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ACTIVE LEARNING VIA MECHANICAL ENGINEERING-BASED EXTRACURRICULAR ACTIVITIES

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Abstract

Currently, the institution of higher education in Japan has proposed a more efficient learning environment, in particular for engineering students. With the rapid decline in Japan's birth rate, the Japanese College of Technology is looking at enhancing and maximising their human resource development. We have created an environment to allow active learning for highly motivated students as part of their extracurricular activities. This paper describes how the college conducts a trial by promoting active learning as part of its extracurricular activities in the mechanical engineering department.

The project is named "Mech. Cafe - Mecafe", and this is meant to encourage students to take part in mechanical projects voluntarily. In this Mecafe, the students will participate in technical and engineering competition events such as "Student Formula Car Project", "Flow Visualization Contest", or some in-house events which include "Handmade Powder Metallurgy Workshop" and "EV Car Design Project". As today's students are pressed for time, it would be difficult for them to participate in such events. Therefore, it is important to create a conducive environment for them to take up these projects, as this will in turn help them to become more creative and motivated in their work.

We have seen some positive results from this trial. The Project-Based Learning (PBL) in extracurricular activities will keep our teaching environment competitive without making major changes to our educational curriculum. However, we found that our teachers face challenges during the trial. For instance, the "Student Formula Car Project" involves some metal work processes such as welding, cutting and assembling work. As a result, the teachers need to take responsibility for these safety issues even if the students had volunteered to take part in these activities. It is noted that such existing safety issues had significantly undermine the acceptance of our proposal on the extracurricular activities in our college.

Keywords: *active learning method, engineering design, undergraduate research, project-based learning, mechanical engineering*

Introduction

It is well known that the labour force of Japan will decrease rapidly by the problem of a decrease in the birth-rate. The Japanese population is down 0.21% in 2013. New baby is born in every 31 seconds while the other Japanese dies every 25 seconds. It is predicted that the number of death is keep increasing, and people aged 65 years or older will account for a 30% of the total population in 2040. In order to maintain the scale of Japanese industry, it is important to perform engineering education for young generation because technical level in the labour force has a major impact in productivity and level of research and development in industry. Our institution, Japanese college of technology, was established in 1962 to educate engineers who can sustain the economical growth as demands from Japanese industries. In recent years, demands from industries are changing radically as the globalization of industrial activities rapidly proceeds. Now we must review our roles in future, confirm our new task for the next generations and cultivate innovative human resources for Japanese industries.

Active learning is effective educational technique to make student creative and innovative. It also cultivates self-realization of the students. Since it has been suitable for our educational task, Japanese college of technology has implemented project/problem-based learning as we have many practical training curriculums which are represented by scientific experiments, workshop training and practical manufacturing skills. Mizokami (2007) classified the types of active learning in practical training as follows;

Problem exploring type: which students plan a learning theme themselves and investigate it.

Conclusion of the investigation is presented as output type articles which depend on what they learned about the theme.

Problem solving type: which a teacher plans a learning theme or task roughly and students investigate or achieve it. Conclusion of the investigation is presented as outcomes type articles which depend on how they achieve the theme.

Mizokami also mentioned that learning processes in practical training are “information gathering”, “interview, questionnaire investigation and experiment”, “production”, “group discussion”, and “presentation”, etc. Education system in Japanese college of technology can easily implement such learning processes in classes as teachers are conducting detailed teaching in small classes which are allowing close attention to students.

However, scholastic ability of our students has declined gradually in recent years. It seems that some students hard to get motivation for learning. The significant gap exists between postures of such students and requests from teachers although the students have entered into our college after they had admitted our admission policy. So teachers must spend more time for supplementary class. Now we have realized that it is important to promote motivation in engineering activities to perform practical training effectively, especially for *problem exploring type* active learning. However, educational budgets, manpower and spare time for additional supplementary class are completely restricted due to our characteristic educational system which is congested curriculum schedule.

