Industry-University Collaborative Education Program for Ph.D. Students

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1 INTRODUCTION

The environment surrounding Japan has been in a state of rapid change. Expansion of the manufacturing of technologically advanced products, which was traditionally Japan's area of expertise, is now performed worldwide. In addition to manufacturing, planning and development have expanded overseas as well, advancing the globalization of business development and the international division of labor. The cultivation of leaders in business strategy planning for global corporations, competitive global research development, global business development, establishing international standards, and foreign diplomacy is necessary in this age. The acquisition of creative methods, understanding social and economic systems, and leading innovation is vital in the development of a technology-oriented nation. We believe that such leaders and innovators are borne from Ph.D. researchers that have acquired problem comprehension skills as well as creativity and problem solving skills based on investigative ability and profound insight.

Until now, Japanese graduate school education has focused mainly on advanced research related to a specific field, and the Ph.D. course graduates, although highly specialized, lack broad-based knowledge. In many cases, these Ph.D. graduates have been shunned from the industrial world, in which the development of highly integrated products is essential. Based on the social requirements stated above,

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today's Ph.D. program must focus on the ability to work in a broader spectrum and apply one's skills to a multidisciplinary setting while maintaining a high level of expertise [1-3].

This paper outlines the development of an education program for Ph.D. students to cultivate literacy and competency, in addition to comprising a doctoral thesis and highlighting the ability to achieve results through innovative research. The program aims to cultivate fundamental attainment, specialized knowledge, literacy (language, information literacy, technological literacy, legal knowledge, and ethics), and competency (creativity, problem identification and solution, planning and execution, self-management, teamwork, leadership, a sense of responsibility and duty). In order to cultivate these abilities, simply attending lectures is insufficient, so we have to develop industry-university collaborative education programs.

2 EDUCATION PROGRAM

2.1 Global Center of Excellence for Mechanical Systems Innovation

The "Global Center of Excellence for Mechanical Systems Innovation (GMSI)" [4] was created in an effort to promote the education program outlined above. The program targets Ph.D. course 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 GMSI provides an internationally predominant research base to foster researchers who will become future leaders in industry and academia [5].

2.2 Education Program Overview

The program focuses on (1) cultivating a bird's-eye-view of the role of engineering in society, (2) cultivating competitiveness based on international understanding and specialized knowledge, and (3) cultivating leadership in industry and academia. In order to realize these educational objectives, we are conducting the curricula as shown in Fig.1. In these curricula, the major industry-university collaborative education programs are Evening Seminar, Internship, and Project Based Learning.

Fig. 1. Outline of Education Program

2.3 Evening Seminar

Discussions that are conducive to students' career development and which address academic-industrial collaboration, engineering ethics, internationalism, and project management abilities, are the main objectives of this seminar.

Domestic and foreign researchers at the forefront of their fields are invited to give a seminar on state-of-the-art topics. It is extremely important for Ph.D. students to train not only research ability but also leadership and management ability during their education. Namely, it is not appropriate for them to terminate their research work by submitting the results to technical journals. In order to expand their outcome, it is extremely important to draw scenarios to develop their results into the application stage, including cost estimation, understanding social needs and group organization.

Evening seminars are also expected to address these areas of learning industry-university cooperation, engineering ethics, international activities and management abilities are also important. Through discussion with the lecturers, Ph.D. students have an opportunity to think themselves about the matters that will be critical to their future careers.

Evening seminars are held monthly and last approximately one hour. After every seminar, students have a chance to discuss with the lecturer. The lecturers are invited from various fields, including corporations, the press, research, and venture capital companies. Attending students have eagerly listened to the lectures and participated in active discussion with the speakers. Thus, it is expected that these experiences will result in expanding their activities in the future.

Figure 2 shows the results of a student questionnaire asking which educational objectives the evening seminars bolstered. Figure 3 shows the degree of benefit felt by the students; most students recognized the evening seminar was beneficial to literacy.

