Inter-department Project Based Learning for Doctor's Course Students

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INTRODUCTION

Today's doctoral education programs must prepare students to be able to work in a broader spectrum and enable them to apply their skills to multidisciplinary settings while maintaining high levels of expertise. Innovative doctoral graduates cultivated with literacy (language, information literacy, technological literacy, legal knowledge, and ethics) and competency (creativity, problem identification and solutions, planning and execution, self-management, teamwork, leadership, and a sense of responsibility and duty) are therefore urgently required to solve some of the world's most complex problems[1-4]. It is not enough for them to attend traditional university lectures or to conduct experiments in laboratories to obtain these abilities.

This paper outlines the development of Inter-departmental Project Based Learning (PBL) for Doctoral Students as a typical curriculum to cultivate these educational objectives. Student leaders and members dealt with industrial world-based themes and found solutions under the guidance of an industrial project manager and with additional help from faculty facilitators. The teams consisted of students with different specializations and nationalities. The main aim of PBL was to provide students with thorough training in problem solving based on needs and integrated cooperation with those from other fields for them to become aware of the importance of trans-disciplinary exchanges and experience team management, and to provide them with rigorous training in communicating results. Instead of students from the same field working toward a specific goal in the fastest possible time, PBL was characterized by students from different departments working together on inter-disciplinary problems.

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1 EDUCATIONAL PROGRAM

1.1 Overview

The School of Engineering at the University of Tokyo offers an inter-departmental education program called the “Graduate program for Mechanical Systems Innovation” (GMSI)[5]. The program targets Ph.D. students in the School of Engineering, which includes Mechanical Engineering, Aeronautics and Astronautics, Precision Engineering, Systems Innovation, Materials Engineering, Applied Chemistry, and Chemical Systems Engineering. The program is aimed at cultivating fundamental attainments, specialized knowledge, literacy (language, information literacy, technological literacy, legal knowledge, and ethics), and competency (creativity, problem identification and solutions, planning and execution, self-management, teamwork, leadership, and a sense of responsibility and duty).

1.2 Relationship between Educational Objects and Programs

GMSI provides several educational programs to cultivate students with the ability to work in a broader spectrum. The corresponding relationship between educational objectives and educational programs is indicated in Figure 1, and it outlines the contribution ratio of the four capabilities that can be expected to be cultivated by each program. Of course, these four capabilities are not developed independently; they are related to and influence one another. We created these segmentations to enable students to recognize achievements by informing them of attainments of educational goals and encouraging participation in a wide range of educational programs[6]. As simply attending conventional lectures is insufficient to cultivate literacy and competency, we had to develop collaborative educational programs between academia and industry. The major collaborative academic-industrial educational programs in these curricula are Career Seminars, Internships, and PBL.

