Education by University-Industry Coordination with Joint Research Project

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Abstract — *In all Japanese universities, an 18-year-old student enters and receives 4 years education. Senior students participate in the laboratory seminar, which is difference from usual class. In addition, in Kanazawa Institute of Technology, the project design subjects, that were project-based learning subjects, were established as a center of the curricula after an educational reform conducted in 1995, and the idea of "the engineer whose think and act by themselves" has been brought up. That is, learned knowledge is reflected in a project while utilizing wisdom. Therefore, "project design III (=graduation thesis)", which senior students study, is set as this part. Also, there is a pattern, that a part of the joint research project between university and industry becomes "Project design III". That is, a student joints a team with a teacher and practicing engineers, and this project is promoted while the student makes idea positively. As a result, the student is encouraged with his/her engineering design skill and core skill by not only a teacher but also practicing engineers. Therefore, the results of the research are produced and the skills of the student improve through this project.*

Based on the above background, in this paper, the example of the senior students, who participated in the joint research project between university and industry, was introduced and the educational effects were discussed.

The educational system, which the practicing engineer could evaluate the skills of the student, was established and tried for 2 years. That is, when 3, 9 and 12 months passed after the project started, the engineering design skill and the core skill of the student was evaluated by the teacher and practicing engineers, and then the evaluation result was shown to the student. Herein, "engineering design skill" includes; 1) skill - to analyze the cause of issues, to establish and solve the problems, and 2) imagination skill - to integrate various kinds of learning and knowledge with the restricted condition. On the other hand, "core skill" includes; 3) acting skill and teamwork - to solve problems while working in a team, 4) self-development skill and self-discipline skill - to continue his/her activity while conforming to engineer ethics, and 5) presentation skill - to make understand and approve plans for another person. Also, the student was evaluated by oneself similarly. In this paper, the result of the trial of 5 students was arranged and the educational effect was analyzed.

The conclusions were as follows; if a student shows a motivation and wrestles actively, various superior matters can be studied, and the student may improve his/her "integrated human skill" very much, under the fusion of "university-industry collaboration project" and "project design III".

Index Terms — *core skill, engineering design skill, evaluation by practicing engineer, university-industry coordination*

INTRODUCTION

In all Japanese universities including Kanazawa Institute of Technology (referred to as "KIT"), an 18-year-old student enters at April and receives 4 years education until 22 years old. Also many students do not have the actual work experience in the society. Furthermore, an education goal up to high school is mainly provided the improvement of the learning.

In KIT, the project design subjects, which were project-based learning subjects, were established as a center of the curricula after an educational reform conducted in 1995. The subject proposes the idea of "the engineer whose think and act by themselves". That is, learned knowledge is reflected in a project while utilizing wisdom. Therefore, "project design III (= graduation thesis)", which senior student studies is set to form this part. This project design III is also a required course, and its annual activity time is approximately 750-1000 hours.

The general academic plan of KIT is a "university-industry cooperation" "technological innovation" and "integrated human skill". Therefore, there is the pattern, that a part of the joint research project between university and industry becomes "Project design III". That is, a student joints a team with a teacher and practicing engineers, and this project is promoted while students make positive ideas. As a result, the student is encouraged with his/her engineering design skill and core skill from not only a teacher but also practicing engineers. Therefore, the results of the research are produced and the skill of the student improves through this project.

Based on the above background, in this paper, the result of the trial by five senior students, who participated in the joint research project between university and industry, was introduced and the educational effects were discussed. Herein, the educational system, which practicing engineers could evaluate the skills of the student, was established and tried for 2 years. The participants were five students belonged to my concrete laboratory in the department of civil and environmental engineering. My laboratory consisted of one teacher, six graduate students and eight senior students.

