Analysis of Relationship Between Preparation and Classroom Activities of Flipped Classroom Using Worksheets

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Abstract. In this research, we examine the relationship between learners' preparation for pre-class learning in flipped classrooms and their participation in class activities and deliverables in online flipped classrooms. In this research, worksheets were introduced into the online flipped classroom to record and analyze learners' learning logs. The analysis showed that in the early stages of the class, the amount of preparation for pre-class learning was found by many groups to contribute to a better assessment of class activities and artifacts. However, as the class progressed and students became more familiar with the class, the difference in the amount of pre-class learning preparation and the amount of class activities between the high and low-scoring groups disappeared, suggesting that there was a difference in the activities during the group work itself.

Keywords: Flipped Classroom · Pre-class Learning · Group Work · Learning Log · Worksheet

1 Introduction

In the field of education, several teaching formats are being utilized. One such format, the Flipped Classroom, has gained attention and garnered several practical reports in many educational settings [1,2]. The Flipped Classroom is a teaching format that switches the traditional roles of classes and homework. Students in a Flipped Classroom engage in pre-class learning, and then use class time to reinforce their knowledge through activities such as group work [3]. In Flipped Classrooms, designing lessons that connect pre-class learning to the in-class activities is important [4,5]. Therefore, pre-class learning is crucial for students to actively participate in class [6,7]. Students who do not have adequate pre-class learning will likely struggle to participate in meaningful in-class activities, such as group work [8]. However, it is uncertain whether students' pre-class learning behaviors align with the teacher's expectations, and if they

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lead to meaningful contributions to in-class activities and outcomes [9]. Limited research examines the relationship between the amount of preparation for pre-class learning and outcomes of class activities in flipped classrooms. Most studies focus on evaluating the effectiveness of the flipped classroom model or designing class activities [10]. Recently, the number of educational institutions offering online flipped classrooms has increased due to the impact of COVID-19. [11,12] It is crucial to examine the relationship between pre-class learning and classroom activities, not only in face-to-face flipped classrooms but also in online flipped classrooms.

In this research, we examine the relationship between learners' preparation for pre-class learning in flipped classrooms and their participation in class activities and deliverables in online flipped classrooms.

This research examines one research question for analysis.

– "Is the amount of preparation for pre-class learning a factor in the evaluation of group work and deliverables?"

2 Related Work

Related work that analyzed the relationship between pre-class learning, classroom activities and artifacts in flipped classrooms is reported.

2.1 Studies Analyzing the Relationship Between Pre-class Learning and Classroom Activities

Jovanovic et al. developed a framework for analyzing learners' pre-class learning efforts in flipped classrooms [13]. They implemented the proposed analytical framework in a flipped classroom with 290 participants and analyzed the learners' pre-class learning efforts on a weekly basis. they found a relationship between eight pre-class learning approaches and classroom activities.

Suzuki et al. analyzed learners' learning behavior in a class in which inversion and pair programming were introduce [14]. They conducted clustering and multiple regression analysis based on learners' learning logs that could be obtained in and out of class. As a result, they found clusters of learners with a deep understanding of the basic learning content and learning content through pre-class learning.

2.2 Studies Analyzing the Relationship Between Pre-class Learning and Class Performance

A study by Brian et al. analyzed the viewing logs of videos that learners engage in during pre-study, as well as their learning grades and class satisfaction [15]. They found that both higher- and lower-achieving learners watched the videos.

They also found that lower-achieving learners engaged in pre-class learning. On the other hand, it was shown that some learners tended to stop watching the video in pre-class learning as they did not feel the need to do so to achieve a high score on the test throughout the lesson sessions.

A study by Dooly et al. analyzed learning logs to understand learning behavior in flipped classrooms [16]. Analysis of each learner's learning history and performance showed that most learners also watched the pre-study videos before class and that the frequency of access increased on days when new online material was introduced and before exams compared to normal times. The study also shows that the earlier learners engage in pre-class learning, the better their learning performance.

3 Data Collection Methodology and Tools

3.1 Methodology

In most previous related studies Chapter 2 analyzed the relationship between pre-class learning in flipped classrooms, classroom activities, and artifacts based on learning logs recorded in a learning management system. In this research, we also take the approach of analyzing learners' learning logs that can be obtained in and out of the classroom, with reference to related studies. To obtain learning records, this study takes the unique approach of capturing the learning behavior activity itself, in addition to the learning records recorded in the learning management system. Here we present two approaches in this research.

3.2 Using Tools

Topic Writer. In this research, worksheets are introduced as a tool for pre-class learning and classroom activities. To realize this, we use a tool called "Topic Writer [17]". Topic Writer is a web-based application that presents worksheets and records students' editing actions. By incorporating this tool into pre-class learning and classroom activities, we can obtain a learning log of students' worksheet edits. Figure 1 provides an example of the Topic Writer screen. The green boxes in the figure highlight the areas where questions are written, while the orange boxes highlight the areas where answers are written. Please note that these color frames are not present on the original screen.

