Inculcating Sustainable Development among Engineering Students, Part 2: Assessing the Impact on Knowledge and Behaviour Change

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Abstract

Issues related to sustainability are the primary focus for the 21st century society. Today's engineering professionals are coming under increased pressure to practice engineering more sustainably. In line with current needs, higher education has a responsibility to produce future engineers who are concerned about sustainable development. Therefore, an understanding on the concept of sustainable development (SD) is the main issue that should be addressed at the stage of education where future engineers are being educated. Educators play a major role in imparting knowledge and commitment towards sustainable development among students through effective teaching and learning approaches to gain meaningful impact. The aim of this study is to assess the impact on knowledge and behaviour change in inculcating SD among first year chemical engineering students enrolled in the 'Introduction to Engineering' course, in which Cooperative Problem-Based learning (CPBL) was implemented as a teaching and learning approach. This study involved 89 respondents. A quantitative study was conducted using a knowledge-behaviour instrument. The Rasch Model framework using WINSTEPS version 3.68.2 was employed in this study. Results from the study revealed that applying CPBL significantly improved the levels of students' knowledge and behaviour change to practice sustainable lifestyles. The study also found that inculcation of SD among first year engineering students can be attained through proper design of problems and learning environment.

1 Introduction

Issues related to sustainability are the primary focus for the 21st century society. Today's engineering professionals are coming under increased pressure to practice engineering more sustainably. The terms of 'Sustainable development' has come to be commonly understood as;

> *'Development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs'*
>
> *(World Commission on Environmental and Development, 1987, p. 43)*

In line with current needs, higher education has a responsibility to produce future engineers who are concerned about sustainable development (SD). Therefore, an understanding on the concept of SD is the main issue that should be addressed at the stage of education where future engineers are being educated. To achieve this, educators play a major role in imparting knowledge and commitment towards SD among students through effective teaching and learning approaches to gain meaningful impact. Gro Harlem Brundlant, chair of the World Commission on Environment and Development (WCED), strongly emphasized that;

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

According to ‘Preliminary Reports of Malaysia Education Blueprint (2013 – 2025), the Malaysian education system has come under increased public scrutiny and debate, as parents’ expectations rise and employers voice their concern regarding the system’s ability to adequately prepare young Malaysians for the challenges of the 21st century. The quality of teaching, building on existing good practice, and rewarding high quality teaching with better career pathways that support teachers in the classroom. Fiedler & Deagan, (2007) indicates that people’s motivation to change indeed comes from knowledge. In addition, education nowadays needs to produce students who are knowledgeable, think critically and creatively, have leadership skills and are able to communicate with the rest of the world. Therefore, quality teaching is the most effective lever available to transform education and deliver improved outcomes for students.

This paper presents the effectiveness of CPBL in inculcating SD among the first year engineering students. This is the second of a two-part paper that describes the implementation of CPBL in the Introduction to Engineering course that focus on the impact on knowledge and behaviour attained by students after undergoing CPBL to solve SD related problems.

2 Related work on Awareness of Sustainable development in Malaysia

The Malaysian Ministry of Education has formally introduced environmental education since 1983. The main objective is to educate the society to be more sensitive and concerned about environmental issues, to be knowledgeable, skilled and committed in order to act as individuals or collectively. Recent studies have been conducted in Malaysia to examine people’s perception of environmental issues based on their respective educational backgrounds, and practice of sustainable lifestyles. For instance, Zarrintaj Aminrad, et. al. (2012), Sharifah et al (2012), Tamby et. al. (2010), Abu-Samah et. al. (2009), Marzuki. A. (2009), Sumiri. S.K. (2008) and Nadeson & Nor Shidawati (2005) have conducted studies on public and Malaysian primary, secondary and tertiary students. In summary, results showed that the level of knowledge and attitude with respect to environmental concerns has generally remained low. Mamat, M.N. (2009) found several findings from his study on the ‘effective instructional design for value dominant education in public universities in Malaysia’. He revealed that instructional design should correlate with course objectives, contents and activities. He also mentioned that lectures and discussions are normal instructional approaches used by the teachers to acknowledge sustainability issues. The current trend of tertiary education in Malaysia focuses less attention to affective-dominant outcomes, compared to cognitive and psychomotor dominant outcomes (Mamat, M.N. 2009). Generally, it was concluded that Malaysians have a low to moderate level of understanding on environmental issues and low degree of commitment in practising sustainability. Therefore, more studies are needed to better understand people’s behaviour and lifestyle, and how best to formulate a sustainability-pro society, especially in the Malaysian context.

