

Engineering Education Instructed by Innovation Center for Research and Engineering Education in Utsunomiya University

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Abstract

The aim of this paper is to introduce activities of Innovation Center for Research and Engineering Education (ICREE) which has been founded since 2002 in order to carry out engineering education for undergraduate and graduate students in Utsunomiya University. The mission of ICREE is to instruct students to obtain the sense of originality, activity and motivation through producing something new. ICREE is composed of four divisions, i.e., the first one is the problem-based education division that plays an important role to educate undergraduate student. The second one is the technical research division that performs to develop a new system of production skills. The third one is support for research and education division that helps students and teachers use machine tools correctly. The forth one is contribution to local society division that provides basic engineering skills and lots of fun to enjoy producing something especially for students of primary school. Since engineering education has been performed mainly in the problem-based education division, we introduce activities of its division in more detail. On top of that, ICREE has developed and performed spiral engineering education program supported by Ministry of Education, Culture, Sports, Science and Technology since 2005. This spiral engineering education program is different from piled up educational program which has been carried out usually in university.

1. Introduction

For Japan without natural resources, it is indispensable to educate students who have engineering sense of producing something new by their own efforts, because engineering industry contributes greatly to financial basis of Japan. This means that Japanese economy never fails to break down without great financial support of engineering industry. On the other hand, Japan is now facing challenges due to declining of birthrate and it is also pointed out as social problem that the number of students who wish to go on engineering college decreases gradually linking with such declining of birthrate. This phenomenon is correlated closely with the lack of curiosity for science of junior and high school students, which has been also pointed out as another aspect of social problem in Japan. The cause of lack of curiosity for science is not clear, but it is true that the status of engineer in Japan is relatively lower compared with the

other jobs, for example, medical and commercial business. These characteristic situation of Japan has a great impact on engineering education of university.

From this point of view, Ministry of Education, Culture, Sports, Science and Technology recognized the necessity of foundation of innovation center for engineering education around 2002. Innovation Center for Research and Engineering Education (ICREE) in Utsunomiya University has been founded since 2002 in order to carry out engineering education for undergraduate and graduate students [1]. This is the first innovation center in Japan. Therefore, the mission of ICREE is to instruct students who obtain the sense of originality, activity and motivation. In order to perform its mission, characteristic educational systems have been developed and carried out for students, i.e., problem-based learning, project-based learning, internship program, support for student project and so on. The purpose of this paper is to introduce such activities of Innovation Center for Research and Engineering Education.

2. Innovation Center for Research and Engineering Education

ICREE has covered over four major fields in terms of activity and division is organized for each of major fields. Figure 1 shows the schematic diagram of such four major divisions. Four divisions have the main purpose described as follows. The problem-based education division takes charge of developing and practicing educational programs which encourage students to develop the sense of own ship and creativity in engineering. The technical research division aims at recording and digitizing engineering skills and techniques of specialized engineers, using IT technology, in order to share and transfer such valuable assets in the industry. It also conducts research projects to create advanced manufacturing systems for the next generation. The mission of the support for research and education division is to support academic staff and students in preparing specimen and setting up experimental apparatus required for advanced research projects in the faculty. The contribution to local society division not only provides basic skills to build up creative production, but also supports science education, experienced-based learning and presentation of sophisticated skills for students of from primary school to university. ICREE has also provided service to students, faculty and staff, and industries, as the “back-bone” of education and research activities in the faculty of engineering.

With reference to organization, ICREE have been mainly managed by eight persons who are director, co-director, associate professor, associate and technical officers. Important agenda for ICREE has been discussed and determined by management committee which is composed of representative of each department. Since problem-based education division especially plays an important role in engineering education, problem-based education and internship program are operated by professional committee. Organization of ICREE is displayed in Figure 2.

