Journal of Engineering Education Research
Vol. 15, No. 5, pp. 3~7, September, 2012

PBL Based Engineering Education to Cultivate Leadership Spirit in Postgraduate Students

Kazutaka Yokota† · Masatomo Maruoka · Junji Takaki · Shinichi Watanabe
Innovation Center for Research and Engineering Education, Faculty of Engineering, Utsunomiya University

ABSTRACT

Utsunomiya University started a 3-year project to develop an education program for postgraduate students to cultivate leadership spirits. The program is centered on a PBL in which each group of students is required to find an engineering or social problem themselves and start a project to solve the problem. Projects vary widely, from a straight product development to a summer program for children or local area development. Student groups are advised by senior engineers from industries. They give advice as to how a project should be managed and run, but will not give instructions. The PBL is compulsory for all students in the engineering master course students. The new education program also includes a series of lectures by engineers to show engineers' job, activities, and career in the industry. Internship programs are also provided, in which students will be given opportunities to actively apply their knowledge and skills to real engineering tasks offered by the industry. The students are expected to gain something more than just experiences.

Keywords: Engineering education, Problem Based Learning, Postgraduate Education Program

I. Introduction

Innovation Center for Research and Engineering Education (ICREE) was founded in 2002 in order to provide engineering education for all undergraduate students and postgraduate students in Utsunomiya University, against the background that the number of students in engineering fields of higher education will decrease in Japan, therefore, it is increasingly important for the students to have original and creative ideas, and motivation so that industries sustain their technical edges over their competitors [1,2]. The paper introduces a new PBL program for postgraduate students in Utsunomiya University. The new program is aimed at cultivating leadership spirits among students, and centered on a PBL program in which a group of students are required to find an engineering or social problem themselves and start a project to solve the problem.

Received 4 October, 2011; Revised 12 June, 2012
Accepted 10 September, 2012
† Corresponding Author: yokotak@cc.utsunomiya-u.ac.jp

II. Innovation Center for Research and Engineering Education

Innovation Center for Research and Engineering Education has four divisions as shown in Fig. 1. The first and the most important division is the education division. It carries out a number of education programs for undergraduate and postgraduate students: a PBL program for the first year undergraduate students, which will be described in the chapter 3, internship programs according to the level of students, a series of lectures on the latest industrial topics by engineers, student projects to plan, design and build engineering products, and demonstration programs to introduce technical and engineering skills in the manufacturing industry to students. The research and education support division supports academic staff and students to set up experimental apparatus and prepare specimen in their research projects. The technical research division conducts research projects to create new, advanced manufacturing technologies, while at the same time it records and studies traditional engineering skills. The contribution to the local society division organizes science

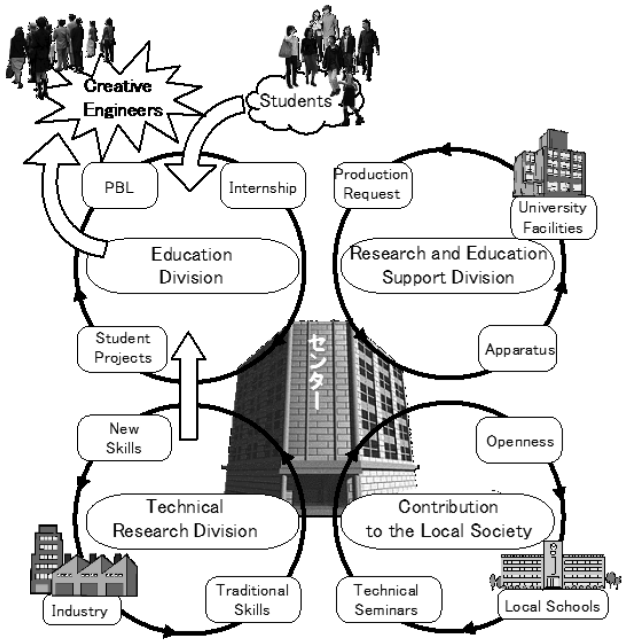


Fig. 1 ICREE

and technology education programs to local primary, junior and senior high school pupils.

III. Spiral Education Program and a PBL Program for the 1st Year Undergraduate Students

Lectures and various education programs carried out by the education division of ICREE are organized in the concept of "Spiral Education" scheme [3,4].

In the traditional education program, students are first to learn knowledge (What) through a series of lectures on basic subjects, such as mathematics, physics, and chemistry, and on specific subjects according to departments in the university, such as strength of material in the department of mechanical engineering. The students are then to acquire how to use the knowledge (How), and actually apply their knowledge to exercise and experiments (Action). They tend to realize engineers' mission (Why) only after they are engaged in graduate projects and required to perform their acquired knowledge and skills. While this type of "stacking up" methodology certainly make students learn step by step, it is not very desirable that they will understand their mission (Why) only just before their graduation.

