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Application of grouped flipped classroom to two-year actual class and its statistical evaluation

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Abstract—In a flipped classroom, the roles of a classroom and homework are reversed. We propose a method for increasing the effectiveness of the flipped classroom lessons based on the self-study log information. Specifically, when students study by e-learning at home, we collect and analyze their learning logs and then classify students into groups based on their study time and the degree of understanding of the material. We call our proposed method a grouped flipped classroom. We applied it to actual lessons during 16 weeks in the autumn semesters of 2017 and 2018 at the Shonan Institute of Technology. The results revealed that students' performance improved after the grouped flipped classroom lessons, especially in the group of students who had low understanding during self-study: there was a statistically significant difference between their average scores in the tests after the self-study and after the face-to-face lessons. In addition, the average scores in the tests after the face-to-face lessons were higher for students in the grouped flipped classroom than for students in conventional style classes (lecture style class and mixed ability class).

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

I. INTRODUCTION

Reversing the roles of the classroom and home study, known as classroom flipping, has been attracting increased attention due to the expected improvement in learning. In a flipped classroom, students study a new lesson at home and then deepen the newly obtained knowledge through face-to-face learning in class. We have developed and evaluated a method of increasing the effectiveness of classroom flipping.

In our proposed flipped classroom method, students are divided into three groups before each class based on their e-learning self-study logs and level of understanding. The groups consist of students who (A) studied the lesson and fully understood the contents, (B) students who studied the lesson but did not fully understand the contents, and (C) students who did not study the lesson and therefore did not understand the contents. The face-to-face learning sessions in class are conducted separately for each group, hence the name of our method, the "grouped flipped classroom."

We compared the grouped flipped classroom with a conventional flipped classroom without grouping. The effectiveness of the grouped flipped classroom was evaluated by the final test results and a questionnaire [14]- [17]. We discovered that the proposed method is effective of raising the standard for students with low understanding [18]. We also showed that our proposed method is also effective for students with high level of understanding, advanced classes [19] [20]. We applied the grouped flipped classroom method to actual lessons in the autumn semester of 2017 at the Shonan Institute of Technology. We showed that the application of the proposed method has increased the test scores [21]- [26]. We also conducted an evaluation of the method by questionnaire [27] [28].

In this paper, we report the results of applying the proposed method to actual lessons in 2017 and 2018 and use two-year data to show statistically that the students' performance has improved.

In Section II, we describe the related work. In Section III, we describe how to apply the grouped flipped classroom method to actual classes. We show the evaluation results in Section IV. Section V concludes this paper by summarizing the key points and mentioning future work.

II. RELATED WORK

A. Flipped classroom

The flipped classroom was proposed by Jonathan Bergmann and Aaron Sams [1] [2] in 2012. They flipped the conventional method of lecture style, conducting a reverse class with a video of a recorded lecture. They have reported that the flipped classroom method increased attendance and decreased failure rates.

Strayer [3] pointed out the need for students to self-study using online lecture videos and to attend face-to-face classes for more active learning. Several other researchers [4] [5] [6] agree that flipped classrooms are effective in using technology and promoting more advanced and deeper learning.

In a typical flipped classroom, students use lecture videos, but not all instructors have the time and facilities to record lecture videos for online education. Several studies have shown the effectiveness of using social network websites [7] and the online course materials of the Massachusetts Institute of Technology (MIT) [8].

There are two models for flipped classrooms [9] [10]. One is a mastery learning model which aims at all the members to reach a certain level or higher (e.g., lowering the failure rate or pushing all members to obtain a certain number of points). The other type is an advanced and high-ability learning model. This model aims at developing high learning skills and acquiring high learning abilities.

B. Browsing History Visualization System

When browsing teaching materials on the Web, the log of the Web server shows that someone has downloaded a PDF file with teaching materials. However, it is impossible to see for how many minutes the material was viewed. To solve this problem, we developed a web-based learning support system called the browsing history visualization system [11]. In this system, information such as the duration (in seconds) for which the teaching material was opened (per page) can be recorded. Furthermore, this system can authenticate the users in cooperation with Moodle learning platform [12]. In other words, this system shows who is viewing which page for how many seconds.

C. Edit History Visualization System

We developed a learning environment of a programming language for beginners [13]. This system has features such as easy preparation of the learning environment and grasping of the learning situation of the learner. For “ease of preparing the learning environment,” we created an environment that can be used with a browser. Therefore, learners can learn using not only a PC, but also a smartphone or a tablet. As for “grasping the learning situation of the learner,” the difference between the previous state of the source code and the execution results is displayed on the teacher’s screen. If the teacher sees this difference, he or she can check the modifications made by the learner.