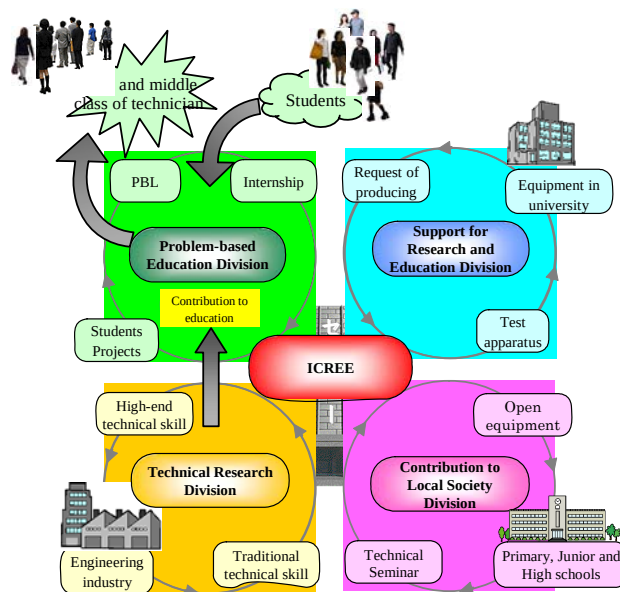


Figure 1: Four major divisions of ICREE

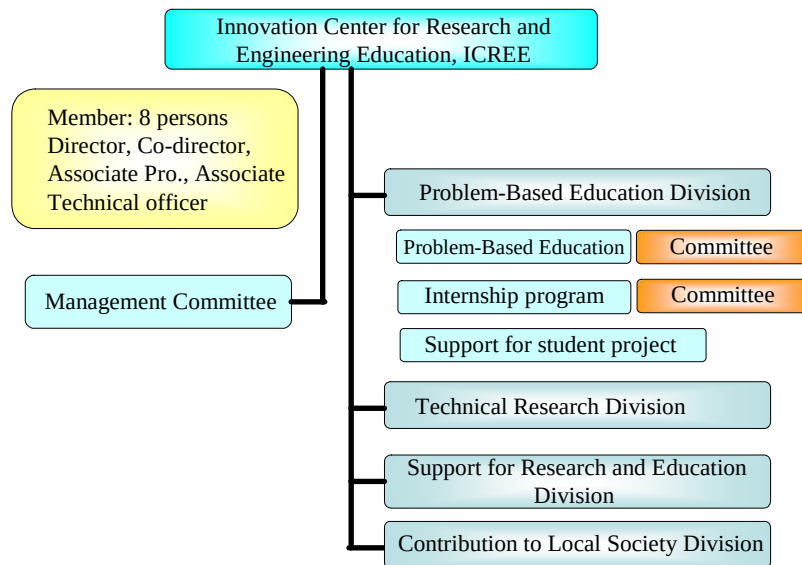


Figure 2: Organization of ICREE

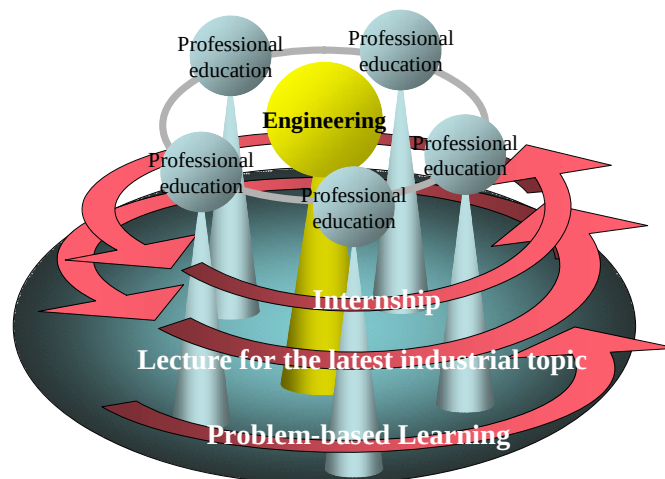


Figure 3: Conceptual diagram of spiral staircase for educational system of ICREE

ICREE has presented several kinds of original lectures for students. Such lectures are introduced step-by-step to make students understand the reason why you should learn the engineering knowledge in university. At first, problem-based learning program for freshmen is adopted as a practical lecture. It is designed to cultivate sense of creativity in the students. Groups composed of students are required to grapple with a given problem through discussion and research within each group, for which there can be more than one solution. It is necessary for students to find out a solution of their own by trying various strategies and approaches. Every year, this program has been reviewed and evaluated by faculties in order to provide better education to students than previous year.

ICREE gives a series of lecture for sophomore students. Skilled engineers in industries are invited to give a talk to students on such topic as company organization, product development, and related technologies. Students are able to have a glimpse of innovative activities in the industries through skilled engineers. ICREE also provides students with internship programs, in which the students work together with employee of company for a short period and are expected to obtain first-hand experiences in engineering, so that they will recognize the meaning and values of what they have to learn professional lectures in university.

ICREE supports student projects too, in which students and academic staffs try to exercise their engineering knowledge and skills to construct various highly specialized products such as canoe made of concrete, electronic vehicle, formula car and intelligence robots.

These educational systems mentioned above have been performed linking with professional subjects of department, as if it were a spiral staircase. Figure 3 indicates conceptually the spiral relationship between educational system of ICREE and professional subjects of department [2]. In next chapter, individual education systems of ICREE are described in more detail.