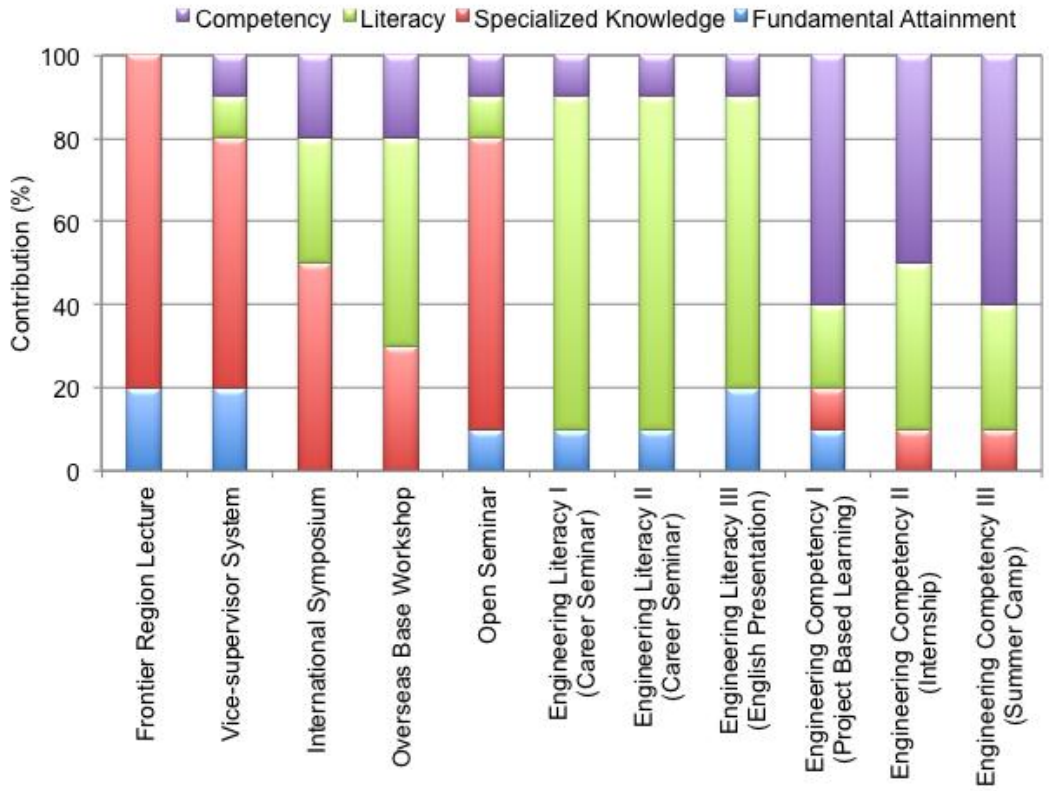

Fig. 1. Education Program

1.3 Career Seminar

Discussions that are conducive to students' career development and that address academic-industrial collaboration, engineering ethics, internationalism, and project management capabilities are the main objectives of these seminars. Domestic and foreign researchers at the forefront of their fields are invited to provide seminars on state-of-the-art topics. It is extremely important for Ph.D. students to not only exercise research capabilities but also leadership and management capabilities during their educational programs. Namely, it is not appropriate for them to terminate their research work by submitting the results to technical journals. It is extremely important for students to draw scenarios to develop their results into the application stage to expand their outcomes, including cost estimates and an understanding of social needs and group organization. Career seminars are also expected to address these areas of learning and academic-industrial cooperation, engineering ethics, international activities, and management abilities are also important. Ph.D. students have an opportunity to think about matters that will be critical to their future careers through discussions generated by the seminars.

1.4 Internship

Students visit industrial facilities or overseas research institutions and engage in research activities on topics proposed by the host institutions. Students interested in participation based on the topics proposed by these institutions are recruited, and after the content and dates are confirmed with the applicants and topic proponents, a research plan is submitted and the internships are implemented. The internships last from two to six months. Prospective interns are recruited based on theme proposals from industry and the theme proposer and prospective interns make adjustments to the proposals and periods, and the internships move toward implementation based on the submission of research plans. It is essential to provide educational programs before implementation that are related to intellectual property rights and confidentiality and to obtain approval related to the publication of reports when the research is completed.

2 PROJECT BASED LEARNING

2.1 Aims and Framework

PBL aims to achieve problem solving based on innovative ideas or non-conventional viewpoints. PBL fosters teamwork and project management by integrating different fields and needs-oriented R&D approaches. Real-life themes are provided by industries and PBL teams should submit business solutions by the deadline to attain these educational objectives. Themes do not involve the serial problems of present products or services by companies but future conceptual themes. Finding solutions to these themes means setting personal agendas and achieving goals under constrained conditions.

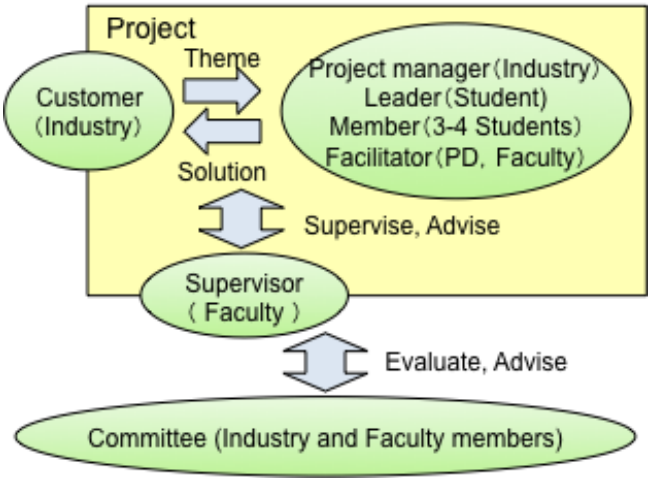

Fig. 2. Project Based Learning Framework

PBL is not always directly useful in working on themes for doctoral theses. The main aim is learning how to work in teams, and understanding the attitudes, strategies, management, and communication that this entails. From this point of view, this type of training is necessary in doctoral programs. The main reason for this is because after graduating with a Ph.D. and then looking for employment, graduates not only need research capabilities, but the ability to communicate as well. Research on doctoral theses alone does not develop these other mandatory capabilities.

