

An Examination of the Effects of Group Learning on Knowledge Engineering to Conceive of a Study Support System

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Abstract

The purpose of the practice described in this paper was to create peer assessment and review through group learning and to deepen our understanding of intelligent Computer Assisted Instruction (CAI), which is the last study contents of knowledge engineering. First, in order to give a solid knowledge, a lecture based on conventional knowledge transfer was carried out in the first six weeks of a class. The system that best supports the learning of a subject was considered through group learning in the second six weeks. First, the contents, functions, etc., of a study support system were discussed through brainstorming. Students wrote their ideas on sticky notes and stuck them on simili paper. They arranged the sticky notes on the paper according to the types of items in the system. Then, they created a slide about the conceived system. Last, they carried out a presentation to share their knowledge with other groups using the slide.

Analyzing questionnaires revealed the following: Understanding of content was deepened by group learning, and feeling changed so that group activities might be performed very enthusiastically; students came to believe that undertaking a series of activities developed their skills in solving a problem. The activities that were useful for improvement of consciousness became clear; 23 groups were classified into four characteristic clusters.

1. Introduction

It is important not only for students to be taught knowledge, but also for them to be able to think about it with their heads, to create knowledge themselves, and to get to know the pleasure of learning. This allows students to understand and search for information using their heads and hearts, and experience the excitement of study [6], [7]. To deepen thought and build knowledge as an experience, it is said that an emotionally stirring experience is important [11].

It is said that repeating the experience such that students compare opinions with others and analyze these opinions by discussing them with several other learners is important. Adachi et al. practiced a group activity in a comprehensive task and exercise according to groupware [1]. They reported that two factors allow students to understand opinions and

grasp work, and to manifest opinions and execute work in evaluations of group activities. Kaneda et al. performed group learning in robot-building and reported that an understanding of importance of the cooperative work and communication, and the difficulty of creating an organization could be accomplished [4]. Nishino et al. practiced information education through group learning, and reported that the group with a higher evaluation of a product had a more cooperative or exogenous attitude [8]. Nishinosono is developing guidance that asks students to conceive of an ideal school to teach “instructional methods and technology” through learning in teams for knowledge creation, in order to train teachers who can solve problems and create knowledge through their own initiative [9], [10]. These trials are not meant to carry out group learning by covering content that is difficult to understand in courses. A part of a course is not cut in order to carry out the trials by group learning. Activities that are most useful for improving the attitude of group learning have not yet been clarified.

It is thought that group learning creates a point of contact for peers' views and remarks, provides a multilateral standpoint, and deepens understanding [12]. Furthermore, group learning creates ideas for intellectual functioning [2], [3], [5]. Therefore, the author considers improving knowledge engineering through group learning. A conventional knowledge transfer-type lecture was carried out for the first six weeks. A solid knowledge base was provided, and a class to make students conceive of a study support system through group learning was designed for the second six weeks. Students were required to share their investigations, discuss a study support system to assist learning, and conceive of this system. Students wrote their ideas on sticky notes. The sticky notes were stuck on simili paper and arranged according to the contents of the system. Each group explained their conceived system to other groups using the simili paper. The other groups assessed each system. Each group was required to create a PowerPoint slide on the basis of the evaluation. Each group carried out a presentation about the contents of what they conceived to share their knowledge.

After practicing this group learning, the author analyzed questionnaires used to evaluate the activities. The author reports on changes in skills and the activities that were useful for these changes. Groups are classified into the characteristic clusters.

2. Instructional Design and Method

2.1. Lesson plans

The course studied is Knowledge Engineering, an elective subject in the second term for second-grade students in the department of information science at university "A." The course was carried out as shown in Table 1. A 90-minute lesson was delivered 14 times in 14 weeks. However, the lesson was extended for about 30 minutes for presentations in the thirteenth week. Conventional face-to-face lessons were carried out through projecting slides on the screen until the sixth week. The midterm examination was carried out in the seventh week. In the eighth week, an outside lecturer gave an academic lecture about the current situation of study support systems for processing knowledge.

The ninth to fourteenth weeks were the period during which the study support systems were conceived through group learning. The theme of this paper was developed during this period. A report was submitted in the fourteenth week. The final examination was carried out in the fifteenth week. One teacher performed both lectures and group learning. Meanwhile, the presentation time for each group is 10 minutes, including questions in the thirteenth week. With 23 groups, this means there were 230 minutes of presentations in total. This is equivalent to about 2.6 times the course time, so the

Table 1. Lesson plans

No	Lesson contents	Activities, discussion contents and so on
1	About Knowledge Engineering	Lecture, fill in structured notebook
2	Knowledge representation	"
3	Knowledge base	"
4	CAI	"
5	Intelligent CAI	"
6	Case of intelligent CAI	"
7	Midterm examination	
8	Academic lecture about the current situation on the study support system	
9	1. Discussion	Deciding title, collecting information and discussing contents for study support system
10	2. Discussion	Discussing contents for study support system
11	3. Explanation by simili paper	Explaining by simili paper and discussing the contents
12	4. Creation of slides	Creating and correcting slides
13	5. Presentation	Presenting using slides
14	6. Writing of report	Writing report
15	Final examination	

groups were divided into two classrooms. Since the presentations were made in the two classrooms to save, three students assisted as chairperson and timekeepers.