Knowing the status quo, the questions that arise are: ‘What is the gap between ‘knowledge and action’ and ‘does teaching and learning approach have an impact in inculcating the understanding about SD and promoting students' behaviour change towards a sustainable lifestyle'. The aim of this study is to investigate the impact of the teaching and learning approach to develop students' knowledge in promoting behaviour change towards sustainable lifestyles, which will have an impact on how they behave as an engineer in the future. Cooperative Problem-Based learning (CPBL) was chosen as the teaching and learning approach for inculcation of SD among engineering undergraduates.

3 Methodology

The sample in this study consisted of 89 (51.7 % male and 48.3 % female) students who were enrolled in the 'Introduction to Engineering' course. A quantitative study was conducted using a knowledge-behaviour instrument. Students were asked to rate and answer the same questionnaire at the beginning and end of the semester. The Rasch Model framework using WINSTEPS version 3.68.2 was employed in this study.

This study employs an instrument with 25 items that consisted of five sections namely: demographic information, environmental issues, concept of sustainable development, self and social pro-environmental behaviour towards practicing sustainable lifestyles. Table 1 presents the description of 5 point Likert-type scales of students' knowledge and behaviour towards sustainable development. Precaution Adoption of Process Model (PAPM) of changing individual behaviour, proposed by Weinstein and Sandman (1991), was adopted to describe the 5 point Likert-type scales of students' behaviour towards practicing sustainable lifestyles.

Table 1: Likert-type scales of students' knowledge and behaviour

Likert-type Scales	Knowledge	Behaviour
1	Never heard	Never aware on issue
2	Know but cannot describe in detail	Aware on issue but not to engage
3	Understand and can discuss	Have an interest to engage on issue but not sure to contribute
4	Understand, can discuss and relate with others issues	Contribute on issue but still not to practice
5	Expert	Practice on issue as a part of lifestyle

The instrument was tested for reliability and unidimensionality before further analysis using Rasch Model. Table 2 shows the reliability coefficients of Cronbach Alpha of the subscales using SPSS and compared with Rasch Model. According to analysis using SPSS, the reliability results of each subscale exceeded 0.6 (George and Mallery, 2003). In Rasch analysis, all the values of items' separation indexes that exceed 3.0 are considered as excellent levels of separation. In addition, the respondents' separation index also exceed 1.5; this is considered as acceptable levels of separation. These results indicate that person reliability has high consistency to score either lower or higher than expected from the study. Item reliability indicates that the questions are reliable in measuring the proper item. From these statistical perspectives, no items were deleted due to reliability concerns.

4 Results and Analysis

Table 3 presents the summary of the Rasch analysis. Rasch analysis was conducted to identify whether the questions need to be further evaluated and unidimensional. There is either one of three rules to be achieved and fall inside the ranges. The rules are Point Measure Correlation (x where $0.4 < x < 0.8$), Infit/Outfit mean square (MNSQ) (y where $0.5 < y < 1.5$) and infit/outfit z-standard (ZSTD) (z where

-2 < y < +2 (Linacre,2007 and Bond & Fox, 2007). For instance, item BSc10A *'I pick up litter when I see it in public area'* – after the CPBL case study indicates that the infit and outfit mean square (MNSQ) fall outside the ranges and will be categorized as a suspected misfit item. However, this item is bound within the range of Point Measure Correlation. According to the rules, BSc10A is accepted as a fit item. The results show that none of the questions in this study should be deleted as misfit items. Therefore, all items are acceptable for further analysis.

