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Evaluation by Questionnaire on Grouped Flipped Classroom Method

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Abstract—Flipped classrooms, in which the roles of a classroom lesson and homework are reversed, have recently begun to attract attention. Specifically, the students study on their own by using digital teaching materials or e-learning prior to school hours and apply their learning mainly in classroom discussions. We proposed a method for an effective flipped classroom based on the log information of self-study called a "grouped flipped classroom." We tested the grouped flipped classroom method over 16 weeks of actual lessons in the autumn semester of 2017 at Shonan Institute of Technology. The results revealed that the grouped flipped classroom improved students′ performance. In this paper, we evaluate the questionnaire results collected when applying the grouped flipped classroom to actual lessons.

Index Terms—Flipped-Classroom, e-Learning, Blended-Learning, Effective Classroom

I. Introduction

Classroom flipping, i.e., the reversal of the roles of the classroom and home study, has been attracting increased attention due to the expected improvement in learning. In a flipped classroom, students study the lesson before coming to class and then obtain more advanced face-to-face learning in class. We have developed and evaluated a method to make classroom flipping more effective [1].

In our proposed flipped classroom method, students are divided into three groups before each class on the basis of their e-learning self-study logs and level of understanding. The three groups are students who studied the lesson and fully understand the contents, students who studied the lesson but do not fully understand the contents, and students who did not study the lesson and so do not understand the contents. The face-to-face learning in class is done separately for each group. We called this the "grouped flipped classroom." We compared a grouped flipped classroom with a conventional flipped classroom without grouping, and the effectiveness of the grouped flipped classroom was shown by final test results and a questionnaire [8] [9] [10] [11]. We showed bottoming up to be effective for students with low understanding [12] and showed that not only bottoming up but also advanced classes could be effective for students with high understanding [13] [14]. We applied the above grouped flipped classroom method to actual lessons in the autumn semester of 2017. The results revealed that the proposed grouped flipped classroom method improves students' performance.

In this paper, we evaluate the questionnaire result collected when applying to actual class.

In Section II, we describe the objectives and effects of the flipped classroom and explain the details of the proposed flipped classroom method. In Section III, we describe how to apply the grouped flipped classroom method to actual classes. Specifically, we describe a learning method using Moodle (a learning management system) during self-study, contents of the self-study, and the method of the self-study achievement test. We show the evaluation result by questionnaire in Section IV. Section V concludes this paper by summarizing the key points and mentioning future works.

II. Related Work

A. Flipped classroom

The flipped classroom has been reported to increase the attendance of the students and decrease their failure rate [2]. In another report, the flipped classroom led to better exam results than conventional lectures [3]. Furthermore, other researchers found that recognition of "the effect of the class" and "participation in one's own class" increased [4].

In addition, there are two types of flipped classroom [5] [6]. One uses the mastery learning model (flipped-mastery model). Its aim is to have all students reach a standard above a certain level, such as a lower failure rate or obtaining 80% on a test. This type of flipped classroom is basically for individually instructing the learners who do not learn enough in a face-to-face classroom. In contrast, the other type of flipped classroom uses the advanced and high-ability learning model. The follow-up lessons are not taught in the face -to-face classroom, and the purposes are to teach more complex contents and raise knowledge for more advanced students.

B. Grouped flipped classroom

In this section, we will describe the grouped flipped classroom method that we proposed. We added up the time every student spent doing self-study by using a support system for making learning/teaching materials in connection with Moodle in the flipped classroom. Students take an examination to determine their degree of understanding from self-study.

We think that the students who achieve good results in the self-study achievement test can probably understand the content that they are supposed to learn regardless of whether they study for a short or long time. However, there are two groups of students who obtain low marks in the self-study achievement test. One group cannot understand the contents because they did not study them, and the other cannot understand the contents even though they studied hard.

As described above, we proposed a method that divides students into three groups by using log information of self-study time and degree of understanding, and then each group has a face-to-face class. The three groups are as follows: (A) students who can understand the contents, (B) students who cannot understand because they do not do self-study, and (C) students who cannot understand even though they do self-study for a long time. By this proposed method, we can provide face-to-face classes for every group on the basis of their degrees of understanding. Thus, we think that the proposed flipped classroom can be more effective than the conventional flipped classroom in which students are not put into groups.

We compared the grouped flipped classroom with a conventional flipped classroom without grouping, and the effectiveness of the grouped flipped classroom was shown by final test results and questionnaire [8] [9] [10] [11]. We showed that bottoming up is effective for students with low understanding [12] and that not only bottoming up but also advanced classes could be effective for students with high understanding [13] [14].

