INTEGRATING SUSTAINABILITY IN ENGINEERING CURRICULUM THROUGH INCORPORATION OF PROBLEM-ORIENTED PROJECT-BASED LEARNING (POPBL) LEARNING STRATEGY

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ABSTRACT

With the demand and challenges faced by engineering graduates to be more competent and perform work in the world’s current complex situation, new learning method based on the principle of using problems as a starting point for the acquisition and integration of new knowledge need to be incorporated in the curriculum development and as innovation in students’ learning strategy. The traditional method of teaching need to be improvised to enable students to be innovative, creative with critical thinking skills, effective communication and problem solving skills are much required of graduates to be sustained and succeeded in the real world. This paper will highlight a problem-oriented and project-based learning (POPBL) paradigm utilised in the Environmental Engineering program, Universiti Malaya. The study showcased the actual benefits that this particular learning strategy provides for the students and the university through the integration of POPBL concept in the curriculum with the implementation of an integrated solid waste management solution for the whole campus as part of the greening of campus initiatives. Throughout the implementation of the project, the students managed to recover more than 1000kg recyclates monthly, thus saving on operations cost and reducing environmental burden. The study shows that the students embraced the sustainability concept, improved their capabilities while enhancing the integration of non-technical issues into the environmental engineering curricula, creating a balance between problem occurrence and innovative problem solving. The project integrated in POPBL gave hands-on experience to the engineering students in solving sustainability-related problems not only in term of particular technical aspects, but the ability to identify the economical and social aspects of the problems.

Keywords: Problem Oriented Project Based Learning, Engineering curriculum, sustainability, learning strategy

INTRODUCTION

Many educational institutions particularly in the tertiary level are formulating strategies and methodologies to shift the conventional teaching and learning process toward a more engaging and outcome based educational model to produce quality graduates with sound capabilities to perform in the real world. Contrary to the traditional teaching and learning method, the latest educational models are designed to provide a comprehensive educational framework that is able to present a student’s capability to solve problem with not only theoretical knowledge, but also on the soft skills such as interpersonal, management and communication abilities. Project Oriented Problem Based Learning (POPBL) is one of the educational models to achieve the aforementioned education transformation. A problem-based approach to learning enables students to learn both content and thinking strategies by advocating experience based education of solving complex problem that does not have a single correct answer [1]. Self-directed learning and other life-long learning skills inter alia creative, innovative, critical and analytical are among the criteria for any career pursuer to sustain in this competitive globalised world. In order to achieve all those competences, learning institution has to move away from the conventional teacher-centred approach to a more pragmatic approach using POPBL concept. PBL serves as a catalyst for students to become active learners as it situates learning in real-world problems and makes students responsible for their learning by having a dual emphasis on helping learners develop strategies and construct knowledge.

This paper reviews the experience of the initiation and implementation of a Project-Oriented and Problem-Based Learning (POPBL) for an Integrated Waste Management (IWM) project in the period from academic year 2009 to 2011. Recognizing the equal significance of the development of students’ personal skills and abilities and the
technical and professional competences, POPBL is applied throughout the project planning and execution phases. The IWM project emerged as a result of a series of continuous efforts by a group of students to champion recycling and recovery of organic waste in the campus of University of Malaya (UM), driven by the current state of unsustainable waste management trend in the country. The applications of POPBL in this endeavour by the author who lead the team further empower and expedite the journey toward realizing IWM model in the campus.

PROBLEM STATEMENT

Waste management has been recognized as a pertinent environmental issue in Malaysia since the 1980s with the robust increment of industrialization, urbanization and modernization activities resulting from the country’s rapid economic development. The issues concerning waste management comprising the consideration of policy, economic, financial, administration, legal, technological and behavioural aspects. The requirement of multi facet disciplines in waste management sector pose numerous challenges to either the federal, state or local government to uplift their capacity in providing a sustainable and integrated waste management services to the people. Various elements and parties have to be integrated to promote and mainstream the implementation of an integrated waste management (IWM) model in the country.

