A REPORT OF CROSS-COURSE-TYPED PBL AND STUDENTS' SELF-ASSESSMENT

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ABSTRACT

National Institute of Technology, Sendai College, Hirose Campus has been conducting surveys on students' generic skills (GSs) through the standardized tests in Japan since 2014. The educational effect of our curriculum is confirmed by analyzing the survey results and by comparing our students' average scores with those of university students. From the results of this continuous survey, while it became clear that our campus curriculum was effective in helping students grow in both Literacy and Competency skills, it was also revealed that some Competency skills were not fully / could be further developed. Based on the survey results, we are trying to improve our curriculum and lessons focusing on students' skills that have not yet grown sufficiently. As an example of the improvements, we reorganized the classes of experimental practices and a cross-course-typed PBL was offered as an experimental subject for 4th-year students. By grouping students from different specialities and having them solve practical problems in groups, we tried to improve the students' skills of team activities, planning, and implementing. From social issues defined in the SDGs and issues related to COVID-19, various themes were selected, and the students seriously worked on them in PBL. In this paper, we will introduce practical attempts of the PBL to develop student's GSs.

KEYWORDS

Personal Skills, Interpersonal Skills, Project-Based-Learning, Evaluation of Generic Skills, Standards: 5, 7, 8, 11

BACKGROUND

In engineering education, it is important not only to help students acquire specialized knowledge and skills but also to cultivate their generic skills (GSs) to utilize the acquired knowledge and skills in the real world. CDIO Syllabus 2.0 also emphasizes the importance of GSs by defining "Personal and Professional Skills and Attributes" and "Interpersonal Skills: Teamwork and Communication." Hence, many educational institutions around the world are promoting students' GS development by introducing active learning (AL) and problem / problem-based learning (PBL).

National Institute of Technology, Sendai College (Sendai KOSEN) proposed an A^3 learning system to develop students' GSs in 2014 and carried out a large-scale reorganization of the curriculum into the one that incorporated many techniques of AL and PBL. While the curriculum was reorganized, the evaluation of students' GSs was conducted by an objective method, and the educational effect of the changes in educational methods has been continuously surveyed. In 2018, the survey from students' admission to graduation was completed, and the GS growth

characteristics of our students were clarified. Kawasaki et al reported at the 16th CDIO International Conference (CDIO 2020) that the GSs of Sendai KOSEN students grew steadily as their year progressed. On the other hand, a detailed analysis revealed that some skills did not improve, and Yajima et al will report the results and propose some measures to improve those skills at IEEE global engineering education conference (EDUCON 2021).
We aimed to realize more effective GS development by improving the curriculum and educational contents based on the results of the continuous survey and started some attempts in 2019. As an example of improvement, in this paper, we will give a practical report on "cross-course-typed PBL (course-integrated PBL: CI-PBL)" to develop skills to be strengthened. This study is based on an annual GS continuation survey, but students have not taken the PROG test at the end of the PBL project. Therefore, in order to confirm the students' feelings of growth, self-evaluation of the students was conducted before and after the project. Although the student's self-assessment showed sufficient growth, we further plan to analyze the effect of the PBL by using the results of the PROG test in the future because the self-assessment is not considered to be absolutely reliable as the indicator of students' progress.

GENERIC SKILLS GROWTH CHARACTERISTICS OF STUDENTS AT SENDI KOSEN, HROSE CAMPUS

At our school, Progress Report on Generic Skills (PROG), which is a standardized test in Japan (Kawaijuku Group, 2020), has been used to evaluate students' GSs. The reason for adopting PROG is that it is an objective test and is widely used in higher education institutions in Japan. GSs are difficult to evaluate objectively and different evaluators can give different evaluations. By using PROG, we can avoid such subjective evaluations. Furthermore, there is a great advantage that we can compare our students' scores with the average scores of university students who took the same test. From the results of the continuous survey, it became clear that our students' GSs develop steadily as the year progresses. However, on the other hand, the comparison with the average value of university students revealed that some skills in the Competency part need to be further strengthened and developed.
Figure 1 shows the scores of 1st-year students (blue) and those of 5th-year students (red), who enrolled in 2014, in the main 3 categories and medium 9 contents in the Competency part. Here, the differences (red score minus blue score) is the growth score at our school. Also, as reference data, the average value of university students in 2018 is shown in black. As is clear from Fig. 1, in the main categories, our students' "(3) Problem-solving skills" did not grow, and the score of the 5th-year students was lower than the average score of the university students. Also, although "(1) Teamwork skills" improved, the score of the 5th-year students was also slightly below the average of university students. Among the medium contents, "(3-2) Planning solutions" and "(3-3) Implementing solutions" were the skills that need to be strengthened in the future since no growth was seen or the growth was small and lower than the average value of university students. For "(1-1) Relating with others", "(1-2) Cooperating with others", "(1-3) Team management" and "(2-3) Behavior control", growth was observed. However, the scores were measured equal to or lower than the average value of university students. Therefore, we consider that these skills can be further improved. These results make it clear that our students' skills related to team activities, planning, and implementing must be strengthened.