Rubric. In this research, we developed an original rubric as a measure for learners to evaluate the worksheet they submitted after completing the group work.

A rubric is "an index of evaluation consisting of numerical measures of success and descriptors of the characteristics of the perceptions and actions found in each measure [18]. The rubric developed in this research was developed by the first author based on discussions with class instructors and a reference book [19]. The classes covered in this research are described in the next sections, but because the worksheet questions to be addressed in each class session are different, a separate rubric was developed for each worksheet. An example of the rubric to be used is shown in Table 1. The rubric has five evaluation points with a three-point scale for each point. The maximum score is 25 points.

Table 1. Example of Topic Writer screen

evaluation point of view	Fulfilled (5 points each)	Partially fulfilled (3 points each)	Not met (1 point each)
Structure of the entire worksheet	The student correctly understands the intent of the questions and is able to answer all items correctly and clearly according to the format throughout the worksheet.	Correctly understands the intent of the questions and correctly answers at least half of the items in accordance with the format throughout the worksheet.	Not understanding the intent of the questions correctly and not answering the items on the half correctly according to the format throughout the worksheet.
sentence structure	The book contains research and specific explanations of data that provide evidence for what each item claims to be true. It also relates to the theme of the textbook chapter	The book contains generally specific explanations for what each item is trying to assert. It also relates to the theme of the textbook chapter	It clearly states what it wants to claim for each item, but does not explain more than half of the specifics. Also, there is no connection to the theme of the textbook chapter
Content 1	At least 3 specific opinions in each of the SWOT analysis items (Strengths, Weaknesses, Opportunities, and Threats)	Two specific opinions are written for each of the SWOT analysis (Strengths, Weaknesses, Opportunities, Threats).	Only one specific opinion was entered for each of the SWOT analysis items (Strengths, Weaknesses, Opportunities, and Threats)
Content 2	School A is able to write specifically in both sections about strategies to respond to threats by leveraging its strengths and strategies to capture opportunities for growth by overcoming its weaknesses, corresponding to the opinions entered in the SWOT analysis.	With regard to strategies to respond to threats by leveraging School A's strengths and strategies to capture opportunities for growth by overcoming its weaknesses, one or the other of the two items is specifically written to correspond with the opinions entered in the SWOT analysis.	Regarding strategies to respond to threats by leveraging School A's strengths and strategies to capture opportunities for growth by overcoming its weaknesses, the school failed to write strategies that correspond to the opinions entered in the SWOT analysis in either section (the school entered strategies that have nothing to do with what was entered in the SWOT analysis).
Content 3	The student is able to write specifically about strategies to avoid the worst case scenario, which is a multiplication of School A's weaknesses and threats, corresponding to the opinions entered in the SWOT analysis.	The students are generally able to write a specific strategy to avoid the worst-case scenario, which is a multiplication of School A's weaknesses and threats, corresponding to the opinions they have filled out in the SWOT analysis.	The strategy to avoid the worst-case scenario, which is a combination of School A's weaknesses and threats, does not correspond to the opinions entered in the SWOT analysis, and the strategy is not specific (the results of the SWOT analysis indicate a strategy that cannot be considered at all).

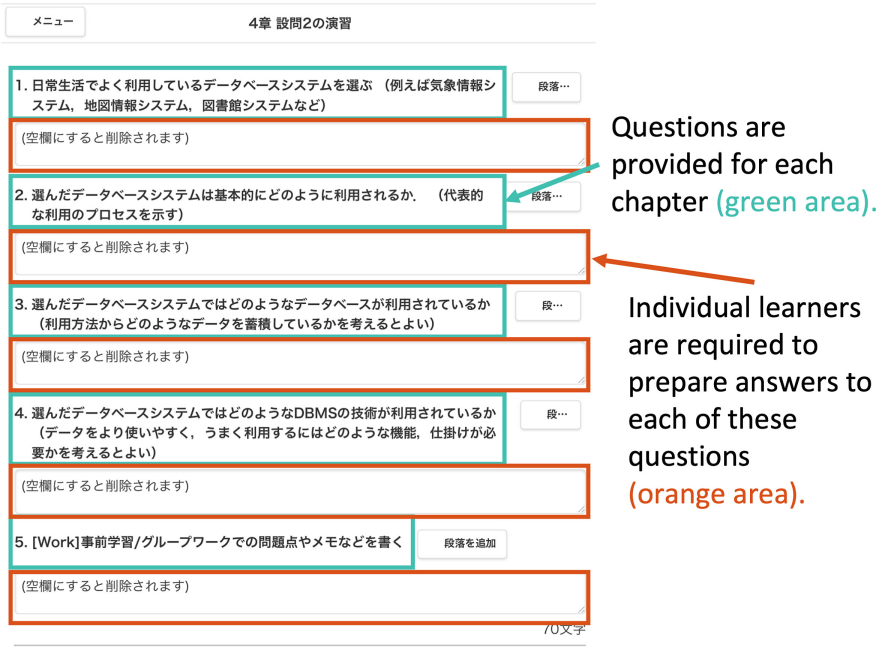

Fig. 1. Example of Topic Writer screen

4 Data Collection

This section describes the classes from which data will be collected for this research and the data that will be analyzed.