2.2. Purposes of this lesson

The purposes of this course, which was carried out from the ninth to the fourteenth week were as follows: (1) the content of the lectures in the first half of the course is supplemented, "conceiving of a study support system" through group learning; (2) groupthink was fostered by causing interaction

among students; (3) knowledge is created by solving problems.

2.3. Instructional method

Ninety-two students were enrolled in the course. Each group consisted of four students. Twenty-three groups worked on the lesson. During group learning, the teacher moved around the classroom appropriately. Then, he asked questions and gave instructions so as not to become a bystander. Students were required to contribute some ideas to the system conceived by the group. Communication was spread throughout the groups, and their ideas were expressed in the group. The teacher told students that they could respect, compare, develop, extend, and raise each peer's opinions in order to enable them to conceive of their system.

The last six weeks of the course are referred to as the first to sixth sessions in the following. A flow diagram of the group learning activities is shown in Figure 1. An idea is added and written on a sticky note during the first and second sessions. The contents conceived at the end of the second session are summarized on the simili paper. Until the second session, divergent thinking is given priority so that as many ideas as possible are proposed. The contents are summarized in the end phase. The system is explained using the simili paper in the third session. Then, mutual evaluation is carried out. The contents are modified and summarized through convergence thinking by referring to the evaluations. Slides about the contents are created in the computer room in the fourth session. Presentations are carried out in front of the whole class in the fifth session, to share information about the proposed study support system. Students copy a report framework document file to put an explanation and a table for each item from the folder on the server. They are required to describe what was required for each item. The report is divided into items that were written in collaboration with students in the group and those that were written privately. It is written in the sixth session. It must be submitted by the fifteenth week.

Twelve kinds of evaluation sheets were created and distributed appropriately. Both own-group evaluation and peer-group evaluation were carried out. In order to understand the situation of discussions in each group, a sheet of "records of group discussions" was distributed in each session. In order to understand the change of consciousness through group learning and discussion, a sheet called "personal record for discussions" was distributed to each student. These were submitted at the end of each session.

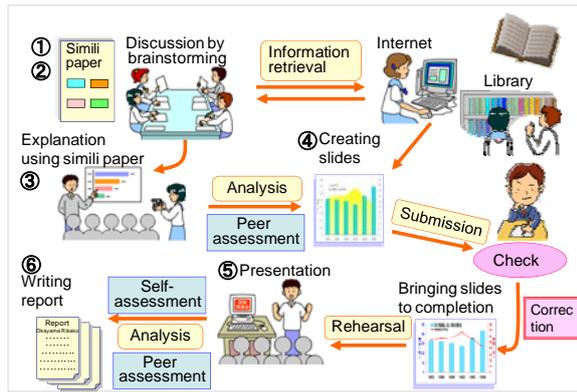


Figure 1. Flow diagram of group learning activities

3. Analysis of Findings and Discussion

Five kinds of educational information were analyzed in order to understand the learning effects gained by the group learning described in Chapter 2. Changes to the “personal record of discussions” in the six sessions will be analyzed. The relationship of these changes to the number of sticky notes on a group’s simili paper and rating value is investigated. Twenty-three groups were classified into four clusters based on contents of simili paper and evaluations to understand the characteristics of the groups. The change of the consciousness is found by analyzing the degree of consciousness related to the skills of 29 items from the first, third, and fifth sessions. The relationship between consciousness and activity is analyzed to understand which activities are useful for the improvement of consciousness.

The signs ***, **, and * mean that significant differences are recognized at the significance level 0.1, 1, and 5%, respectively. The sign “+” means that a significant difference tendency is recognized at the significance level of 10%. The significant difference will be judged at the 5% significance level.

3.1 Change in the personal record of discussions

Students wrote in their “personal record of discussions” each session, and submitted it at the end of session. There were 16 items in total. Items (1)–(14) shown in Table 2 were rated in five rating values. The five rating values were 5, positive; 4, slightly positive; 3, neither positive nor negative; 2, slightly negative; and 1, negative. Item (15) asked about learning hours outside of the lesson, and item (16) was space for free description. The teacher let students look back on their activities and estimate their endeavors using this survey.

An analysis of variance in one-way layout that corresponds according to items was carried out for data of 58 common presenters in the first to fifth sessions for an average rating scale values of items

(1)–(14). The result is shown in Table 2, where M, SD, and MSe in are an average, a standard deviation, and the mean square of an error respectively. The multiple comparisons were carried out using the least significant difference (LSD) method. The results of the rating scale values of the second to fifth sessions over the first session are displayed in columns 1-2 to 1-5.

The results of the analysis of variance show that the items with a significant difference increase as time increases for the first session. Searching the contents decided on in the group and giving an explanation on simili paper heightened comprehension and motivation. Increasing comprehension means that discussions progressed and thoughts were summarized easily. As a result, it is thought that evaluation became higher, especially in the third session.

Based on results of an analysis of variance, items (1)–(14) are considered in the following.

The rating scale values in the third session and the fifth session became high regarding items (9) “Do you conceive of the study support system outside classes?,” (10) “Do you examine the study support system outside classes?,” and (7) “Are there adequate materials used for discussions?” Since preparation for presentation was required, it is thought that this raised the rating value.

The rating values of item (4) “Is what you should do clear?” gradually rose through the fifth session. The rating values of (5) “Did discussions progress premeditatively?” went up suddenly at the second session, and the value was maintained after that.