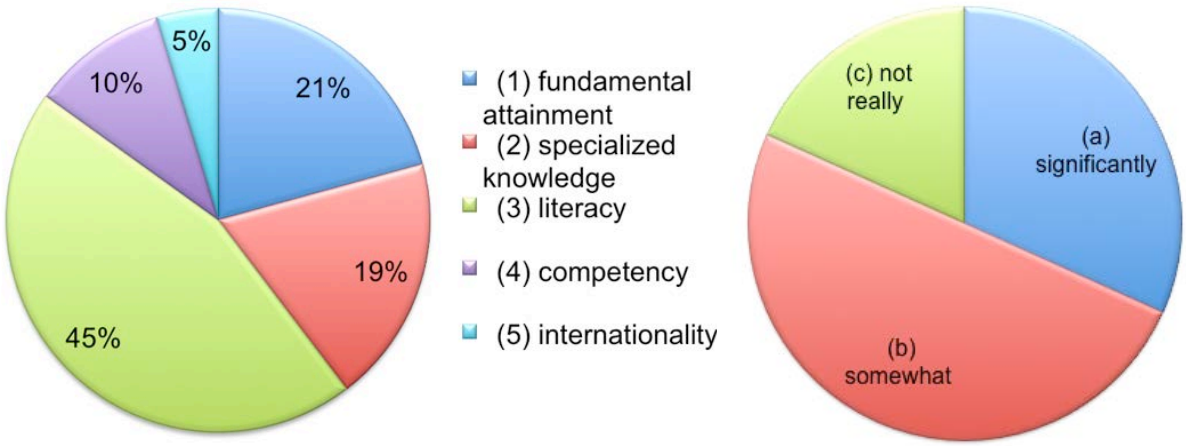

Fig. 2. Educational objectives benefited with Evening Seminar

Fig. 3. How much benefited from Evening Seminar

2.4 Internship

Students visit industries or overseas research institutions and engage in research activities on topics proposed by the host institutions. Students interested in participating based on the topic proposed by the these institutions are recruited, and after confirming the content and dates with the applicants and topic proponents, a research plan is submitted and the internship is carried out. The internship duration is from two to six months. Figure 4 shows the typical internship implementation procedure. Based on theme proposals from industry, prospective interns are recruited, the theme proposer and the prospective interns make adjustments to the proposal and period, and the internship moves toward implementation based on the submission of a research plan. Before implementation, it is essential to provide education related to intellectual property rights and confidentiality matters, and to obtain approval related to the publication of a report upon completion of the research.

The Japan Society of Mechanical Engineers (JSME) outlines the following four types of internships. Type (a) "worksite tour" is from one to a few days, type (b) "short-term practical onsite work experience" is from one to two weeks, type (c) "long-term onsite work experience" is from three weeks to two months, and type (d) "long-term" PBL is four months or more of project-based learning in which an intern participates in autonomous training based on an industral theme. Because this internship program is designed for doctoral students who are expected to catch a glimpse of some of the real problems inside an enterprise, the program corresponds to types (c) and (d).

The students are expected to gain the following benefits from the internship program.

- Research in real society and experience a development site
  Differences in research planning, speed, and progression
  Differences in awareness of cost, quality and safety
- The importance of clarifying the background and goal of research
  Awareness of market needs and research outlets
  Need for the capacity to discover problems and to possess broad knowledge
- Need for communication and presentation skills
  Everyday technical discussions at research development site
  Group work experience
- Need for research schedule management
- Image of work in society

Figure 5 shows the students questionnaire results of educational objectives benefited by participation in the Internship. Figure 6 shows how much students benefited from the Internship. From these figure, internship benefit in the areas of literacy, competency and internationality. Many students felt benefit was moderate.