JOINT RESEARCH PROJECT BETWEEN UNIVERSITY AND INDUSTRY

For "creation of ideas" and "verification of results" for the development, the company may need the support by the teacher who is a scholar. On the other hand, for "serendipity of needs" and "supply of seeds", the teacher may require the support by the company who has a market. When the speculation of these both corresponds, a university and industry joint research project begins. In my laboratory, these projects are promoted with 10 companies now.

SCHEDULE OF PROJECT DESIGN III

An annual schedule of project design III is shown in Table 1. The students promoted to the last school year belong to a laboratory. Then, a teacher introduces some project themes to students. The student selects a project theme with one's own interest by him/herself and continues the activity for 1 year. Herein, some themes are related to the university and industry joint research projects. Students usually study independently. The student, teacher and practicing engineers gather to discuss every 1-4 months. Also the final result is reported and presented in the university by the student.

Time	Activity of student
April	・ Student belongs to a laboratory. ・ Project theme is chosen.
April ~ June	・ Purpose of project is recognized. ・ Schedule is drafted. ・ For understanding of the problem, literature is surveyed and elementary knowledge is reviewed.
July ~ December	・ Research activities are promoted. (investigation, experiment, analysis, discussion, evaluation, verification, etc.) ・ Experiment of other students is supported and is contributed to his/her research.
January ~ March	・ Result is reported and is presented in university.
March	・ Graduation. After April, he/she is entered the graduate school or gets a job.

TABLE 1

ANNUAL ACTIVITY OF SENIOR STUDENT IN PROJECT DESIGN III

PROCEDURE OF EVALUATION OF STUDENT'S SKILLS

Evaluation person

The evaluating persons were the student, the teacher and practicing engineers. Also, the five evaluated students were shown in Table 2.

Evaluated skill and its timing

Table 3 shows the five evaluated skills and its timing. Also, Table 4 shows the example of the students' behaviors for the evaluation level. When 3 months (June), 9 months (December) and 12 months (March) passed after the project started, the engineering design skill and the core skill of the student were evaluated by three persons. Also the item of the evaluated skills increased as time past by.

student	year	sexuality	after graduation	research theme	practicing engineer
Mr. A	2008	male	entrance into graduate school	development of new repair method for deteriorated reinforced concrete	2 engineers work at a company for the road maintenance. All 2 persons are professional engineers. 1 person is doctor.
Mr. B	2009			development of building material reducing global warming	4 engineers work at research laboratories of a construction company. All 4 persons are professional engineers. 1 person is doctor.
Mr. C				development of new fiber sheet strengthening reinforced concrete	1 engineer works at research laboratories of a fiber company.
Mr. D			getting job	development of recycling method of pulled down concrete	3 engineers work at research laboratories of a construction company. 2 persons are professional engineers. All 3 persons are doctors.
Miss E		female		evaluation of life extension for concrete using stainless steel	

TABLE 2

Characteristic of student, research theme and practicing engineer

Skill No.	item		Timing		
			Jun	Dec	Mar
1)	engineering design skill	skill - to analyze the cause of issues, to establish and solve the problems	○	○	○
2)		imagination skill - to integrate various kinds of learning and knowledge with restrictions condition	-	○	○
3)	core skill	acting skill and teamwork - to solve problems while working in a team	-	○	○
4)		self-development skill and self-discipline skill - to continue his/her activity while conforming to engineer ethics	-	○	○
5)		presentation skill - to make the understand and approve plans for another person	-	-	○

TABLE 3

Evaluation skill and its timing

The procedure of the evaluation is shown in Figure 1. Firstly the teacher evaluated the student's skills and followed by the practicing engineer's evaluation. Then, the evaluation results were combined as a feedback to students, and finally students evaluated themselves. Also, each person described the evaluation results and each individual student behaviors.

