VISUALIZING THE EFFECTIVENESS OF CROSS-COURSE-TYPED PBL ON GENERIC SKILLS

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ABSTRACT

National Institute of Technology, Sendai College, Hirose Campus has been conducting a general skills (GSs) survey using external standardized tests in Japan since 2014. The results showed that our students' skills related to teamwork, planning, and practice were inferior to the average of university students and needed to be strengthened. Therefore, in the academic year 2020, we arranged a cross-course-typed (integrated) PBL as one of the experimental subjects in the 4th grade, in which students with different specialties were grouped together to solve practical problems and try to improve their skills in team activities, planning, and practice. Through this cross-course-typed (integrated) PBL class, the results of the GSs standardized test that they took improved. By comparing the test results, it was found that there was a significant improvement in the skills of team management, planning solutions, and self-control after the cross-course-typed PBL. In addition, the students conducted self-assessment before and after the integrated PBL class in 2020 and 2021, and improvement in all the targeted skills was observed. The peer assessment and teacher assessment were generally close to the self-assessment, and it was found that the integrated PBL class led to the improvement of students' skills.

KEYWORDS

Project/Problem-Based-Learning, Visualization of Educational Effectiveness, Generic Skills
Standards: 5, 7, 8, 11, 12

INTRODUCTION

In engineering education, it is important not only to help students acquire specialized knowledge and skills but also to develop general skills (GSs) to apply the acquired knowledge and skills in the real world. Hence, many educational institutions, regardless of their types or classifications, focus on developing their students' GSs. National Institute of Technology, Sendai College, Hirose Campus has been working on students' GSs development since 2014 by extensively reorganizing its curriculum to incorporate many techniques of active learning (AL) and problem- / project-based learning (PBL). To assess the impact of curriculum

improvements on GSs, self-assessments by students, peer assessments among students, and direct assessments by faculty using the curriculum are used for short-term school events and courses. In addition, to track changes over time, we have used a standardized GSs test as an objective assessment method and have measured students' skills once a year. In 2018, the five-year survey from enrollment through graduation was completed and it revealed the growth characteristics of students' skills in our curriculum. The results of the survey of Hirose Campus students indicate that they were able to develop abilities in many of the literacy and competency assessment items. This result can be attributed to educational improvements such as the introduction of AL and PBL on our campus. On the other hand, however, it also became clear that they were not able to develop some skills (Team management, Planning solutions, and Implementing solutions) enough. In order to effectively develop these three skills, we began implementing cross-course PBL for the fourth-year students in 2020. This was because we believed that by creating groups of students unrelated to their course affiliation to work on the project, we could selectively and effectively develop the three targeted skills. The effectiveness of PBL based on students' self-assessment and assessment by faculty was reported at the 17th CDIO Conference (Yajima et al., 2021). The results of the self-assessment revealed that the students felt growth through the experience, and furthermore, the self-assessment, peer assessment, and teacher assessment after the PBL showed improvement in the target skills. This paper reports the results of an assessment of the effectiveness of cross-course PBL using the annual objective GSs assessment method.

In addition, we will also report the results regarding the implementation of the cross-course-typed PBL for the new 2021 fourth-year students to confirm the continuous score growth, and the self- and peer assessment of each student's skills based on the rubric conducted before and after the PBL, as well as the assessment conducted by teachers.

CHARACTERISTICS OF GSS GROWTH OF STUDENTS AT NATIONAL INSTITUTE OF TECHNOLOGY, SENDAI COLLEGE HIROSE CAMPUS AND POSITION OF CROSS-COURSE-TYPED PBL