4.1 Subject Classes

The subject of this research is “Information Management,” a course for second-year undergraduate students offered at Future University Hakodate in the first semester of the 2021 academic year (AY). This class was flipped in AY 2019, and in AY 2021, due in part to COVID-19, the class was flipped online. Data were collected from 108 students enrolled in this class (some students may be absent depending on the class session). There was a total of 15 class sessions, 8 of which were in the form of preliminary study and group work. A summary of these eight class sessions is shown in Table 2. In this research, the three class sessions in Table 2 that took place between 5/12∼6/16, 2021, are included in the analysis. In Class 4 and 5, the same group members (hereafter referred to as the “first half group”) were used for group work, and in Class 6, the group members were replaced by new group members (hereafter referred to as the “second half group”).

Table 2. Summary of class sessions in which pre-class learning and group work were conducted

Class Schedule	Class Session	Student completing a course	Number of groups	Number of worksheet questions
4/7	Class1	110	30	nothing
4/14	Class2	110	30	7
4/28	Class3	110	30	6
5/12	Class4	106	28	5
5/26	Class5	108	28	12
Group member changing				
6/16	Class6	108	28	8
6/30	Class7	98	28	5
7/14	Class8	99	27	5

4.2 Subject Class Flow

The flow of the class ins shown below.

1. Pre-class learning
   Students are required to study the corresponding chapter of the textbook [20] and the questions for the group work exercises (designated questions) before the next class, using the class video and textbook. The pre-class learning worksheet presented in Topic Writer contains the same questions that will be discussed in the group work. Students are asked to write their opinions on a pre-class learning worksheet and submit it to the learning management system. After submitting the worksheet, students will take a comprehension quiz.
2. Textbook Description
   The teacher explains the content of the chapter in the textbook that the students have studied beforehand.
3. Group work
   Group work will take place in Zoom breakout sessions with 3–5 participants per group. In the group work, the content of the learning worksheet prepared in the pre-class learning is shared with the group. The class worksheet to be completed in class is the same content as the pre-class study worksheet. Each group shares their responses from the pre-class learning, discusses as a group, and completes a class worksheet presented in Topic Writer. Only in the class worksheet is there a space for each learner to write down what he/she answered in the pre-class learning worksheet.
4. Submission of class worksheets
   The representative of the group submits the class worksheet created by the group work to the learning management system.
5. Explanation of the next class and questionnaire
   The instructor then explains the next chapter and previous learning. After the explanation, the learner reflects and completes a questionnaire in the learning management system.

4.3 Data Collected

Of the student learning logs that can be obtained from this class, the data used in this study are shown in Table 3.

Table 3. Data for analysis obtained from the target classes

Pre-class learning	Class work (Group Work)	Output (Class worksheet)
Amount of text in pre-class learning worksheet	Edit count in class worksheet	Amount of text in class worksheet
Edit count in pre-class learning worksheet	Working time in class worksheet	Number of group conclusion opinions
Creation time in pre-class learning worksheet		Number of group memo opinions
		Rubric scores

5 Result and Discussion

Two analyses were conducted to validate the RQ established in Chapter 1.

1. Trend analysis of Output (class worksheet)
2. Analysis of the relationship between pre-class learning, class activities, and artifacts for the high and low-Scoring groups.

5.1 Trend Analysis of Output (Class Worksheet)

In this section, we analyzed how the group's scores trended over the class sessions analyzed the opinions described in the class worksheets and analyzed the correlation between the number of letters described in the class worksheets and the rubric score.

Analysis of Changes in Rubric Scores per Class Session. We examined changes in rubric scores for the entire group over the three lessons included in this study. Figure 2 shows the changes in the rubric scores.

The box plots in Fig. 2 show the distribution of overall rubric scores per class session. The average rubric score for each lesson is indicated by a green star. Figure 2 shows that the mean score increased from Class 4 to Class 5, while the mean score remained almost unchanged from Class 5 to Class 6. On the other hand, the box plots became smaller as each class session progressed, indicating that the overall score improved with each class session.