Table 2. Change in the rating scale value of the personal record of discussions and result of analysis of variance

Item	First		Second		Third		Fourth		Fifth		Analysis of variance		Multiple comparisons					
	m	SD	m	SD	m	SD	m	SD	m	SD	MS	F-ratio	1-2	1-3	1-4	1-5		
(1) Did you work on the class with interest?	3.1	0.8	3.5	0.8	3.5	0.8	3.5	0.8	3.7	0.9	0.7	6.1	***	***	***	***	***	
(2) Did you work on the class eagerly?	3.2	0.8	3.9	0.8	3.8	0.7	3.8	0.7	3.8	0.8	0.3	8.7	***	***	***	***	***	
(3) Was the class fun?	2.9	0.9	3.5	0.9	3.4	0.8	3.4	0.8	3.5	1.0	0.6	7.6	***	***	***	***	***	
(4) Is what you should do clear?	3.0	1.1	3.3	0.8	3.6	0.9	3.9	0.9	4.0	0.7	0.8	17.1	*	***	***	***	***	
(5) Did discussions progress premeditatively?	2.8	0.9	3.6	0.9	3.6	0.8	3.5	0.9	3.7	0.9	0.5	10.6	***	***	***	***	***	
(6) Could you do what you wanted to do?	3.1	0.7	3.4	0.7	3.4	0.8	3.3	0.8	3.4	0.9	0.4	3.5	***	***	***	***	***	
(7) Are there adequate materials used for discussions?	2.8	1.1	3.2	1.0	3.5	0.8	3.2	0.9	3.5	0.9	0.7	7.0	*	***	***	***	***	
(8) Are you confident about conceiving of the system to understand well?	2.6	0.8	3.0	0.9	3.3	0.8	3.3	0.8	3.3	0.9	0.7	7.0	*	***	***	***	***	
(9) Do you conceive of the study support system outside of class?	2.7	0.9	2.8	0.8	3.5	0.9	3.4	0.9	3.9	0.8	0.5	27.3	*	***	***	***	***	
(10) Do you examine about the study support system outside of class?	2.7	1.1	2.9	0.8	3.3	0.9	3.4	0.9	3.9	0.9	0.6	16.6	*	***	***	***	***	
(11) Is what you should do in the following session clear?	3.2	1.1	3.5	0.8	3.5	0.9	3.9	0.9	3.7	0.8	0.7	6.6	+	*	***	***	***	
(12) Are discussions useful for summarizing thoughts?	3.3	1.0	3.8	0.8	3.7	0.8	3.7	0.9	3.9	0.8	0.5	7.5	***	***	***	***	***	
(13) Are words or advice from the teacher helpful?	3.2	1.0	3.3	0.9	3.3	0.8	3.4	0.9	3.5	1.0	0.5	3.0					*	
(14) Do you look forward to telling peers about your system?	2.9	0.8	2.7	0.9	3.1	0.8	3.1	0.8	3.2	1.0	0.5	4.5	*	+	***	***	***	
Average rating value	3.0	0.2	3.3	0.3	3.5	0.2	3.5	0.2	3.6	0.3								

*** p<.001, ** p<.01, * p<.05, + p<.1

These show that group learning progressed rather smoothly.

The rating values of items (8) “Are you confident about conceiving a system that will be well understood?,” (2) “Did you work on the class eagerly?,” (1) “Did you work on the class with interest?,” (12) “Are discussions useful for summarizing thoughts?,” (3) “Was the class fun?,” and (6) “Could you do what you wanted to do?” went up suddenly at the second session, and the

value was maintained after that. This means that the interest, volition, pleasure, and usefulness were maintainable after a group decided on the contents of its system.

The rating values of items (11) “Is what you should do at the following session clear?” and (14) “Do you look forward to telling your peers about your system?” rose gradually. The contents of the systems became clear as the students worked, and their comprehension was deepened slowly. It follows that the fun of explaining their systems to their peers increased.

While the teacher went around the classroom, he asked each group about its degree of progress and heard the contents currently discussed. The opportunity for the teacher to advise was basically the same from the first to the fourth session. In the fifth session, students’ questions were given priority, and after these questions were answered, the teacher asked one more question during the discussion time for each presentation. Since the rating values of item (13) “Are words or advice from the teacher helpful?” did not change significantly until the fourth session, this means that the words and advice from the teacher essentially had the same degree of utility. However, since significant differences were recognized at a 5% significance level in the fifth session, words or advice from the teacher seemed to be helpful to some degree. In group learning, the role of teachers is to arrange circumstances so that students can work smoothly. It took only a very short time to address each group in one lesson. Since items (1), (2), (3), (4), (5), and (11) rose quite high, it is thought that group learning was performed smoothly. The average rating value of item (13) rose from 3.2 to 3.5. These facts show that the role of the teacher was almost achieved.

The responses to item (15) “time required to conceive of study support systems” for the first to fifth sessions are shown in Table 3. The time asked about is of the following three kinds. As to the study support systems, ① conceived time, ② investigated time, and ③ working time taken to carry out the assignment from the last session to today. The sum total was 23.2 hours. It turns out that the time required for each of these activities increased gradually. In particular, it increased rapidly at the fifth session by about 12 hours. It is thought that the students used the time to discuss their presentation in the fifth session, to summarize the contents, to create slides, and to practice the presentation.

The correlation between the time spent and the rating value of each item from (1)–(14) is not so strong. Items (1)–(14) are not so relevant to individual learning time or investigation time. This result shows that student consciousness is not related to spent time.