III. APPLICATION TO ACTUAL CLASS

A. Overall explanation of class

We applied the grouped flipped classroom method to actual lessons in "Practical Training for Basic Programming" in the autumn semester of 2017 at Shonan Institute of Technology. This class was conducted by two faculty members (A, B). We divided 16 weeks into 2 sets of 8 weeks. One faculty member conducted grouped flipped classroom classes, and the other conducted regular classes. There were two 90-minute classes (180 minutes in total) per day. The content of the lesson is the basic content of the Java programming language. In consideration of the effectiveness of iterative learning, the overlapping of class contents was allowed between two faculty members.

In this paper, one of the two faculty members mentioned above (Faculty A) uses a grouped flipped classroom. Faculty A conducted 8 lessons for 98 students (Dimidiate 1) and then 8 for 85 students (Dimidiate 2) and used the proposed grouped flipped classroom method for six lessons. As for the other lessons, one was conducted in a lecture style as usual (lecture style), and the other was conducted by mixing students who did well on the self-study achievement test and students who did not (mixed group).

TABLE I
DESCRIPTION OF CLASS

First 8 weeks	
Faculty A	carries out flipped classroom for Dimidiate 1
Faculty B	carries out regular classes for Dimidiate 2
Second 8 weeks	
Faculty A	carries out flipped classroom for Dimidiate 2
Faculty B	carries out regular classes for Dimidiate 1

As shown in Table I, students in Dimidiate 2 had already received regular classes for the first 8 weeks in Java programming language by Faculty B before changing to the flipped classroom conducted by Faculty A. Note that the basic understanding of the students in Dimidiate 2 was possibly higher than that of the students in Dimidiate 1.

B. Overall explanation of flipped classroom

First, Faculty A conducted eight weeks of flipped classroom lessons for Dimidiate 1 and then another eight weeks of flipped classroom lessons for Dimidiate 2[1]. The lessons for all 8 weeks are shown in Table II. Also, as shown in Fig.1, all lessons in Table II were implemented as an eight-week flipped classroom.

TABLE II
CONTENTS OF CLASS OF FACULTY A

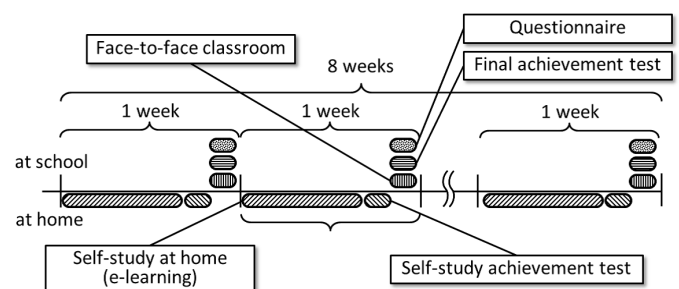|	内容
1st (9th) week	Java language (Input/Output)
2nd (10th) week	Java language (Variable/Arithmetic)
3rd (11th) week	Java language (Branch)
4th (12th) week	Java language (Repetition)
5th (13th) week	Java language (Array)
6th (14th) week	Java language (Method)
7th (15th) week	Java language (Class I)
8th (16th) week	Java language (Class II)

Fig. 1. Overall composition of flipped classroom approach

[1]Faculty B's regular classes are outside the scope of this paper.

C. Explanation of flipped classroom for one week

The procedure for each week is as follows. We prepared the materials and tests for 8 weeks and gathered results in Moodle.

- [at home] Self-study material
- [at home] Self-study achievement test
- [at school] Self-study achievement test (again)
- [at school] Lecture materials
- [at school] Final achievement test
- [at school] Questionnaire after class

1) Self-study material: We used the browsing history visualization system [7] to acquire the learning log of how much time the learner took for self-study. User authentication was realized by linking the browsing history visualization system with Moodle.

2) Self-study achievement test: At the end of the self-study period, a self-study achievement test was carried out by using the quiz function on the same Moodle system. The test was as a hole filling problem of the Java program. The maximum score was 10 full points.

3) Grouping of learners: The self-study achievement test was closed at 23:55 the day before classes were held. From this deadline to the beginning of classes the next day, the students needed to be divided into three groups on the basis of the relationship between self-study time and self-study achievement test score. We developed a grouping tool to make this work more efficient.

4) Face-to-face class: In face-to-face classes in the university's classroom after one-week self-study, students were grouped using the student number display function of the grouping tool. Specifically, we conducted classes in different face-to-face lessons for each group as described below[2].