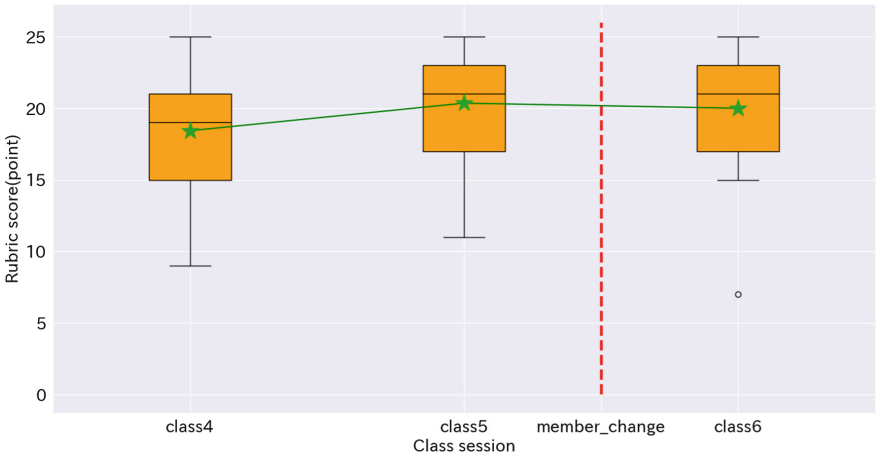

Fig. 2. Changes in the rubric score per class session

Analysis Between the Class Worksheet's Amount of Text and Rubric Score. We confirmed that the overall score trend improved with each class session. Next, we analyzed which class worksheets had the highest rubric scores. As mentioned in the target class in Sect. 4.2, the questions in the pre-class learning worksheet and the worksheet in the class worksheet are identical in content. Therefore, it was assumed that there are two types of opinions in class worksheet, as follows.

1. Opinions adopted from the group members' pre-class learning worksheets
2. New opinions that emerged during the group work

Therefore, we categorized each of the opinions written in the concluding part of the class worksheet one by one, and based on the results, we classified the class worksheet into the three types shown in the Table 4.

Table 4. Contents of three class worksheets categorized based on the type of opinion

WS type	Summary
WS type1	Worksheets where at least 70% of the class worksheet consists of input from the pre-class learning worksheet.
WS type2	Worksheets where at least 70% of the class worksheet consists of input from new opinions from group work.
WS type3	Worksheets containing about half of the opinions from the pre-class learning worksheet and half of the new opinions that emerged during the group work. (Worksheets other than WS type1 and WS type2)

Correlation Analysis of the Class Worksheet Amount of Text and Rubric Score. The relationship between the amount of writing on the class worksheet and the rubric scores was examined using Spearman's correlation analysis. The results of the correlation analysis of the three analyzed class times are shown in Fig. 2. As shown in Fig. 2, each chapter is visualized in a scatterplot. In the scatterplot, the shape of the points in each group is changed by the type of class worksheet in Table 4, described in Sect. 5.1.2. The vertical axis of the graph represents the amount of text on the class worksheet, and the horizontal axis represents the rubric score.

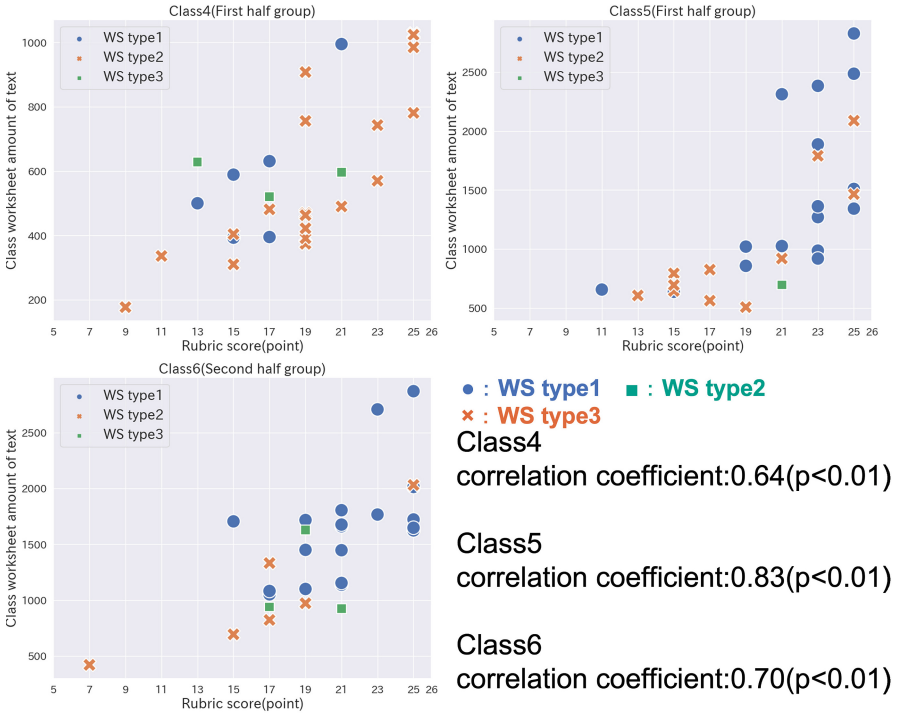

Fig. 3. Results of correlation analysis for each class times

Figure 3 shows that there was a strong positive correlation between the amount of text on the class worksheets and the rubric score for all the class sessions analyzed. As a consideration that led to this result, it can be assumed that each teacher and TA, when scoring the rubric, judged that the class worksheets with many words were well answered because they were able to describe many things, considering different things in response to each question.