Takahashi (2005) noted a hypothesis that the origin of the decline of greediness for learning in Japanese schools arose by dilution of communitarian class culture, which gives to students an environment of "*exposure to other views*" and "*need for approval from classmate or teacher*" efficiently. He said that such environment is connecting to formation of learning motivation in students. Then he suggested that extracurricular activity should be considered to examine the decline of greediness for learning. Investigation of Mizokami (2009) may proof this hypothesis as he found that students who spent much time positively for extracurricular activities show the characteristic as follows;

(1) They have capability to carry out study in extra-class, and positively design for life.

(2) They consider rich human relations and club activities to be the importance of student life.

So it can be found that well-balanced extracurricular activities with classroom studies are important to get positive motivation in self-learning and self-development.

On the other hand, extracurricular activities in the educational institution can cultivate not only mental and physical health but also self-realization which sustains motivation in student life. Actually, it is presented that the establishment of educational supporting community to encourage student’s extracurricular activities performed in Kanazawa Institute of Technology significantly not only promotes the satisfaction in students life but also the number of the entrance examination applicants of the department (Demura, Tani and Hattori, 2006; Hattori, Matsuishi and Tani, 2006). This fact indicates that the environment of *problem exploring type* active learning with “*extra-class support*” should be maintained to enhance more advanced human resource development in the university.

Enrichment from "*exposure to other views*", "*extra-class support*" and "*curricular support*" is found to a device, which develops the further quality of active learning in Japanese universities (Mizokami, 2007). Tokito and Kubota (2013) found that the extracurricular experience effects student’s self-development, and noted that it is necessary to set environment to build communities for participants, to give students central roles, and to set a common goal for both students and teachers. In these viewpoints, we suggest that our college need to perform more active learning program to give student more motivation for leaning positively. The proposal should be suggested as *extra-class support* with considering of our less educational budgets and manpower.

In this paper, active learning environment as an extracurricular program, which is voluntarily proposed by students who want to make active action in mechanical engineering, is presented. We have tackled with establishment of the learning environment as extracurricular activities. The attempted project is named “*Mech. Cafe - Mecafe*”, which is taken as the science cafe. Students plan to participate or apply to some technical and engineering competition events, such as “*Student Formula Car Project*", “*Flow Visualization Contest*”, “*Preventing the Fastening Failure of Bolts*”, or some in-house events which is prepared by our school, such as “*Handmade Powder Metallurgy Workshop for junior high school students*” and “*EV Car Design Project*”, etc. A few results of their trial which aims to attend the events are presented.

Materials and Methods

The purpose of *Mecafe* project, which we have attempted to establish the environment and community to propose active leaning as extracurricular activity, is as follows;

(1) To maintain the environment where students can perform engineering activity in extra-class.

(2) To produce a community that can share a student’s motivation for the other student or teacher.

(3) To use the output from the activity for the publicity work of our department.

Firstly, a student proposes the contents of activity. Several teachers become an adviser. Advisers select the proposal which has feasibility and give a student permission of execution. Then the student organizes the other students who agree with the activity. Thus the *problem exploring type* active learning was attempted as extracurricular activity by the supporting of teacher’s advice.

The budgets of the activity were distributed from the exhibition expense of campus festival event. An in-

house grant given through competition in our college, which name is “student challenge project”, has also been allotted. These amounts of a budgetary ceiling are 100,000 yen, respectively.

The environment for the activity has been prepared by our department as computer design exercise room and common rooms which are provided by advisor. Typical 3D CAD software and 3D printer are available in these rooms, and members of the projects can use these rooms under the permission of advisors. The progress of each project is reported in the meeting held once per week. In order to share the proposal and work of each student, "Cybozu live" which is web based groupware was used. 3 to 5 students took part in one project.

Results and Discussion

Flow Visualization Contest: The Japan Society of Mechanical Engineers (JSME) performs this event every year. In this event, the students of university/college participate per a group or laboratory, and perform the presentation which tells the fun of fluid engineering to the general public. Our group developed the portable flow visualization equipment as shown in figure 1, and participated in the event. The exterior of equipment is made from plastic corrugated paper. The smoke generated with smoke generetor is passed by the channel, and is lit up by the LED light. Since smoke passes along the tandem type nozzle, a flow serves as a line and can be sighted as shown in figure 2. The nozzle and the bell mouse for minimizing disturbance were created with 3D printer. Thus, since it was an easy material and work, the student was able to create characteristic equipment at a low price with safely work. Activity time was about 300 hours and the price of expense was about 30,000 yen including smoke generator. In the contest, although they did not result in the award, many particioants admired the competitive performance of the equipment (Figure 3). They continuing the activity trough the year for next competition.