At the beginning of the class, the students did not understand what kind of preparation they should do or with what kind of attitude they should address the group learning. However, it is thought that they deepened their comprehension of study support systems as group learning progressed. Their consciousness changed so that they might perform group activities very enthusiastically.

Reflection is useful so that spiritual awakening and learning from some activities can be used in following activities and daily life. Students learn from an experience through thinking about the meaning of the activity. The personal records of discussions make such reflections conscious.

When members of a group propose an opinion and share it, it becomes the learning not only of an individual but also of the group. This creates a range of consciousness and learning spreads. This triggers so that students consider their actions as members of a group and change what they have learned. When they learn from involvement with peers and share ideas with peers, the range of learning spreads. Their perspective widens as they exchange opinions.

Table 3. Average time required (minutes)

Required time	1	2	3	4	5	Sum
Conceived time	19.4	50.0	98.5	78.4	253.0	499.3
Investigated time	13.4	43.9	67.6	61.7	151.0	337.6
Working time	11.1	58.8	76.9	100.0	308.0	554.8
Average time	44.9	154.7	246.0	244.1	717.0	1391.7

3.2 Relationship between the number of sticky notes on simili paper and rating value

Each group is arranged in descending order of the first principal component of every four clusters based on principal components analysis and described in next section 3.3. The column “simili paper” in left side in Table 4 shows how simili paper is put together. The column “rating value by other groups” means the value of the peer assessment of the explanation using simili paper, content of the study support system, and presentation using PowerPoint, respectively.

While each group discussed its system, sticky notes sized 75mm in width by 50mm in height were put on simili paper in order to summarize the contents. The number of sticky notes per group was in the range of 10 to 75, and the average was 34. Ninety students attended any class of the group study. Seventy-five students stuck the sticky notes on simili paper during the discussions. The average number of sticky notes per student was 8.8. The maximum and minimum numbers of sticky notes were 25 and 0 respectively. Fifteen students did not offer an opinion at all. It is suggested that these students likely did not contribute much to conceiving the system for the groups to which they belonged.

Drawing figures is helpful to develop an idea, because it allows students to clarify their overall

outlook and think concretely. The number of sticky notes with which the figure was drawn is shown in the column “number of figures.” Window configuration, learning process, and student models are drawn on sticky notes. The average number of sticky notes describing a figure was 4.5. Group 16 had 36 figures, which stands out among the groups. Thirteen groups used figures, which was 56.5% of the whole.

Since the number of sticky notes stuck on simili paper represents the number of opinions in the discussions, a group with many sticky notes was considered to have succeeded in the group activity. The correlation coefficients *r* of the number of sticky notes with the number of figures, and average evaluations for explanation and system by other groups are $r=0.77^{***}$, 0.44^* , and 0.43^* respectively. They have significant correlation. The correlation coefficient between the number of figures and an average evaluation for the explanation by simili paper is $r=0.43^*$. The correlation is significant. These facts show that the explanations of the groups that had many sticky notes or/and drew many figures on sticky notes were more intelligible. It shows that the groups that used figures explained concretely and acquired higher evaluations from the other groups.

The teacher separately evaluated the parts of a report written in cooperation, and the parts written by individuals using five rating values. The correlation coefficients of the number of sticky notes with the rating value of the cooperation part of the report, the rating value of the individual part, and the number of characters in consideration (1/1000) are $r=0.76^{***}$, 0.59^{**} , and 0.46^* respectively. They had significant correlation. This shows that groups that stuck more sticky notes on their simili paper had higher evaluations of the cooperation part and the individual part of their reports, and more characters of consideration in the reports. This shows that more ideas were proposed by the groups with more sticky notes. It suggests that multilateral standpoints and deep understanding can be caused by expressing, comparing, agreeing with, denying, and analyzing others’ opinions, and by repeating discussions. Moreover, it suggests that groups with smooth activities in the beginning stages could also role-share smoothly for their reports, could finish the part in for which they had responsibility, and could explain their studies to each other.

After collecting information, discussing, presenting their thoughts, and looking back on these activities, the students’ activities and thoughts were considered and summarized. Then, a student wrote their considerations in the report. The range of the number of characters in the considerations was from 368 to 6,631. The average number of characters was 2,344. Thus, the author found that the number of characters in the consideration was greatly different among groups. This is considered to depend on

differences in positiveness and deepening of thinking through group learning. Since students who worked through discussions positively deepened their thoughts, it was shown that their understanding and ideas about a study support system were deep and the contents of their reports were also substantial. The number of characters described in the report is one of the indices that demonstrated whether the student had positively participated in group activities.

Nine students wrote, “time is insufficient” in the item “Comment about when you conceived of the study support system” in their reports. The other nine students wrote the same comments in their “personal records of discussions” for the fifth session. It is supposed from this description that they were expressing regrettable feelings that they could not conceive of a satisfactory study support system in the five sessions, or that they wanted to improve much further over many hours.