As reported in CDIO 2021, our school uses an external standardized test, Progress Report on Generic Skills (PROG) (Kawaijuku Group 2020), to evaluate students' GSs. In the academic year 2018, the continuous survey on students' GSs from the year of entrance to the year of graduation was completed. The GSs growth characteristics of our campus students were evaluated and reported at the 16th CDIO International Conference (Kawasaki et al., 2020). The report revealed that the literacy and competency of our students had been growing steadily as their grades progressed. Further detailed analysis and comparison with university students revealed the skills that need strengthening and could be further developed. While all of their literacy skills grew enough, some of the competency items needed to be strengthened, and others could be strengthened. Figure 1 shows the first-year scores (blue) and fifth-year scores (red) for students enrolled in 2014 in the major and medium categories of competency assessment items. The difference (red minus blue) is the growth score at our school. As reference data, the average value for college students in 2018 is shown in black. It is clear from Figure 1 that, in the large category, (3) Problem solving skills did not grow, and even the 5^{th}-grade score is lower than the average score of college students. In addition, (1) teamwork skills also showed some growth, but the score of 5th graders was lower than the average score of college students. In the middle category, (3-2) Planning solutions and (3-3) Implementing solutions showed no growth or little growth, and their scores were lower than the average for college students, indicating that these skills need to be strengthened in the future. For (1-1) Relating with others, (1-2) Cooperating with others, (1-3) Team management, and (2-3)

Behavior control, growth was observed, but it was equal to or lower than the average value for college students. These results suggested that team activities and behavior control were skills to be improved. They indicated that the skills related to team activities, planning, and practice were inferior to the average for college students and needed to be strengthened.

In order to improve these skills, the school started a cross-course-typed PBL (CI-PBL) for the fourth-year students in 2020. In that class, the students were divided into groups regardless of their specialized course in order to conduct more practical team activities and to master project management on a large-scale PBL. As reported in the 2020 paper (Yajima et al, 2021), the students' self-assessment using a unique rubric as a criterion was found to help improve their skills. David Boud (1995), on the other hand, points out areas of concern for evaluation using self-assessment and examines each of these. Therefore, we report the results of GSs before and after the course for the students who took the cross-course-typed PBL in 2020 using a standardized external GSs test, which is an objective evaluation method. The PROG results (objective evaluation) also revealed that the target skills were sufficiently developed.

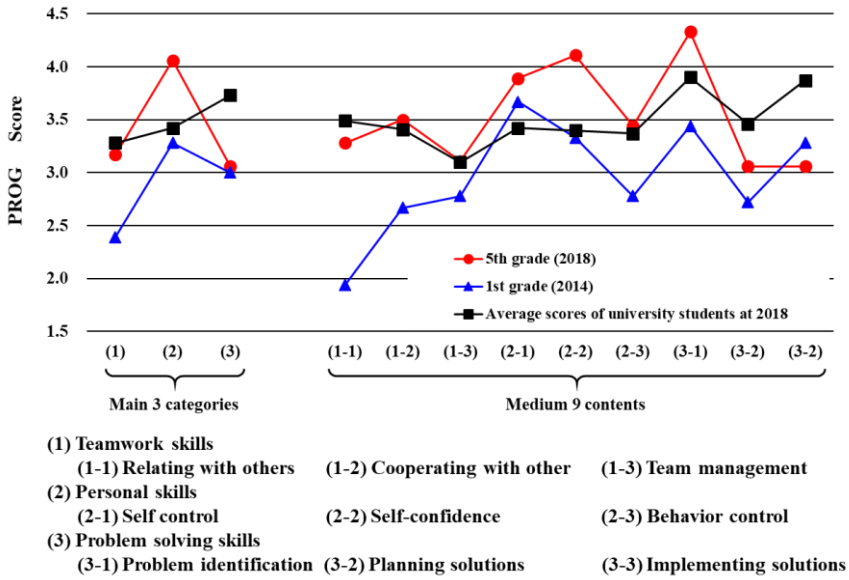


Figure 1. PROG scores of the detailed elements of Competency part.

COMPARISON OF SCORES ON THE STANDARDIZED GSS TEST BEFORE AND AFTER THE CROSS-COURSE-TYPED PBL

We examined what changes occurred in GSs as a result of the cross-course-typed PBL implemented in 2020. Figure 2 shows the standardized test scores and extended scores for the same students in their third- and fourth-years. Figure 3 shows the growth in scores of last year's fourth-year students who took the cross-course-typed PBL class, and the average growth scores of students who did not take the cross-course-typed PBL class for the past three years and the average growth scores for the past five years. For the major category (3) Problem solving skills, which was the issue (weakness) of the students on this campus, we evaluated (7) Problem identification, (8) Planning solutions, and (9) Implementing solutions in the middle category in Figure 2. As a result of the assessment, it was found that the 4th grade students improved their scores by about 0.3-0.6 points compared to when they were in the third year. . In addition, from Figure 3, when we compared the skills of the students who took the cross-course-typed PBL with the average of the skills of the students who did not take the

cross-course-typed PBL for 3 and 5 years, the skills of the former were higher than those of the latter.

