was conducted from September 2011 to September 2012, namely beginning of semester 1, end of the semester1 and beginning of semester 3. Statistical package PASW 18 was used to conduct statistical test. The mean scores of these responses were compared and contrasted in the analysis. The data were tested for normality where the values of skewness and kurtosis ratios are at the range between +2 and -2. The Cronbach Alpha reliability test showed an average coefficient of 0.846. With this level of reliability, all items in the questionnaire were included to obtain an overall satisfaction score of each respondent. This means that the results have a strong impact to the study.

Research Question

To what extend does CPBL could inculcate students' behaviour associated to pro-self and pro-social development in practicing sustainable lifestyles.

Table 5 presents the mean scores of students' behavioural changes on pro-self and pro-social. The mean scores on pro-self increased significantly from pre-test to post-test (M=-1.025, SD=0.771), t (119) = (-14.57), $p < 0.05$. While the mean scores on pro-social also increased significantly from pre-test to post-test (M=-1.231, SD=0.766), t (119) = (-17.61), $p<0.05$.

Table 5. Results of t-test of Significance of Differences in Test Scores

	Paired Differences	t	df	Sig. (2-

					95% Confidence Interval of the Difference				tailed)
		Mean	Std. Dev.	Std. Error Mean	Lower	Upper			
Pro-self	Before - After	-1.025	.771	.070	-1.164	-.886	-14.57	119	.000
Pro-social	Before - After	-1.231	.766	.070	-1.369	-1.092	-17.61	119	.000

5.2 Students' Behaviour Change on Self Development

Figure 2 shows the mean scores of longitudinal study on students' behaviour change towards practicing sustainable development on self development. The observation was carried out over three (3) semesters. At the beginning of semester 1 and referring to the stages of individual behaviour change (Model of PAPM) students' behaviour moved from stage 2(aware on issue but not to engage) to stage 3 (have an interest to engage on issue but not sure to contribute). Item of recycle was the highest changes compared with waste management and water conservation. While at the beginning of Year-2 (semester 3), there is no changes on waste management but slightly dropped on water conservation and recycle but still at the same stage (3). This means that CPBL with a real problem related to sustainable issues (Waste to Wealth) has significantly improved their lifestyles to be more concerned person.

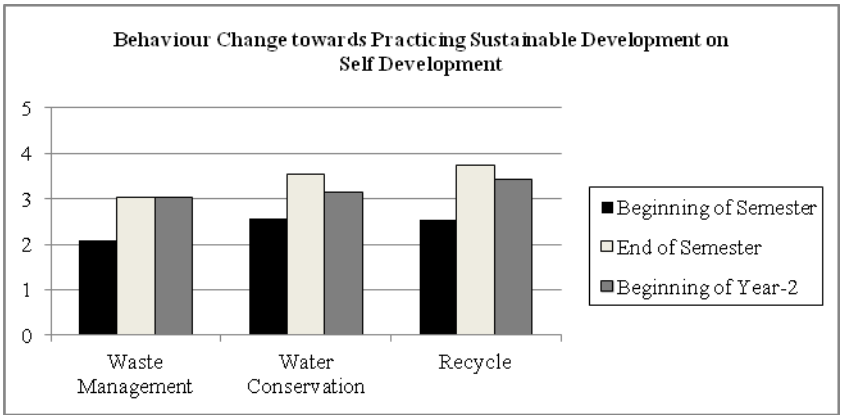

Figure 2. Students' Behaviour Change towards practicing sustainable development on self development

5.3 Students' Behaviour Change on Social Development

Referring to Figure 3, the mean scores of students' behaviour change of three items related to practising sustainable development on social development moved from stage 2(aware on issue but not to engage) to stage 3 (have an interest to engage on issue but not sure to contribute). At the beginning of semester 1, item of participate in sustainable programmes was the lowest mean score but at the end of semester 1, this items has the highest increment compared to others. Additionally, item of able to discuss with friends was the highest mean score. Similar with the results of self development, it was found that the levels of students' behaviour change dropped at the beginning of Year-2 (semester 3) and item of participate in sustainable programmes has the lowest mean score. This means that the five principles in cooperative learning have successfully developed students' skill in team working and communication. This learning environment has promoted positive relations not only among their team members but also be more cooperative among the society in discussing and participating in social programmes.