In the spiral education scheme adopted by ICREE, students are exposed first to why they need to learn, and are expected to grow strong motivation to acquire knowledge, and skill to apply knowledge, and to have desire to be original and creative. ICREE's programs are designed for students to learn "Why" first, then, "What", "How", and "Action", rather than "What"-"How"-"Action"-"Why" in that order in the traditional program.

That is the reason why ICREE provides a PBL program to the first year students [5-7]. In the PBL program for the first year students, students are organized into groups of 4 to 5 students from different departments, and tackle simple engineering challenges set by academic staff. They are expected to exercise originality, and cooperation skills to achieve the goal, and must make oral presentation on their activities and results. The program is effective to cultivate students' motivation for their later, specialized studies in their department. However, problem-finding and problem-solving skills which are essential for the good engineer are not tested and reared in this program. To this end, a new PBL program was created for graduate students as described below.

IV. A PBL Program for Postgraduate Students

1. Outline of the Program

In this program each group of students in Master's Degree Course is required to find an engineering or social problem themselves and start a project to solve the problem in 15 weeks [8,9]. Rough schedule is shown in Table 1. Notable features of the program are as follows:

1. The program is compulsory for all students in the engineering master course students.
2. A student group consists of 4 or 5 students from different major fields.
3. A project is declared by the student group, rather than given by teaching staff. The student group is also required to define its expected output at the end of the term.

Table 1 Program Schedule

Week 1	Orientation
Week 2	Group Discussion and Proposal of the Project
Week 3 through 15	Project Executions
Week 16	Presentation

Table 2 Fields of Student Projects

Field	Examples of Projects
Social Projects	Regional Problem Educational Problem
Technical Projects	Product Development Technology Development
University Project	Improvement in Student Life Improvement in University Services and Facilities

4. Student groups are advised by senior engineers from industries. They give advice as to how a project should be managed and run, but will not give instructions as to what to do next.

Projects vary widely, from a straight product development to a summer program for children or local area development (Table 2).

2. Guiding Principles

We set the following principles for the teaching staff to guide student groups:

1. The project must be run by students themselves.
2. In case of foreseeable failure or stagnation of activities in the project, the teaching staff is to give hints or suggestions to resurrect the project, but refrains from give direct orders.
3. A score mark will be given to the individual student, considering his/her contribution to the student group, final reports and presentation of the group.

In order to implement the above policies, the followings must be observed when giving out advices:

a. Advices will be given to the student group so that the group will carry out Plan-Do-Check-Action (PDCA) cycles throughout the project.
b. Advices should bring students' attention to "Dead line", "Quality", and "Cost".
c. If a project is to end with insufficient output, its student group should be advised to evaluate the cause of unsatisfactory end.
d. Communication within the student group must be made active.
e. All students in a student group must contribute to the final presentation. The final report of the student group consists of two parts: the group report and the self-assessment report by each student.
f. Teaching staff observes and records activities and progress of each project so that the records can be reflected on the score mark of the student.

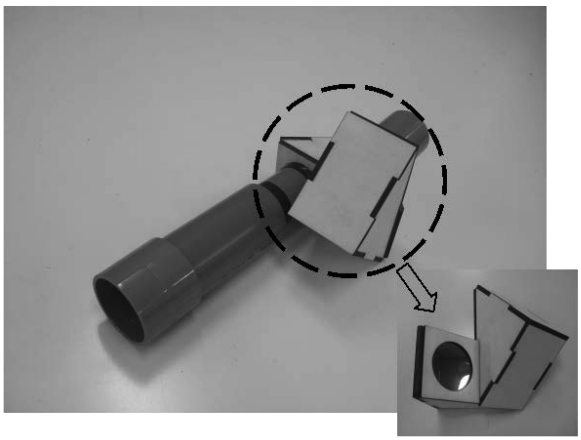
3. Results

In this section, we show a summer science school project in 2010 as an example of the PBL program.

A student group declared a one-day science school for primary school children to understand the principle of the telescope and build one. Before the interim presentation of the project in the 8th week, the student group had planned the outline of the school, and built a prototype telescope made of a milk carton and a magnifier, in the hope that children will feel comfortable with common articles in the household (Fig. 2 (a)). As the first prototype didn't perform well, the group went on to improve their design four times, and came up with the 5th prototype as shown in Fig. 2(b), which will show the uninverted image through a prism. By the final presentation at the end of the term, the group had completed detailed planning of the school, contents of the program, and arrangements to let children build their telescopes.