Table 4. Contents of simili and peer assessment

Group No	Simili paper		Explanation by simili		System		Presentation		No. of slide submissions	Report			Personal record of discussions					Attendance rate	Cluster
	No. of sticky notes	No. of figures	Rating value by other groups	Rating value by own groups	Rating value by other groups	Rating value by own groups	Rating value by other groups	Rating value by own groups		Rating value of cooperation part	Rating value of individual part	No. of characters in consideration	First	Second	Third	Fourth	Fifth		
18	75	36	4.6	4.0	4.8	4.2	3.8	3.4	1	5.0	4.3	2.7	2.8	3.3	4.3	3.6	3.8	0.95	1
18	44	3	4.2	3.1	4.2	3.7	3.3	4.0	1	4.0	2.6	2.1	2.6	3.3	4.1	4.0	4.5	0.75	
17	30	0	4.3	3.7	4.7	4.0	3.3	3.8	0	3.0	2.9	2.2	2.8	3.3	3.7	3.9	4.2	0.95	
3	41	0	3.6	3.9	3.4	3.7	3.5	3.6	2	4.4	4.3	4.2	3.4	3.8	3.7	3.8	4.0	1.00	
19	72	15	3.2	3.3	3.4	3.5	3.2	3.6	2	5.0	3.1	2.7	3.2	3.4	3.7	4.1	4.1	0.85	
12	75	18	3.9	2.9	3.5	3.3	3.0	3.4	1	5.0	4.8	3.6	3.1	2.9	3.5	3.2	3.6	1.00	
6	36	3	3.3	3.8	3.5	3.9	3.2	3.6	0	4.2	2.9	1.8	3.6	4.0	3.7	3.6	3.7	0.95	
4	43	2	3.1	2.9	3.4	3.3	3.3	3.9	2	4.6	3.8	2.7	3.3	3.3	3.2	3.8	3.9	0.95	
21	44	9	3.5	2.8	3.6	3.3	3.1	3.8	1	3.4	1.9	2.9	3.4	3.6	3.7	3.4	3.6	0.90	
5	48	0	3.3	3.3	3.4	3.0	2.8	3.6	0	5.0	4.8	2.6	2.8	3.8	3.0	3.5	3.6	0.75	
22	16	0	3.3	2.9	3.3	3.0	3.3	3.5	1	2.7	3.0	1.8	3.1	3.4	3.6	3.8	3.7	0.85	
2	29	1	3.5	2.6	3.5	3.4	3.5	2.9	0	3.9	2.1	3.9	2.7	3.4	3.1	3.2	3.4	0.50	
11	23	4	3.6	3.1	3.4	3.1	3.2	3.5	0	2.1	2.0	1.9	3.5	3.5	3.4	3.4	3.5	0.75	
9	13	0	2.6	2.9	3.0	3.1	2.8	3.5	1	3.0	3.8	2.8	2.9	3.2	3.3	3.1	3.5	0.80	
7	32	3	3.0	2.4	3.1	3.2	2.7	3.0	0	3.5	3.4	2.2	2.9	3.2	3.7	3.0	3.3	0.80	
8	17	0	2.8	2.7	2.8	3.1	3.2	3.0	0	3.6	3.0	2.8	2.5	3.2	3.2	3.2	3.3	0.85	
13	29	0	3.1	2.3	3.3	2.5	3.3	3.0	2	3.3	2.0	1.8	3.1	3.4	3.4	3.5	2.8	0.70	
1	14	1	2.4	2.7	2.4	2.8	1.0	1.0	0	1.7	1.3	1.2	3.1	3.0	3.0	3.1	2.6	0.55	
15	26	0	3.8	3.3	3.9	3.7	3.6	3.4	1	4.8	3.0	2.9	2.6	2.9	3.4	3.3	3.4	0.95	
23	24	0	4.3	3.4	3.7	3.9	3.4	4.1	1	2.0	2.0	1.7	2.1	3.1	3.5	2.9	3.5	0.70	
20	27	1	3.8	3.2	3.8	3.2	3.6	2.9	0	2.6	1.4	1.2	2.7	3.3	2.6	3.7	3.5	0.95	
14	10	0	3.2	3.1	3.4	2.9	3.2	3.7	1	2.7	1.0	1.2	2.3	3.0	3.0	3.3	3.5	0.75	
10	20	8	3.4	3.0	3.5	3.1	3.3	3.4	0	2.8	3.0	1.0	2.7	2.9	3.1	1.9	3.1	0.35	
m.	34.0	4.5	3.5	3.1	3.5	3.3	3.2	3.4	0.7	3.6	2.9	2.3	2.9	3.3	3.4	3.4	3.6	0.81	
SD	19.1	8.4	0.6	0.5	0.5	0.4	0.5	0.6	0.8	1.0	1.1	0.9	0.4	0.3	0.4	0.5	0.4	0.17	

3.3 Characteristics of groups based on contents of simili paper and evaluations

One that had almost no information for the principal component and had no effect on the characterization of groups was removed from the variables of the object to conduct the analysis. In order to understand the characteristics of the groups, principal component analysis was performed for the 17 items shown in Table 4 using the correlation matrix. The 17 items are the number of sticky notes on simili paper, number of figures, evaluations by the other groups and own group for explanation using simili paper, evaluations by the other groups and own group for the system, evaluations by the other groups and own group for presentation, number of slide submissions, rating value of the cooperation part of the report, rating value of the individual part, number of characters in consideration, and rating values of the first to the fifth sessions in the personal records of discussions. However, only one person in

group 1 attended the fifth session. The group did not submit the file of the slide, and did not give a presentation. Therefore, the rating scale value by the other groups is 1, own-group evaluation of the one attendee is 1, and number of slide submissions is 0 for group 1.