Preventing the Fastening Failure of Bolts: The competition was performed by The Association for the Advancement of Manufacturing & Technology. The idea, which can sight it immediately when a failure of a bolt to fasten arises, has been invited only for students in college of technology in Kansai Area. There were 156 applications and our group won the highest award and prize of 200,000 yen. In the activity, students processed new structure of the bolt, and they checked their idea so that it might become the structure which a failure to fasten does not occur. Based on the test result, they drew up the intelligible proposal document, and explained the unique idea. Activity time was about 30 hours and the price of expense was about 1,000 yen.

Student Formula Car Project: Student formula car convention is a content of Society of Automotive Engineers (SAE) of Japan which regulation is same as American Formula SAE®. The aim of the convention is to activate engineering education by offering the

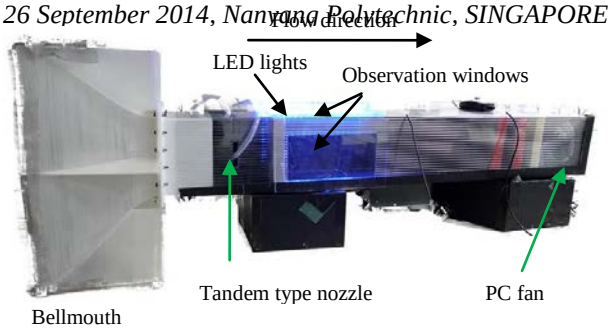

Figure 1 Photograph of the portable flow visualization equipment

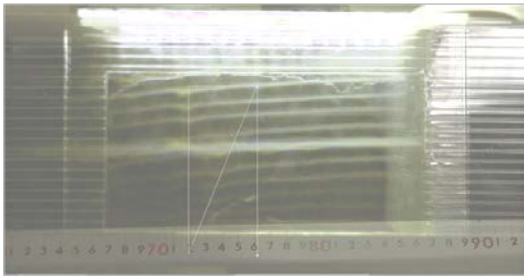

Figure 2 Flow lines generated by tandem type nozzle

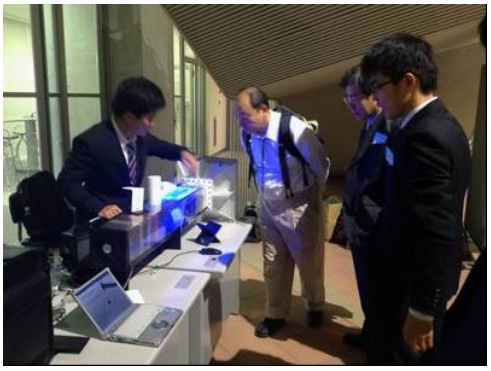

Figure 3 Presentation in the contest

opportunity of craftsmanship. By the student himself constructing a formula car team, developing and manufacturing the small racing car of a formula style in about one year, students learn the essence of craftsmanship and realize severity and joy of engineering. In an athletic meet, students compete for the collective strength in manufacturing of formula car, such as marketing, planning of manufacturing, concept of car design, and cost competitiveness, rather than compete for the running performance of the developed formula car. In order to participate in the convention, students visited the activity of the neighbouring universities first. The adviser gave them the racing cart which is the most fundamental formula car, and promotes self-learning of the member.

However, the activity in student formula car project includes some metal working processes such as welding, cutting, etc., assembling work, firing engine and running test. As long as the age of our students is not coming of age, the advisor must have responsibility in safety issues even though the activity is voluntarily proposed from the students. The advisor finally has to suggest making a contract with the parents of the

students in safety issues to evade lawsuit for injuries which may happen in the activities. Moreover, sufficient money is required in order to manufacture the formula car which can be run safely. This project is difficult for attaining only in extra-curricular activity in our department. Probably, it will be hard to participate in a competition until permission of total support is supplied from our college. However**,** even though it is hard for students without much time with few budgets, to make their effort to participate in the events, to make an environment for such projects is very effective to get some students creative and motivated themselves. Now, the students are just going to design of their own formula car by finishing an understanding of a regulation in the competition. They are also striving for self-study as shown in figure 4 as they are doing disassembly and assembly work of an engine.