Table 2: Values of Cronbach Alpha using SPSS and Rasch Model

Subscales	No. of items	Cronbach Alpha using SPSS	Rasch Model: Item reliability	Item separation	Respondent reliability	Respondent separation
Environmental Issues	7	0.806	0.98	6.44	0.74	1.67
Concept of Sustainable Development	3	0.725				
Self development of behaviour towards SD	6	0.722	0.97	5.59	0.82	2.12
Social development of behaviour towards SD	6	0.793				

Table 3: Summary of Statistical Results from Rasch Analysis

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

4.1 Analysis of Students' Knowledge

The Person-Item Distribution Map (PIDM), shown in Figure 2, revealed the spread of students' abilities to responses and spread of items on students' knowledge about environmental issues and concept of SD. The distribution of students' position is on the left side of the vertical dashed line and items on the right. The mean of person is higher than the mean of items. This typically suggested that the items are easy for the capability of the students. The items are grouped according to the subscales of knowledge. For example, before undergoing CPBL, KBK2 '*students' knowledge about the three components of sustainable development*', KBK3 '*students' knowledge about the principles of sustainable development*' and KBK1 '*students' knowledge about the definition of sustainable development*' were highly difficult for students to practice. Most students thought that they have no knowledge about the sustainable development. However after completing the problem, all the items became easier for the students to practice. KBK1, KBK2 and KBK3 were moved at the bottom of the map below the mean. Students found that they have the knowledge and could discuss issues on SD with friends.

Referring to Figure 2, for the items on students' knowledge on environmental issues before undergoing CPBL, all of them were spread normally around the mean. It showed that students have the prior knowledge about environmental issues and could discuss briefly with friends. KT7 '*Green Technology*', KT9 '*Waste Management*' and KT4 '*Environmental Degradation*' were found to be difficult for students to practice at the beginning of the semester. Nevertheless, after undergoing CPBL, these items were found to be much easier to practice. On the other hand, KT1 '*Air Pollution*' and KT5 '*Global Warming*' were the easier items for students at the beginning of the semester. At the end of semester, however, students realized that they actually lack knowledge about SD since they found that there were actually a lot more to find learn about SD. This is why most students selected quite higher difficulty after CPBL i.e. KT1A '*Air Pollution*' and KT5A '*Global Warming*'.

