A NEW APPROACH TO ENGINEERING EDUCATION AT TSURUOKA KOSEN

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ABSTRACT

As a new approach in the Integral Engineering Class (IEC) at Tsuruoka KOSEN (National Institute of Technology Japan), a joint PBL class of the second- and the fourth-year students was conducted, and the fourth-year students acted as facilitators in their group discussions. Fourth-year students are intended to support the second years' discussions by supplementing their knowledge and experience, leading to deeper second-year student discussions. Furthermore, experience in teambuilding and leadership are expected to lead to the development of initiative in fourth-year students. The effects of the joint class were investigated using a questionnaire survey on self- and mutual evaluation. A preliminary analysis of the questionnaire results suggests certain positive effects from the group discussion process, such as active discussion, diversity of opinions, and summarized group opinions. We intend to continue improving the IEC based on the questionnaire results.

KEYWORDS

KOSEN, Integral Engineering Class (IEC), Active learning, PBL, Leadership, Standards: 3, 7, 8.

INTRODUCTION

Tsuruoka KOSEN (National Institute of Technology Japan) considers the following competencies to be essential for high performing engineers who can successfully contribute to solving real-world problems: (1) creativity: the ability to discover and solve practical issues; (2) initiative: presentation skills and their expressiveness; (3) team-building skills: cooperation/collaboration and leadership; (4) communication skills: active listening, dialogue and discussion. These abilities correspond to CDIO syllabus 2: Personal and Professional Skills and 3: Interpersonal Skills. To this end, Tsuruoka KOSEN instituted a new "Integral Engineering Class (IEC)" for first-year students to fourth-year students. It is based on active learning and designed to develop the skills needed for engineers. In the IEC, students learn about engineering ethics, intellectual property, entrepreneurship, and career plans. In addition, a wide variety of project-based learning (PBL) group work is introduced for each year to develop creativity, team-building skills, and communication skills.

The main purpose of the curriculum is to instill "generic skills," such as initiative, communication, and teamwork, over the four years that students are in the program by using active learning in the classroom. The integral engineering curriculum is delivered through lectures and project-based learning (PBL) classes where teams work together. Lectures are on engineering ethics, intellectual property, entrepreneurship, and career plans so that students acquire the basic knowledge necessary for working as an engineer. For example, engineering practitioners are invited to give lectures with the goal of delivering technical knowledge and cultivating an engineering mindset in the students. After the lecture, small groups discuss the lecture contents in order to cultivate their understanding and thinking skills by discussing themes and summarizing their ideas.

In each of the four years of the program, PBL is used intensively to cover various themes. Group work helps students to learn about team building, and to comprehensively develop their abilities for finding and presenting solutions. A further goal of group work is to foster initiative and communication. The generic skills being fostered in PBL are required in the real world and can be attained through active learning. See Figure 1 for a flowchart of how PBL framework relates to real world skills.

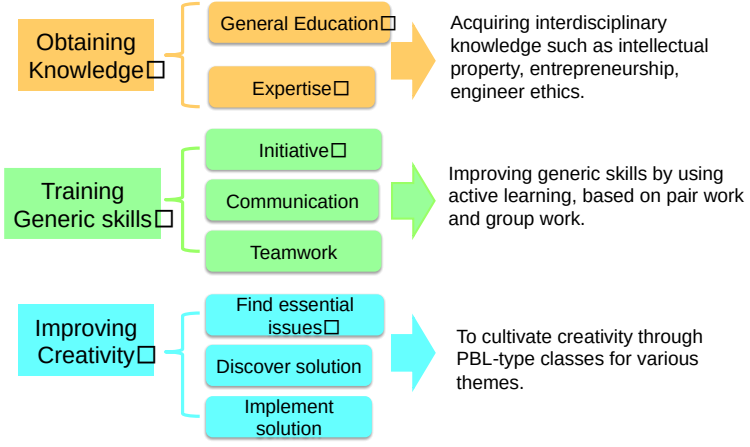


Figure 1. Framework for integral engineering curriculum

METHODS

One of them, there is a joint PBL class for second- and fourth-year students, in which the fourth-year students are the facilitators for the second-year students' group discussion. The fourth-year students can support the second-year students by supplementing their knowledge and experience, and this can allow for second-year students to engage in deeper discussion. In addition, the experience of team building, and leadership can lead to the development of initiative among fourth-year students.

Group work that mixes different years has been introduced in other KOSENs (engineering colleges) and universities (Hiraishi, T. *et al*., 2017; Uchida, S. *et al*., 2017), but the unique characteristic of our approach is that second-year students are encouraged to generate ideas. Fourth-year students specialize in facilitating and consulting group work, drawing out second-years' ideas, and helping them to summarize those ideas. By setting up the fourth-year

students' role in this way, it is expected that they understand the work of improving the quality of the teams' outputs which contributes to leadership education.

In the current study, a group of eight students consisting of four second-year students and four fourth-year students were the participants. The theme of the group work was sustainable development goals (SDGs) (United Nations, 2015). The second-years attended a lecture on SDGs and related global environmental issues prior to the group work. The fourth-years had attended the same lecture two years prior, and they participated in the group work on the premise that they had knowledge of the lecture content on SDGs. The group was presented with a problem to be solved, and the students were required to present their solution. We verified the effects of this approach by administering a questionnaire survey to each of the second- and fourth-year students.