Table 1. Project Based Learning Theme

PBL Titles of 2013

No.	Company	Title
1	NEC Corp.	A Proposal of Efficient Business Communication Style to Accelerate the Japanese Company's Globalization:Phase2
2	Ebara Co. Ltd.	Innovation of sustainable and economically rational waste treatment system
3	Leading Forum	Increasing Quality of Life of Elderly in Urban Area - Vehicle Sharing with Path Planning for Elderly-
4	JAL, ANA, Boeing	Build a business plan for supplying alternative fuels to Tokyo airports by 2020

PBL Titles of 2012

No.	Company	Title
1	NEC Corp.	A Proposal of Efficient Business Communication Style to Accelerate the Japanese Company's Globalization
2	Ricoh Co. Ltd.	Feasibility Study of Input-System for IT Devices with a Paper-like Feeling Phase II
3	Railway Technical Research Institute	Applicability of Robot Technologies to Railway Works.
4	Toshiba Corp.	Study of Applications and Control Scheme with Using Neuron-Machine Interface

PBL Titles of 2011

No.	Company	Title
1	East Japan Railway Co.	Sustainable Systems for Local Railway Network
2	Ebara Co., Ltd.	Innovative Power Generation based on Ocean Energy
3	NEC Corp.	Drafting of a new service business using cloud technology in IT service
4	Ricoh Co. Ltd.	Feasibility Study of Input-System for IT Devices with a Paper-like Feeling

PBL Titles of 2010

No.	Company	Title
1	Toshiba Corp.	Development of Next Generation Chemical･Immunoassay Micro-fluidic System Using μTAS Technique
2	HItachi Ltd.	Proposal on functual super-insulated window for Zero Emission House
3	Cibernet Systems / Ebara Corp.	Research on Industrial Application using Augmented Reality
4	Ricoh Co. Ltd.	Design/Development innovation for an integral-type industrial architecture
5	Airbus	Airbus Fly Your Ideas Challenge 2011
6	Continental Automotive	Reduce CO2 emission using AFFP

PBL Titles of 2009

No.	Company	Title
1	HItachi Ltd.	Feasibility Study for Zero-Emission in Urban Space
2	Shinkawa Technology	Application of Energy-harvest System for Wireless Sensor
3	Toshiba Corp.	Design Guide Proposal for New Drive Actuator utilizing MEMS technology
4	East Japan Railway Co.	Application of Micro Nano Technology for Rapid-Transit Rail Cars
5	Nippon Koki Co. Ltd.	Pratical Use of Recycling System of Underwater Demolition
6	Ebara Corp.	Customer Service Innovation for Industrial Machinery
7	NEC Corp.	Service Design Based on Customer Satisfaction

Figure 2 outlines the scheme to implement PBL. Industry proposes a project theme and students form a team with one student acting as the team leader. A project manager from industry and a faculty facilitator work directly with this team, and a faculty member supervises the execution of the project. The participating students have different specializations, and teams are formed to keep students from the same department separate.

Students are lectured about basic project management by the faculty when PBL starts and previous PBL examples are provided by experienced students. Teams set their own project goals through discussions on themes proposed by industry. The first presentations on PBL goals are made. Teams collate the results into reports after they make midterm and final presentations. A review committee comprised of faculty and industry members provide advice at the presentations and evaluate the results obtained from PBL.

2.2 Themes

Industries are welcome to propose themes that should be dealt with but not those that are too pioneering or too risky, such as new businesses, new applications, new markets, innovative improvements to quality, technological challenges to be addressed, or difficult problems for which there are no resources. Table 1 summarizes the PBL themes for the last five years. The themes do not involve serial problems with the present products or services of companies, and detailed goals were not defined when the proposals were made.

2.3 Example of PBL

A project on handwritten input on IT devices was carried out in 2012. It was clarified that the main reason people did not use tablets as handwriting devices was “feeling.” Physical models of the styluses were created in this project to actualize a comfortable writing experience. The comfortable writing experience in the physical models was broken down into two factors of 1) smoothness, which was the static and the dynamic friction coefficient between the stylus and the tablet’s surface and 2) softness, which was the damper and spring coefficient. The optimal physical parameters for the two factors were investigated through experiments on friction and the feel of writing using the prototype styluses.