The generation of Municipal Solid Waste (MSW) is increasing at a staggering amount from about 17,000 metric ton (MT) per day in 2001 to 23,000 MT per day in 2010 [2]. The major component of MSW is food waste followed by papers and plastics waste. In Kuala Lumpur alone, the MSW generation is about 3000 MT per day. The monthly generation of food waste in Kuala Lumpur was about 37956.87 tons in January 2011[3] and it is estimated to show annual increment of 9% [4]. Out of the generated waste, less than 5% is being recycled by the workers in Transfer Station at Taman Beringin, while the rest are disposed directly in sanitary landfill in Bukit Tagar situated 62km away from the transfer station. Different from other developed countries, landfill disposal is still the main method for solid waste management throughout the country without much recovery effort and strategies. Out of the 176 landfills in the country, there are only 8 sanitary landfills and the rest are non-sanitary landfills [2]. Currently, the government is in the process of upgrading the non-sanitary landfills to sanitary landfills. Besides, the financial burden of waste management cost is taking its tolls. Both the federal and local government have spent huge amount of expenditure in waste management. Local government normally spend 40 – 60% of their annual expenditure in waste collection and disposal while federal government is expected to spend about RM 2 billion per annum for waste management in Malaysia once the Solid Waste and Public Cleansing Management Act 2007 that introduces institutionalization, federalization and privatization of solid waste management [2].

Therefore, MSW management is a significant drawback of sustainable urban planning in the country. In Malaysia, the sources of MSW are categorized with solid waste arises from residential, commercial or institutional area. Table 1 shows the composition of MSW generated from three different sources [5]. In Malaysia, the existing mixed MSW with high organic fraction poses a huge challenge in steering toward an IWM system. MSW in Malaysia has a high percentage of perishable organic fractions. Organic Fraction of Municipal Solid Waste (OFMSW) such as food waste and green waste constitute the most (60% - 80%) of our country total waste streams that exclude source segregated dry recyclables (Table 1). The high fraction of organic waste contributes to the high moisture content and low caloric value in our MSW. As an “active” waste, OFMSW is the fundamental cause of pollution in a landfill, i.e., landfill gas (LFG) like methane gas is a significant greenhouse gas while landfill leachate causes pollution on nearby waterbodies especially at non-sanitary landfills. In a sanitary landfill, leachate treatment plant (LTP) consumes considerable amount of energy (electricity) and the efficiency of the LFG recovery is considerably low. In Malaysia, the existing mixed MSW with high organic fraction poses a huge hindrance in steering toward an Integrated Waste Management (IWM) system. In the case of institutional area, significant amount of recyclates particularly papers and plastics present in the waste stream can be reduced with proper recycling collection mechanism. Food waste is the major component of OFMSW and requires effective source segregation scheme to increase the recovery rate. Green waste represents a significant percentage of MSW in institutional area and size/volume reduction is important in the management of green waste.

<table>
<thead>
<tr>
<th>Waste stream</th>
<th>Waste sources</th>
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<tbody>
<tr>
<td>Residential</td>
<td>Commercial</td>
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</table>

Table 1: MSW composition by source in Kuala Lumpur, 2002 (percentage by weight)
Various waste reduction strategies have been attempted in most cities and countries in the field of municipal solid waste (MSW) integrated management. The key to the success of such strategies has generally been found to be MSW source separation, which is considered an effective means of enhancing waste recycling and disposal reduction [6-8]. Source separation refers to the separation of MSW into several categories at the generation source according to the different characteristics of each material before further treatment.

Few studies have been conducted to evaluate the mechanism of source separation activity or the separation actor itself, and even fewer quantification studies have been carried out. They have also provided plentiful theoretical foundations for the environmental behavior intention of people from a social psychology and behaviouristic viewpoint. Several factors directly or indirectly influence source separation activity [9] considered the significance of providing an explicit guideline regarding waste separation to actors. Configuration and design of separation-related facilities [10-15] particularly waste bins, are proposed as external conditions that influence behaviour to waste separation. Behavior to waste separation is also influenced by the frequency and mode of collection-transportation [14-16] together with community management and the environment [17]. The actors' environmental values, attitudes, and cognition also all directly influence separation activity [18]. Legislation and policy, psychological factors, punishment, rewards, and profit are also good motivators that are approved by actors. The possible influences are listed in two columns in Table 2. These include the external conditions and internal motivations that influence the behaviours of the community to source separate their solid waste generated daily.