REORGANIZATION OF EXPERIMENTAL PRACTICES

We are making many efforts such as lesson improvement to develop the skills related to team activities, planning, and implementing, our students' weaknesses revealed in the survey. As the biggest attempt, we have reorganized the contents of the experimental practices, and we

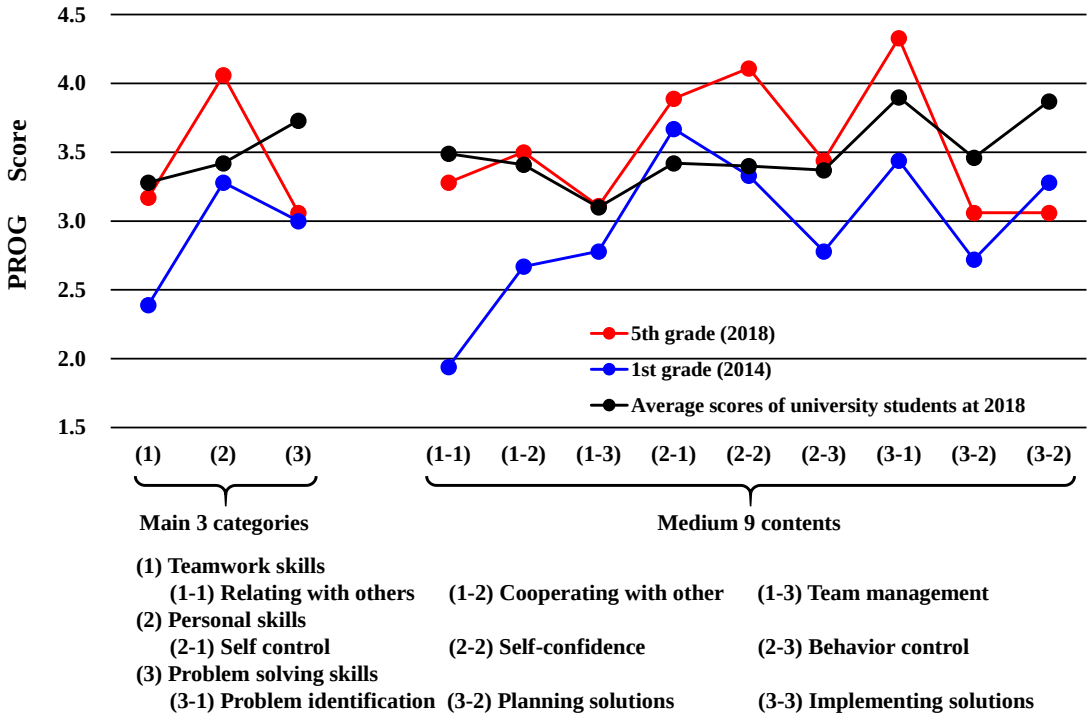


Figure 1. PROG scores of the detailed elements of Competency part.

will introduce the outline in this paper. The skills to be developed in the experimental practices before the improvement are shown as follows,

1st and 2nd years: acquisition of engineering literacy (how to write the reports and read the literature), elementary experimental techniques, presentation skills and elementary skills of collaboration.

3rd and 4th years: acquisition of advanced engineering literacy, and middle- and high-levelled experimental techniques, and skills of group activity.

5th year: comprehensive and practical problem-solving skills through graduation research (Project Based Learning).