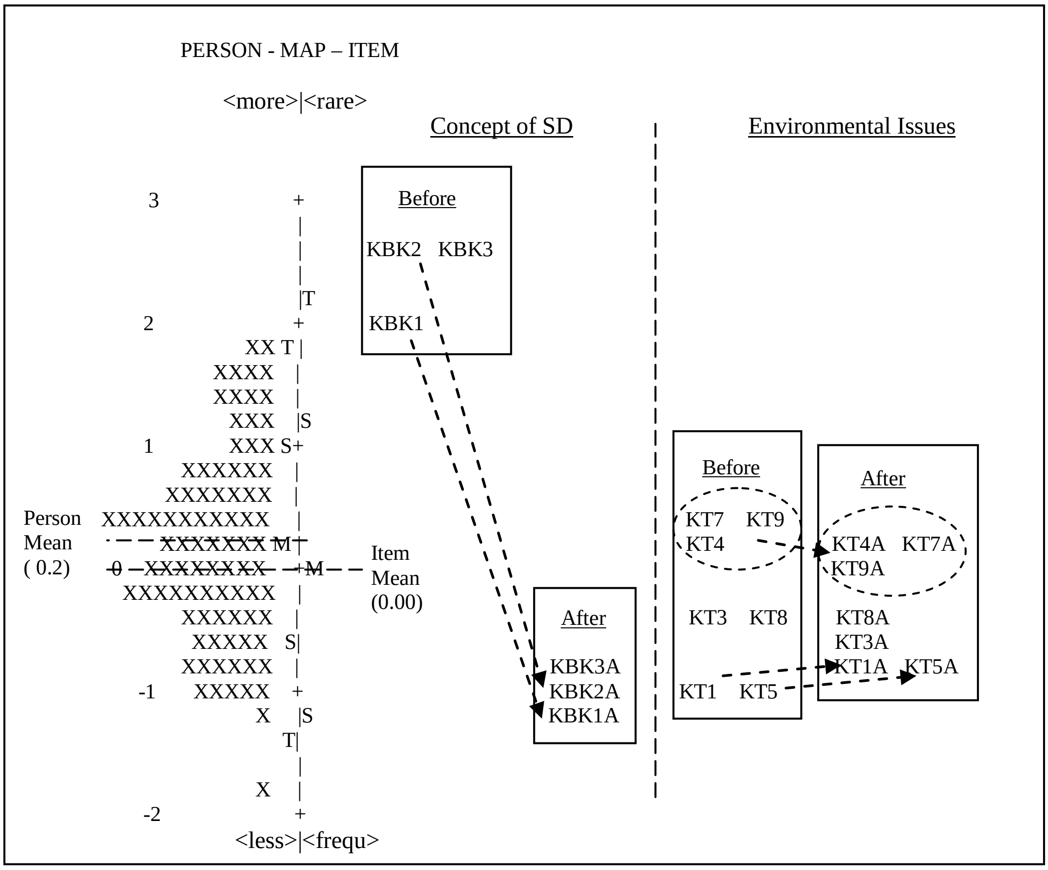

Figure 2: Person-Item-Distribution Map (PIDM) of Students' Knowledge before and after undergoing 'Introduction to Engineering' course

4.2 Analysis of Students' Pro-environmental Behaviour

Figure 3 shows the Person-Item Distribution Map (PIDM) of students' pro-environmental behaviour towards practicing sustainable lifestyles on social development and self development. The scales of item range from '*never aware on issue*' to '*practice on issue as a part of lifestyles*'. According to the distribution of the map, the mean of person is lower than the mean of item. This condition indicates that the items are quite difficult for students to practice. Before undergoing the CPBL problem, the students reported that social development as a difficult item to practice. Most of the items are located above the mean. Referring to Figure 3 at the beginning of the semester, BSc4 '*I attend public talk about sustainable issues*' and BSc8 '*I invite my friends to take part on sustainable programmes'* were the most difficult items for the students to practice. Students reported that before CPBL, they either were 'never aware' or 'aware but not to engage' on social development. Meanwhile, BSc11 '*I volunteer to work with sustainable activities*' was the easier item to practice. Students have an interest to engage and contribute but still not to practice. However, after CPBL, BSc11 '*I volunteer to work with sustainable activities*' and BSc2 '*I discuss with friends about sustainable issues'* were the easier items to practice. Under the activities inside the CPBL cycle, students developed communication and team working skills. Therefore, it is not surprising to see results that showed students improving their social skills with parents, friends and society.

