Comparison between flipped classroom and team-based learning in a prosthodontic class at Tokushima University

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Abstract

Background: Active learning is a concept that allows students to study and learn actively by themselves to get knowledge. There are several methods of active learning, including flipped classroom (FC) and team-based learning (TBL). In FC, students are required to study before classes. In TBL, students study before the class, take the Individual Readiness Assurance Test (IRAT) and Group Readiness Assurance Test (GRAT), and then discuss Group Assignment Projects (GAPs) during class. The purpose of this study was to compare the effectiveness between FC and TBL using longitudinal term-end examination data.

Methods: Flipped classroom and TBL effectiveness was assessed from the results of the term-end examinations at the end of the semester from 2014 to 2017. The students were asked to answer questions on the favorable and unfavorable responses of FC and TBL. To check the difficulty of the term-end examinations, control dentists took the same examinations. The dentists were clinical prosthodontic residents who graduated within 3 years from undergraduate course. All prosthodontic residents attended the referential examinations.

Results: The term-end examination score of FC and TBL did not show a statistical difference. Multi-way ANOVA showed that the referential examination scores by the dentists were significantly higher than that of the students ($P < 0.0001$). According to the students, the favorable responses of FC and TBL were on the study habit and the video contents, while the unfavorable responses were mainly on the study materials.

Conclusions: There is no statistical difference between FC and TBL on term-end examination scores. There were no interactions between the test period and the participants (students or dentists), and the test period and class format.

Background

Active learning is a concept that allows students to study and learn actively by themselves to get knowledge. There are several methods of the active learning [1-16] including flipped classroom (FC) and team-based learning (TBL). In FC, students are required to study before their classes and take their examinations after the pre-class study, then the students attend the class [3, 17-20]. The teachers give some task to the students in the class of the FC (feedback lecture, question and answer time or examinations again, etc.). Recently, personal computers or electric devices have become popular, and the study materials used before classes are mostly electronic slides or videos [1, 4-6, 12].

Team based learning is a modified style of FC [21]. Students study before classes, and the students take Individual Readiness Assurance Test (IRAT) and Group Readiness Assurance Test (GRAT), then discuss Group Assignment Projects (GAPs) in class [7, 8, 10, 11, 13-16]. Students studied the study material before the class and at the beginning of the class, each of them took the IRAT, which has multiple-choice questions, to check their preparation level. The students were then divided into small groups, each group discussed the study material, and each group took the GRAT, which had the same

questions as the IRAT. We started TBL in prosthodontic classes in 2013. We reported that TBL is an effective method for student learning [13-16] and the term-end examination results of TBL classes were significantly higher than those of the traditional lecture classes [13].

The purpose of this study was to compare the effectiveness between FC and TBL using longitudinal term-end examination data. We have reported the one semester results on the effectiveness between FC and TBL [16] and found that the term-end examination results showed that TBL classes had slightly higher scores than FC without statistical significance. However, one semester result was not enough to evaluate the comparison, because there were several factors for the results (examination difficulty, student favorite for study topic, student – teacher relationships etc.). In the current study, we gathered data for several years and analyzed the longitudinal data. Also, a previous study reported that video teaching showed slightly better results on the student skill [2] and we compared the effect with video.

Methods

This study was approved by the Tokushima University Hospital Clinical Research Ethics Committee (No. 1893). Tokushima University School of Dentistry has six-year Doctor of Dental Surgery (DDS) program. Tokushima University has two semesters, and one semester has 15 classes. One class duration is 60 minutes. From 2014 to 2017, two types of active learning (FC and TBL) were introduced in fixed prosthodontic classes (latter half semester of 3rd-year and first half semester of 4th-year dental school students). The 3rd- and 4th-year students are pre-clinical students and they studied prosthodontic from the latter half semester of 3rd year. In the 15-class series, seven classes in the first half were FC using e-learning (Tokushima Learning Management System (LMS); Moodle (http://Moodle.org/)), one special lecture was held, and seven classes in the second half were TBL classes. The same students took both FC and TBL classes. The special lecture was done by a visiting teacher from another university and it was the typical passive-learning lecture style.

Fig. 1 shows the framework of FC and TBL. Regarding FC, the students were required to study the topic with the study materials and to answer the pre-class examinations through e-learning. The students could access the system through their personal computers or smartphones. The students were required to answer five questions in each pre-class study. However, they did not know the correct answers until they attended

the actual classes. The students took the pre-class examinations between seven days and one day before the class. Before the class, the teacher reviewed each student's score, and the system calculated the percentage of correct answers for each question. The teachers could know who answered the questions correctly. In the class, the teacher gave feedback lecture to the students and accepted questions from students. In 2016, we started to show a video to the students as a pre-class study material. Because a previous study reported that video teaching showed slightly better results on student skills [2]. The video used PowerPoint slide show with the teacher's narration about the class topic. The video was around 10-15 minutes.