Specifically, the students who took PBL showed greater growth in (3) Team management and (8) Planning solutions showed greater growth. This suggests that the acquisition of project management knowledge and its application in practice led to the improvement of skills. In addition, there was also a significant improvement in (4) Self-control skills. It is thought that self-assessment led to the improvement of self-control because it allowed the participants to evaluate themselves objectively and learn about themselves. In addition, the results of Figure 1 show that the students' performance in (1) Relating with others was about the same as the university students' average, but they exceeded in all other skills, especially in (3) Team management, (7) Problem identification, and (8) Planning solutions. These results indicate that the PBL was effective in improving the students' team management, problem identification, and planning skills. In the case of (9) Implementing solutions, it is necessary to improve the education on how to transfer the solution plan to practice.

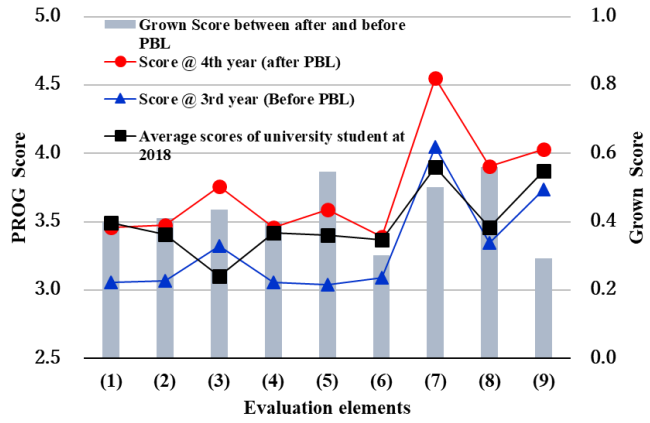


Figure 2. Relationship between PROG scores and extension scores before and after taking an integrated PBL class.

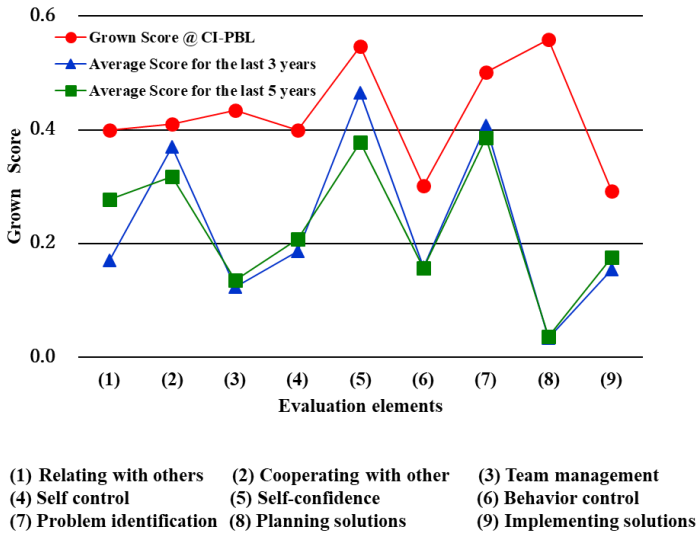


Figure 3. Relationship between PROG Score Growth with and without Integrative PBL Courses.

CROSS-COURSE-TYPED PBL IN 2021

The cross-course-typed PBL is one of the experimental subjects in Hirose Campus. Hirose Campus consists of three courses as follows: The Information Systems Course, which focuses on software; the Information and Telecommunication Course, which focuses on communication; and the Intelligent and Electronics Course, which focuses on hardware. The PBL is a compulsory subject for all courses and is taken by all of about 120 fourth-year students at Hirose Campus and is a 2-credit course that is offered every week for 180 minutes a week (90 minutes x 2, 2 sessions) for 15 weeks. Students are divided into 24 groups (about 5 students per group) regardless of their course affiliation. Each group has a set budget to spend and is free to purchase items within the budget and will have one support teacher. The purpose of this course is to improve students' skills in team activities, planning, and practice by forming groups with students of different specialties and conducting large-scale PBL projects.