Table 1. Questions

Ⅰ	Did you share the theme in your team?
Ⅱ	How was the team atmosphere?
Ⅲ	How active was your team?
Ⅳ	Did you gather diverse opinions?
Ⅴ	Were the team's ideas summarized?
Ⅵ	Did your facilitators (or second-year students) employ active listening?
Ⅶ	How many questions did your team ask each other?
Ⅷ	Could your facilitators (or second-year students) organize ideas well?
Ⅸ	How easy was it to understand the facilitation?
Ⅹ	Did the facilitator hold a neutral position?

RESULTS AND DISCUSSION

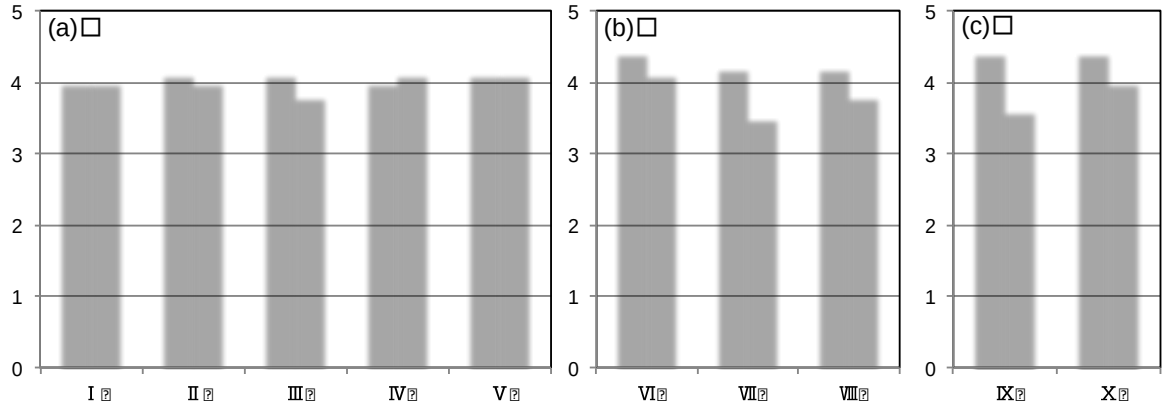
The questionnaire was comprised of 10 questions: group work in general (Ⅰ to Ⅴ), mutual evaluation (Ⅵ to Ⅷ), and the facilitator (Ⅸ to Ⅹ). Answers were on a 5-point Likert scale (not good: 1 to good: 5). Questionnaire results are shown as the average score for second-years and fourth-years respectively for each question. The results are shown in Figure 2.

The first part of the questionnaire about group work in general shows that both the second-year students and fourth-year students gave average high scores of 4 points or over. In other words, both groups of students experienced a high level of satisfaction with the process and output of the group work, demonstrating that this approach was effective. See Figure 2a for a histogram showing the results .

The second part of the questionnaire was on mutual evaluation comprising active listening, asking questions, and organizing ideas. The results showed that second-year students evaluated fourth-year students very highly, with an average of 4.2 points or more. On the other hand, the fourth-year students evaluated the second-year students with low average scores of 3.5 on the number of questions asked. This suggests that the second-year students did not demonstrate enough initiative from the perspective of the fourth-year students. See Figure 2b for a histogram showing the results.

The third part of the questionnaire concerned facilitators, and second-year students' evaluations of fourth-year students were very high. In other words, it was suggested that the support of the fourth-year students for the second-year students was very effective when undertaking group work. On the other hand, the fourth-year students scored the facilitations lower, indicating that they did not believe that the second-year students were easy to work with. See Figure 2c for a histogram of the results. The fourth-year students had received training on facilitation in advance of the group work, but it is thought that more extended training may be necessary.

The fourth-year students generally gave lower scores than the second-year students, but this is probably due to the Dunning–Kruger effect (Kruger, J., & Dunning, D. 1999). That is, it can be inferred that there is a difference between the level considered necessary by the second-year students and the level considered necessary by the fourth-year students. However, overall, there are similar tendencies demonstrated by the scores given by both second- and fourth-year students, and it is considered that the group work process and outputs were effective. In the future, as a way of verifying the effect of these initiatives, we are considering more objective verification by conducting the PROG test (Kawasaki, K. *et al*., 2020).



2nd year students	4.0	4.1	4.1	4.0	4.1	4.4	4.2	4.2	4.4	4.4
4th year students	4.0	4.0	3.8	4.1	4.1	4.1	3.5	3.8	3.6	4.0

Figure 2. Results of questionnaires. Blue: second-year students; red: fourth-year students

CONCLUSIONS

As part of the IEC, we conducted a joint PBL class in which fourth-year students acted as facilitators for the second-year students' group work and verified the effectiveness of that approach. Each group on the theme of SDGs consisted of four second-year students and four fourth-year students in the same course. As facilitators, the fourth-year students specialized in consulting of the group work. The second-year students concentrated on coming up with ideas. The purpose was to verify how they would affect the promotion of group work by clarifying the role. After the work, questionnaires were conducted for each of the second-year students and

fourth-year students to verify whether the group work proceeded smoothly or not. From the questionnaire results, especially in areas concerning group work process and output, the scores that both groups gave were high, and positive effects of this class were seen. On the other hand, weaknesses such as a lack of initiative on the part of second-year students and lack of facilitation skills in fourth-year students were also seen. We will feed these results back and use them for improvements to the IEC.

ACKNOWLEDGEMENTS

We would like to thank the teachers at Tsuruoka KOSEN for their cooperation in the integral engineering curriculum.

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