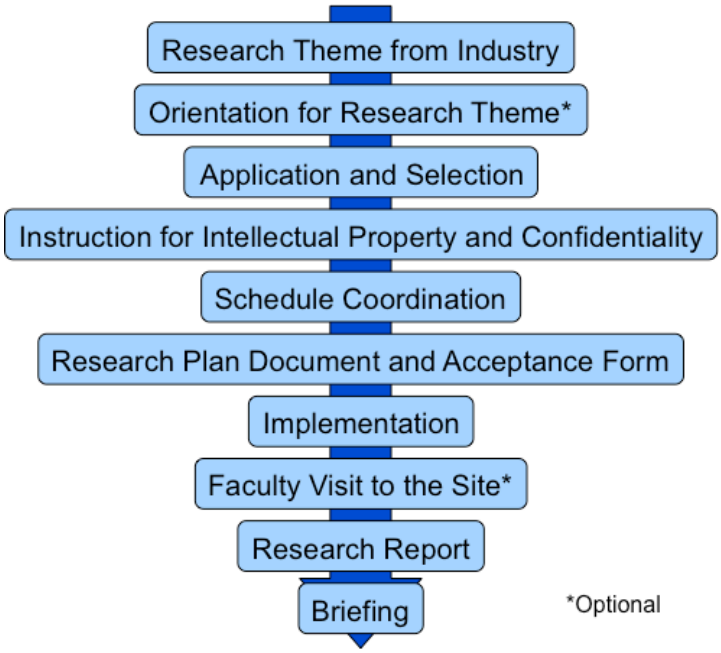

Fig. 4. Internship Implementation Procedure

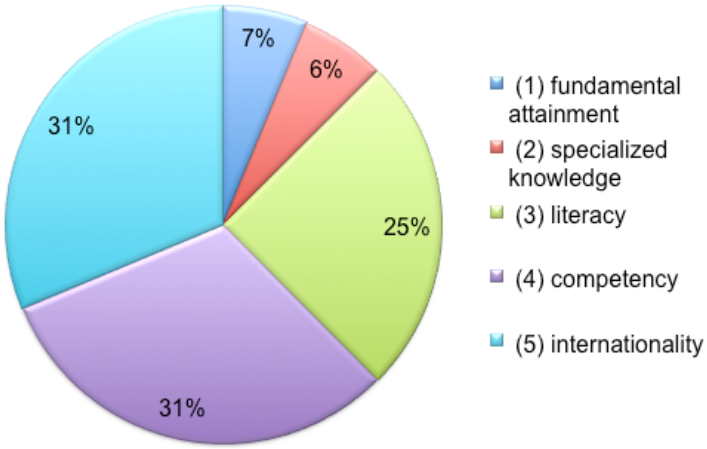

Fig. 5. Educational objectives benefited with Internship

Fig. 6. How much benefited from Internship

2.5 Project Based Learning

The aim of Project Based Learning (PBL) is to provide tough training in problem resolution based on needs and integrated cooperation with other fields, to become aware of the importance of trans-disciplinary exchange, to experience team management, and to give tough training in communicating results. Instead of students from the same field working toward a specific goal in the fastest possible time, PBL is characterized by students from different departments working together on an interdisciplinary problem.

Although PBL is now attracting interest in society at large, it was originally designed as a type of learning through working in groups on living themes proposed by industry. As mentioned previously, the main objective of PBL is to practice how to move forward with a project and how to communicate results. PBL is not meant to be

directly useful in working on the theme of a doctoral thesis. The aim is learning how to work in a team, and understanding the attitude, strategy, management, and communication that entails. Lectures and training from this point of view in a doctoral course is necessary. The reason is because after graduating with a Ph.D. when looking for a job in society, graduates will not only need research capacity, but the ability to communicate as well. It is thought that research for a doctoral thesis alone does not develop these other required abilities.

Figure 7 shows the PBL implementation scheme. Industry proposes themes, students form a team with one student acting as the team leader. A project manager from industry and a faculty facilitator works directly with this team, and a supervisor manages the project execution. After the midterm and final presentations, we put together the results in a report. A review committee comprised of faculty and industry members advise and evaluate the PBL results.

Figure 8 shows the questionnaire results regarding which educational objectives are benefited by PBL. Students answered that PBL had a large benefit to competency. Figure 9 shows many students felt a significant benefit from PBL, which was more than evening seminar or internship. We also received positive feedback on PBL regarding high student satisfaction, as shown in figure 10. Figure 11 shows that PBL was useful to acquire team working 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”. Although there were opinions expressing interest from the industrial side that provided the themes, areas that require improvement were pointed out as well. Such areas of improvement included clarifying the process of obtaining final results, the necessity of training to obtain the basic tools to execute a project, and the necessity of measuring up to the expectations of a doctoral course. Some students felt the workload was too high.

