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Introduction to Environmental Engineering: A Problem-Based Learning Approach to Enhance Environmental Awareness among Civil Engineering Students

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Abstract

The Department of Civil & Structural Engineering (JKAS), Universiti Kebangsaan Malaysia offers an Introduction to Environmental Engineering course (KH2173). This is an introductory course for civil engineering students with the main purpose is to ensure that the students understand the basic engineering and science of environmental pollution. The course applied a PBL approach in the teaching and learning process, with PBL component constitutes to approximately 30% from the total course assessment. Team working was applied in the PBL approach with 3 to 5 students in a group. Various PBL topics on environmental issues were given to or proposed by the students.

Keywords: Department of Civil & Structural Engineering; Introduction to Environmental Engineering; Teaching & Learning; Problem-based Learning

1. Introduction

What is Problem-Based Learning (PBL)? PBL is an education approach that starts at the McMaster University in the 1960s and subsequently has been expanded to North America and elsewhere in the world (Albanese & Mitchell, 1993). It has been well accepted in the medical field with more than 82% of medical schools in the United States using the PBL approach for teaching basic science to a variety of degrees offered (Jonas et al. 1989). Further, it has been applied in various disciplines including business, education, architecture, law, engineering and social work (Savery & Duffy, 1995).

Currently environment and sustainable development is an important curricular component in higher education which aims to create human capital that meets the needs of the job market and works to preserve the earth's finite resources. It covers all areas of education. Malaysia needs engineers, scientists, and those who are experts in various

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fields to jointly assist in sustaining national development, which not only depends on the earth's resources but also on worker's skills and expertise to preserve those resources. Keene & Blumstein (2010) argue that changing environmental education requires the cooperation of various organizations and academic disciplines. The National Higher Education Strategic Plan, which was launched in 2007, prioritizes the transformation of higher education. The plan aims to achieve excellence and sustainability in higher education beyond the year 2020 (Kementerian Pengajian Tinggi, 2011) and outlines seven main foci related to that goal. Among the plan's stated goals is the effort to improve the quality of teaching and learning to produce innovative and ethical individuals with the capacity to think critically and who are committed to a common moral standard.

What is the problem in PBL means? It is a question or issue given to students during the teaching and learning process, which happen in their surroundings. The students are then required to resolve the problem by using knowledge they learned previously. According to White (1995), problems that are given to students should be the issues or situations that actually happened in real-life, sequential and have to be appropriate for students to undertake the problem in a group that lasted for a week or more. In the PBL approach, problems are given earlier before the lecture is given. This is different from the conventional teaching method whereby the problems are given to students at the end of each section being taught in the classroom. Dunlap (2005) stated in his paper that PBL as an exercise to the real problems that help students to acquire knowledge and skills in the workplace. At present, professional workforce of innovative, competitive and highly skilled are much required. To enhance these talents, educators need to provide an appropriate learning environment that can lead to the learning process that stimulate students' critical thinking toward solving the real problems in the workplace.

The PBL learning process requires all students to be actively participate in the classroom. However, this may be difficult for a class with a large number of students of more than 100. During the PBL process, students are required to work in small groups (3 to 5 students in each group) so that they can exchange knowledge and mutually help each other. They cannot only depending on text books alone, but will also gather information from other sources such as websites, journals, newspaper and interviews. The students will then solve the problem based on the information and knowledge that were obtained from their findings.

The teaching and learning approach based on the PBL is a key component in the current education system in Malaysia, which is the *Outcome-Based Education* (OBE). OBE emphasized on the "results" or the outcomes. Each course offered has its own course objectives and the "results" are to be achieved by the students at the end of the course or upon completion of their studies at the university. In implementing an effective teaching and learning at Universiti Kebangsaan Malaysia, the Faculty of Engineering has provided a series of seminars, lectures and workshops on OBE teaching and learning approach to all lecturers. This is to provide exposure and knowledge to lecturers on how to implement an effective teaching and learning using the concept of PBL. Lecturers may obtain new ideas so that they can apply PBL innovatively in their teaching process, which also include the evaluation of the outcome by measuring of the students' achievement.