Group A: As a result of self-study, learners understood the contents of the week's lesson, so they solved the exercises on Moodle at their own pace. Some learners finished the prepared exercises beforehand, so we prepared more additional problems for them to work on.

Group B: These are students who were unable to understand the content because they did little or no self-study. They moved to a different room and studied the self-study content. After that, a second self-study achievement test (Again) was carried out to measure comprehension degree. They were reorganized into Group A or C in accordance with the test results.

Group C: Students who did not understand the contents even though they spent a lot of time doing self-study were seated near Faculty A, who explained the lesson content in an easy to understand way. After encouraging feedback, the learner solved the exercise problems prepared on Moodle like Group A.

[2]As described in Section III-D, there was a week in which face-to-face classes were conducted without grouping as a control experiment.

5) Final achievement test: At the end of each lesson, a final achievement test was conducted to measure the final understanding level. The final test was also carried out as a self-study achievement test as described in Section III-C2 by using the quiz function on Moodle. The problem was to complete a full-scale Java program different from that in the self-study achievement test.

6) Questionnaire after class: Finally, at the end of the lesson time, we conducted a questionnaire on the level of comprehension on grouping and difficulty level of classes as shown in Fig 2.
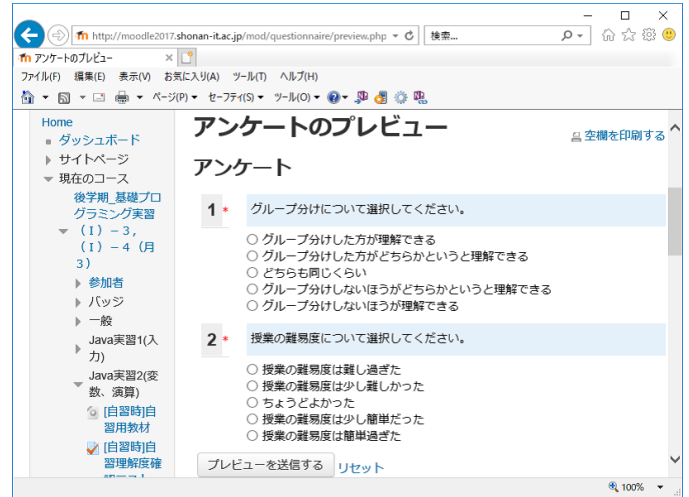

Fig. 2. Questionnaire after class

D. Explanation of lessons for 16 weeks

Basically, the flipped classroom described in Section III-C was conducted for students of Dimidiates 1 and 2 for eight weeks. To analyze the control experiments, lecture-style lessons were also conducted in the 4th and 13th weeks as shown in Table III. As a result, it is possible to compare test results for the 4th and 12th weeks and test results for the 5th and 13th weeks. The mixed groups in the 6th and 15th weeks contained one Group A student (leader) and one or two Group B and C students (total of 2 to 3 people). As a result, it is possible to compare test results for the 6th and 14th weeks and test results for the 7th and 15th weeks.

TABLE III
DESCRIPTION OF CLASS

Dimidiate 1		Dimidiate 2	
1st week	Grouped	9th week	Grouped
2nd week	Grouped	10th week	Grouped
3rd week	Grouped	11th week	Grouped
4th week	Lecture-style	12th week	Grouped
5th week	Grouped	13th week	Lecture-style
6th week	Mixed-group	14th week	Grouped
7th week	Grouped	15th week	Mixed-group
8th week	Grouped	16th week	Grouped

IV. Evaluation by questionnaire

In this chapter, we analyze results of the questionnaire performed at the end of each face-to-face lesson about the degree of comprehension in group lessons and the difficulty level of the lesson.

A. Questionnaire items

The questionnaire had two items.

Q1. Please select one statement about your comprehension in group lessons.
  A1. I understand more due to group learning.
  A2. If I had to say, I understand more due to group learning.
  A3. Group learning does not affect my level of understanding.
  A4. If I had to say, I understand less due to group learning.
  A5. I understand less due to group learning.

Q2. Please select one statement about the difficulty level of the lesson.
  A1. This lesson was too difficult.
  A2. This lesson was a little difficult.
  A3. The difficulty level of this lesson was just right.
  A4. This lesson was a little easy.
  A5. This lesson was too easy.

B. Questionnaire results

We conducted the questionnaire for 6 weeks for Dimidiates 1 and 2 except for the first week of guidance and weeks for control experiments.