As a result of principal component analysis, the amount of information of component 1 is 39.7%, and the amount of information of component 2 is 15.4%; these two components will have 55.1% of the information data. A coefficient in the first component is positive for all items in the readjusted component matrix. The coefficients of following items have larger values: number of sticky notes on the simili paper (0.75), number of figures (0.55), rating value for explanation using simili paper by other groups (0.73), rating value for the system by other groups (0.77), rating value by own group (0.79), rating value for presentation by other groups (0.64) and by own group (0.67), personal records in the third and fifth sessions (0.72, 0.82), rating value for the cooperation part of the report (0.69), and rating value for the individual part of the (0.56).

The following items in the second component have coefficients of larger absolute values: rating value for explanation using the simili paper by other groups (-0.57), rating value for the system by other groups (-0.53), number of characters in consideration (0.50), and rating value for personal records in the first session (0.71). The coefficients of principal component are shown in parentheses following an item. The first characteristic is named “vigor of activity” from coefficients of the first principal component. The second characteristic is named “poorness of evaluation” from coefficients of the second.

Using the first and second principal component scores, 23 groups are classified into four clusters by cluster analysis and a scatter plot is shown in Figure 2. The first cluster is group Nos. 16, 17, and 18 shown by O marks in the lower right. The second cluster is group Nos. 3, 4, 5, 6, 12, 19, and 21 shown by □ marks in the upper right. The third cluster is groups Nos. 1, 2, 7, 8, 9, 11, 13, and 22 shown by x marks in the upper left. The fourth cluster is group Nos. 10, 14, 15, 20, and 23 shown by △ marks in the lower left.

This figure shows the following. The first cluster (O) is groups who were active with sufficient evaluation. The second cluster (□) is groups who were active with insufficient evaluation. The third cluster (x) is groups who were not so active with insufficient evaluation. The fourth cluster (△) is groups who were not so active with sufficient evaluation. The groups belonging to the first and second clusters had many sticky notes, many figures, and a high rating value of their explanation using simili paper, their systems, their presentations, and

their slides by the other groups. In addition, the groups also had high rating values for the cooperation and individual parts in their reports. That is, it is noted that the groups were active and conducted discussions smoothly.

The groups belonging to the third and fourth clusters had fewer sticky notes and fewer figures than the first and second groups. The average attendance rate of group members in the five sessions is shown in the furthest right column of Table 4. The average attendance rates for the first and second clusters are 0.88 and 0.91 respectively. The average attendance rates for the third and fourth clusters are 0.73 and 0.74 respectively. It turns out that the groups belonging to the third and fourth clusters had lower average attendance rates.

Thus, whether groups were active or not is found by looking at the contents of the simili paper on which the results of discussions were arranged. This determined the quality of the explanation using the simili paper, the presentation, and the report created in the series of activities. Then, when students summarized the result of the group’s learning on simili paper, it is thought that a teacher should instruct members of a group to allow them to improve the contents of their sticky notes and increase the number of stick notes. Furthermore, it seems that the teacher should devise a plan to boost the attendance rate.

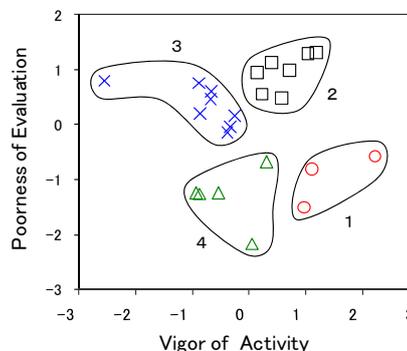


Figure 2. Classification of groups

3.4. Change of consciousness related to skill

The degree of consciousness related to skill in 29 items was investigated at the first, third, and fifth sessions [7]. An analysis of variance in one-way layout was carried out for the rating values of each item about three times in 29 items. The results are shown in Table 5.

The items with significant differences or significant tendencies are shown in Table 5. When a significant difference was recognized, a multiple comparison was carried out for three combinations of rating values among the first, third, and fifth sessions

using the LSD method. The results are shown in columns 1-3, 1-5, and 3-5 respectively.

The analysis of variance was carried out for the average rating scale values in each session. The result is shown in bottom row of Table 5. Since the F ratio is 14.8, significant difference was recognized. Then, after multiple comparisons were carried out, the significant difference was recognized from the