Students were supposed to acquire the necessary skills gradually as the year progresses. The composition was strongly conscious of team activities, planning and implementing, however, it became clear from the continuous survey that these skills had to be further strengthened. Therefore, we reorganized the experimental subjects for the 3rd and 4th years. In the experiment of the 3rd-year students before the change, it was an “instruction type” in which the students conduct the experiment planned and scheduled by the teachers. This "instruction type" experiment was replaced by a “students design and implementation type” in which the students themselves make an implementation plan with the group members and manage the schedule. By changing to the "students design and implementation type", discussions, consultations and reflections within the group became active, and the students were able to be strongly aware of planning and progress management. In the self-assessment using the rubric of the 4-step evaluation before and after the experiment, almost all of the students felt that they were able to improve their skills such as independence, responsibility, teamwork, and self-management by one step or more. Yajima et al plan to report specific improvement methods and evaluation results at EDUCON 2021 regarding the experimental improvement performed in the 3rd year.

Further development of the improvement of the 3rd-year experiment was carried out, and in 2020, a CI-PBL was offered in the 4th-year experiment. Students engage in more practical team activities by being grouped regardless of their course and conduct large-scale PBL for learning project management. In this paper, we report the implementation contents of CI-PBL and the results of self-evaluation of each skill of the students before and after PBL.

COURSE-INTEGRATED PBL

Sendai KOSEN is a five-year technical college where students aged from 16 to 20 study engineering. The Hirose Campus has three courses: Information Systems Course (Software), Information and Telecommunication Systems Course (Communication / Computer-Network), and Intelligent and Electronics Systems Course (Hardware / Electronic Devices). As one of the experimental subjects in the 4th year, CI-PBL was placed. CI-PLB is a compulsory subject and will be taken by all (about 120) students every year. Its format is 180 minutes (2 classes) per week for 15 weeks, and students get 2 credits. The students are divided into 24 groups regardless of their courses, and one support faculty member belongs to each group. This subject aims to improve selectively and efficiently the skills related to team activities, planning, and implementing by forming groups with students from different specialities and working on large-scale PBL. The theme of this year's PBL is "solving problems in the community and our school, or creating something useful and interesting". Furthermore, when setting tasks, conditions such as "making someone outside the group happy" and "making sure that some kind of challenges for the group is included" are imposed.
The schedule for CI-PBL is shown in Table 1. The first week is guidance (explanation of the purpose, goals to be achieved, evaluation method, schedule, and so on) and creating projects by individual students using the brainstorming method. A workshop on how to determine the theme of team activities (projects) by an expert is held in the second week. The third week is a workshop on project management and how to use a Work Breakdown Structure (WBS) and a Gantt chart. Every group prepares a WBS and Gantt chart in the 4th to 5th weeks, and a theme and project presentation by each group was held in the 6th week. In the 7th-11th weeks, they implemented their projects, and in the 12th week, a contest-styled outcome presentation was held. In the 13th to 14th weeks, they summarized and reviewed the entire project and made their final report. In the final week, all students will have a personal interview with the teachers.

At first, CI-PBL was planned to be conducted in a face-to-face class. However, due to the influence of the novel coronavirus (COVID-19) in 2020, implementation in a face-to-face should be avoided as much as possible. Fortunately, the National Institute of Technology, to which our school belongs, has a comprehensive license agreement with Microsoft, and every teacher and student has an MS365 account. Therefore, by utilizing Teams' online meeting function and team collaboration software "Miro", we managed to hold CI-PBL in online format up to the 6th week, which were a workshop, presentation and so on. The project was conducted face-to-face, while taking sufficient countermeasures against infectious diseases, such as putting as small a number of students in a classroom as possible. As a result, we were able to carry out the originally planned content on schedule without degrading the lesson quality.
Next, the themes of each groups' project are shown in Table 2. The themes ranged from projects dealing with social issues such as COVID-19, environmental issues, and drunk driving prevention to projects aiming to publicize our school or improving convenience. As an example of the project deliverables, the group 4’s project "Development of a monitoring system for the congestion status of our school cafeteria", which won the award for excellence in the contest, is described.