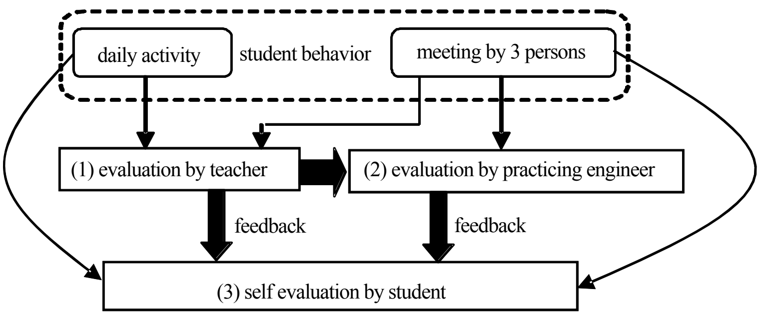


FIGURE 1

Procedure of evaluation

Skill		Level = 3	Level = 2	Level = 1
No.	keywords	A student performed in even the difficult situation. A student performed effectively in the normal situation.	A student performed in the normal situation.	A student did not performed.
1)	problem establish skill	・ The essence of research purposes was understood. ・ The new problem that occurred during an activity, was found and developed.	・ One of technical problems and social conditions was respectively understood, but the other was not understood. ・ I felt that the connection of a particular problem was important.	・ The research purposes was not understood. ・ The conversation in the meeting was not understood. I felt that an unknown term was recorded and was surveyed by a literature or a dictionary just after a meeting.
2)	scheduling skill	・ Priority was made clear. ・ The tool in the laboratory was validly utilized, and the experiment could be promoted.	・ A short plan was made, but a long plan cannot be made. ・ The reconsideration of the plan was not possible.	・ A plan could not be made.
	imagination skill	・ A new idea was proposed while utilizing literature survey and advice by others.	・ The idea that improved an existing method was proposed.	・ While restricting by a textbook and standards, I hesitated about the proposals of ideas.
3)	acting skill	・ Cooperation was received after explaining purpose if an activity was difficult while working alone.	・ An advice was received from a teacher, graduate students or practicing engineers by talking about my ideas.	・ Urging was not performed to others.
4)	self-development skill	・ Along with my research activities, "participating in a lecture and site inspection" or "interest to a research of another person" was acted.	・ My research was worked, but there was not proposing in a new action.	・ My research was worked under the instructions from a teacher and practicing engineers.
	self-discipline skill	・ In accordance with engineer ethics, it complied with the collective rule in the laboratory. ・ I devoted to courtesy so that a partner did not have unpleasantness.	・ The rule was to follow without disturbing the harmony in the laboratory.	・ There were many egocentric behaviors. ・ A promise such as the deadline was not kept.
5)	presentation skill	・ Using a report and/or presentation, my opinion was to arrange logically and then to explain clearly.	・ The several sections were explained, but the combined result did not introduce. ・ I felt that the presentation on the basis of a conclusion was important.	・ I noticed that the presentation was out of focus. ・ I had no confidence in my paper and/or presentation. ・ I hesitated about the information announcement.

TABLE 4

Example of student's behavior for evaluation level

EVALUATION RESULT

Table 5 shows the evaluation result of Mr.B, as an example.

Person	Student			Teacher			Practicing engineer		
timing / skill	Jun	Dec	Mar	Jun	Dec	Mar	Jun	Dec	Mar
1)	1	2	2	1	2	3	1	2	3
2)		1	2		1	3		1	3
3)		1	3		2	3		2	3
4)		1	2		1	3		2	3
5)			3			3			3