Table 5. Change of consciousness related to skills

Consciousness	Rating value						Analysis of variance		Multiple comparisons		
	First		Third		Fifth		MSe	F-ratio	1-3	1-5	3-5
	m	SD	m	SD	m	SD					
(1) Interest in computers	3.8	1.0	3.8	0.8	3.9	0.8	0.8	0.2			
(2) understanding of computers	3.3	1.0	3.1	0.8	3.1	0.8	0.7	0.7			
(3) technical skills with computers	2.9	1.0	3.1	0.9	3.3	0.9	0.9	3.5	*		
(4) methods of computer use	3.0	0.9	3.1	0.9	3.4	0.7	0.7	4.7	**	*	
(5) skill in clarifying problems	2.8	0.8	3.0	0.8	3.0	0.7	0.6	1.6			
(6) skill in mapping out a plan	2.9	1.0	3.3	0.9	3.2	0.9	0.9	3.4	**		
(7) deepening of understanding knowledge	3.0	0.9	3.2	0.8	3.2	0.7	0.7	1.9	+	+	
(8) skill in studying independently	3.3	1.0	3.2	0.8	3.3	0.8	0.8	0.3			
(9) skill in collecting information	3.1	0.8	3.3	0.9	3.3	0.9	0.7	1.7	+		
(10) skill in sorting information and necessary data	2.9	0.9	3.2	0.9	3.2	0.8	0.8	2.8	+	*	
(11) skill in analyzing information	2.9	1.0	3.1	0.9	3.0	0.8	0.9	0.3			
(12) skill in expressing self-opinions in sentences	2.8	1.0	3.3	1.0	3.5	0.9	1.0	8.3	**	***	
(13) skill in expressing through non-verbal media	2.6	0.9	3.0	1.1	3.0	1.0	1.0	4.6	+	**	
(14) skill in creating simple explanations	2.7	0.8	2.9	1.0	3.0	1.0	0.9	1.6	+		
(15) skill in giving a presentation	2.3	0.9	3.0	1.0	3.3	0.9	0.9	20.3	***	***	
(16) skill in understanding others' explanations	2.8	0.9	3.1	0.9	3.3	0.9	0.9	5.9	+	**	
(17) skill in communicating with others	2.9	0.9	3.2	0.8	3.2	0.8	0.7	4.3	+	**	
(18) skill in accurately judging self-evaluations	3.2	0.9	3.3	0.9	3.4	0.9	0.8	1.0			
(19) skill in accurately judging others' opinions	3.3	0.9	3.1	0.8	3.3	0.9	0.8	1.7		+	
(20) skill in improving and correcting	2.9	1.0	3.0	0.8	3.2	0.9	0.8	1.5	+		
(21) skill in performing detailed investigations	3.1	1.0	3.4	0.9	3.5	0.9	0.9	2.8	+	*	
(22) skill in completing research	2.9	1.0	3.5	0.9	3.7	0.9	0.9	13.7	***	***	
(23) skill in cooperating with each other	3.2	1.0	3.1	0.9	3.1	0.9	0.8	0.2			
(24) sense of fulfillment	3.3	1.0	3.4	1.0	3.5	0.9	0.9	0.4			
(25) sense of accomplishment	3.1	1.0	3.4	1.0	3.4	0.8	0.9	2.1	+	*	
(26) skill in solving one's own problems	2.9	0.8	3.2	0.8	3.2	0.7	0.6	2.9	+	*	
(27) skill in organizing information	2.7	0.9	3.2	0.8	3.3	0.8	0.7	9.1	**	***	
(28) skill in thinking independently	3.1	1.1	3.3	0.9	3.4	0.8	0.9	2.1	+	*	
(29) skill in creating something	2.7	1.1	3.4	0.9	3.4	0.8	0.9	15.7	***	***	
Average	3.0	0.3	3.2	0.2	3.3	0.2	0.7	14.8	*	**	

*** p<.001, ** p<.01, * p<.05, + p<.1

first session vs. the third session and the first session vs. the fifth session. However, no significant difference is recognized between the second and third sessions.

Next, multiple comparisons were carried out for the average rating scale values of each item, for the first vs. third session, the first vs. fifth session, and the third vs. fifth session. The number of items with significant differences was nine, fifteen, and one. This showed that consciousness heightened by gradation from the first session to the fifth session. However, the improvement between the third and fifth sessions was slighter than between the first and

third sessions. The following can be considered the cause. After the explanations using simili paper were finished in the third session, the study support systems that each individual group conceived was fixed. Then, referring to advice from other groups, the teacher required students to correct their ideas. In the fourth session, they arranged and summarized their ideas on a slide. However, since the contents of the study support systems were not modified greatly, it seems that there would be little improvement of consciousness.

3.5. Useful activities for change of consciousness

In order to know which activities will improve the consciousness related to skills from the relationship between consciousness and activity, some activities were undertaken for each consciousness. When we investigate the consciousness related to each skill in the third and fifth sessions, 26 activities were written on a survey sheet. Students chose activities useful for each consciousness among them. The activities useful for improving the consciousness of skills were totaled as a cross table. In the following, consciousness number is described in parentheses as shown in Table 5, and activity number is shown in a circle. The activity is expressed with a circled number.

The numbers of activities enumerated at the third and fifth sessions were 2,916 and 4,488 respectively, and 7,004 in total. The numbers were united as the cross table for consciousness and activities.

Many cells in the table had frequencies of less than five. The cluster analysis was conducted for the table using Ward's method with consciousness as a variable and activity as a case. As a result, the activities were classified into four groups.

Group 1 consists of nine activities as follows: ⑧ discussing in a group, ⑨ discussing with other groups, ⑭ completing the design for the study support system, ⑮ creating slides, ⑯ modifying slides, ⑰ completing slides, ⑱ practicing the presentation, ⑲ presenting using simili paper, and ⑳ presenting using PowerPoint. This group is made up of activities related to the presentation.

Group 2 consists of five activities as follows: ④ investigating study support systems, ① evaluating the study support systems of one's own group, ② hearing presentation of other groups, ③ evaluating the study support systems of other groups, and ④ analyzing the rating value by other groups. This group is made up of activities related to evaluating.

Group 3 consists of 11 activities: ② understanding the whole issue, ③ deciding to investigate, ⑤ process to examine study support systems, ⑥ summarizing so as to understand what

was examined, ⑦ explaining what was examined, ⑩ process to conceive study support systems, ⑪ process to design study support systems, ⑫ summarizing what was examined about study support systems, ⑬ process to complete design of study support systems conceived, ⑮ writing a report, and ⑯ elaborating on and rewriting a report. This group is made up of activities related to investigating and summarizing.