III. APPLICATION TO ACTUAL CLASSES

A. Overall description of classes

We applied the grouped flipped classroom method to actual lessons in “Practical Training for Basic Programming” in the autumn semesters of 2017 and 2018 at the Shonan Institute of Technology. Most of the students were college freshmen (18 years old), and the ratio between men and women was about 20:1. This course was conducted by two faculty members. We divided 16 weeks into two sets of eight weeks. One faculty member (Faculty α) conducted grouped flipped classroom lessons, and the other (Faculty β) conducted regular classes. There were two 90-minute classes (180 minutes in total) per day. The content of the lessons was 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 fiscal year 2017, faculty α conducted eight lessons for 98 students (Part 1) and then eight more lessons for 85 students (Part 2) and used the proposed grouped flipped classroom method for six lessons. As for the other lessons, one was conducted in a usual lecture style (lecture style), and the other was conducted by mixing students who did well on the self-study achievement test and students who did not do well (mixed group). In fiscal year 2018, faculty α conducted eight grouped flipped classroom lessons for 90 students (Part 1) and then eight more for 99 students (Part 2).

TABLE I
DESCRIPTION OF CLASSES

First set of 8 weeks	
Faculty α	carries out flipped classroom lessons for Part 1
Faculty β	carries out regular classes for Part 2
Second set of 8 weeks	
Faculty α	carries out flipped classroom lessons for Part 2
Faculty β	carries out regular classes for Part 1

As shown in Table I, students in Part 2 had already received regular classes for the first eight weeks in Java programming language by Faculty β before changing to the flipped classrooms conducted by Faculty α . Note that the basic understanding of the students in Part 2 was possibly higher than that of the students in Part 1.

B. Overall description of flipped classroom

Faculty α conducted flipped classroom lessons for eight weeks first for Part 1 and then for Part 2¹. The lesson contents for all eight weeks are shown in Table II. Also, as shown in Fig. 1, all lessons in Table II were implemented as eight-week flipped classroom lessons.

TABLE II
CONTENTS OF CLASSES OF FACULTY α

	Contents
1st week	Java language (Input/Output)
2nd week	Java language (Variable/Arithmetic)
3rd week	Java language (Branch)
4th week	Java language (Repetition)
5th week	Java language (Array)
6th week	Java language (Method)
7th week	Java language (Class I)
8th week	Java language (Class II)

C. Grouped flipped classroom

In this section, we describe our proposed grouped flipped classroom method. We added up the time each student spent on self-studying by using a support system for making learning/teaching materials in connection with the Moodle learning platform in the flipped classroom. Students have to take an

¹Faculty β ’s regular classes are beyond the scope of this paper.

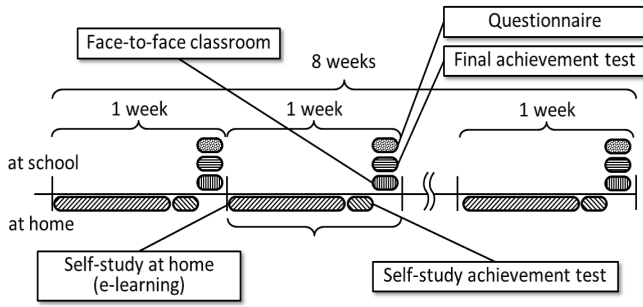


Fig. 1. Overall composition of flipped classroom approach

examination to demonstrate their degree of understanding after self-studying.

We think that the students who demonstrate 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 a 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.

We propose to divide students into three groups by using the log information of self-study time and the degree of understanding. These groups then study in face-to-face classes. 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. Using our proposed method, we can provide face-to-face classes for every group based on their degree of understanding. We think that the proposed flipped classroom lessons are more effective than the conventional ones in which students are not divided into groups.

D. Description of lessons for 16 weeks

The grouped flipped classroom was conducted for students of Parts 1 and 2 for eight weeks. To analyze the results of the control experiments, lecture-style lessons were also conducted in the 4th and 13th weeks, as shown in Table III. It is therefore possible to compare the test results for the 4th and 12th weeks and the 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). Therefore, it is possible to compare the test results for the 6th and 14th weeks and the test results for the 7th and 15th weeks. In the second year (2018), there was no control experiment; only grouped flipped classroom lessons were conducted.