2. Teaching and Learning Methodology

Introduction to Environmental Engineering (course code KH2173) is a course for civil engineering students with the main purpose is to ensure that the students understand the basic engineering and science of environmental pollution. Students are required to identify sources of pollution and its impact on the environment and public health. Students are also exposed to the methods used to control pollution. The aspects discussed in this course include the basic concepts of environmental engineering, water resources management, water treatment, waste water treatment, sewerage, air pollution, solid waste and hazardous waste management. In general, this course introduces the concept of environmental management such as sustainable development, environmental impact assessment, legal and ethical environment strategy.

Initially the course learning outcomes (CO) were identified to satisfy the Programme Objectives (PO) for Civil & Environment and Civil and Structural Engineering Undergraduate Degree Programmes. The PO for Civil & Structural Engineering Degree Programme and Civil & Environmental Engineering Degree Programme are shown in TABLE 1. The relevant PO identified for the Introduction to Environmental Engineering course are PO1, PO2, PO4, PO5, and PO6.

Table 1. Program Outcomes (POs) for Civil & Structural Engineering Degree Programme and Civil & Environmental Engineering Degree Programme

Program Outcomes, PO	
PO1	Ability to acquire and apply mathematical, science, and engineering principles toward technical competency in the fields of Civil & Structural Engineering/Civil & Environmental Engineering
PO2	Ability to identify engineering problems and formulate a solution.
PO3	Ability to design a Civil & Structural Engineering project/Civil & Environmental Engineering within realistic limitations, including economic, environmental, social, political, ethical, health, and security and sustainability.
PO4	Professional understanding and ethical responsibility and commitment.
PO5	Ability to plan and conduct an experiment and then to analyze and interpret the data collected.
PO6	Ability to use techniques, skills and modern technique tools entailment for engineering practice.
PO7	Ability to communicate effectively, not only with other engineers but also with society at large.
PO8	Ability to function effectively as an individual in groups and to lead or manage a group or teammates effectively.
PO9	Commitment to lifelong learning.
PO10	Ability to use elements in construction project management, asset management, public policy, administration, business, and entrepreneurship.

The CO were explained to the students in the first week of academic semester by the lecturer informing all students on the teaching and learning methods that will be conducted throughout the course. TABLE 2 shows the CO, teaching and assessment methods for the course.

Table 2. Course Outcome (CO), Teaching and Assessment Method for the Introduction to Environmental Engineering course

No	***Course Outcomes (CO)***	***Teaching Methods***	***Assessment***
1	Ability to understand environmental issues, basic environmental management & planning, sustainable development, ethics, legislations and standards	Lecture & PBL	Examination & Technical Report
2	Ability to carry out calculations for environmental system	Lecture & Tutorial	Examination
3	Ability to understand and identify suitable management and treatment in water supply, wastewater, solid waste, hazardous waste, air and noise.	Lecture	Examination & Technical Report
4	Ability to understand the flow process of EIA report submission, the environmental impact from a proposed project and their mitigation methods.	Lecture & PBL	Examination & Technical Report
5	Ability to conduct experiment for water quality parameters such as BOD, COD, TSS etc.	Laboratory Experiment	Examination & Laboratory Report
6	Aware of professional and ethical responsibility of an engineer in relation with the environmental	PBL	Technical Report

The assessment structure on students' PO achievement of the overall Introduction of Environmental Engineering course are as following:

- Final examination (40%) to evaluate PO1, PO2 and PO4
- Mid Semester Examination (20%) to evaluate PO1, PO2 and PO4
- Assignments (10%) to evaluate PO1 (four number of assignments were given)
- Laboratory experiments (15%), to evaluate PO5 and PO6 (four experiments were given)
- PBL Projects (15%) to evaluate PO4 (two mini projects were given)

For the Introduction to Environmental Engineering course, PBL component constitutes to approximately 30% from the total course assessment. Team working is applied in the PBL approach. To organise a lesson in a relatively large class of approximately 100 students, it is rather a difficult task for the instructor to interact or ask questions to each student individually during the lecture. Thus, discussions among the students and lecturers were made in a group during the PBL project meetings. In this course, students were divided into 3 to 5 students for each group.

3. PBL Projects

The tasks for the PBL projects and assignment were given to students during the first week of the academic semester that are to be completed within 12 weeks. The PBL projects for the Introduction to Environmental Engineering course had started since the academic session of 2005/2006. Various topics on environmental issues were given to the students. Initially, in the academic session of 2005/2006 and 2006/2007 a total of ten topics were given to 20 groups of students, thus two groups were working on the same topic. All topics were related to real-life environmental problems that were occurring surrounding them. The aim of having two groups of the same topic is to make comparisons between the groups. Each group had meetings with lecturers on the second, third and the seventh week of the semester. These meetings were to guide the students in the early stages of the project and before starting laboratory works. During the meetings students were encouraged to give their opinions to enhance critical thinking on environmental issues.