The TBL format was described in our previous report [13-16]. Briefly, the students were given a printed handout for their home study, one week before each TBL class. At the beginning of the TBL class, the students took an IRAT with multiple-choice questions to check their preparation level. The students were then divided into small groups with five to seven members, and each group took the GRAT after the group discussion, which had the same questions as the IRAT. Group Readiness Assurance Test questions were answered with a scratch-off answer sheet. The students enjoyed scratching off the sheet to have the correct answer and concentrated to have correct answer with the team members. When the students had correct answer in the first scratch off, they had 10 points. When the students had wrong answer at first and correct answer in the second time, they had 5 points. When the students had wrong answer twice, they did not get any point. Following teacher feedback on the IRAT and GRAT, the students worked for GAPs, which involved practical clinical questions. Each group showed the answers using number boards. Finally, the students were evaluated by the other students on their performance in peer evaluation (Fig. 1).

The students studied in FC and TBL, and these study contents were the same as previous traditional study contents. Flipped classroom and TBL effectiveness was assessed from the results of the term-end examinations. Multiple-choice questions were answered by the students and the questions contained FC and TBL study topics. The term-end examination questions were not same as IRAT, GRAT or GAPs. Since we did not know the

difficulty of examination questions, a referential examination with the same questions was given to dentists who did not make the term-end examinations. The dentists were clinical prosthodontic residents who graduated within 3 years from undergraduate course. All prosthodontic residents attended the referential examinations. To investigate the learning effects of the class format (FC and TBL), the results of the term-end examinations, which adopted multiple-choice questions from the Japanese National Board examination, were calculated (289 students). Also, to check the degree of difficulty of the term-end examinations, dentists (64 members) who were not involved in the preparation of the term-end examination questions took the same examinations (Table 1). The students were asked to answer the questions “What do you think about the advantages of flipped classroom and team-based learning?” and “What do you think about the disadvantages of flipped classroom and team-based learning?” at the end of the classes.

Table 1: Participant numbers

	Students		Dentists	
	Male	Female	Male	Female
2107 3rd	23	20	5	5
2017 4th	24	15	4	5
2016 3rd	26	17	4	6
2016 4th	19	18	3	5
2015 3rd	23	20	5	4
2015 4th	15	28	5	5
2014 3rd	13	28	5	3

The dentists were clinical prosthodontic residents who graduated from undergraduate course within 3 years. The students entered University 18 years old in Japan usually.

Multi-way ANOVA was performed to check the effectiveness of FC and TBL and participant type (students and dentists). To determine the effect of the video in the pre-class study introduced in 2016, we compared the correct answer rate of the term-end examination before 2015 and after 2016 with t-test. EZR was used for all statistical analysis. EZR is a statistical software that extends the functions of R and R Commander

and is distributed free of charge on the homepage of Saitama Medical Center or Jichi Medical University. Statistical significance was accepted at $p < 0.05$.

Results

FC and TBL effectiveness on term-end examination in each year

Table 2 shows the correct answer rate of each term-end examination. Each examination showed a different score. The term-end examination score of FC and TBL did not show a statistical difference ($P = 0.389$). As a result of multi-way ANOVA, the referential examination scores obtained by the graduated dentists were significantly higher than that of the students ($P < 0.0001$). The 3rd-year students in 2015 and 4th-year students in 2016 were the same, and this group showed a higher score than the other student groups although there were no statistical differences.

Table 2: Term-end examination score

		Term-end exam	Referential exam
2017 3rd	FC	58.1 ± 24.8	76.4 ± 27.2
	TBL	71.2 ± 25.5	75.2 ± 26.8
2017 4th	FC	61.5 ± 26.5	80.8 ± 19.8
	TBL	59.3 ± 26.0	81.3 ± 22.3
2016 3rd	FC	60.3 ± 24.2	69.1 ± 28.7
	TBL	58.7 ± 21.2	72.1 ± 27.5
2016 4th	FC	77.9 ± 24.2	81.3 ± 24.6
	TBL	73.3 ± 20.5	85.4 ± 16.2
2015 3rd	FC	73.7 ± 17.1	67.1 ± 27.7
	TBL	67.3 ± 26.1	77.8 ± 23.9
2015 4th	FC	58.0 ± 24.8	71.2 ± 29.9
	TBL	61.3 ± 28.5	64.3 ± 28.1
2014 3rd	FC	64.8 ± 18.6	66.8 ± 28.4
	TBL	70.1 ± 29.5	73.4 ± 26.1

Data are presented as mean ± SD. Referential examination was taken by dentists who did not make term-end examinations. Multi-way ANOVA showed that there was a statistical difference on participants (students and dentists) and no difference between FC and TBL. FC: flipped classroom, TBL: team-based learning, 3rd: 3rd-year students, 4th: 4th-year students.