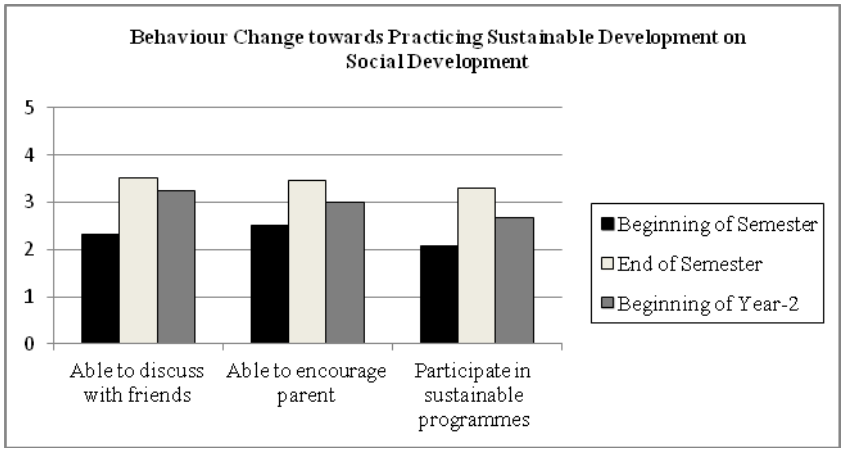

Figure 3. Students' Behaviour Change towards practicing sustainable development on social development

5.4 Students' Perception on Course Evaluation

Figure 4 shows the students' perception on course evaluation (1- strongly disagree to 5 – strongly agree). Most of the students agreed that CPBL has developed their knowledge and understanding about the importance of sustainable development, the learning environment taught them a systemic way of thinking and also conveyed them to be a sustainable person. Results that were achieved from students' behaviour change on self development showed that CPBL has developed significant positive impact on students' changes. For instance, after CPBL, students have acquired positive behaviour change especially on issue related to sustainable problem. As the problem was about 'Waste to Wealth' by applying the concept of 3Rs, item of recycle becomes the highest amongst three items of self development. It was also exhibited as the highest improvement after the course.

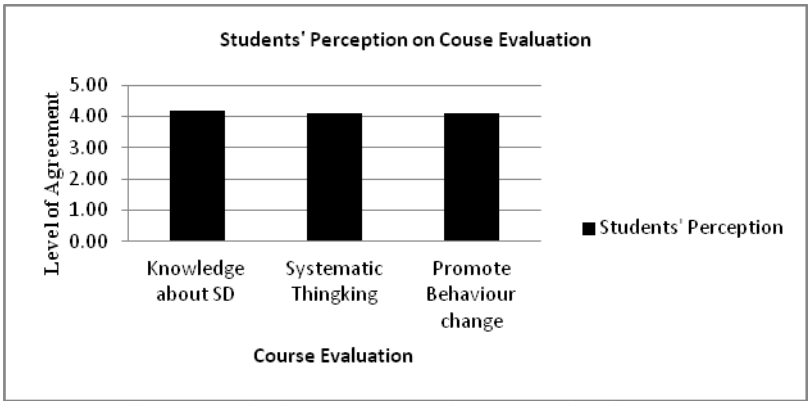

Figure 4. Levels of Agreement on Students' Perception of CPBL

On the other hand, results of students' behaviour change on social development have proven that CPBL has motivated students to learn and retain significantly more information about the issue. Through cooperative learning, students have developed their communication skill from the group interaction and work presentation. This learning environment has reformed their social skills which they could discuss with friends, able to encourage parent and willing to participate in sustainable programmes.

6. Conclusion

This study shows that the combination of CPBL as an instructional approach and a problem related to sustainable issue could promote students' engagement in behaviour change. The CPBL learning environment has positively filled in the gap between 'knowledge' and 'action'. The finding revealed that students gained deep learning from CPBL activities and increased their level of self and social development towards sustainable development. It was found that the level of students' behaviour changed in sequent at the end of semester. These findings were significantly agreed with the model of 'Precaution Adoption of Process Model' that was selected as an indicator to measure students' behaviour change. However, results of both developments at beginning of semester 3 revealed that students' behaviour change slightly declined. These findings indicated that issue on sustainable development should be continuously embedded into the curriculum for the engineering programmes. In summary, implementing CPBL as a teaching and learning approach will enhance students' learning and could transform the lifestyle of our future engineers significantly.

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