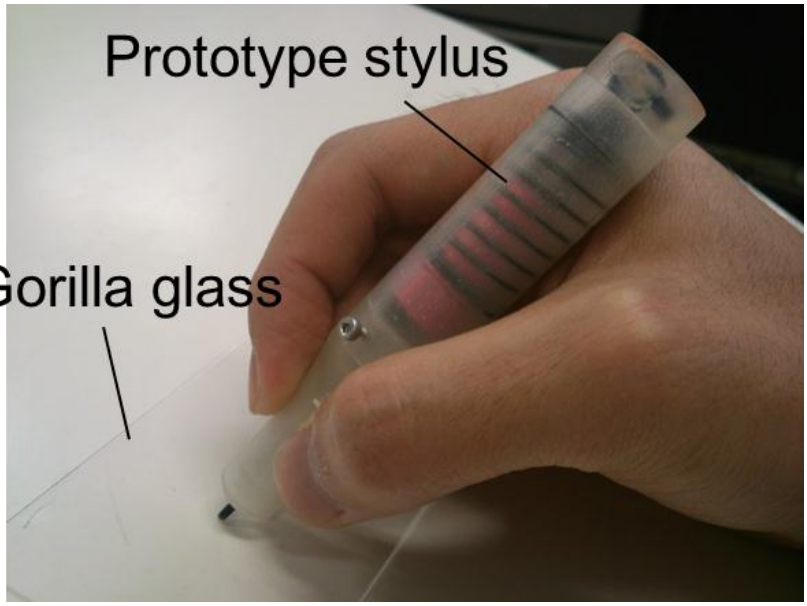

Fig. 3. Writing feeling experiment setup

2.4 Evaluations by Students

We administered a questionnaire to the students after they had finished their final presentations and submitted their reports. We received positive feedback from the students on PBL (Fig. 4 presents the results for the last 3 years), who expressed high levels of satisfaction with it. However, Figure 5 indicates that some students felt the workload was too demanding.

Figure 6 has the results from the questionnaire on which areas students found PBL to be beneficial. Many students answered that PBL was useful to acquire teamwork and communication skills. There were many positive reviews, such as “working collaboratively with corporate members was great training for teamwork”, “I was able to learn how to solve problems with other team members”, “new ideas were created through the fusion of industrial and academic worlds, and through the students’ nimble and fresh ideas”, and “I felt there was great value in the growth attained from these experiences”. These comments indicated that students appreciated the opportunity to work in teams composed of various experts from different backgrounds. The team discussions were conducted in English as almost all the teams had international students. This is one reason students found communication skills to be beneficial. Their replies may be characteristic responses in Japanese universities.