2.1 Problem-based learning for freshman

ICREE has for their mottoes “learn through experience and improve the sense of originality, creativity and initiative”. From this point of view, problem-based learning is introduced as compulsory subject for all about 450 freshmen of engineering. The aim of this problem-based learning is to stimulate self-awareness as engineer and motivate students to study hard as they are promoted to a higher degree. This problem-based learning triggers to have freshmen recognized as a beginner in engineering fields.

As for problem-based learning, all freshmen have to produce something original in cooperation with the other students as a group activity. Themes of problem-based learning are prepared for and presented to students by faculties and staffs of ICREE. They pick out freely these themes as they like it. After that, considering their request of theme, ICREE divide all students into five students each which compose one group unit. And five students are in five different departments, i.e., mechanical, electrical, chemical, civil and information departments. This style of composition is one of unique features because they have an opportunity to work together with members of different major. Since there are 450 freshmen, about 90 groups are composed and chose about 16 given themes. For example, one of these themes is to build up bridge strengthened by using only spaghetti. In order to carry out smoothly and effectively this PBL program, systematical management is required. Figure 4 shows schematic diagram of organization of this PBL program.

Students deal with problem using imagination, experienced skills and discussions without professional knowledge. In this problem-based learning, it is pointed out as characteristic features that three students have obtained the certificate of utility model registration as a

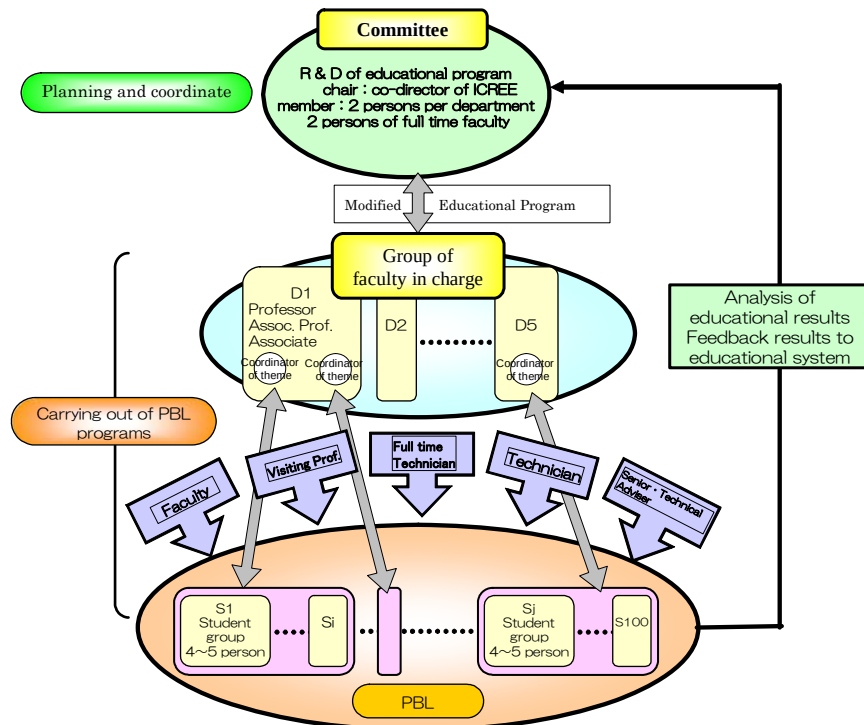


Figure 4: Schematic diagram of organization of problem-based learning

inventor of mathematical educational tool, which suggests that this type of the problem-based learning is effective system to inspire their motivation.

Every year, ICREE has obtained information about PBL program by means of questionnaires. According to questionnaire, about 60 % of students have been satisfied with this PBL instruction and answered that cooperation and initiative are needed to carry out PBL.

2.2 Lecture for the latest industrial topics

ICREE has arranged the lecture for sophomore and graduate students, which was instructed by graduated students of our own university to introduce the latest industrial topics and actual business work. About fifteen graduated students, who are limited to be middle class employee of a company, are invited to give students lecture. Students are able to learn the relationship between actual work of a company and the professional knowledge lectured at university. Therefore, students can understand the reason why they have to learn professional knowledge at university.

From the side of ICREE, it is hard task to arrange schedule of invited lectures, but the relationship between university and engineering companies is strengthen more and is able to make use of internship program which is described in next chapter. As for the improvement of this lecture, it might be better for ICREE to prepare for a lecture of not only industrial topics but also management of engineering, because students understand totally organization of company by learning both sides of actual business work and management of engineering. In order to give a lecture of such management of engineering, it is needed to invite directors of company.