IV. EVALUATION

In this chapter, we report the evaluation results of applying the grouped flipped classroom method to the actual two-year classes. The legends of the graphs in Figs. 2 to 7 follow the regular expression:

TABLE III
DESCRIPTION OF CLASSES

Part 1		Part 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

$$(2017|2018) - (1|2)(\text{Total}|A|B|C) (\text{Self}|Last)$$

where 2017 and 2018 represent fiscal years, 1 and 2 represent students in Parts 1 and 2, and “Total” represents the entire group of students. A, B, and C represent groups A, B, and C, “Self” denotes a self-study achievement test, and “Last” denotes a final achievement test².

A. Total Evaluation

The overall average scores per week for the self-study achievement test and the final achievement test are shown in Figs. 2 and 3³. As described in Section III-A, we divided students into Parts 1 and 2. Students in Part 2 were expected to have a lot of prior knowledge about the Java language as they had taken regular lessons in the first eight weeks given by Faculty β . This is considered to be the reason why students in Part 2 scored higher overall. The arrows in Figs. 2 and 3 mean that there is a difference in the average value at or above the 5% significance level in a t -test. We show the p -values of t -tests in Tables IV and V.

TABLE IV
 p -VALUES OF t -TESTS OF THE DATA IN FIG. 2

week	2	3	4	5	6	7	8
2017-Self	0.793	0.320	0.015*	0.121	0.000*	0.901	0.998
2018-Self	0.736	0.639	0.053	0.000*	0.009*	0.064	0.001*

*: $p < 0.05$ TABLE V
 p -VALUES OF t -TESTS OF THE DATA IN FIG. 3

week	2	3	4	5	6	7	8
2017-Last	0.035*	0.000*	0.001*	0.535	0.000*	0.048*	0.180
2018-Last	0.178	0.087	0.323	0.798	0.389	0.361	0.777

*: $p < 0.05$

²For example, “2017-1Total Self” represents the average self-study achievement test results for all students in Part 1 of 2017, and “2018-2A Last” represents the average final achievement test results for Group A students in Part 2 of 2018.

³For the first week, students were told to avoid self-studying in advance and were not subject to evaluation. The same applies to the subsequent graphs.