<table>
<thead>
<tr>
<th>External conditions</th>
<th>Internal motivations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Separation facilities</td>
<td>Environmental profit</td>
</tr>
<tr>
<td>Awareness</td>
<td>Sense of honour</td>
</tr>
<tr>
<td>Separation transportation</td>
<td>Economical profit</td>
</tr>
<tr>
<td>Participation atmosphere</td>
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</table>

A major challenge in improving services in waste management for the community in UM is effective co-operation with the various stakeholders (e.g., students, cleaners, academic staffs, and top management etc.). Initiatives to improve waste management services require participation of all involved parties; in order to be successful, all actions have to be credible, transparent, socially sustainable and, as far as possible, Consulting and training activities on sustainable waste management should become a priority in order to support related initiatives [19]. Lei found out that office buildings had an initial separation ratio of 80% and a stable separation ratio of 65.86%, whereas residential communities and primary and middle schools did not have a stable separation ratio [20].

**Table 2: The influencing factors on source separation of solid waste**

**IWM PROJECT AS POPBL STRATEGY IN SOLID WASTE MANAGEMENT**

The project was incepted by final year Environmental Engineering students and a lecturer from the Department of Civil Engineering, Faculty of Engineering, University of Malaya who advocated the needs to address the challenges posed by the inevitable environmental liabilities in waste management and carefully identified the major drawbacks concerning the low environmental performance of MSW management in the country. They initiated a chain of activities to development a recycling management system in the faculty with minimal cost. In July 2009, VeeCYCLE, a student group was formed to run an integrated recycling project in Faculty of Engineering. The
project established a recycling management model which has resulted in the development of an organized and effective waste and recyclables collection system in the faculty. 45 sets of an integrated waste and recyclables collection facility called PRO Bin were introduced to replace the existing rubbish receptacles in the faculty. PRO Bin is a user friendly set of bins that are retrofitted from the existing semi circle rubbish bins with some alteration in the opening coloring schemes. It facilitates the good practice of separation at source.

In January 2010, Organic Waste Diversion (OWD) Project in UM campus was introduced by the same group of students to recover the campus food waste and green waste from ending up in a landfill. Recognizing the serious problem caused by food waste in the country, Green Bag Scheme was introduced to all the twelve residential colleges as an instrument to gather the support and participation from the important stakeholders in food waste separation at source. With the collaboration from JPPHB (Department of Development and Asset Maintenance of UM), Deputy Vice Chancellor of Development, UM Environmental Secretariat UM Cares and all the residential colleges management, Green Bag Scheme has managed to achieve its purposes and goals in food waste segregation. The OWD project basically has three components of food waste separation at source, collection system and on-site treatment.

The OWD project and VeeCYCLE were further streamlined and restructured as a two pronged approach in spearheading Zero Waste Campaign, a continuous campaign in reducing waste generation in UM campus. VeeCYCLE is an all time student group that design effective recyclates collection and advocate recycling behaviour among the campus communities. The immediate step is to promote waste separation at source with the provision of PRO Bin as an integrated collection facility. On the longer term, a central sorting area will be ready once the recycle collection system becomes stable. OWD project embarks on on-site food waste treatment with composting as an intermediate, proven and cost effective solution. Scaling up of the daily composting operation is done through improvement in efficiency. Size reduction and composting of green waste is carried out with mechanical process with shredder and mixer. At the mean time, feasibility of on-site anaerobic digestion for food waste is explored with continuous research and experiment. Ultimately, the project aims to mainstream mechanical biological treatment of organic waste as an integrated and BPEO (Best Practicable Environmental Option) for municipal organic waste. Chronology of the development of IWM project is shown in Table 3.