2.3 Internship program

Internship program is useful for students to learn directly the management and duties of company through actual work. Besides, these actual experiences in company greatly contribute to take a job in their future. From the standpoint of company, it is also a good opportunity for company to let students understand attraction and discipline of company. At the same time, it is also true that company is able to get unexpected advice from students. Internship program has been prepared for undergraduate, graduate and doctoral students [3]. Two kinds of internship programs have been carried out for undergraduate and graduate students. One is the experience-based internship program which means to make undergraduate student experience actual work in company. The other is the problem-based internship program which is to have graduate students suggest a clue to solve problem of company by applying their professional knowledge and skills. On top of that, it is pointed out as characteristic feature that doctoral

Table 1: Classification of internship program provide by ICREE

Type of internship		Content	Period	Grade
Experienced-based internship program		Students experience actual work of company with employee. They can learn directly relationship between school work and actual work.	From 1 week to 1 month	Undergraduate, Master
Problem-based internship program	Problem-based internship	Students tackle problem proposed by company by means of professional knowledge of engineering and technical skills.	From 2 weeks to 1month	Master
	Mutual internship	Doctor students carry out research work with company by using professional knowledge and skills. It is required to solve the problem proposed by company.	1month and over	Doctor

students are able to participate in internship program which is called as mutual internship program. By taking part in this program, doctoral students learn more deeply research and development in the company. On the other hand, joint research work with doctoral students brings the solution of problem to the company. Classification of internship program provided by ICREE summarize as shown in Table 1.

Figure 5 shows number of participant of internship program every year. Figure 5 suggests that participant decrease gradually for some years to come. In order to recover previous level, it is necessary to advertise advantage of internship to not only students but also faculty member. Besides, it is pointed out that participant of mutual internship program is few and far between compared with the other internship program. This tendency seems to be caused by the difficulty of mutual internship because doctoral students are required to solve the problem and suggest the way to deal with the problem. Therefore, careful preparation discussed with supervisor is needed before carrying out mutual internship program. Adding to this, it is also pointed out as the cause that almost all doctoral students in our university are member of company. This fact means that internship program for member of company is needed to prepare.

After students finish internship program, they have to submit the report concerned with experienced work and present what they experienced and how to feel about internship program. Almost all students report that internship program is profitable from the point of considering their own future.

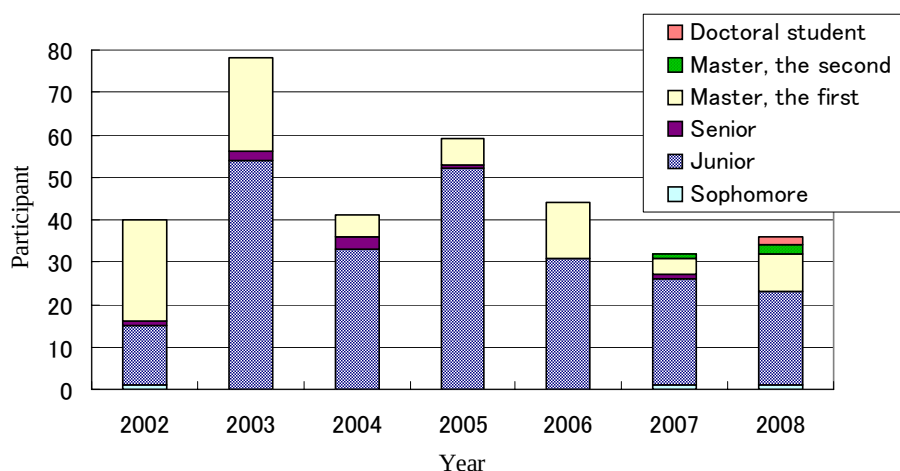


Figure 5: Number of participant of internship program every year

2.4 Projected-based learning for graduate student

ICREE has started opening project-based learning for graduate student since 2008 in order to improve their independency and ability to solve the actual problem. In general speaking, the process of plan, do check and action, which is usually abbreviated to PDCA, is basic process to solve the problem in company. However, it is uncommon for graduate students to experience to solve the actual problem by using PDCA process. It is also obvious that PDCA process is applied for research work of graduate students, but supervisor plays an important role with reference to selection of master's thesis and instruction.

In project-based learning presented by ICREE, students have to suggest project planted by their own and make the detailed report including PDCA process. This PBL education is different from master's research work from a point of respecting independency of graduate students.