Table 1. Schedule of Course-Integrated PBL

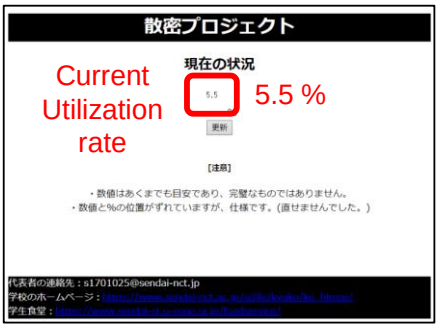
Week	Contents	Method, etc	Submissions
1	Guidance (explanation of the purpose, goals to be achieved, evaluation method, schedule, and so on) and creating projects by individual students using the brainstorming method	Online meeting, Individual work	
2	Workshop on how to determine the theme of team activities (projects) by experts	Online meeting	
3	Workshop on project management and how to use a Work Breakdown Structure (WBS) and a Gantt chart	Online meeting	
4	Decide the project theme and create WBS and Gantt chart	Online meeting, Team activities	Personal daily report, Team activity report, Self-assessment sheet
5	Create WBS and Gantt chart and prepare for the interim report meeting	Online meeting, Team activities	Personal daily report, Team activity report
6	Interim report meeting	Online meeting, Team activities	Personal daily report, Team activity report
7	Execution of the project	Face-to-face, team activities	Personal daily report, Team activity report
8			
9			
10			
11			
12	Achievements report meeting and Contest	Online, report video	Personal daily report, Team activity report, Voting card for a good project
13	Project summary and report preparation	Face-to-face, team activities	Personal daily report, Team activity report, Project report, Mutual-assessment sheet
14			
15	Personal interviews by teachers	Face-to-face, interviews	

Table 2. List of themes of each group.

Group No.	Theme of PBL
1	Development of a time card using a QR code for attendance confirmation
2	Development of remote shooting system in refrigerator using Raspberry Pi
3	Development of a system that provides precautions when using an online system
4	Development of a monitoring system for the congestion status of our school cafeteria
5	Creating video content for our school PR
6	A project for ON / OFF automation of ceiling light
7	Development of Web application for tourists
8	A project to introduce our school through KARUTA
9	A project to make an easy-to-wash grater
10	Creation of our school introduction pamphlet
11	Project on improving the usage environment of personal computers
12	Creating an easy-to-understand school map
13	Development of smart disinfection system using human movement detection technology
14	School facility maintenance project that meets local demands and ecology
15	A project for visualization of classroom' environment
16	Manufacture of inexpensive and effective filters
17	Creating a school life guidebook for international students
18	Creating a pamphlet that conveys the attractions and dangers around our school and Ayashi Station
19	Creating a grasping system of submissions
20	A project for drunk driving prevention
21	Making tableware that is kind to the environment
22	Development of self-adjusting whip mixer
23	Creation of cards (KARUTA) with infectious disease countermeasures
24	Awareness campaign to inform the danger of drunk driving

(a)

(b)



(c)

Figure 2. Overview of the created System of Group 4.

WBS : Work Breakdown Structure

content : Creating a Web system that shows the congestion status of the cafeteria

Achievement : Avoidance of congestion in the cafeteria

1.Preparation
- 1.1 Create a website
  - 1.1.1 Programing the contents of the site by html
  - 1.1.2 Specification of layout by css
  - 1.1.3 Addition action by Java script
- 1.2 Production
  - 1.2.1 Selection of equipment
  - 1.2.2 System design
  - 1.2.3 Design of fixing jig
  - 1.2.4 Debug
- 1.3 Negotiation
  - 1.3.1 Proposal to the clerk(cafeteria)
- 1.4 Announcement
  - 1.4.1 Creating a poster

2. Implementation
- 2.1 Installation of Web camera
- 2.2 Opening a Web site by XFREE
- 2.3 Notification of poster

3. Presentation
- 3.1 Preparation of presentation materials
- 3.2 Presentation at the achievement briefing

4. Finishing
- 4.1 Tidying-up
- 4.2 Meeting of reflection

Figure 3. Work Breakdown Structure of Group 4.

To prevent COVID-19 infection, Group 4 developed a system that manages the number of people using the school cafeteria by posting the congestion status of the cafeteria on the website in advance. Figure 2 shows an overview of the created system. First, the inside of the cafeteria is photographed with a Web camera (a), and the number of users is counted using image processing technology (b). Next, the congestion status is calculated by dividing the counted number of users by the number of seats. By posting the calculated school cafeteria utilization rate on the website (c), anyone can know the congestion status of the cafeteria at any time. COVID-19 infections can be reduced by users in the school cafeteria checking congestion with this system and avoiding congestion. Next, Fig. 3 and Fig. 4 show the created WBS and Gantt charts for executing the project. Throughout the project, the students seemed to have acquired skills in team activities, planning, and implementing.