<table>
<thead>
<tr>
<th>Period</th>
<th>Happenings</th>
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<tbody>
<tr>
<td>May - June 2009</td>
<td>- Planning of an integrated recycling system in Faculty of Engineering (FEUM) and forming of VeeCYCLE, as a volunteering student group</td>
</tr>
<tr>
<td>June 2009</td>
<td>- Obtained support from lecturer to empower VeeCYCLE and their ideas in promoting sound recycling communities in UM</td>
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<tr>
<td>July 2009</td>
<td>- Presentation to Dean of FEUM to endorse the proposed integrated recycling management in FEUM with PRO Bin and a series of alteration in waste and recyclates collection and handling</td>
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<tr>
<td>August 2009</td>
<td>- Introduction of 45 sets of PRO Bin by the retrofitting of the existing semi circle rubbish bins in FEUM</td>
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<td>- Capacity building (training) program to the cleaner of FEUM as one of the primary stakeholders about the new recycling system</td>
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<tr>
<td>Sept – Nov 2009</td>
<td>- Full operation of integrated recycling management system in FEUM with cooperation from cleaners and staffs by weekly collection</td>
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<tr>
<td>Jan – May 2010</td>
<td>- About 1000 kg of recyclates were collected every month</td>
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<tr>
<td>October 2009</td>
<td>- Official launching of VeeCYCLE and PRO Bin in FEUM</td>
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<td>- Set up of a new recyclates storage area, funded by FEUM</td>
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<tr>
<td>November 2009</td>
<td>- Inception of Organic Waste Diversion (OWD) project with the recognition of the severe negative environmental impact caused by organic waste especially food waste</td>
</tr>
<tr>
<td>December 2009</td>
<td>- Survey and study of waste stream and generation in UM campus for the preparation of a technical report on OWD project</td>
</tr>
<tr>
<td>January 2010</td>
<td>- Presentation to Deputy Vice Chancellor (Development) to obtain green light to implement OWD project</td>
</tr>
<tr>
<td>Feb – March 2010</td>
<td>- Introduction of Green Bag Scheme to incorporate food waste separation at source as a good practice to all the kitchen staffs of all residential colleges in UM</td>
</tr>
</tbody>
</table>
- Stakeholders engagement and emergence of strategic partners, involved parties and supporting parties of the project

**April 2010**
- Stakeholders roundtable discussion to obtain the support and commitment of all residential colleges in the Scheme

**May – June 2010**
- Capacity building and training for kitchen staffs on Green Bag Scheme
- Sourcing for food waste treatment companies for organic waste collection and off-site treatment
- Formulation of food waste collection system
- Study of the treatment options of the diverted food waste (methods, on-site/off-site, costing, sustainability, viability, etc)

**June 2010**
- Secured funding from a foundation to run OWD project and extend the integrated recycling system to entire campus by introducing Zero Waste Campaign
- Stakeholders consultation with JPPHB on contract management

**July 2010**
- Presentation to Vice Chancellor for the endorsement of Zero Waste Campaign as cornerstone of IWM project
- Implementation of Green Bag Scheme

**August 2010**
- Carried out waste audit for food waste arise in residential colleges
- Engaged government agencies for solution on treatment of food waste

**Sept - Nov 2010**
- Planning of Zero Waste Campaign
- Official launching of Zero Waste Campaign

**December 2010**
- Meeting with National Solid Waste Management Department about solution to big scale on-site food waste treatment

**Jan - Feb 2011**
- Continuous monitoring of Green Bag Scheme
- Meeting with consultant from IGES (Institute for Global Environmental Strategies) about the treatment of food waste

**March 2011**
- Discussion with JPPHB on proposed in-house organic waste treatment project with Takakura Composting method
- Training and dialogue session with 160 cleaners from various faculties on new recycling management system and introduction of PRO Bin to entire campus

**April – May 2011**
- IGES site visit to UM for demonstration of compost seed cultivation
- Set up of a composting site at UM central waste disposal area

**June – July 2011**
- Trials and experiments on food waste composting with Takakura composting
- Planning on the full scale operation of composting for food waste and size reduction of green waste to reduce the organic waste to landfill

Various programs were carried out to enable the implementation of the projects, including awareness publicity program for students and staffs, capacity building program for the kitchen staffs and cleaners, discussion and meeting with strategic partners both UM and external bodies as well as several site visits to enhance the students’ knowledge in waste management. The programs promote the development of communication, information, negotiation and consultation skills among the students. The successful implementation of these two projects were managed to catch the attention of UM top management to impose the necessary policies in waste management related matters as well as to secure a one year funding of MYR180,000 from a local well known foundation. With the budget, the projects are poised to further strengthen their roles in realizing IWM model by enabling on site, in-house organic waste treatment operation and expanding the coverage of recycling collection points (PRO Bin). The IWM project is developed through the fundamental elements of: (1) Concept of waste separation at source; (2) Strategic stakeholders’ management; (3) Effective implementation instruments; (4) Funding and budget administration; (5) Capacity building for best practices. (6) Workable operation mechanism and management system.
The comprehensive combination and interconnectivity of the fundamental elements develops a functional and sustainable IWM model when they are effectively utilized and organized by a working committee comprising of committed students and staffs.