Next, we focused on which type of worksheet was used most often in each class. The number of questions on the class worksheet and the type of class worksheet for each class session are shown in Table 5.

The results in Table 5 show that Class 4 is the majority group of WS Type 2 class worksheets, while Class 5 and Class 6 are the majority group of WS Type 1 worksheets. One possible explanation for this result is that the number of questions on the class worksheet may be related to the number of questions on the worksheet. Many questions on the class worksheet shortened the time available for group work to discuss each question, and we suspect that the discussion was more about discarding opinions that group members had prepared in advance of the class than about generating new opinions. However, since the WS type 2 group was in the minority in all the class sessions, it can be assumed that all groups wrote a certain number of pre-study opinions in the conclusion section of the class worksheet. The number of WS type 1 group increased in class 6 after the group member exchange than in class 5 before the exchange. This suggests that the second half of the group may have shared the efficient group work approach of the first half of the group.

Table 5. Number of class worksheet questions in each chapter and number of groups per type of class worksheet

	Class4 (First half group)	Class5 (First half group)	Class6 (Second half group)
Class worksheet Number of problems	5	12	9
WS type1	6	16	19
WS type2	3	1	3
WS type3	19	11	6

The results of the above analyses suggest that the tendency of groups with high rubric scores and pre-class learning influenced the opinions written on the class worksheet.

5.2 Analysis of the Relationship Between Pre-class Learning, Class Activities, and Artifacts for the High and Low-scoring Groups

The results in Sect. 5.1 suggest that pre-class learning has an impact on in-class activities and artifacts. Therefore, we focused on the high and low-scoring groups on the rubric evaluation for each class session and analyzed the similarities and differences in the amount of preparation for pre-class learning and the amount of activity in class. The groups analyzed for each class session are shown in Table 6 below.

Table 6. Groups to be analyzed per class session

Groups	Class4 (First half group)	Class5 (First half group)	Class6 (Second half group)
High score groups	6 groups (Score:23∼25)	6 groups (Score:25)	6 groups (Score:25)
Low score groups	8 groups (Score:∼15)	6 groups (Score:∼15)	6 groups (Score:∼15 +3 groups from 17scores)

We focused on the high and low-scoring groups in the rubric evaluation for each class session and analyzed the similarities and differences in the amount of preparation for pre-class learning and the amount of activity during class. The amount of preparation for the relational graph pre-class learning is defined as the amount of text on the pre-class learning worksheet. The amount of class activity is defined as the time spent working on the class worksheet, and since the number of members varied by group, we used a scaled value based on the following formula.

$$(ClassActivity) = \frac{\text{Total time on class worksheets for group members(s)}}{\text{Number of group members} \times 300(s)} \quad (1)$$

Figures 4 and 5 show the relationship graphs between Class 4 and Class 5, respectively, worked on by the first half of the group. The horizontal axis of each figure shows the amount of text on the pre-class learning worksheet, which is the amount of preparation for the pre-class learning. The vertical axis shows the amount of time spent working on the class worksheet, which is the amount of class activity. The box plots show the amount of text on each group's pre-class learning worksheet. The box plots are shown as blue for higher rubric scores and red for lower rubric scores. In terms of the relationship graph, the more the box plot is positioned to the right, the more the group belongs to learners who have a greater amount of pre-class learning preparation. The higher the box plot is positioned, the more likely it is that more than one person is manipulating the class worksheet, or that the class worksheet is being manipulated continuously over a long period of time. However, the scale of the diagram of the relationship graph depends on the number of questions on the class worksheet, so the scale differs from class session to class session. The following can be observed in Figs. 4 and 5.

A) Regardless of the rubric score, groups with long box plots were found in both class sessions.
B) Red box plots with lower rubric scores are more likely to cluster closer to the origin, while blue box plots with higher scores are more likely to be located farther from the origin.
C) In both class sessions, there is a high-scoring group (a group in which all group members have less preparation for learning before class but more activity in class) in the upper left corner of the graph.
D) In both class sessions, there is a high-scoring group (a few group members belong to the group with a high amount of pre-class learning but a low amount of class activity) in the lower right corner of the graph.

