Findings from the implementation of project-based learning in civil engineering education

Chung Lim Kwan[1a]

[1]Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University, Kowloon, 999077, Hong Kong

Abstract. The primary objective of the implementation of teaching and learning methods is to ensure that students attain critical thinking and all-roundedness with professional competence in civil engineering education. Students are tailored to develop abilities such as analytical, problem-solving and communication skills for solving real-life civil engineering problems. In particular, Design Project, which is one of the compulsory courses to be completed by final year degree students in Civil Engineering for the fulfillment of the degree requirements, is implemented through Project-based learning (PBL). The design project aims at enabling students to develop the first hand practical design experience before graduation. Students are required to apply their prior knowledge and engineering skills acquired in subjects of various disciplines of the civil engineering programme. Findings from the implementation of the PBL in this course are reported based on the views and feedbacks collected from the students. The issues related to the implementation of PBL such as student's learning experience and student's workload are also explored in the study.

Keywords: Experiential learning; project-based learning; learning experience; learning outcomes; professional practice; theory-practice integration

1 Introduction

Learning is simply conceived as a four-stage cycle and a continuous process whereby concepts are derived from and continuously modified by experiencing things. It begins from "concrete experience" to "observations and reflections", then to "formation of abstract concepts and generalizations" as well as "testing implications of concepts in new situations". The process of experiential learning is first introduced in the work of Dewey, Lewin and Piaget, [1-4, 9]. All the models proposed by Dewey, Lewin and Piaget were identified to have the following common characteristics, [6]. Learning is best conceived as

[a] Corresponding author: ceclkwan@polyu.edu.hk

a process, not in terms of outcomes. It is a continuous process grounded in experience. The process of learning requires the resolution of conflicts between dialectically opposed modes of adaptation to the world. Therefore, learning is by its nature a tension- and conflict-filled process. New knowledge, skills or attitudes are achieved through confrontation among four modes of experiential learning. In addition, learning is a holistic process of adaptation to the world and involves transactions between the person and the environment. Learning is the process of creating knowledge as well.

Kolb [6] popularized their works and stated that experiential learning is a multidimensional process in his multi-linear model of adult development. Learning is further defined as the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience. Kolb's model portrays two dialectically related modes of grasping experience - concrete experience grasped through apprehension and abstract conceptualization grasped through comprehension, and two dialectically related modes of transforming experience - active experimentation and reflective observation via extension and intention respectively.

1.1 Project-based learning

There are many pedagogies in which experiential education is practiced. Project-based learning (PBL) is one of the teaching and learning methods. Students have to work together in teams as project groups to solve a real-life project. The PBL approach aims at fostering student-centeredness and teamwork, enabling students to develop critical thinking and independent thinking, enhancing their problem-solving, management and communication skills, encouraging them to find information on their own, and enabling them to integrate prior knowledge and theory into practice for professional practice, [8, 10, and 5]. Throughout the PBL approach, the course instructor acts a facilitator to monitor the progress of the project, to guide the students to find information from different sources, and to discuss with them for solving any problems related to the project. The principles of PBL are aligned with the idea of learning by doing [2]. The PBL approach put an emphasis on learning activities which are long-term, interdisciplinary and student-centered. Students should develop skills that prepare them for the future.

1.2 Context of the study

The implementation of teaching and learning methods is to ensure that students attain critical thinking and all-roundedness with professional competence in civil engineering education at the Hong Kong Polytechnic University. Students are tailored to develop abilities such as analytical, problem-solving and communication skills for solving real-life civil engineering problems. In this regard, Design Project, which is one of the core subjects to be accomplished by final year degree students in Civil Engineering for the fulfillment of the degree requirements, is implemented through Project-based learning (PBL). The design project aims at enabling students to develop the first hand practical design experience before graduation. Students are required to apply their prior knowledge and engineering skills acquired in elementary and intermediate subjects of various disciplines of the civil engineering programme such as Structural Mechanics, Structural Analysis, Design of Steel Structures, Design of Concrete Structures, Geology, Soil Mechanics, Construction Management, Transportation and Highway Engineering, and other subjects.

Upon completion of this subject, students will be able to achieve the following intended learning outcomes.