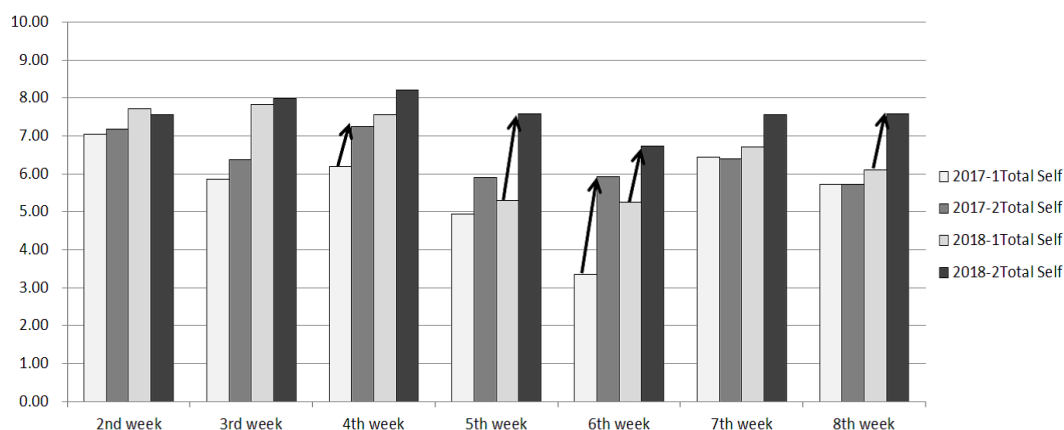


Fig. 2. Weekly Overall Average Scores in Self-Study Achievement Test

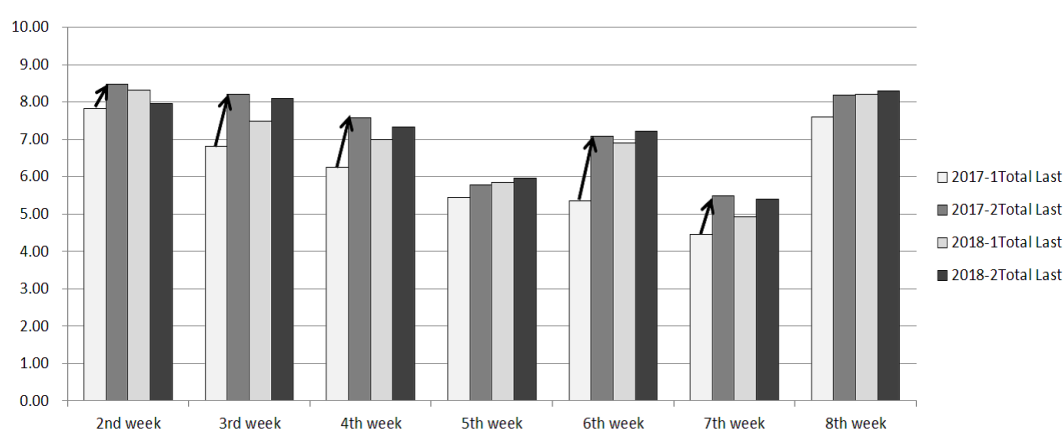


Fig. 3. Weekly Overall Average Scores in Final Achievement Test

B. Comparison by Group

Figures 4, 5, and 6 show the changes in the scores for the self-study achievement test and the final achievement test of the students in groups A, B, and C. Group A students attained high marks in the self-study achievement test, but their scores did not rise further in the final achievement test. However, students in Groups B and C clearly scored higher in the final achievement test than in the self-study achievement test. The arrows in Figs. 5 and 6 show the difference in the average value at or above the 5% significance level in the t -test. We show the p -values of t -tests in Tables VI and VII.

TABLE VI
 p -VALUES OF t -TESTS OF THE DATA IN FIG. 5

week	2	3	4	5	6	7	8
2017-1B	0.000*	0.002*	0.117	0.270	0.000*	0.422	0.067
2017-2B	0.000*	0.000*	0.001*	0.136	0.000*	0.047*	0.003*
2018-1B	0.003*	0.434	0.244	0.017*	0.005*	1.000	0.000*
2018-2B	0.000*	0.030*	0.068	0.191	0.000*	0.531	0.045*

*: $p < 0.05$

TABLE VII
 p -VALUES OF t -TESTS OF THE DATA IN FIG. 6

week	2	3	4	5	6	7	8
2017-1C	0.016*	0.008*	0.248	0.002*	0.000*	0.000*	0.000*
2017-2C	0.074	0.013*	0.000*	0.166	0.016*	0.271	0.000*
2018-1C	0.018*	0.069	0.000*	0.001*	0.000*	0.782	0.000*
2018-2C	0.159	0.022*	0.183	0.076	0.000*	0.391	0.000*

*: $p < 0.05$

C. Effect of Grouping in Face-to-Face Class

The results shown in this section are for 2017 only, as we could not conduct the control experiment in the second year. Figure 7 shows the final achievement test scores for Group A students in Parts 1 and 2. As mentioned in Section IV-A, students in Part 2 tended to have high scores overall. However, when we look at the weeks 5 and 7 (which were weeks 13 and 15 for students in Part 2) in Fig. 7, students in Part 2 have lower scores⁴. Weeks 5 and 7 are weeks in which lecture-style classes (week 5) and mixed ability grouping (week 7)

⁴There is no difference in the average value of the data in Fig. 7 at or above the 5% significance level in the t -test.

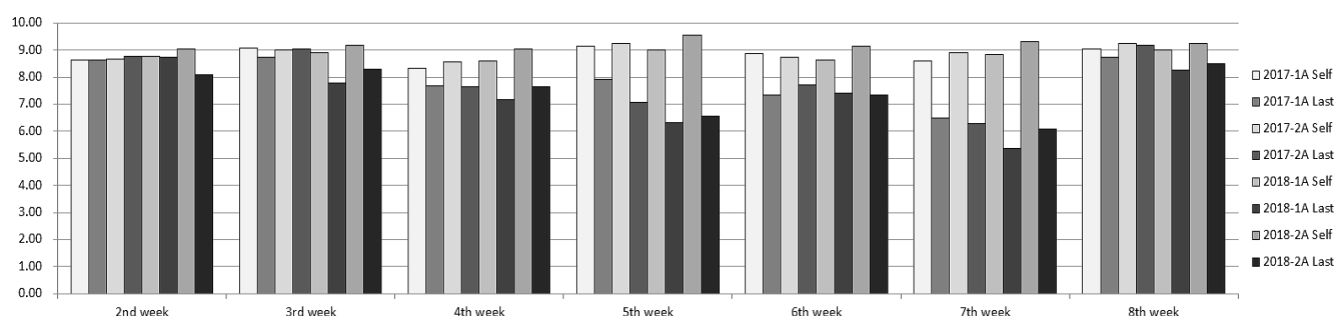


Fig. 4. Changes in Scores in Self-Study Achievement Test and Final Achievement Test for Group A