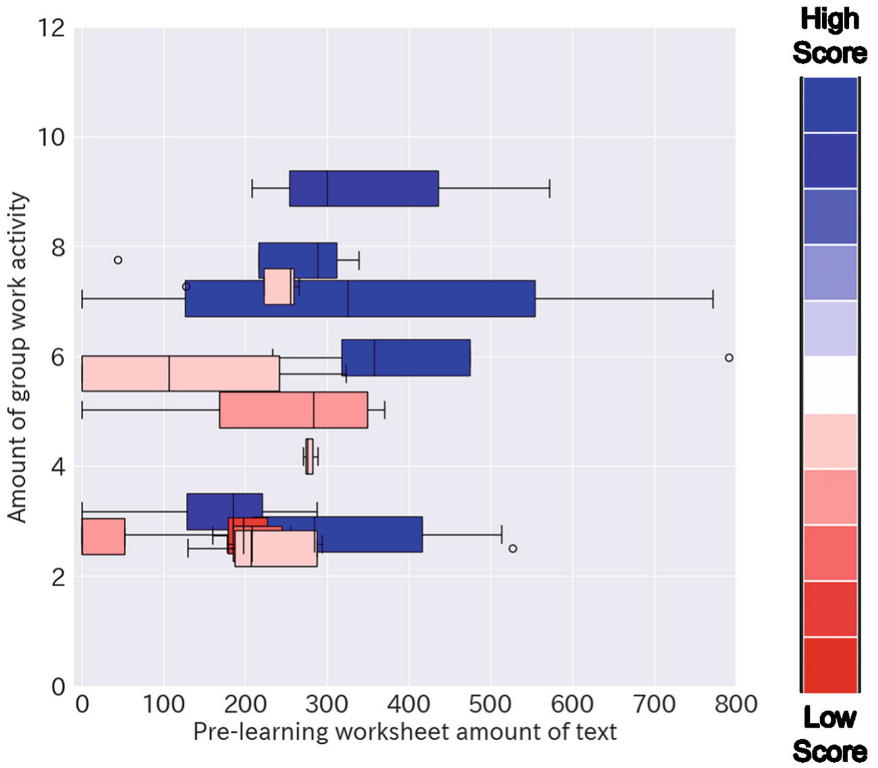

Fig. 4. Graph of Relationship between Amount of Preparation for Prior Learning and Amount of Classroom Activities for Class4(Second Half Group)

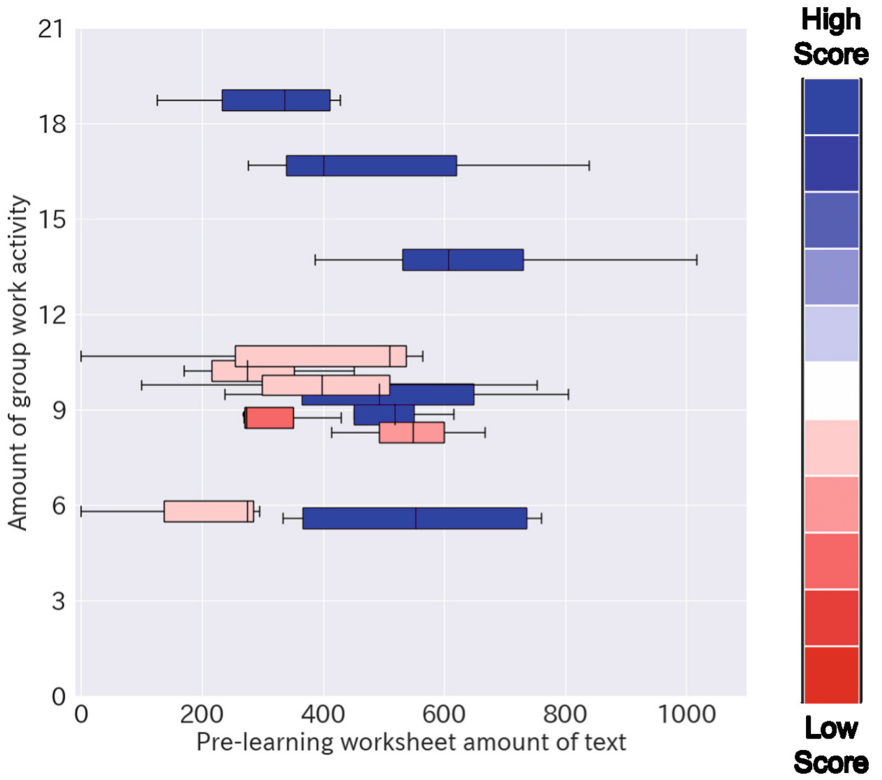

Fig. 5. Graph of Relationship between Amount of Preparation for Prior Learning and Amount of Classroom Activities for Class5(First Half Group)

The results in A suggest that the amount of preparation for pre-class learning is not uniform among the members of each group and that there is a mix of learners who prepare well and those who do not.