**PRINCIPALS OF POPBL IN IWM PROJECT**

POPBL has to start with the analysis of a research problem followed by the design of the project to solve the problem through the implementation of the activity planned in order to solve the problem under study. The learning outcome is not merely general knowledge and forming an overview, but the development of analytical skills and an ability to argue and present solutions and answer to challenging questions [21]. The project was originated from the quest in searching for an integrated solution to MSW management problem in an institutional area with the implementation of projects to develop new waste management system. Throughout the project development process, learning opportunities are vast from technical know-how, management knowledge to soft skills enhancement. Figure 1 shows the inputs, process and outputs of IWM project as POPBL in environmental engineering education. [21]

![Figure 1: Input, Process and Output of IWM project](image)

i. **From student-centered committee to students and staffs working group formation**

The recycling initiative by VeeCYCLE was integrated in Environmental Impact Assessment (EIA) subject as POPBL strategy. The subject was designed for the final year Environmental Engineering students in Faculty of Engineering, UM. VeeCYCLE was designed as a group project to the students and incorporated as the assignment for EIA subject. After some explanation and motivation from the lecturer, the group of students developed self initiative to form their organization structure shown in Figure 2 based on each student’s ability and strength. Minimal instruction was given by the lecturer in order to enhance self-learning ability among the students. This approach was student-centered and able to gain commitment from the students.
With the development of VeeCYCLE to OWD project team, a new group of volunteers involving a bigger stakeholders were formed. The introduction of Zero Waste Campaign created a committee comprising of students and staffs in a working group Figure 3 to ensure the implementation and sustainability of IWM project. The working group has a combination of different management levels from students and staffs of UM to produce synergistic cooperation in steering the project toward its goals (Figure 4).

Figure 2: Organization chart of VeeCYCLE

Figure 3: Organization chart of working committee of ZWC

Figure 4: Roles and responsibility of different strategic partners and stakeholders
ii. Construct an extensive and flexible knowledge base

Constructing extensive and flexible knowledge goes beyond having students learn the facts and problem of solid waste management. It involves integrating information across multiple areas such as the environmental, economical and social dimensions. Such knowledge is coherently organized around the deep principles in an area and it is also flexibly retrieved and applied under different circumstances [22-23]. Application of knowledge in a variety of problem situations in the IWM project helps to develop increasingly flexible knowledge among the students involved. For instance, the students reuse and retrofit the existing rubbish bins into recycling bins in order to increase the total number of recycling bins available in the faculty instead of procuring the ready-made recycling bins from the market had shown a cost saving of about 88%. Besides, the capacity building and awareness program to engage the participation from the primary stakeholders and campus community in waste segregation manifest the success in social and behavioural dimension. The other example is the development of waste generation data in UM campus by the implementation of waste audit (Figure 5-7).

![Figure 5: Data of waste audit on food waste in residential colleges on 30th August 2010](image1)

![Figure 6: Data of waste audit on food waste in residential colleges on 31st August 2010](image2)
iii. Development of effective problem-solving skills

We must embed learning in contexts that require the use of effective problem solving skills in order to encourage the students to develop these skills [24-26]. Different from conventional method, discussing problems in POPBL group (before beginning to research the learning issues) activates relevant priority knowledge and facilitates the processing of new information [27]. Hence, in the case studied, students are more able to construct new knowledge when they relate the issue of low recycling culture in the campus to what they have learned in class. For instance, the students managed to develop new knowledge in solving problems during discussion and brainstorming by identifying three contributing factors to low recycling culture in the campus namely: (1) lack of recycling bins; (2) convenient rubbish bins discourage source separation; (3) poor management of the existing recycling bins.