Group 4 consists of one activity: ① operating a computer, an activity related to computer operation.

Then, cluster analysis was conducted on the same cross table using Ward's method with activity as a variable and consciousness as a case. As a result, consciousness was classified into four groups.

Group I consists of (16), (17), (18), (19), (20), (26), (28), and (29), which refer to consciousness about problem-solving skills in thinking and improving.

In the same way, group II consists of (6), (7), (8), (9), (11), (12), (13), (14), and (15). It refers to consciousness about skills in expressing and explaining.

Group III consists of (10), (21), (22), (23), (24), and (25). It refers to consciousness about communications and cooperation.

Group IV consists of (1), (2), (3), (4), and (5). It refers to consciousness of computers.

Frequency in the above-mentioned cross table was added up for every cluster of consciousness and activity. The results are shown on the left of Table 6. Each expected frequency of cells in Table 6 was more than 70. Therefore, this table was considered to be a 4x4 contingency table. The χ^2 test was conducted for this table. As a result, the frequency deflection was recognized ($\chi^2(9) = 1125.8, p < .001$). Therefore, a result of residual analysis is shown in the lower left of Table 6. Significant deflection is shown by a * mark in the lower-right cell of Table 6. Activities useful for improving consciousness are explained by significant cells with greater frequency in the following.

Group 1, activities related to presentation, is significantly useful for improving group III consciousness about communications and cooperation.

Group 2, activities related to evaluating, is significantly useful for improving group I, consciousness about problem-solving skills in thinking and improving.

Group 3, activities related to investigating and summarizing, is significantly useful for improving group II, consciousness about skills in expressing and explaining.

Group 4, activities related to computer operation, is significantly useful for improving group IV, consciousness of computers.

This means that investigating as a group, arranging the contents of the discussion, conceiving study support systems, and dispatching the information by explaining and presenting to peers are all useful for improving consciousness related to skill.

Table 6. χ^2 test and residual analysis of the cluster of consciousness and activity

Clusters of consciousness and activities	Observed frequency				Sum	Expected frequency			
	1. activity related to presentation	2. activity related to evaluating	3. activity related to investigating and summarizing	4. activity related to computer operation		1. activity related to presentation	2. activity related to evaluating	3. activity related to investigating and summarizing	4. activity related to computer operation
I. Consciousness about problem-solving skills in thinking and improving	618	627	858	42	2145	727.5	393.1	912.3	112.1
II. Consciousness about skills in expressing and explaining	609	377	1230	48	2264	767.8	414.9	962.9	118.3
III. Consciousness about communications and cooperation	813	213	591	36	1653	560.6	303.0	703.0	86.4
IV. Consciousness of computers	471	140	470	261	1342	455.1	246.0	570.8	70.1
Sum	2511	1357	3149	387	7404	2511	1357	3149	387
	Adjusted residual					Result of significant test			
I. Consciousness about problem-solving skills in thinking and improving	-5.0	14.1	-2.2	-8.0		***			
II. Consciousness about skills in expressing and explaining	-7.1	-2.3	10.7	-7.9			***		
III. Consciousness about communications and cooperation	12.5	-5.9	-5.0	-6.3		***			
IV. Consciousness of computers	0.8	-7.5	-4.8	25.6				***	

*** p<.001

4. Conclusion

This course, in which students constructed and created knowledge, was conducted using group learning. Information gathering, discussing, and conceiving study support systems through group learning caused many interactions among students, such as within a group, between groups, and within a class. One teacher designed, taught, and practiced the course, in which about 90 students participated. Although the teacher could not take much time to respond to each group one on one, it is thought that the desired purpose was essentially attained.

The results of analyzing the information acquired through this practice are as follows. Students worked through group learning for more than 23 hours. This increased motivation, pleasure, planned development, confidence, the explicitness of doing, and the usefulness of discussions by causing an interest in study support systems. Furthermore, since an opportunity to reflect on them could be obtained, the systems that they conceived were evaluated objectively.

The following was found through this practice:

- (1) Groups that were able to perform activities such as thinking by themselves, having discussions positively, and sharing work actively could conceive better systems, and were properly appreciated.
- (2) It seems that the difficulty, pleasure, etc., of working in cooperation could be known.
- (3) Groups that used figures to explain concretely acquired higher evaluations from the other groups.
- (4) More ideas were proposed by the groups with more sticky notes. It is suggested that multilateral

standpoints and deep understanding can be caused by repeating discussions.

(5) Since students who worked positively on discussions deepened their thoughts, their understanding and ideas about study support systems were deep and the contents of their reports were also substantial.

(6) Whether groups were active or not was determined by looking at the contents of the simili paper.

(7) The consciousness heightened by gradation from the first session to the fifth. Students came to think that many skills needed in the case of solving a problem improved.

(8) Activities that are helpful in the improvement of consciousness also became clear, as follows: Activities related to presentation are significantly useful for improving consciousness about communications and cooperation. Activities related to evaluating are significantly useful for improving consciousness about problem-solving skills in thinking and improving. Activities related to investigating and summarizing are significantly useful for improving consciousness about skills in expressing and explaining. Activities related to computer operation are significantly useful for improving consciousness of computers.

The author wants to ensure that individuals or groups who do not participate positively in group learning do not appear in future.

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