To check the results of B in detail, we summarize the means of the characteristics shown in Table 7 of pre-class learning, amount of activity during group work, and class WS of the learners in the high and low-scoring groups. Tables 8 and 9 summarize the means for Class 4 and Class 5, respectively. Tables 8 and 9 show that in both class sessions, students in the high rubric score group prepared more in advance and engaged in more in-class activities than students in the low rubric score group. It was also found that the class worksheets reflected many of the opinions on pre-class learning. This suggests that if members are poorly prepared for pre-class learning, they are likely to engage in fewer class activities and produce poorer artifacts.

The results of C and D revealed the existence of several unexpected groups, such as a group that actively participates in class activities even when pre-class learning is insufficient, and a group that does not discuss the topic again in class but engages in minimal activities because of pre-class learning enough.

Table 7. Correspondence table between labels and label meanings used in Tables 8, 9, and 10

Process	Label	Summary
Pre-class learning	a-1	Amount of text in pre-class learning worksheet(characters)
	a-2	Edit count in pre-class learning worksheet (times)
	a-3	Creation time in pre-class learning worksheet
Class activity (Group work)	b-1	Edit count in class worksheet (times)
	b-2	Working time in class worksheet
Output (Class worksheet)	c-1	Number of pre-class learning worksheet opinions adopted into the class worksheet(opinions)
	c-2	Number of opinions on the pre-class learning worksheet that were not adopted by the class worksheet(opinions)

Table 8. Class4 Comparison of feature averages for learners in high and low-scoring groups

Class4	a-1	a-2	a-3	b-1	b-2	c-1	c-2
Average of learners in the high scoring group	303	10	0:26:06	38	0:29:44	3.1	5.0
Average of learners in the low scoring group	200	7	0:32:32	30	0:22:09	1.5	3.1

Next, the relationship graph for the latter group, Class 6, is shown in Fig. 6. From the results in Fig. 6, the following can be read.

Table 9. Class5 Comparison of feature averages for learners in high and low-scoring groups

Class5	a-1	a-2	a-3	b-1	b-2	c-1	c-2
Average of learners in the high scoring group	501	30	1:43:03	76	1:00:26	14.9	11.0
Average of learners in the low scoring group	362	22	1:08:22	104	0:44:57	6.7	16.9

A) As in the first half of the group, the amount of preparation for pre-class learning varied considerably among group members, regardless of their rubric scores.
B) Compared to the first half of the group, the overall amount of preparation for learning before class tends to increase, as indicated by the larger values on the horizontal axis of the graph.
C) Regardless of the rubric rating, all the box plots fall near the center, and although there is a large difference in the rubric rating, there is no longer a large difference in the amount of preparation for pre-class learning or in-class activities.

The results in A suggest that even if the group members change, some learners in the group will be serious about pre-class learning while others will not.

Regardless of the rubric rating, all box plots are located near the center, and although there is a large difference in the rubric rating, there is no longer a large difference in the amount of preparation for pre-class learning or in-class activities.

To confirm the results of C, Table 10 summarizes the respective averages of the amount of preparation for pre-class learning, the amount of activity during group work, and the number of pre-class opinions reflected in the class worksheet for learners in the high and low-scoring groups in Class 6. Table 10 shows that learners in the low-scoring group showed more preparation for pre-class learning in some areas than those in the high-scoring group, and the amount of classroom activities was also higher in the low-scoring group. This suggests that as the class progressed and the group members changed, the first half of the group shared their approach and there was no significant difference in the amount of preparation for pre-class learning or class activities in any of the groups. On the other hand, the number of opinions adopted in the class worksheets was higher in the high-scoring group, suggesting that there were differences in online discussions and efforts other than working on the class worksheets that were excluded from the analysis in this study, and that these differences may have led to differences in rubric scoring.

5.3 Research Question Validation Summary

A summary of the results of the analysis in Sects. 5.1 and 5.2 is given below.

- The result suggest that pre-class learning has an impact on classroom activities and deliverables.
- At the beginning of the course, it was found that the group of learners with a high level of pre-learning preparation had a higher number of class activities and that several groups contributed to higher rubric scores for the outputs.
- It was found that in some groups, the amount of pre-class learning preparation did not contribute in a positive way in several groups.
- Although the amount of preparation for pre-class learning tended to increase overall as class sessions progressed and members were replaced, there was