In the academic year 2021, the theme was the same as last year: "solving a problem or creating something interesting in the community or at the school," and when setting up the project, we also imposed conditions such as "making someone other than the group members happy" and "the project must include some kind of challenge for the group. Compared to last year's PBL, the 2021 PBL was held in a way that each student was given more responsibility by clearly assigned roles (project leader, general manager, treasurer, etc.) in addition to the division of tasks. To make it more effective, workshops on entrepreneurship by outside experts were also conducted before the start of project activities.

In the first and second weeks, guidance was given to the students, explaining the purpose of the course, achievement goals, assessment methods, and schedule. In the third week, we had group work on entrepreneurship education and know-how about starting a business based on actual ideas. In the fourth week, students learned how to use the Work Breakdown Structure (WBS) and Gantt chart, which are essential for project management. In the fifth and sixth weeks, students decided on the topics to be covered in the group work. In the seventh week, students presented their work on the theme, roles, and WBS/Gantt chart in a midterm debriefing session. The weeks 8-13 was spent implementing and summarizing the project. In the 15th week, individual interviews were conducted by teachers. Table 2 shows the list of project themes for each group. We found that many of the themes were business-based, as the students were expected to start their own businesses using their ideas for solutions.

Table1. Schedule of Course-Integrated PBL

Week	Contents	Method, etc	Submissions
1	Guidance (explanation of purpose, achievement goal, evaluation method, schedule, etc.) and design thinking workshop by experts	Face-to-face	
2	Workshop on how to determine the theme of team activities (projects)	Face-to-face	
3	A workshop to simulate the experience of starting a business	Face-to-face	
4	Project management training, determination of project theme, creation of WBS and Gantt chart	Face-to-face, Team activities	Personal daily report, Team activity report, Self-assessment sheet
5	Review project plans (themes, plans, etc.) as a team	Face-to-face, Team activities	Personal daily report,Team activity report
6	Create WBS and Gantt chart and prepare for the interim report meeting	Face-to-face, Team activities	Personal daily report,Team activity report
7	Interim report meeting	Face-to-face,, Team activities	Personal daily report,Team activity report
8-12	Execution of the project	Face-to-face, Team activities	Personal daily report,Team activity report
13	Prepare for the achievements report meeting	Face-to-face, Team activities	Personal daily report,Team activity report
14	Achievements report meeting and Contest	Online, report video	Personal daily report, Team activity report, Voting card for a good project
15	Personal interviews by teachers	Face-to-face, interviews	Personal daily report, Team activity report, Project report, Self-assessment sheet, Mutual-assessment sheet

Table 2. List of themes of each group.

Group No.	Theme of PBL
1	PC Classroom Usage Management Application
2	OMATASE, a service that eliminates the anxiety of the other party during appointments
3	Development of "Yomitoru-kun" attendance confirmation system
4	Sai-Say, an application to reduce mishearing by people with auditory information processing disabilities
5	NCT Bullet, a recruiting business that connects technical college students with companies
6	MAKER, an app that provides cooking recipes to improve health through better eating habits
7	Ayashi Online Agent, an app that allows you to complete procedures outside of government office and bank hours.
8	Development of Umbrella, an umbrella that is easy to disassemble and assemble
9	A service that provides opportunities for people who live alone to cook
10	Development of mud splash prevention curtain for rainy days
11	Development of a system to reduce congestion in cafeterias
12	Content development for quick and easy access to detailed school information
13	Development of a PC controller for sound game players
14	Development of Home Delivery Box with GPS to Prevent Theft
15	Development of a community-based restaurant map to find restaurants in the neighborhood
16	A company that provides support to people in poverty and those who have trouble disposing of things they no longer need
17	Online try-on application "MY FITTING ROOM"
18	Used teaching materials trading service "Saiteki"
19	Consideration of ways to make residents feel more comfortable by observing good manners on their way to school
20	Development of an umbrella with a drone attached
21	Development of a learning support application "Kachi-gumi"
22	Development of an automatic waste separation bin
23	Development of "Easy Communication," a calling application for easy communication
24	Developing an optimized task management application