C. Analysis of Q1 results

In this section, we analyze whether there are differences of opinion among students in different groups in the results for Q1 (comprehension in group lesson). Table IV shows the crosstabulation of the groups and the Q1 results for Dimidiate 1, Dimidiate 2, and total for Dimidiates 1 and 2 (called Total).

We conducted a χ^2 test on results for Dimidiate 1, Dimidiate 2, and Total in Table IV. The p values were $0.0105 < 0.05$, $0.2257 > 0.05$, and $0.0044 < 0.05$, respectively. Significant differences were found in Dimidiate 1 and Total but not Dimidiate 2. Therefore, we then performed residual analysis on Dimidiate 1 and Total, the results of which are shown in Table V. Items in bold indicate significant differences (i.e., an absolute value of 1.96 or more).

In the results, Group A in Dimidiate 1 had significantly more students who answered "I understand more due to group learning" and significantly fewer students who answered "I understand less due to group learning." In contrast, Group C in Dimidiate 1 had significantly fewer students who answered "I understand more due to group learning" and significantly more students who answered "I understand less due to group learning." Conversely, in Total, Group A had significantly fewer students who answered "I understand less due to group learning," whereas Group C had significantly more students who answered the same. In summary, we can say that many students in Group A are favorable to grouping but many students in Group C are unfavorable[3].

D. Analysis of Q2 results

In this section, we analyze whether there are differences of opinion among students in different groups in the results for Q2 (difficulty of lesson). Table VI shows the crosstabulation of the groups and the results for Dimidiate 1, Dimidiate 2, and Total.

We conducted a χ^2 test on results of Dimidiate 1, Dimidiate 2, and Total in Table VI. The p values were $0.0637 < 0.05$, $3.0445 \times 10^{-6} < 0.05$, and $3.9134 \times 10^{-8} < 0.05$, respectively. Significant differences were found in Dimidiate 1, Dimidiate 2, and Total. We then performed a residual analysis, the results of which are shown in Table VII.

In the results, Group A in Dimidiate 1, Dimidiate 2, and Total had significantly more students who answered "This lesson was too easy." Also, Group A in Dimidiate 2 and Total had significantly fewer students who answered "This lesson was a little difficult." Group B in Dimidiate 1, Dimidiate 2, and Total had significantly fewer students who answered "This lesson was too easy." Group C in Dimidiate 2 and Total had significantly more students who answered "This lesson was a little difficult" but significantly fewer students who answered "This lesson was too easy." In summary, many students in Group A did not feel that the lessons were difficult but many students in Group C did.

E. Analysis of the relationship between Q1 and Q2 results

In this section, we analyze the relationship between the results for Q1 (comprehension in group lesson) and Q2 (difficulty of class). Table VIII shows the crosstabulation of Q1 and Q2 for Dimidiate 1, Dimidiate 2, and Total[4].

Polychoric correlation coefficients are used to obtain the correlation between qualitative variables (ordinal scale). First, we calculated the polychoric correlation coefficient for results of Dimidiate 1, Dimidiate 2, and Total in Table VIII. Correlation coefficients were -0.0668 for Dimidiate 1, 0.0612 for Dimidiate 2, 0.0114 for Total, and no high correlation was found.

Next, as in the previous section, we conducted a χ^2 test on results of Dimidiate 1, Dimidiate 2, and Total in Table VIII. The p values were $9.4109^{-7} < 0.05$, $0.1868 > 0.05$, and $1.5256^{-5} < 0.05$, respectively. Significant differences were found in Dimidiate 1 and Total but not for Dimidiate 2. Therefore, we then performed a residual analysis on Dimidiate 1 and Total, the results of which are shown in Table IX.

As the polychoric correlation coefficient was low, it is impossible to discuss the overall trend. However, from Table IX, it can be said that a student who thought that lesson was difficult (A1 to Q2) was negative toward grouping (A5 to Q1). These results are considered to be due to the fact that students who are able to talk to each other easily and

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[3]We discuss this reason in Section IV-E.

[4]Unlike Table IV and Table VI, Table VIII is a table corrected only by answers of Q1 and Q2 without considering groups A, B, and C.