SELF-ASSESSMENT OF GENERIC SKILLS BEFORE AND AFTER CI-PBL

The CI-PBL is a subject aimed at strengthening the skills in team activities, planning and implementing which our students need to develop. Since the GS survey using the PROG is an

annual survey, it is not possible to measure immediately before or after this PBL. Therefore, as a skill for the success of the project as a team, we conducted self-evaluation of students before and after PBL on six elements related to independence and collaboration. The six elements of self-assessment are specifically "reflection on myself", "time management", "responsibility", "abilities to listen closely", "transmission power", and "skills of report, contact and consultation". Furthermore, after PBL, mutual assessments by the members in the same group and assessments by faculty members were also conducted, and these assessment results are described below.

Table 3 shows the rubrics used for the assessments. The six skills of independence and collaboration were assessed by defining 1 to 4 criteria in the rubric. Figure 5 shows the self-assessment results before and after the PBL. The results are expressed by using the average score of all students. It is apparent from Figure 5 that the self-assessment scores after PBL is 1.0 point or higher than those before PBL in all elements. It can be seen that students felt a big growth subjectively through the CI-PBL. Next, Figure 6 shows the results of the assessment of themselves, mutual assessment by group members and assessment by teachers after PBL.

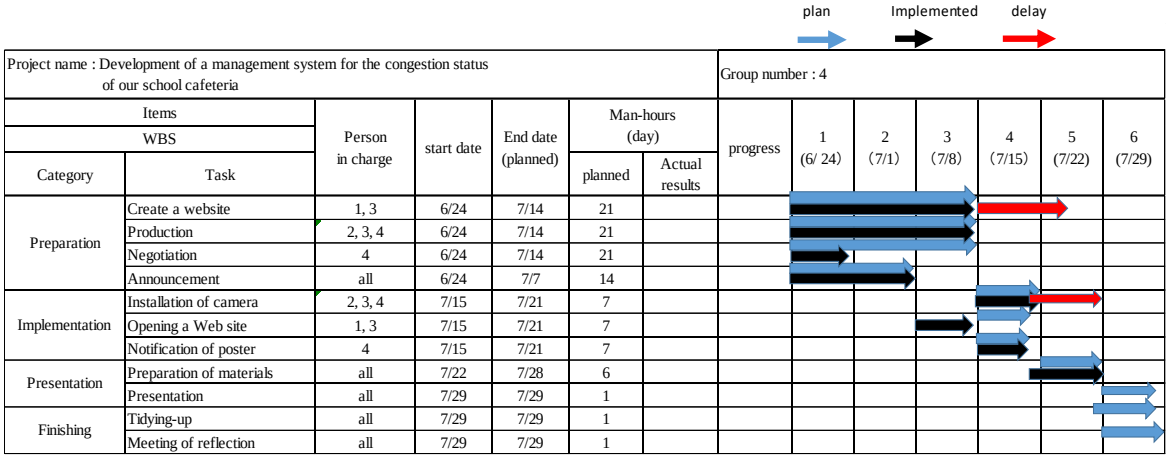
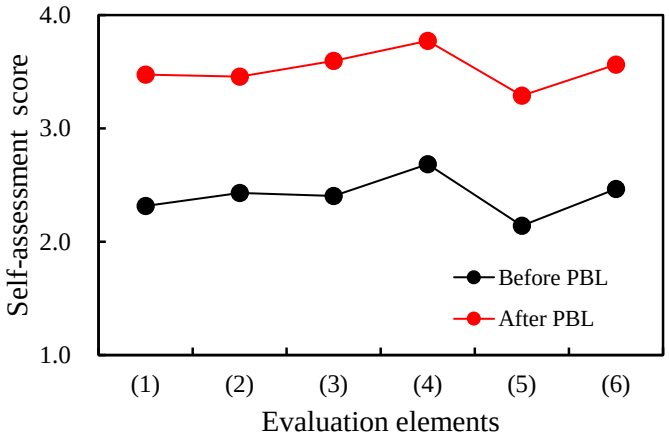


Figure 4. Gantt Chart of Group 4.

Table 3. Rubric for personal evaluation.