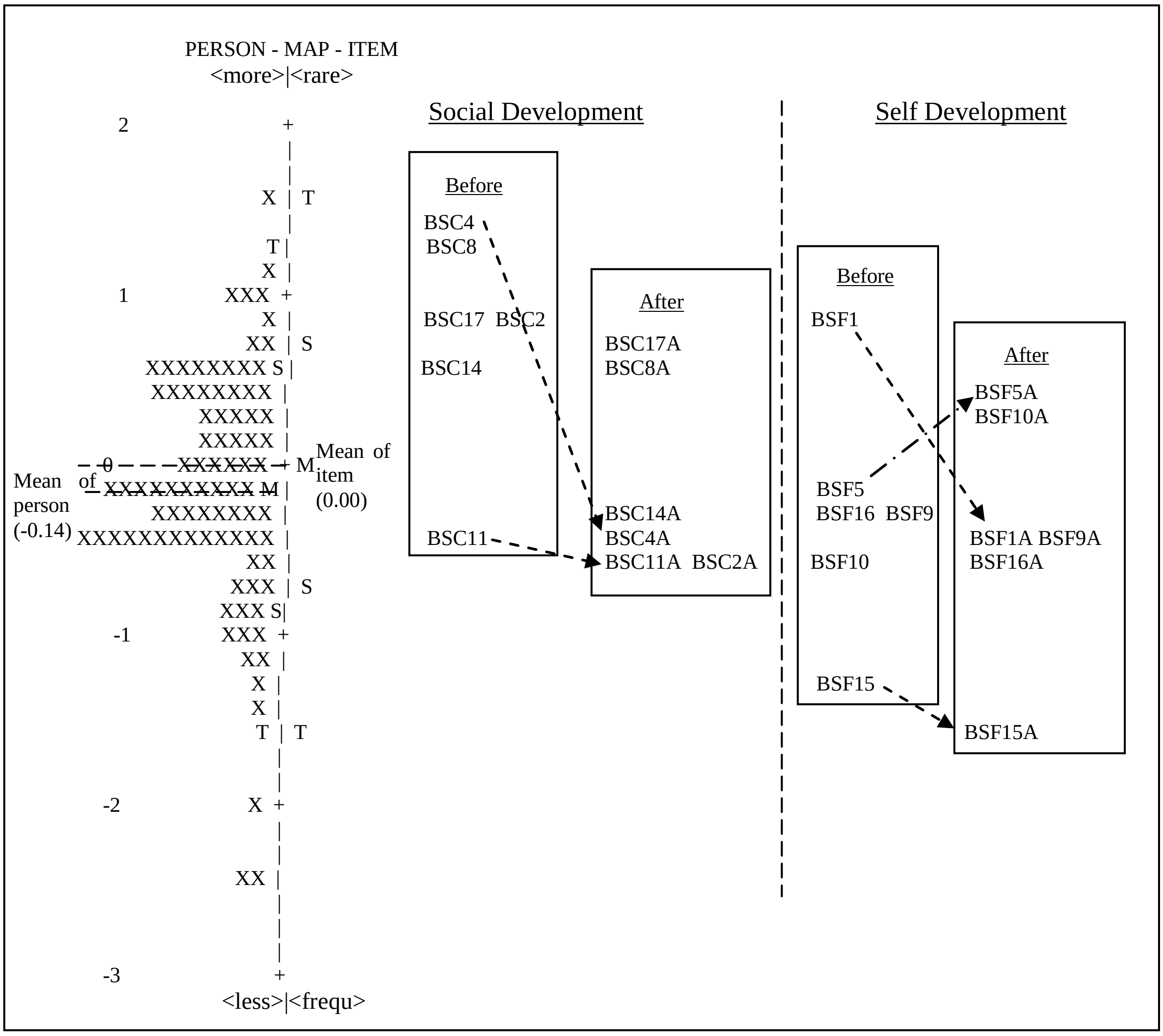

Figure 3: Person-Item-Distribution Map (PIDM) of Students' Pro-environmental Behaviour before and after undergoing 'Introduction to Engineering' course

Referring to students' behaviour on self development, 5 of 6 items are located below the item mean logit 0.00. This means that the 5 items became easier for the students to practice. BSf15 '*I do not let water to run from a faucet when it is not necessary*' is the easiest item to practice. Students reported that they have been practicing this as a part of their lifestyle. BSf1 '*I watch or listen to media programmes about sustainable development'* was rarely practised before CPBL. Students are either 'never aware' or 'aware on issues but not to practice'. This means that they are not interested to know and learn about SD. However, after CPBL, Figure 3 shows that most of the items moved below the item mean, except for BSF5: '*I separate domestic trash for recycling*' and BSF10 '*I pick up litter* *when I see it in public area*'. Both items change from easily to more difficult to practice. This is because, from an interview conducted, students reported that this is due to the change of living environment from home to university dormitory, which have change their way to manage waste. For example, there is not much litter lying around their living spaces to pick up.

5 Discussion & Conclusion

This study demonstrates the impact of CPBL to students' knowledge and pro-environmental behaviour change towards sustainable development. After item analysis with the Rasch model, the findings provided valuable information in inculcating SD through teaching and learning approach.

Firstly, CPBL has successfully developed students' knowledge about the concept of SD. This study found that most of the students have the prior knowledge on environmental issues but lack of knowledge on concept of SD.

Secondly, the study implies that CPBL has successfully promoted pro-environmental behaviour change. The study also found that students developed their social development behaviour higher than self development behaviour. 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 behaviour 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, as well as to support learning. On the other hand, students' self development on pro-environmental behaviour remained consistent.

Finally, the study found that the combination of CPBL as an instructional approach and a problem related to sustainable issue could promote students' engagement in pro-environmental behaviour change. As mentioned by Sharifah (2009), the current practice of disseminating environmental knowledge through lectures is not an effective method to the challenge of educating for SD. Therefore, educators should be informed on how teaching and learning approaches can be effectively implemented in their classroom. This study provides insight into the benefits and gives suggestions that could be placed into the classroom (Mohd-Yusof, K. et.al, 2011a&b). In summary, this learning environment is essential to prepare the engineers needed to face the Grand Challenges on Engineering in the 21st century.

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