- Utilize the techniques, skills, and modern engineering tools necessary to undertake authentic engineering practice within constraints under guidance of industrial and academic supervisors;
- Identify, structure and analyze task-focused and diverse engineering problems arising from the changing constraints that influence civil engineering projects, such as economic, environmental, legislative, social, political, ethical, health and safety, sustainability, and technological considerations;
- Synthesize logical solutions to civil engineering problems independently with a creative and imaginative mind;
- Work professionally and ethically;
- Communicate logically and lucidly through drawing, calculation, and in writing;
- Present ideas and arguments verbally in formal presentations and informal discussions
- Negotiate informally with peers, function effectively in multi-disciplinary teams and take responsibility for an agreed area of a shared activity;
- Recognize the need for, and develop an ability to engage in life-long learning.

They have to form a working team of 5 to 6 students as a project group to work on a civil engineering project, to appraise two distinct and viable schemes for the proposed structure, to carry out detailed design and detailing on key members of the selected scheme, and to make formal presentations on the project. The project will last for one term. In general, students are expected to have regular group discussions and meetings with their supervisors. The project is divided into four stages. In particular, students are requested to make group presentation and submission of the project works for assessment of the subject learning outcomes in stages II and IV.

- Stage 1 - Feasibility Study and Scheme Appraisal
- Stage II - Submission of Scheme Report and Presentation
- Stage III -Detailed Design for the Selected Scheme
- Stage IV - Submission of Final Report and Presentation

Evaluation of the implementation of the PBL in this course was conducted based on the views and feedbacks collected from the students at the end of stage IV in the first semester of the academic year 2014-2015.

2 Methodology

A total of 99 final year degree students were evenly split up into 2 small classes in the first semester of the academic year 2014-2015. In each class, students had to form a group of 5 to 6 members to participate in both schematic design and detailed design of a civil engineering project under the supervision of academic staff and industrial supervisors as facilitators. The views and feedbacks on the subject were qualitatively collected from students via individual questionnaires. The feedback can help the course instructor to reflect on his/her teaching and learning activities of the course and to consider whether these activities should be further modified afterwards. In order to explore the issues related to the implementation of PBL such as student's learning experience and student's workload, the following items and questions are addressed in the questionnaire.

- I have a clear understanding of what I am expected to learn from this subject
- The teaching and learning activities (e.g. discussions, case studies, projects, presentations, etc.) have helped me to achieve the subject learning outcomes

- The assessments require me to demonstrate my knowledge, skills and understanding of the subject
- I understand the criteria according to which I will be graded
- Relative to the subject learning outcomes, the workload for this subject has been:
- On average, about how many hours per week during semester time did you spend on studying the subject?

The level of attainment such as "Strongly agree", "Agree", "No strong view" and "Disagree" is to be selected by students in response to the first four items of this questionnaire. The number of students enrolled is 99 and the number of returns is 60. The response rate is 60.6%.

3 Findings

The following findings which are related to the student's learning experience of the subject through the implementation of PBL are reported and shown in Table 1. Based on the collected data, 76% of students agreed that they understood what they were expected to learn from the course. In addition, 75% of students agreed that the teaching and learning activities such as project, discussions and presentations helped them to achieve the learning outcomes of the course. 79% of students also agreed that the assessments required them to demonstrate their knowledge, skills and understanding of the course. 73% of students agreed that they understood the criteria for assessment of student's performance. However, 56.5% of students pointed out that the workload for the course was too heavy and 69% of students spent 11 hours per week or above on accomplishing the project.

Table 1. Distribution of the level of attainment about the student's learning experience of the course

Item	Strongly agree	Agree	No strong view	Disagree
I have a clear understanding of what I am expected to learn from this subject	25%	51%	17%	7%
The teaching and learning activities (e.g. discussions, case studies, projects, presentations, etc.) have helped me to achieve the subject learning outcomes	25%	50%	15%	10%
The assessments require me to demonstrate my knowledge, skills and understanding of the subject	26%	53%	17%	4%
I understand the criteria according to which I will be graded	22%	51%	17%	10%

4 Conclusions

It is concluded that the student's learning experience can definitely be enriched as students commented that the course helped them to understand more about the design in the industry, to be familiar with the Code of Practices, and to acquire practical skills in engineering such as the use of engineering software. Students also benefited a lot from integrating theory into practice through the implementation of PBL in the course. However, students argued that the workload for the course was too heavy for the achievement of the intended learning outcomes. This reluctance which was identified in the implementation of PBL can be mitigated by choosing a medium scale project.

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