In the case of OWD project, green bags were introduced for the containment of food waste as an important strategy to reduce leakage and improve cleanliness. A Code of Practice for Green Bag Scheme had been introduced as a regulatory instrument in ensuring the effective implementation of the Scheme (Figure 8). Besides, the collection system for food waste, decision in on-site or off-site organic waste treatment was critically discussed and reviewed with strategic partners in both environmental and economical contexts.
The students advocated that sustainable solid waste management requires participation, support and commitment from all layers in every community including the students and academic staffs. Hence, the students designed and proposed a source separation system in Faculty of Engineering, UM. The development of effective problem-solving skills includes the ability to apply appropriate metacognitive and reasoning strategies [28]. Metacognitive skills refer to the executive control process of planning, monitoring and evaluating of the IWM project for instance.

iv. Develop self-directed, life-long learning skills

Metacognitive strategies are also crucial for development of self-directed, lifelong learning skills. These are the skills that encourage autonomous learning among the students. First, students had a metacognitive awareness of what they understood about solid waste management and also what they did not know, for instance, the environmental and economical dimensions of the existing solid waste management industry in the country. Second, they were able to set learning goals, identifying the objectives and what they would like to learn more about for the task they were engaged in particularly in term of environmental related project management. Third, they were able to plan their learning and select “learn from action” as their learning strategies. In other words, they decided on a course of actions or programs to reach these goals. These actions are incorporated into the execution plan of IWM project throughout the year.

Finally, as they implemented their plan, students set up a monitoring procedure to evaluate whether or not their goals have been attained. For instance, the students did recording of total of recyclable items collected every month according to different categories. Besides, students carried out questionnaire surveys with the community to evaluate the acceptability of the public towards the project. These data and information are important for continual improvement. Figure 9 shows the project learning cycle of the IWM as POPBL in environmental engineering education. In this cycle, also known as the PBL process, the students were presented with a problem scenario. They formulated and analyzed the problem by identifying the relevant facts from the scenario. This fact-identification step helped students represented the problem. As students understood the problem better, they generated goals and objectives for the IWM project. An important part of this cycle was identifying knowledge deficiencies relative to the problem. These knowledge deficiencies became what are known as the learning issues that students researched during their self-directed learning (SDL). Following SDL, students applied their new knowledge and evaluate their objectives and goals from what they had learned. At the completion of each problem, students reflected on the abstract knowledge gained. The lecturer helped students learned the cognitive skills needed for problem solving and collaboration. Because students were self-directed, managing their learning goals and strategies to solve PBL’s ill-structured problems, they also acquired the skills needed for lifelong learning.

Figure 9: The Problem-Based learning cycle of IWM project
v. Effective collaborators and motivated to learn

Dynamic collaboration among team members was developed throughout the project from designing to execution process. The students functioned well as a team in solving the solid waste management problem. Good collaboration encompasses establishing common ground, resolving discrepancies, negotiating the actions that the group is going to take and finally coming to an agreement [29]. The students were given opportunities to exchange ideas and engagement among themselves particularly in the early stage of the project. Table 4 shows the open exchange of ideas to the solution of each problem identified. Explaining one’s ideas is important for productive collaboration and also serves to enhance learning [30].

Students were intrinsically motivated as all of them worked on a task related to environmental protection as a part of their core knowledge as environmental engineers. They were motivated by their own interest in solid waste management, challenges to resource conservation through recycling and sense of satisfaction with the total of recyclable items collected throughout the implementation of the project. Besides, the IWM project provided students with proximal and tangible goals of applying their knowledge to solve the recycling problem. This type of goal is more motivating than those distant, abstract goals that may seem insurmountable.