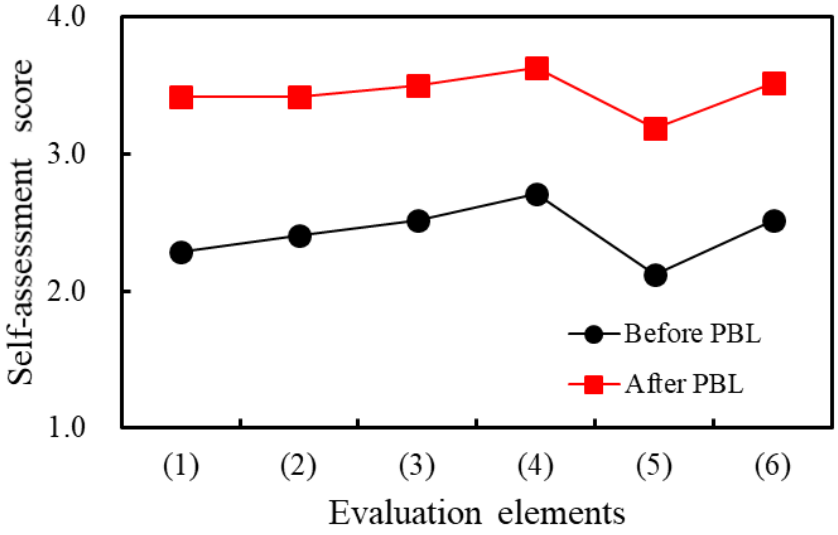
SELF-ASSESSMENT BEFORE AND AFTER THE CROSS-COURSE-TYPED PBL CLASS

For self-assessment, the rubric for the individual assessment in Table 3 continued to be used, and the students' own self-assessment, mutual assessment among students, and assessment by teachers. Figure 4 shows the results of self-assessment before and after PBL, and Figure 5 shows the results of self-assessment, peer assessment, and teacher assessment after PBL. Figure 5 shows the results of self-assessment, peer assessment, and teacher assessment after PBL. This is similar to the results of the 2020 survey, indicating that the effects of the

class were being obtained even when different students took the cross-course-typed PBL course. Figure 5 also shows that the results of self-assessment, peer assessment, and teacher assessment were generally similar. However, for (5) Transmission power, there was a large difference between the students' self-assessment and other assessment, with the self-assessment being lower than the other assessment. This was probably due to the modest self-assertiveness of Japanese people in self-assessment. In the future, we plan to carefully explain the rubric-based assessment criteria to the students and encourage them to actively input their assessments.