Actual school was held in autumn 2010 after the term with 26 primary school children in the local region. A couple of images during the school are shown in Fig. 3. The telescope the children built is made of plastic tubes of different diameters, a prism comprising mirrors and a wooden body, and a couple of lenses. The tubes, wooden plates, and the mirrors were all cut to desired size and precision by the students, and the children were tasked

(a) Prototype No.1



(b) Final Model

Fig. 2 Telescope

to assemble them in accurate manner. The children and their parents were pleased with the completed telescope, and expressed excitement and interest in science and technology.

As the student group completely planned the summer school, designed and improved the telescope for the school through iterative PDCA cycles, and successfully completed their declared project, we would conclude that the PBL program for this student group yielded expected results.

V. Conclusion

The paper introduced the PBL program in the Graduate School of Engineering, Utsunomiya University. In this program students are organized into groups of 4 or 5 students from different major fields, and are expected to find a technical or social challenge to solve, and declare a project on it. Student groups are advised by senior engineers from industries. The program is effective to cultivate students' motivation and leadership, and to give opportunities to experience to exercise problem-finding and problem-solving skills.

Fig. 3 Summer Science School "Build a Telescope"

Reference

1. H. Sugiyama, S. Watanabe, J. Takaki, A. Irie, H. Hasegawa, "Engineering Education Instructed by Innovation Center for Research and Engineering Education in Utsunomiya University", *Proceedings of ACEE 2009*, pp.126-133, 2009.
2. K. Yokota, J. Takaki, S. Fuchizawa, J. Kagami, Y. Nishida, "Organized Approach to Develop Innovative and Creative Mind in Students", *Proc. of Annual Conf. of Japan Society*

for Engineering Education, pp.557-558, 2004. (In Japanese)
3. K. Yokota, J. Takaki, S. Fuchizawa, "Development and Operation of a 'Spiral' Engineering Education Program", *Proc. of Annual Conf. of Japan Society for Engineering Education*, pp.686-687, 2005. (In Japanese)
4. S. Watanabe, J. Takaki, H. Sugiyama, H. Hasegawa, A. Irie, K. Yokota, "Overview for Research and Development of 'Spiral' Engineering Education Project", *J. of Japan Society for Engineering Education*, 2011. (In Japanese)
5. K. Yokota, J. Takaki, S. Fuchizawa, J. Kagami, Y. Nishida, "Problem-Based Learning for the First Year Students in the Faculty of Engineering", *Proc. of Annual Conf. of Japan Society for Engineering Education*, pp.375-376, 2004. (In Japanese)
6. H. Hasegawa, S. Watanabe, J. Takaki, K. Yokota, A. Irie, H. Sugiyama, "Implementation of a Inter-Departmental Core Curriculum 'Problem-Based Learning (PBL)' in the Faculty of Engineering at Utsunomiya University", *J. of Japan Society for Engineering Education*, *58*(4): 21-27, 2010. (In Japanese)
7. S. Watanabe, J. Takaki, H. Hasegawa, A. Irie, H. Sugiyama, K. Yokota, "Student Evaluation o fan Inter-Departmental Core Curriculum 'Problem-Based Learing'", *J. of Japan Society for Engineering Education, 59*(2): 47-51, 2011. (In Japanese)
8. H. Hasegawa, S. Watanabe, J. Takaki, I. Uetake, H. Nagamori, H. Sugiyama, "Project-Based Learning for Master's Degree Course Students as a Common Specialized Subject in the Graduate School of Engineering", *Proc. of Annual Conf. of Japan Society for Engineering Education*, pp.186-187, 2009. (In Japanese)
9. A. Irie, S. Watanabe, J. Takaki, K. Yokota, H. Sugiyama, "Development of Graduate School Education Program based on PBL for Realistic Problems and Situations in Utsunomiya University", *Proc. of Annual Conf. of Japan Society for Engineering Education*, pp.574-575, 2010. (In Japanese).

Kazutaka Yokota

History: Kazutaka Yokota obtained Ph.D. from Imperial College, University of London in 1992, joined the Department of Mechanical Systems Engineering, Faculty of Engineering, Utsunomiya University in 1992, became an associate professor of the Innovation Center for Research and Engineering Education (ICREE), Utsunomiya University in 2004, and currently works as a professor in the Graduate School of Engineering, Utsunomiya University and the head of ICREE. His main interest is in the field of Robotics and Mechatronics, and he is a member of JSME, RSJ, and JSEE.
Phone: +81-28-689-6062
Fax: +81-28-689-6062
E-mail: yokotak@cc.utsunomiya-u.ac.jp