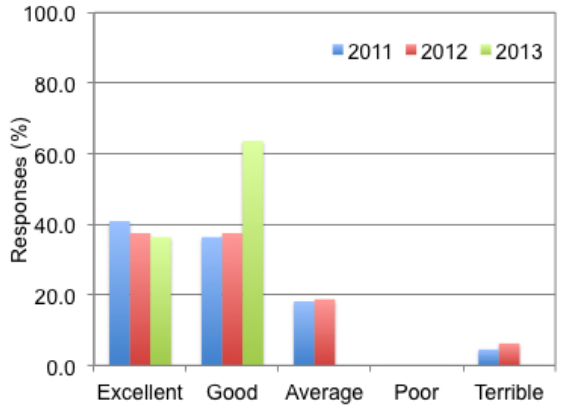

Fig. 4. Satisfaction with Project Based Learning

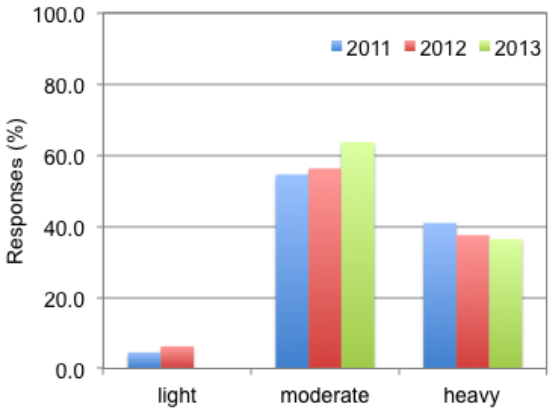

Fig. 5. How heavy Project Based Learning

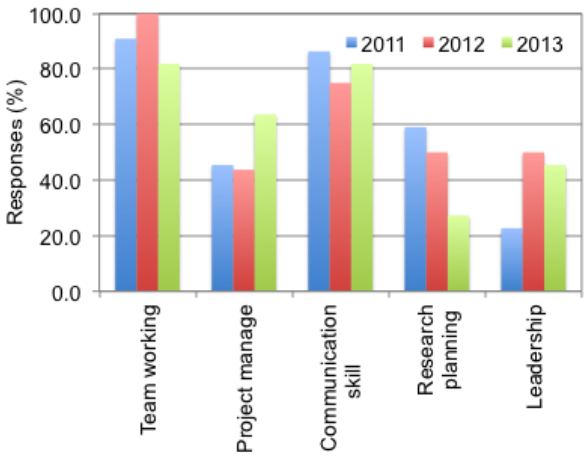

Fig. 6. Benefit of Project Based Learning

We asked students who were enrolled in programs to complete a survey with questions inquiring about which program they felt contributed the most to them attaining the four educational objectives of fundamental attainments, specialized knowledge, literacy, and competency. Typical answers are given in Figure 7. Most students recognized the career seminars were beneficial to literacy and the internships were of benefit in the areas of literacy and competency. Students answered that PBL had a large benefit on competency. Figure 8 shows how much students benefited from the educational program. Many students felt a significant benefit from PBL, which was more than that from career seminars or internships.

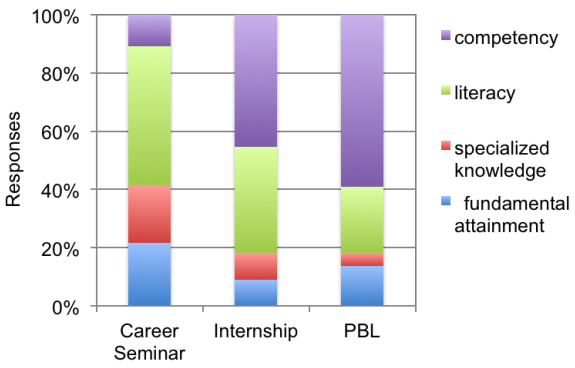

Fig. 7. Educational objectives benefited

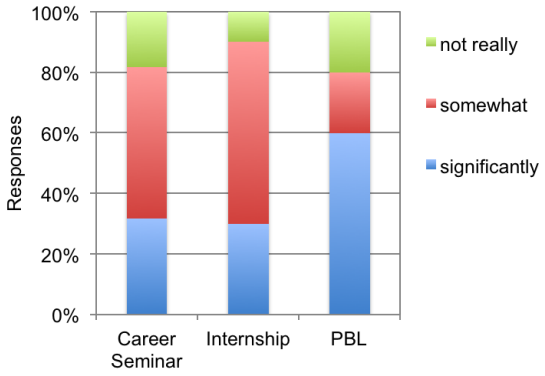

Fig. 8. How much benefited

2.5 Feedback from Industry and Faculty

A panel discussion was held by industry and faculty members at the final presentation of PBL. The theme of the discussion was “challenges to and actuality of academic-industrial educational collaboration.” Industrial members expressed that there were both sophisticated and modest projects, but PBL was an interesting approach for graduate students to take. It operated with the same concepts as those in in-company training for new employees or promotions. Also, there were opinions that required some improvements to be made to execute projects. Such areas of improvement included clarifying the process of obtaining final results, the necessity for training to obtain the basic tools to execute projects, and the necessity for gaining unique attributes from doctoral programs.

Faculty members were concerned about how they evaluated PBL results. It remains a critical issue how faculty evaluated students as individuals even though they participated in PBL through teamwork.

3 SUMMARY

The program was aimed at cultivating literacy and competency in addition to high levels of fundamental and specialized skills. Both industry and academia require programs as operations to nurture international leaders who will lead in the creation of technical innovations. We believe that we can foster human resources that have multidisciplinary application skills that will actively engage students in a wider range of areas by cultivating literacy and competency in addition to in-depth research in specialized fields offered by traditional Ph.D. programs.

We confirmed that students felt the benefits of literacy and competency by participating in these collaborative education programs by academia and industry. In particular, students found PBL to be the most beneficial.

We plan to continue running these programs and make continuous improvements to the curricula based on the opinions of students who participate and industry members who cooperate in these educational programs. We can foster human resources that have multidisciplinary application skills that will actively engage students in a wider range of areas through these continuous improvements to the curricula.

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