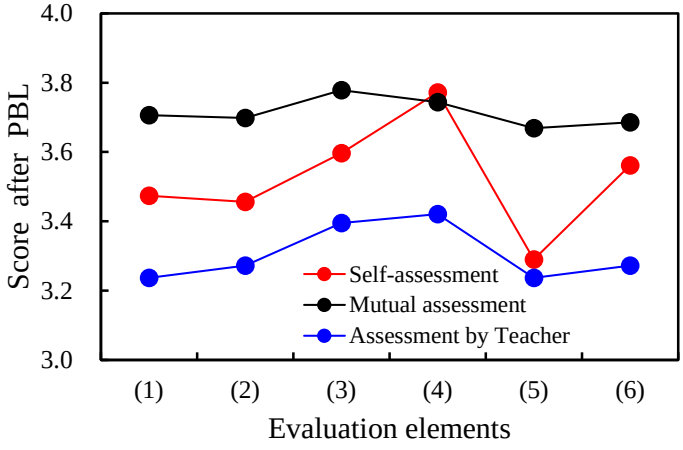
Levels	Skills to make a team project successful					
	Independence			Cooperativeness		
	(1) Reflection on myself	(2) Time management	(3) Responsibility	(4) Ability to Listen closely	(5) Transmission power	(6) Skills of Reporting, Communication and Consultation
4 (Exceeding Standard)	Student can make 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 5. Self-assessment results before and after PBL.

From Fig. 6, it is measured that the score of mutual assessment is the highest, followed by the self-assessment, and the teacher's assessment is the lowest. It is considered that the Japanese temperament, which is considerate towards each other, is observed in the result that the mutual evaluation among students is the highest. As for the result that student self-assessment was observed higher than that of teachers, similar results have been observed in



(1) Reflection on myself **(2) Time management**
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(5) Transmission power **(6) Skills of Reporting, Communication and Consultation**

Figure 6. Self and Mutual assessmentand assessment by teacher after PBL.

another survey. Another survey of our students' GSs, reported by Wako et al, found that the scores tended to increase in the order of "direct evaluation by teachers", "objective evaluation by standardized test (PROG)", and "subjective evaluation by students themselves". In the case of this survey as well, therefore, a true score may be between the student's self-assessment and the teachers' assessment. Hence, in the 6 evaluation items, the scores were located between 3.2 and 3.8 on a 4-point scale, and it is considered that the CI-PBL was able to sufficiently promote the growth of the targeted skills. These results on independence and cooperation are planned to be analyzed for the correlation of the results of the upcoming PROG test this year. Furthermore, the skills related to implementing, which have not been evaluated in this study will be planned to be evaluated using PROG results in the same way. The results of detailed analysis using the PROG survey will be reported in the near future, including the correlation with student self-assessment.

CONCLUSION

Since 2014, Sendai KOSEN, Hirose Campus has been conducting surveys on students' GSs through standardised tests in Japan. The educational effect of our campus is measured by analyzing the survey results and comparing them with the average scores of university students. While through the campus curriculum the students grew in both Literacy and Competency overall, they failed to develop in some elements of Competency sufficiently.
Curriculum and lesson improvements are being made to improve students' skills in our campus. As an example of the improvements, we reorganized the subjects of experimental practices and a cross-course-typed PBL was offered as an experimental subject for 4th-year students. By grouping students from different specialities and having them work on practical problems, we tried to improve the students' skills of team activities, planning, and implementing. From social issues defined in the SDGs and issues related to COVID-19, various themes were selected, and the students seriously and happily worked on them in the PBL class. It became clear from the results of self-assessment that the students felt their growth through the experience.
There were variations in the degree of support and facilitation of the teachers in charge of each group, and there were also large variations in the evaluation by the teachers, so in the future we intend to share the degree of support and evaluation criteria thoroughly. Also, we plan to analyze the correlation with the results of the standardized test, which is planned in the near future, and to utilize it for improving the CI-PBL.

ACKNOWLEDGMENT

In the CI-PBL, one faculty member is assigned to each group, so 24 faculty members cooperated in implementing PBL. We would like to express our heartfelt gratitude not only for the class hours but also for the many efforts they have made, such as attending the project management workshop in advance and providing overtime lectures. Furthermore, the continuous survey is supported by Japan's Ministry of Education, Culture, Sports, Science and Technology's program for accelerating university education. We thank all the faculty members, including the President of the National Institute of Technology, Sendai College for contributing to the improvement of education.

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