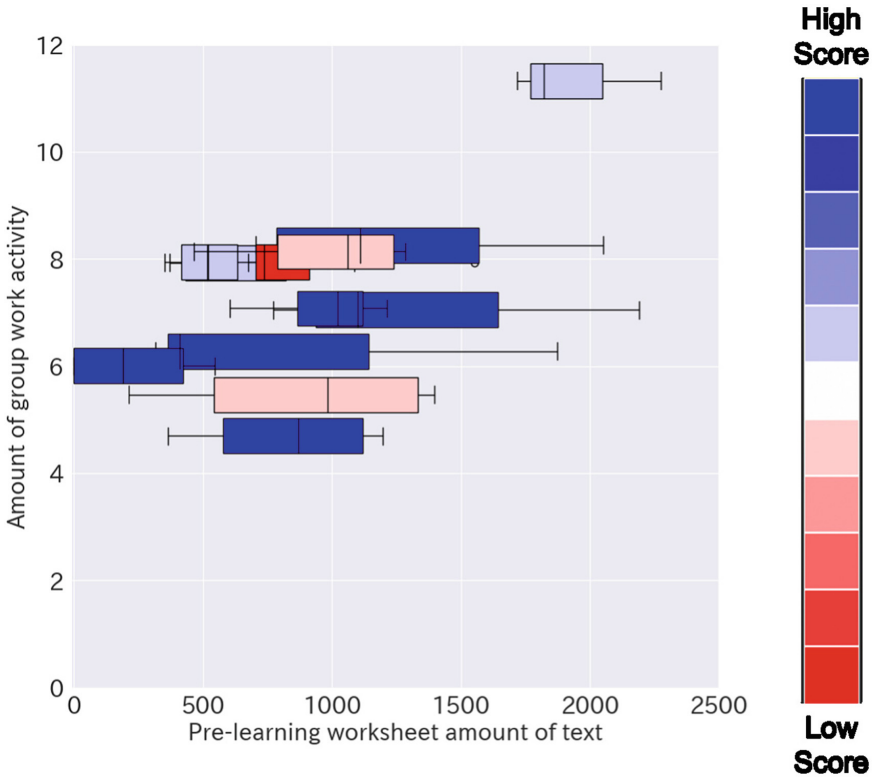

Fig. 6. Graph of Relationship between Amount of Preparation for Prior Learning and Amount of Classroom Activities for Class6 (Second Half Group)

Table 10. Class6 Comparison of feature averages for learners in high and low-scoring groups

Class6	a-1	a-2	a-3	b-1	b-2	c-1	c-2
Average of learners in the high scoring group	897	33	1:29:14	30	0:32:47	12.9	16.0
Average of learners in the low scoring group	1090	33	1:26:50	51	0:37:30	7.9	21.3

no significant difference between the amount of pre-class learning and the amount of class activities, despite the differences in rubric scores.

Based on the above findings, the research question posed in this study was, "Is the amount of preparation for pre-class learning a factor in the evaluation of group work and deliverables?" The answer to this question is presented below. In the early stages of the class, both the high and low-scoring groups were applicable, but as the class progressed and members were replaced, the number of inapplicable groups increased due to differences in effort in class activities rather than pre-class learning.

6 Conclusion

In this research, we analyzed the relationship between learners' preparation for pre-class learning, class activities, and artifacts from learning logs collected during the class in an online flipped classroom. The analysis included an analysis of the relationship between pre-class learning, class activities, and artifacts, focusing on groups with high and low artifact evaluation scores, and trend analysis of artifacts for three class sessions.

The results of the analysis suggested that pre-class learning had an impact on class activities and artifacts, as a certain number of opinions prepared through pre-class learning were described in the artifacts. In the class sessions that were addressed early in the course, the groups that did not adequately prepare for pre-class learning also had lower-class activity and inadequate artifacts. Conversely, several groups that had sufficient pre-class learning contributed to more active classroom activities and higher artifact scores. On the other hand, some groups did not do pre-class learning enough in advance but were able to make up for it in class activities, and others prepared well in advance and did minimal activities in class. While the amount of preparation for pre-class study tended to increase as students became more familiar with the course, there was no longer a significant difference in the amount of preparation for pre-class study or class activities between the low-scoring and high-scoring groups. Because these results are from only one example of an online flipped classroom with worksheets, the results from this analysis do not necessarily apply to other flipped classes. However, it is very interesting to note that in the early stages of the class, pre-class learning does have an impact on class activities and artifacts and that the contribution of pre-class learning varies from group to group.

On the other hand, there are some limitations in this study.

First, it is necessary to obtain data on online discussions and approaches that were not included in this analysis. Although the cost of analyzing the discussions would be higher, we believe that a more detailed analysis of the discussions would reveal differences in classroom activities that could not be revealed in this research.

Second, it is necessary to clarify the effect of learner affiliation, which was not fully analyzed in this research. We believe that if we can clarify what kind of preparation learners have done during group work influences the group, it will lead to the identification of those who need help during the pre-class learning phase.

Finally, the relationship between pre-class learning, class activities, and artifacts needs to be analyzed in more detail by analyzing learners' tendencies not only over the three class sessions but over the entire class period.

We would like to address these limitations and further investigate the relationship between pre-class learning and classroom activities in online flipped classrooms.

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