TABLE IV
SUMMARY OF Q1 RESULTS

Group	Dimidiate 1					Dimidiate 2					Total				
	A1	A2	A3	A4	A5	A1	A2	A3	A4	A5	A1	A2	A3	A4	A5
Group A	50	25	85	7	14	26	20	102	17	13	76	45	184	24	27
Group B	32	19	75	7	16	24	19	68	13	22	56	38	143	20	38
Group C	14	18	59	7	25	12	12	36	9	15	26	30	95	16	40

TABLE V
RESIDUAL ANALYSIS OF Q1

Group	Dimidiate 1					Total				
	A1	A2	A3	A4	A5	A1	A2	A3	A4	A5
Group A	**2.73****	0.06	-0.48	-0.63	**-2.34****	1.81	-0.43	1.35	-0.28	**-3.54****
Group B	0.10	-0.41	0.59	0.04	-0.64	0.35	-0.15	-0.38	-0.16	0.44
Group C	**-3.12****	0.36	-0.10	0.65	**3.26****	**-2.47****	0.67	-1.14	0.49	**3.60****

$* : p < 0.05, \quad ** : p < 0.01$

TABLE VI
SUMMARY OF Q2 RESULTS

Group	Dimidiate 1					Dimidiate 2					Total				
	A1	A2	A3	A4	A5	A1	A2	A3	A4	A5	A1	A2	A3	A4	A5
Group A	58	56	47	9	11	27	50	62	22	21	85	106	109	31	32
Group B	50	48	44	6	1	35	57	40	12	2	85	105	84	18	3
Group C	41	49	26	6	1	22	43	18	6	0	63	92	44	12	1

TABLE VII
RESIDUAL ANALYSIS OF Q2

Group	Dimidiate 1					Dimidiate 2					Total				
	A1	A2	A3	A4	A5	A1	A2	A3	A4	A5	A1	A2	A3	A4	A5
Group A	-0.31	-1.04	0.06	0.28	**3.34****	**-2.38***	**-3.18****	**2.10***	1.52	**4.74****	-1.90	**-2.95****	1.56	1.49	**5.86****
Group B	0.21	-0.49	1.26	-0.43	**-1.96***	1.43	0.96	-0.46	-0.70	**-2.72****	0.97	0.34	0.59	-0.75	**-3.31****
Group C	0.12	1.67	-1.39	0.15	-1.60	1.21	**2.74***	**-2.01***	-1.03	**-2.57***	1.11	**3.01****	**-2.44***	-0.89	**-3.08****

$* : p < 0.05, \quad ** : p < 0.01$

openly during lessons are separated into different groups in the grouped flipped classroom. We think that the reason that students who felt that lessons were difficult were opposed to grouping was that their groups did not contain other students to whom they could freely talk.

V. CONCLUSION

In this paper, we classified students into multiple groups on the basis of the relationship between their learning time and understanding at home, and applied our proposed grouped flipped classroom to actual classes. We conducted a questionnaire on how grouping affects comprehension and the difficulty level of the lesson and analyzed the results. Result revealed that students with high understanding tended to like grouping and that dislike of grouping and feeling the lesson is difficult are correlated. In other words, it became statistically clear that students with less understanding disliked grouped flipped classrooms.

Based on the results of this study, it is thought that an experiment should be done to compare the degree of comprehension of the lesson in classes of friend groups and classes of relative strangers.

TABLE VIII
CROSSTABULATION OF Q1 AND Q2

Q1 \ Q2	Dimidiate 1					Dimidiate 2					Total				
	A1	A2	A3	A4	A5	A1	A2	A3	A4	A5	A1	A2	A3	A4	A5
A1	37	33	14	6	6	16	28	13	2	4	53	61	27	8	10
A2	12	27	18	4	1	13	18	17	3	1	25	45	35	7	2
A3	66	71	70	9	3	35	71	68	22	15	101	142	138	31	18
A4	3	15	1	2	0	5	16	11	6	2	8	31	12	8	2
A5	31	7	14	0	3	15	17	11	7	1	46	24	25	7	4

TABLE IX
RESIDUAL ANALYSIS OF Q1 AND Q2

Q1 \ Q2	Dimidiate 1					Total				
	A1	A2	A3	A4	A5	A1	A2	A3	A4	A5
A1	1.33	0.14	**-2.84****	0.85	**2.23***	**2.06***	1.04	**-3.21****	-1.08	1.51
A2	**-2.44***	1.75	0.62	0.73	-0.64	-1.25	1.12	0.89	-0.39	-1.37
A3	-1.21	-0.59	**2.89****	-0.52	-1.85	**-2.17***	-1.10	**3.18****	0.23	0.07
A4	-1.86	**3.74****	**-2.26***	1.09	-0.81	**-2.50***	**2.72****	-1.38	1.94	-0.35
A5	**3.95****	**-3.52****	-0.07	-1.74	1.22	**4.12****	**-2.81****	-0.90	-0.18	-0.20

$^{*}: p < 0.05, \quad ^{**}: p < 0.01$

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