In the following academic years, i.e. 2008/2009, 2009/2010, and 2010/2011, the students were required to suggest their own topics on environmental issues. The aim for this approach was to encourage the students to be more proactive in conducting their own search for information from various sources. Another PBL projects that were given to the groups of students were to obtain information from various government and private agencies related to environmental protection and services such as the Department of Environment, Department of Irrigation and Drainage, Meteorological Department, the National Department of Solid Waste Management, etc. The aim of this task was to develop awareness among the students on various agencies related to the environment that they may come across in the future at their workplace.

To complete these tasks within a period of 12 weeks, students must provide a log book to record the activities, analysis of the problems and making the proposals; case studies; laboratory work to analyse pollution parameters, and the proposed technological solutions to the problems. The laboratory work was limited to three or four pollution parameters such as Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Total Suspended Solids (TSS), etc. Students were required to write a short laboratory report and answer questions related to the laboratory experiments. Laboratory experiments were supervised by the lecturer concerned, a science officer, and three laboratory assistants.

4. PO Achievement for the Course Assessment

A sample of students' PO achievement for the Introduction to Environmental Engineering course in the academic session 2009/2010 as follows:

- **PO1:** The average total mark of 62.6% is achieved for the course; the average of the top student group is 80.1%, 62.7% for middle achiever and 45% for weak achiever. Overall PO1 is achieved, which is more than 60%.
- **PO2:** The average total mark of 70.6% is achieved for the course; the average of the top student group is 85.3%, 71.5% for middle achiever and 57.4% for weak achiever. Overall PO2 is achieved, which is more than 60%.
- **PO4:** The average total mark of 78.5% is achieved for the course; the average of the top student group is 100%, 88.6% for middle achiever and 40% for weak achiever. Overall PO4 is achieved, which is more than 60%.
- **PO5:** The average total mark of 80.9% is achieved for the course; the average of the top student group is 86%, 81.4% for middle achiever and 77.8% for weak achiever. Overall PO5 is achieved, which is more than 60%.

- **PO6:** The average total mark of 80.9% is achieved for the course; the average of the top student group is 86%, 81.4% for middle achiever and 77.8% for weak achiever. Overall PO6 is achieved, which is more than 60%.

5. Benefits of PBL Approach in Teaching and Learning Process

The teaching and learning process using PBL approach that were carried out during the Introduction to Environmental Engineering course able to encourage and train the students to develop critical thinking, to be actively participate in the classroom/meetings and to be effective team members. In the engineering education, apart from producing engineers who possess in-depth technical knowledge it is also important for the engineers to be able to work effectively as a team member. Team working requires skills such as organising meetings; negotiating, discussing and arguing; solving problems creatively; willingness to give ideas and opinions; leadership; communication (listening, talking and visual presentation) and others relevant skills (Andersen 2003). Team working played an important role in the overall success of projects. The learning process also enhanced the students' skills to interact and communicate orally with each other. According to Wan Hamidon (2005) communication skills is among the important criteria by employers to select workers. The students awareness on environmental issues were at the same time improved by having the PBL activities. Environmental awareness was enhanced through the PBL approach, whereby students were actively involved in gathering relevant information from various sources in solving the problems. No doubt there were a number of students who had difficulties to accept the PBL teaching approach that requires discussions and meetings among students and lecturer. Based on the attendance record of the meetings and complaints made by other team members of the group, only 2% of the students did not attend the meeting sessions that had created problems to other team members. Those students were then been advised by the lecturers on the importance of PBL approach.

6. Conclusions

The PBL approach in the Introduction to Environmental Engineering course is able to enhance the level of environmental awareness among civil engineering students to gain the ability in identifying the sources of pollution and its impact on the environment and the controlling methods. In solving PBL projects, the student will become aware of the professional and ethical responsibility of a civil engineer on the issues of environmental sustainability preservation. In general, the students learning experience on the PBL approach of solving real-life problems had enable the students to achieve the CO and thus the PO as outlined in the Civil & Environment and Civil & Structural Engineering undergraduate programmes offered at the Universiti Kebangsaan Malaysia.

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