Figure 4 Example of activity as a trial to produce formula car

Handmade Powder Metallurgy Workshop for junior high school students: The author suggested the simplified powder metallurgy method in order to conduct the workshop practice which aims to give young students interest in metalworking technology or material science in the common crassroom without any special devices (Taniguchi, Ozaki, Kodama and Nakajima, 2012). Since the suggested method is a theme of undergraduate research in advisor's laboratory, teaching assistant can learn about knowledge of metallurgy by the student in laboratory. The member of *mecafe* who attended as a teaching assistant can realize difficulty of teaching engineering to the participants through helping the workshop. Thus we consider that it is how to promote a motivation that students help the open class or workshop as a teaching assistant.

Campus festival event: In the exhibition of our department in a campus festival, members of *Mecafe* work as leading position in order to tell participants the fun of mechanical engineering. In other words, members offer their labour for the exhibition, in exchange for the budgetary measures for their activities in *Mecafe*. Articles on exhibition were a racing cart, 3D printer, flow visualization equipment, an engine cut model, etc., and the workshop which makes a paper craft bridge was also held. Since many kids come to the exhibition, it is necessary to explain the knowledge of mechanical engineering briefly. The member created the poster panel and performed the presentation, and students other than a *Mecafe* member also participated voluntarily and helped the exhibition. We think that such a presentation becomes an important opportunity to increase students' communications skills, and brings up the students who can tackle with graduation research actively. Figure 5 shows the photograph of the campus festival events.

Figure 5 Photograph of exhibition scenery in campus festival

EV Car Design Project: This is the project to develop an EV car in extracurricular activity. Not only the student of a department of mechanical engineering but the student of the department of electrical engineering has joined to the project. The activity fund was supplied from the "student challenge project" which the school proposed. The member have got the used buggy and replaced its engine into motor. Since permission of work from the college has been obtained - unlike the case of a formula car team - , the members can be able to receive the support from technical staff in producing the car. Figure 6 shows the photograph of body frame after removing engine of the buggy. They have designed EV car by using this frame.

Figure 6 Photograph of body frame of EV car

In the active learning environment which we have prepared for the students who want to make active actions in mechanical engineering voluntarily effectively work as community to give the students motivation in school life although we do not have much budgets of department and manpower of teachers. It is considered that we successfully prepared the environment of *problem exploring type* active learning

and students have build themselves community of "*exposure to other views*" and "*need for approval from classmate or teacher*". For example, almost all proposals from students have been carried out and we could use the results of student's activities as the articles on exhibition, and the results bring us positive motivation in self-learning and self-development of the students as some activities have got prize in the competition or got budgets as the proposal won in the competition of our college. For the moment, we do not investigate how the activity leads to an improvement of scholastic ability of our students because the activities are still on a small scale. So we should improve the environment and promote self-learning in the extracurricular activity more. One of the efforts was performed as a boot meeting for the first grade student has been planned by the member, and new members have joined to our activities. Thus, proposed activity is voluntarily managed by students. We need to find how this activity influenced the improvement of the posture of students for learning in college of technology.

Conclusions

We have attempted conduction of active learning as extracurricular activity. The project named "*Mecafe*" has been established as an "*extra-class support*" from department of mechanical engineering in our college. In the *Mecafe*, the students plan to participate to some technical and engineering competition events or some in-house events such as exhibition in campus festival. These promotions as Project-Based Learning, PBL in extracurricular activities bring us the environment of *problem exploring type* active learning and it will keep our teaching environment competitive without big changes of our educational curriculum and teacher's effort. However, we have also found some risks in teacher's roles in the proposed activities because as long as the age of our students is not coming of age the advisor must have responsibility in safety issues. For example, the student formula car project team could not get permission for their activity in the judgment of our college because safety risk exists in metal working process to develop a formula car due to our poor experience in craftsmanship. It is concluded that such existing safety risks in extracurricular activities in our school restricts our proposal.

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