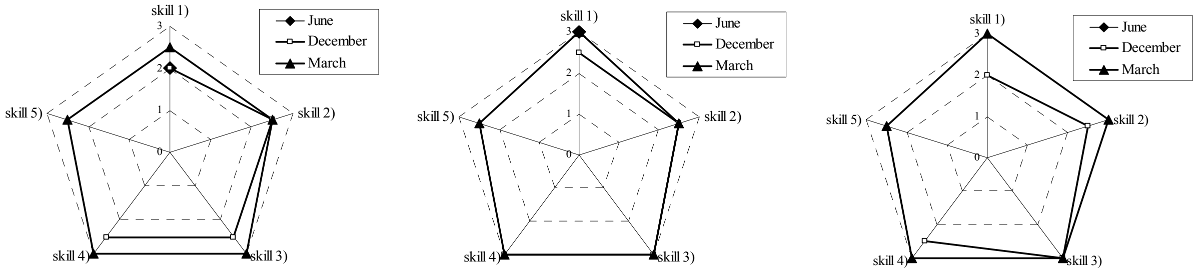
TABLE 5

Evaluation result of Mr.B

ARRANGEMENT AND ANALYSIS

Time dependent changes of student's skill

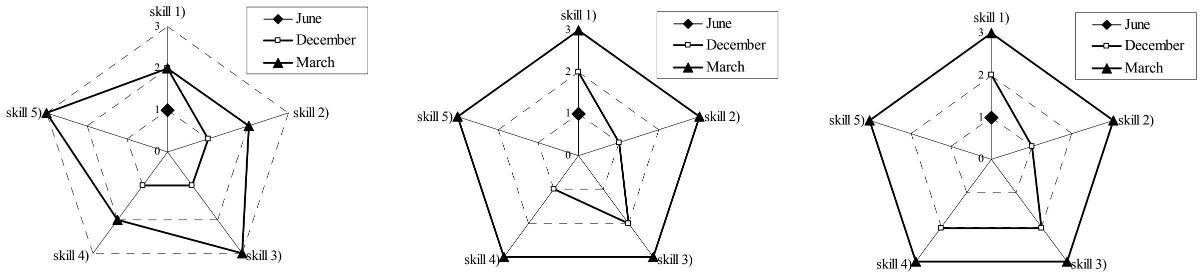
The time dependent changes of the student's skills are shown in Figures. 2 ~ 6. According to these figures, it can be confirmed that almost all skills of each student improved as time past by.



(1) evaluation by student (2) evaluation by teacher (3) evaluation by practicing engineer

FIGURE 2

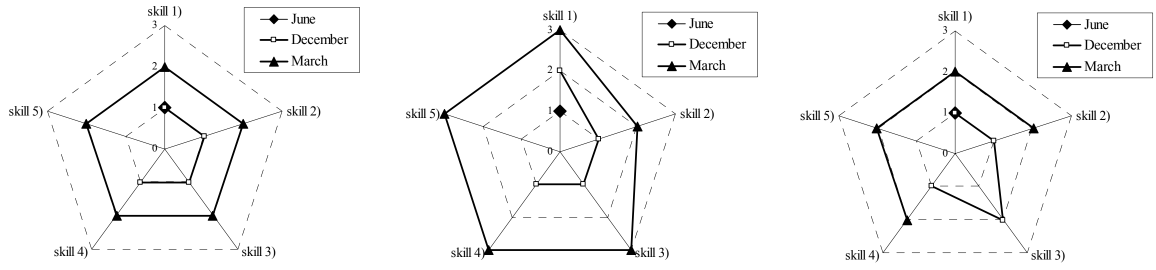
Time dependent changes of skill of Mr.A



(1) evaluation by student (2) evaluation by teacher (3) evaluation by practicing engineer

FIGURE 3

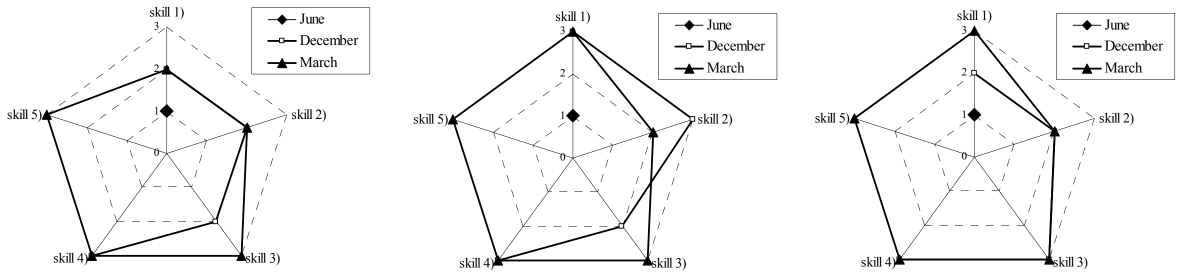
Time dependent changes of skill of Mr.B



(1) evaluation by student (2) evaluation by teacher (3) evaluation by practicing engineer