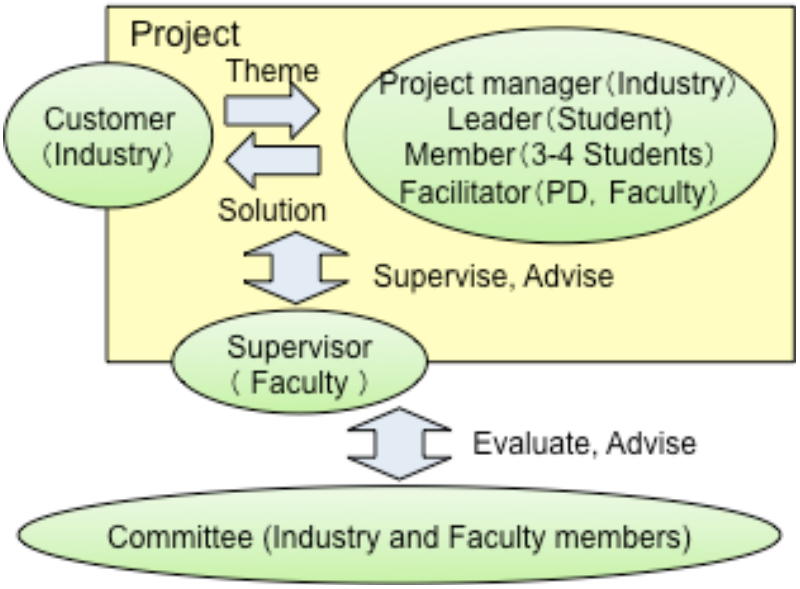

Fig. 7. Project Based Learning Framework

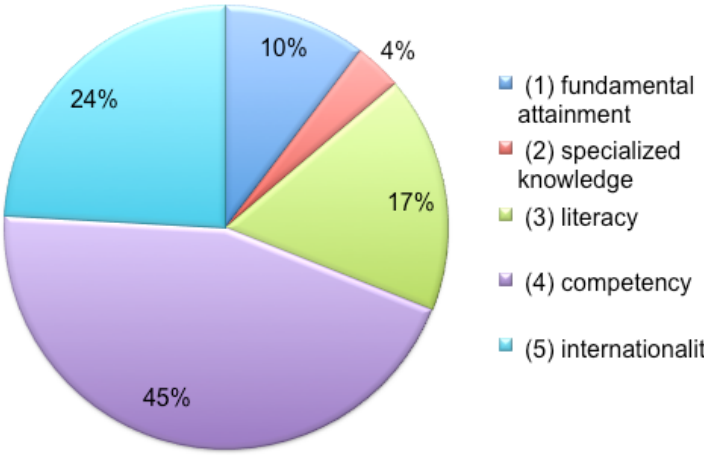

Fig. 8. Educational objectives benefited with Project Based Learning

Fig. 9. How much benefited from Project Based Learning

Fig. 10. Satisfaction with Project Based Learning

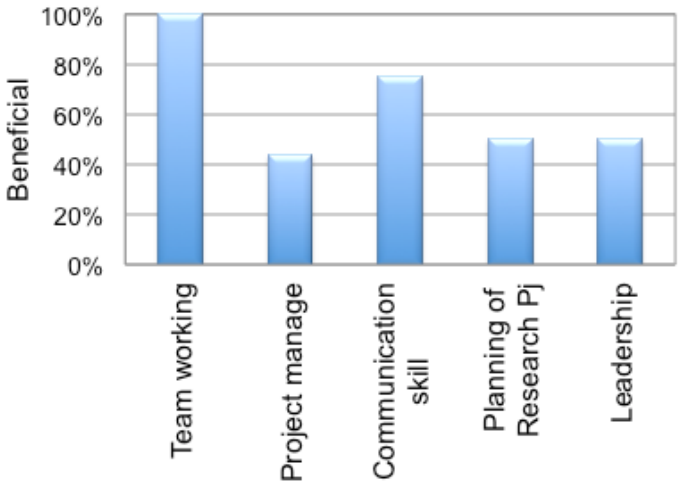

Fig. 11. Benefit of Project Based Learning

3 SUMMARY

The program aims to cultivate literacy and competency in addition to high levels of fundamental and specialized skills. Both industry and academia desire the program as an operation to nurture international leaders who will lead creation of technical innovations. By cultivating literacy and competency in addition to the in-depth research in specialized fields offered from traditional Ph.D. courses, we believe that we can foster human resources with multidisciplinary application skills that will actively engage in a wider range of areas.

We can confirm students feel benefit to literacy and competency by participating in these industry-university collaborative education programs. In particular, students found Project Based Learning to be the most beneficial.

We plan to continue running these programs, making continuous improvements in the curricula based on the opinions of students who participated and industry members who cooperated with these education programs. Through these continuous improvements to the curriculum, we can foster human resources with multidisciplinary application skills that will actively engage students in a wider range of areas.

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