Table 4: The exchange of ideas and action plans associated to every problem identified in the project

<table>
<thead>
<tr>
<th>Problem</th>
<th>Ideas</th>
<th>Learning issues</th>
<th>Action plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>High generation of solid waste</td>
<td>a. Increase recycling</td>
<td>a. What are the compositions of the solid waste generated daily?</td>
<td>a. Waste audit</td>
</tr>
<tr>
<td></td>
<td>b. Promote 3R campaign</td>
<td>b. What is the current rate of generation</td>
<td>b. Questionnaires survey</td>
</tr>
<tr>
<td>Insufficient recycling facilities</td>
<td>a. Purchase recycling bins</td>
<td>a. What is the cost of purchasing a new set of recycling bins?</td>
<td>a. Survey on the current market price of recycling bins</td>
</tr>
<tr>
<td></td>
<td>b. Retrofit the existing rubbish bins into recycling bins</td>
<td>b. How much is the allocation of budget for the project?</td>
<td>b. Design of recycling bins</td>
</tr>
<tr>
<td></td>
<td>c. Set up buy back centre</td>
<td>c. What is the cheapest way to set up 50 sets of recycling facilities throughout the whole faculty?</td>
<td>c. Engage contractor to retrofit the existing rubbish bins into recycling bins</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d. What is the timeline given to the project?</td>
<td>d. Modelling of the current location of rubbish bins and draw a layout of new locations of recycling bins</td>
</tr>
<tr>
<td>Seasonal recycling trend</td>
<td>a. Set up recycling system</td>
<td>a. What is the current trend of recycling?</td>
<td>a. Capacity building sessions the cleaners</td>
</tr>
<tr>
<td></td>
<td>b. Engage the participation from cleaners and top management</td>
<td>b. Who are the stakeholders in solid waste management in a community?</td>
<td>b. Printing of posters and brochures.</td>
</tr>
<tr>
<td></td>
<td>c. Make recycling facilities available in all places</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Commingled solid waste

a. Introduce separation of waste by introducing multi bins system (PRO bins)
b. Introduce green bag scheme to separate organic waste from the rest

Treatment of food waste

a. Off-site treatment
b. On-site treatment

EXPERIENCE FROM IMPLEMENTATION OF IWM PROJECT AS POPBL STRATEGY IN ENVIRONMENTAL ENGINEERING EDUCATION

Through POPBL strategy, students were exposed to the real life situation in solving particular problem related to solid waste management. Prior to this, students were given technical inputs regarding the basic knowledge on solid waste management. As the whole project was student-centered, students were given opportunity to plan and manage the project on their own. However, there were some feedbacks which showed the lack of research ability among the students. This was due to “spoon-fed” learning attitude among some students that create tendency expecting lecturers or supervisor to provide information. Hence, some weaker students were not able to catch up at the beginning of the project as they were used to the traditional way of learning. Yet, this problem can be easily solved when the students helped among each other as a team.

To promote creativity among students, lecturers gave more freedom to students to explore their own learning and construct their own meaning. The program gave more attention to the process of getting to the result rather than just concentrate on knowing the facts. Qualitative result is very important for project review by the lecturers and also the students for continual improvement. This IWM project was a very good project to expose the students to the real scenario in solid waste management field and thus provide them a very good learning structure to improve a selected area in sustainable manner. However, assessment and monitoring in PBL and POPBL in term of learning skills is always become issues [31-32]. For future action, the attention should be given to the effort of producing a model of assessment to quantify the development of life-long learning ability skills among the students.

CONCLUSIONS

Engineering education is a paramount important type of education in providing the nation with innovative, creative and critical thinking human capitals which will contribute to sustainable development of the country. To achieve this, a good and holistic program of engineering education at the tertiary level should be provided. One of the suggestions is the implementation of PBL and POPBL approach. POPBL has structured approach that integrates research elements, generic skills to interdisciplinary curriculum drawn from real life situations. Students work in collaborative groups to identify what they need to learn in order to solve a problem. They engage in self-directed...
learning (SDL) and then apply their new knowledge to the problem and reflect on what they learned and the effectiveness of the strategies employed. The teacher acts to facilitate the learning process rather than to provide knowledge. The goals of PBL include helping students to develop flexible knowledge, effective problem-solving skills, SDL skills, effective collaboration skills, and intrinsic motivation. The integration of IWM project with POPBL learning strategy provides a good and practical learning platform not only to learn from problem but also to apply their knowledge in implementation of the project. This includes the interpersonal skill, entrepreneurship skill, management skill and research skill. However, the limitation of the POPBL is the management aspect and assessment of the students’ progress and result. The second step of this project will be the effort in designing model to assess and quantify student’s benefits from POPBL program incorporated in their environmental engineering education.

REFERENCE