FIGURE 4

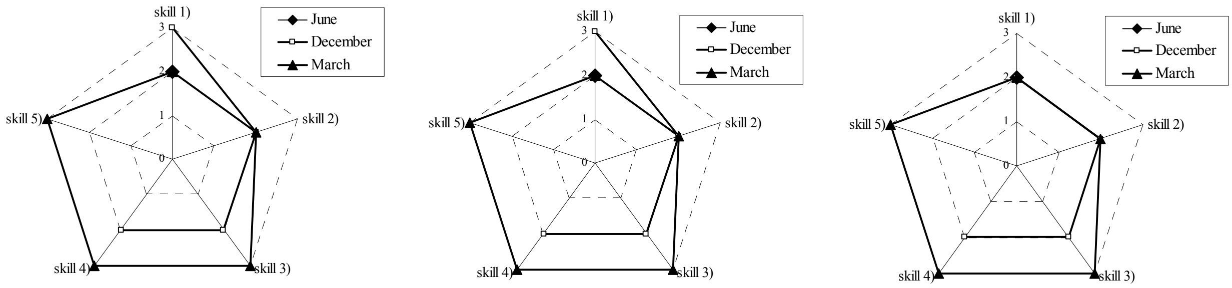
Time dependent changes of skill of Mr.C



(1) evaluation by student (2) evaluation by teacher (3) evaluation by practicing engineer

FIGURE 5

Time dependent changes of skill of Mr.D



(1) evaluation by student (2) evaluation by teacher (3) evaluation by practicing engineer

FIGURE 6

Time dependent changes of skill of Miss E

Influence of practicing engineer’s comment on student’s skill and motivation

The relation of the behavior described by a student and a practicing engineer are arranged in order to analyze the opportunity of skill and motivation improvement. The case of Mr.B is shown in Figure 7.