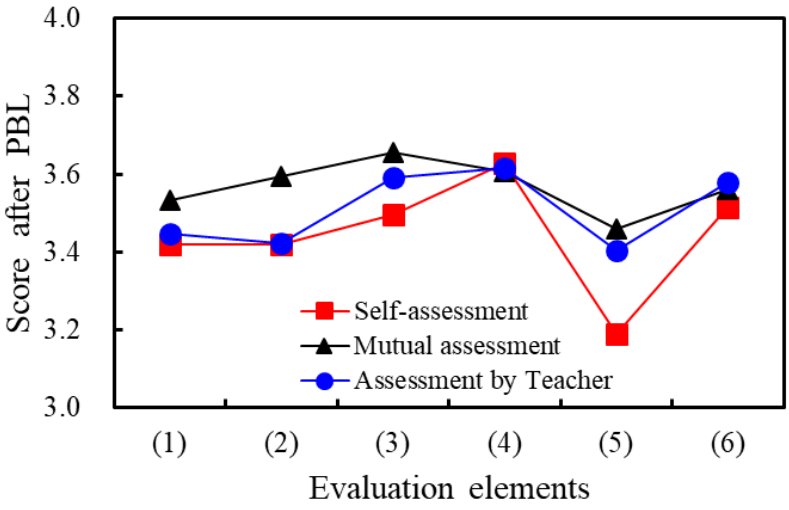
Table 3. Rubric for personal assessment

Levels	**Skills to make a team project successful**					
	Independence			Cooperativeness		
	(1) Reflection on myself	(2) Time management	(3) Responsibility	(4) Ability to Listen closely	(5) Transmission power	(6) Skills of Reporting, Communication and Consultation
4 (Exceeding Standard)	Student can make specific reflections on the personal goals they set each time.	Student can perform their tasks as planned or better.	Student can take positive action to play a role in a group.	In addition to Level 3, student can listen while confirming that they understand the content.	Student can devise ways to convey their opinions in an easy-to-understand manner, such as by drawing diagrams.	Student can report, communicate and consult in an appropriate manner.
3 (Proficient)	Student can set personal goals and reflect on them, but concrete reflections are sometimes inadequate.	Student are able to perform his/her tasks almost as planned, but sometimes he/she do it in a hurry just to meet the deadline.	Student can take actions to play a role in a group.	Student can listen to others while reacting to make it easier for the speaker to speak, such as "nodding."	Student can express their opinions, and most of what he/she say is correctly communicated to others.	Student can report, communicate and consult in an almost appropriate manner.
2 (Progressing)	Student can set personal goals, but they cannot look back enough.	Student can do his/her tasks, but sometimes is late for the deadline.	Student take actions to play a role in a group, but they are sometimes inadequate.	Student listen quietly to others, but often do not understand the content.	Student expresses their opinions, but often the content is not correctly communicated to others.	Student can report, communicate, and consult, but the content is often inadequate.
1 (Unsatisfactory)	Student cannot set personal goals or look back on his/her own.	Student misses the deadline for his/her tasks.	Students cannot take actions to play a role in a group.	Student is looking away, talking wastefully and doing irrelevant things when others are talking.	Student cannot express his/her opinions.	Student cannot report, communicate or consult.
Main evaluation sources	"Reflections on the goal" in personal daily reports, etc.	"Progress of implementation contents" of personal daily report, progress of Gantt chart, etc.	Project initiatives, meeting behavior, etc.	Attitudes when others are speaking at the meeting, etc.	Remarks at meetings and team activities, etc.	Reporting, Communication and Consultation at meetings and team activities, etc.



(1) Reflection on myself **(2) Time management**
(3) Responsibility **(4) Ability to Listen closely**
(5) Transmission power **(6) Skills of Reporting, Communication and Consultation**

Figure 4. A self-assessment results before and after the PBL.



(1) Reflection on myself **(2) Time management**
(3) Responsibility **(4) Ability to Listen closely**
(5) Transmission power **(6) Skills of Reporting, Communication and Consultation**

Figure 5. Self and Mutual assessment and assessment by teacher after PBL.

CONCLUSION

National Institute of Technology, Sendai College Hirose Campus has been conducting a General Skills (GSs) survey using external standardized tests since 2014. The results showed that our students' skills related to teamwork, planning, and practice were inferior to the average of university students and needed to be strengthened. Therefore, from 2020, as one of the experimental subjects for the forth-year students, we arranged a cross-course PBL program in which students with different specialties are grouped together to solve practical problems and try to improve their skills in team activities, planning, and practice. While it was clear that students were improving their self-assessment skills through the cross-course-typed PBL classes in 2020, the results of taking the GSs standardized tests were also evident and will be reported. The results of the GSs standardized tests were also revealed, although it was clear that the students had improved their skills in self-assessment through the cross-course-typed PBL classes. The results of the standardized test comparison also showed significant improvement in the skills of team management, planning solutions and self-control after the cross-course-typed PBL.

In addition, self-assessment before and after the cross-course-typed PBL class were conducted again in 2021, and as in the previous year, improvements in all the targeted skills were observed, and peer assessment and teacher assessment were generally similar to the self-assessment. In the future, we will continue to conduct standardized tests and self-assessments while we correlate and analyze the data to improve students' skills, and utilize the results to improve the cross-course-typed PBL classes.

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REFERENCES

Yajima, K et al. (2020). A Report of Cross-course-typed Pbl And Students' Self-assessment, *In Proceedings of the 17th CDIO International Conference* (CDIO2021), 236-246.

Kawaijuku Group (2021). About Progress Report on Generic Skills (in Japanese):

https://pickandmix.co.jp/prog/

Kawasaki, K. et al. (2020). A Survey of The Progress of Students' Generic Skills, *In Proceedings of the 16th CDIO International Conference* (CDIO2020), 160-169.

David Boud.,(1995). Enhancing Learning Through Self Assessment, *Routledge Falmer*.

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