In last year, four groups composed of fourteen students carried out project-based learning by themselves. One group has instructed primary school students how to produce snow crystal in small bottle. Another group went to the technical high school to introduce campus life and research work of their own. Remaining two groups have planed to instruct freshmen and coached them by introducing PBL education which is compulsory subject for all freshmen. They presented following themes as PBL, i.e., one is to build up sailing boat and the other is to make switching system by using various mechanisms. As for this PBL program conducted by two

groups, it is interesting point whether they have ability to instruct freshmen, or not. According to questionnaire, graduate students have a good reputation of freshmen which is not inferior to that of faculties. This result of reputation suggests not only that it is useful educational system for graduate students to coach freshmen by making use of project-based learning but also that graduate students have potentiality to instruct freshmen correctly by their own efforts.

2.5 Instruction and support for project proposed by student

Students have independently organized projects which are related with manufacturing industrial productions and participated actively in competition to polish up their skills and knowledge. Projects are managed mainly by students and supervised correctly by faculties. At present, four groups have carried out their projects. One group, which is composed of civil engineering students, builds up canoe made of concrete. Another group organized of mechanical engineering fabricate small formula car which is so called by Formula-SAE. The other group, which is gathered with electrical engineering, makes up electrical car. The last group, which is organized by graduate students, produced autonomous vehicle without artificial instruction. For example, student group of Formula-SAE has participated in Formula-SAE which has opened at Pontiac Silverdome of U.S.A. in 2004. They received perseverance award which is given to the team satisfying both running completely all competitions without trouble and the first participation in Formula-SAE. Figure 6 shows the pictures of student projects.

It might be hard for students to firstly organize projects by their own efforts, because they have not enough financial support and place to work. Therefore, it is important for someone else to take care of these projects kindly, which careful assistance leads student to start smoothly project and to inspire activity. On the other hand, it is also difficult for student of existing project to last continuously without giving up, because routine work gradually causes the lack of curiosity. From this point of view, ICREE have not supported financially but also give advices technically to projects proposed by students.

On the other hand, ICREE have considered another aspect of support for student projects. In our university, student projects have been regarded as voluntary after-school activity. However, it is also fact that students have learned the professional knowledge of engineering and skills from designing and producing industrial goods using too much time. These knowledge and skills based on experience is not able to obtain from the regular instruction. To admit student projects as the regular instruction is to lift up their motivation and responsibility. Therefore, ICREE has been planning to give a credit students engaging in projects, which improvement is required to change more reasonably educational system in university.



Formula-SAE project



Autonomous vehicle project



Electrical car project

Figure 6: Student projects supported by ICREE

2.6 Contribution to local society

ICREE have contributed to local society by instructing students of primary school how to build up commercial radio kit, planetarium, electronic robot, handy microscope and so on [4]. ICREE have not instructed students of primary school but also developed teaching materials which are wind-car, motor kit and planetarium to let student understand principle of physics. Such teaching materials are carefully devised to build up easily even primary school students. Figure 7 shows these teaching materials presented by ICREE. At the same time, teaching materials are skillfully designed to inspire curiosity of students. For example, wind-car moves toward not downstream but upstream of wind [5]. This program for primary school students has been performed during

summer vacation every year. Total number of participant is about three hundred students every year. Number of participant gradually increases which shows that this event is useful education for local society. In order to carry out this program every year, it is important to connect closely with representatives of communities and to provide interesting teaching materials.

As already mention above, it is pointed out as social problem that the number of students who wish to go on engineering college decreases gradually linking with declining birthrate and this phenomenon is correlated closely with the lack of curiosity for science of junior and high school students. This fact suggests that it is necessary for student to be interested in science in early stage and keep curiosity of science holding until high school at least. From this point of view, this program for primary school students is likely to prevent the decrease of students who wish to go on engineering collage in further future.



Wind car



Motor kit



Planetarium

Figure 7: Teaching materials designed and presented by ICREE

3. Conclusions

In this paper, engineering educations of ICREE are fully described in detail, i.e., problem-based learning for freshmen, lecture for the latest industrial topics, internship program, project-based learning for graduate student, instruction and support for projects proposed by student and contribution to local society. Especially, problem-based learning for freshmen is considered as distinctive educational system because it is only our university to instruct for all freshmen such problem-based learning as compulsory subject, although problem-based learning system is usually adopted in almost all university.

In order to carry out continuously sophisticated engineering education, it is necessary to improve and change educational systems considering social situation. From this point of view, ICREE have proposed the engineering education for graduate students by adopting project-based learning system. This project-based learning system would not strengthen the relationship between graduate student and society including companies more tightly than the present state, but also trigger to encourage the sense of leadership.

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