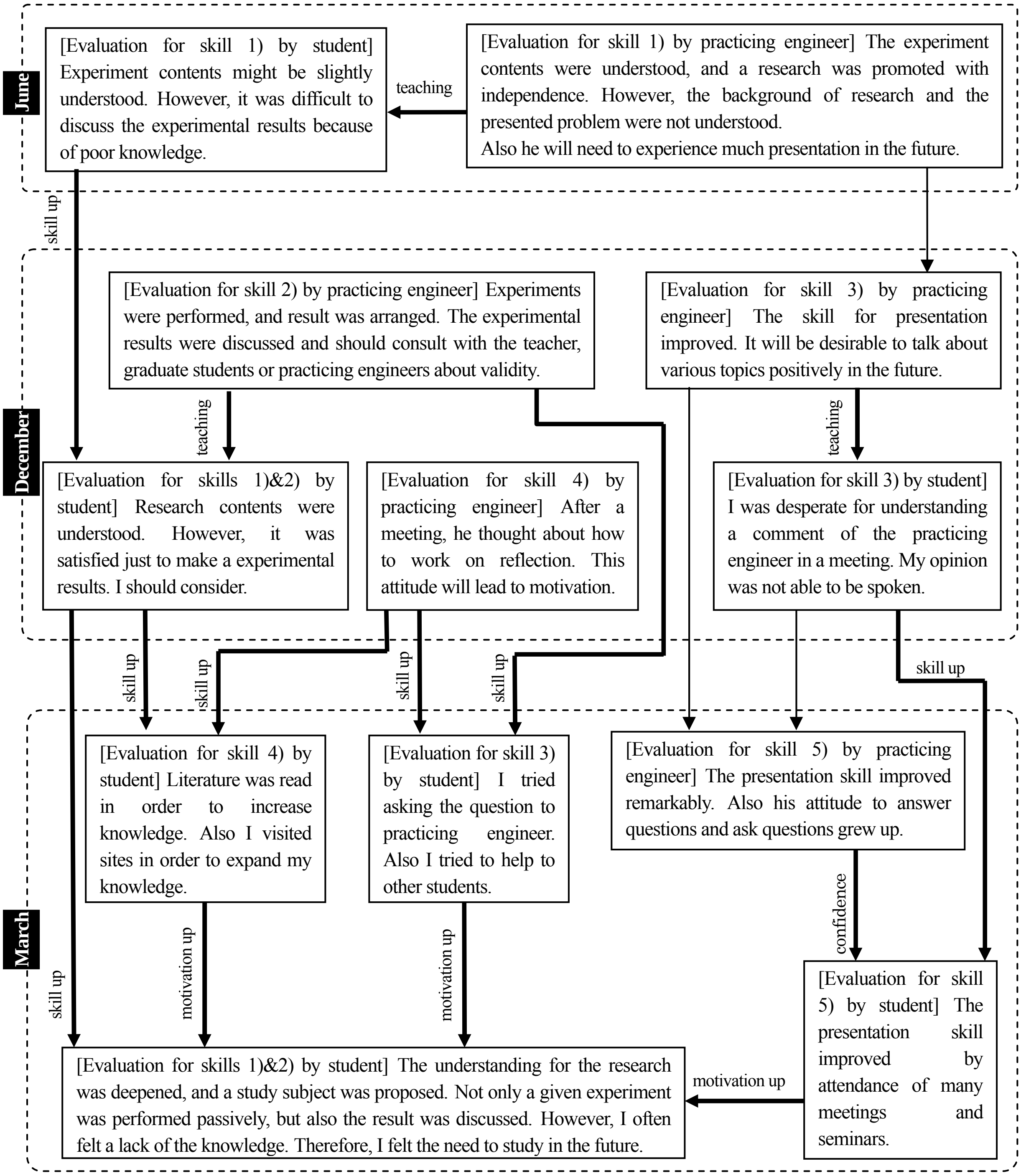


FIGURE 7

Influence of practicing engineer's comment on Mr.B's skill and motivation improvement

According to these figures from all students, it can be confirmed that the student notices the insufficient skill from the practicing engineer's comments and tried to make efforts to improve one's skills. The comment from the practicing engineer was playing an important role compared to the teacher's comments, since the practicing engineer thought and acted in the real society. Then, after the student has confidence with the practicing engineer accepting to his/her skill up, there were the several cases whose more and more skills developed better and motivation got higher. Based on the above analysis, the student felt confident once his/her skills were accepted. Therefore, it is important that not only the teacher but also the practicing engineer teach and encourage students.

Educational effect

The core skill of the student improves practically by promoting the project with the practicing engineers from the real society. Also the engineering design skill improves by harmonizing the various knowledge to develop the practical technology for a market. Additionally, the students feel a necessity of the learning and studying.

Merit of practicing engineer

As for the practicing engineers, only research results are a merit. On the other hand, the time needed for teaching the student is a demerit. Herein, the practicing engineers may know the real skills of the student through an university-industry collaboration project. Therefore, getting a job may be derived if the useful student for the company is found. In this case, the teaching for the student can become a merit for the practicing engineer. Mr.A is going to really get a job in the company of the university-industry collaboration project after his master program. In Japanese situation which shall decide unofficial decision before graduation, it is a superior case that the matching between the company and the student are guaranteed.

CONCLUSIONS

The fusion of "university-industry collaboration project" and "project design III" may attempt the student's skill and motivation improvement very much.

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