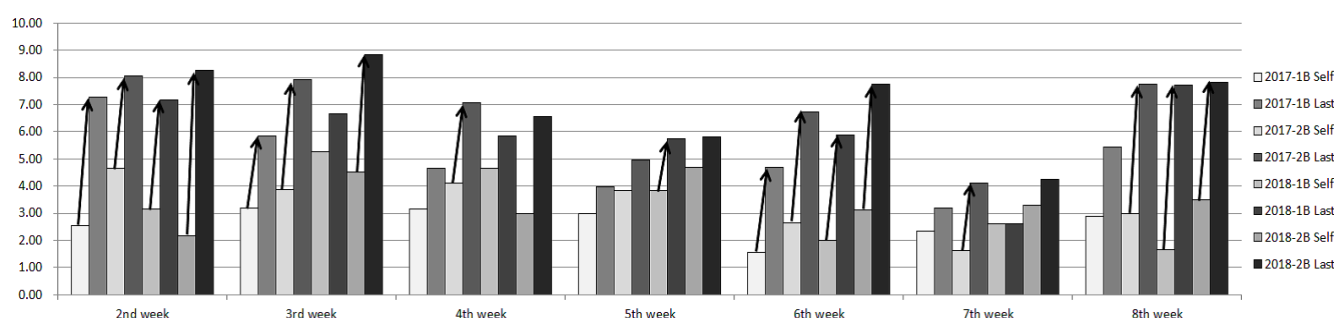


Fig. 5. Changes in Scores in Self-Study Achievement Test and Final Achievement Test for Group B

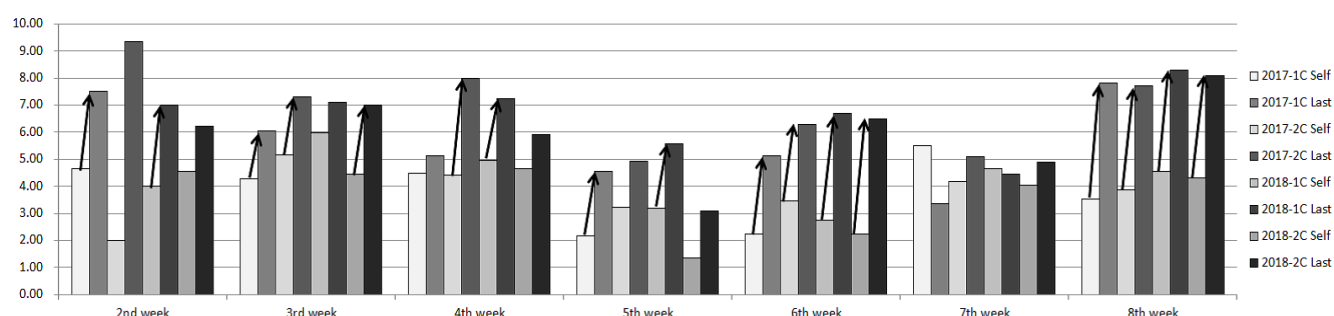


Fig. 6. Changes in Scores in Self-Study Achievement Test and Final Achievement Test for Group C

were conducted for students in Part 2, without offering face-to-face lessons using the proposed method. These results show the effectiveness of the proposed grouped flipped classroom method.

V. CONCLUSION

We applied our proposed grouped flipped classroom method to actual two-year classes for 16 weeks and evaluated its effectiveness. The results of the evaluation showed that the degree of comprehension in students with low level of understanding was significantly higher after the classes than before. We also showed that the grouped face-to-face lessons are more effective than the conventional face-to-face lessons. Some problems were highlighted such as cheating on self-study achievement test (e.g., by obtaining answers from other students) and difficulties in counting self-study time. We are planning to solve these problems while applying our proposed

flipped classroom method to actual classes in the next fiscal year (2020).

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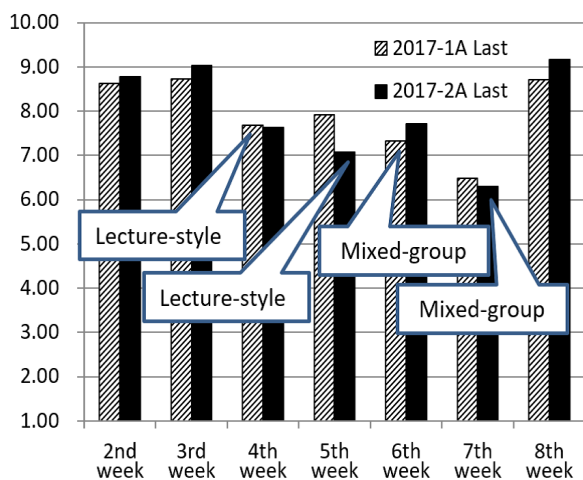


Fig. 7. Scores of Final Achievement Tests for Group A Students in Parts 1 and 2

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