Total comparison between FC and TBL effectiveness

There was no statistical difference between FC and TBL effectiveness in the total sample (P = 0.727) (Table 3). The multi-way ANOVA showed that there was no interaction between the test period (test semester) and the participants (students or dentists). There was also no interaction between test period (test semester) and class format (FC or TBL). There was statistical difference between student score and dentist referential examination score (P = 0.0001) (Table 4).

Table 3: Total term-end examination score

	Term-end exam	Referential exam
FC	67.0 ± 23.1	71.4 ± 27.9
TBL	65.8 ± 25.7	74.1 ± 25.5

Data are presented as mean ± SD. Referential examination was taken by dentists who did not make term-end examinations. Multi-way ANOVA showed that there was statistical difference on examination period, and no difference on participants and between FC and TBL. FC: flipped classroom, TBL: team-based learning.

Table 4: Multi-way ANOVA results

Source	Sum of Squares	df	F	P
Intercept	315.568	1	4971.390	< 0.001
Period	1.409	6	3.699	0.001
Participant	1.328	1	20.916	< 0.001
Class	0.047	1	0.743	0.388
Period * Participant	0.536	6	1.408	0.209
Period * Class	0.14	6	0.368	0.898
Participant * Class	0.008	1	0.121	0.727
Period * Participant * Class	0.407	6	1.068	0.380

Period: Examination period, Class: class format (FC or TBL), Participant: student or dentist

Factors for FC effectiveness

We compared the effectiveness of FC study material with video (after 2016) and without video (before 2016) and found that there was no statistical difference between with and without video in FC (P = 0.888) (Table 5).

Table 5: Term-end examination score with and without video in study materials in flipped classroom

	Term-end exam
With video	64.7 ± 25.8
Without video	65.3 ± 21.3

Data are presented as mean ± SD. T-test showed no difference between with and without video for the end-term examination.

Student comments

Regarding the student comments on FC and TBL, favorable responses of study habit were “I have habit of preparation study.” or “I did preparation to the class because of examination.” and video contents “Pre-classroom video was helpful to study.” or “The video was effective to understand the study material.”. Regarding the student comments on FC, unfavorable responses of study materials were “I wanted to have paper study material at least one week before the class.” or “Study material should cover the examination contents.” (Table 6).

Table 6: Favorable responses and unfavorable responses of flipped classroom and team-based learning

Positive responses (What do you think about the advantages of flipped classroom and team-based learning?)
I have habit of preparation study.

I did preparation to the class because of examination.

I could do preparation because we knew the classroom contents.

I could understand the classroom contents because we needed to do the preparation.

Pre-classroom video was compact.

Pre-classroom video was helpful to study.

The video was effective to understand the study material.

Negative responses (What do you think about the disadvantages of flipped classroom and team-based learning?)

I wanted to have paper study material at least one week before the class.

Study material should cover the examination contents.

Pre-class video and classroom contents were sometimes same.

The deadline of the pre-examination should be just before the class.

Prosthodontic is difficult part for the students and the class was difficult.

The study materials were too much and I could understand the important point.

Discussion

Previous studies reported that TBL classes improved student diagnostic skills and student's critical analytic ability [8], National Board Examination results [10] and course grades on removable denture prosthesis [11]. According to our previous report [13], the average correct answer rate of TBL class showed higher term-end examination score than the regular class that teachers give the ordinary lectures. This current study and previous studies showed that active learning class (FC and TBL) is effective for student education [13-16, 20].

There was no statistical difference between FC and TBL on term-end examination scores on each year (Table 2) or combined data (Table 3). There was no interaction between the test period and the participants; and the test period and class format (Table 4). Both class types (FC and TBL) are more likely to be effective than regular classes because our previous study showed that the average correct answer rate of TBL class showed higher term-end examination score than that of the regular class that teachers

give the traditional lectures [13]. We consider that students can learn how to study by themselves in the active learnings (FC or TBL) [3, 7, 8, 10, 11, 13-19] and the difference between FC and TBL may not be big on the term-end examination score. We also have study limitation and we do not know the reason why there was no difference between FC and TBL. We need to conduct more research regarding the reasons why FC and TBL are effective. We also need to study the long term effects of active learning.

The term-end examination correct answer rate was significantly different in comparison with the time of the trial and for the participants. We consider that one of the reasons is that we made different questions every year, and the difficulty of the examinations are different. When the student score was low, the referential examination score by dentists also had low score. Also, the referential examination scores by the dentists were significantly higher than the students. The dentists had more experiences in clinical situations and might have been able to answer the examinations correctly.

We compared the effectiveness of FC study material with video (after 2017) and without video (before 2016) and found that there is no statistical difference. In 2016, we introduced a video with narration as a pre-class study material, but in our case, there was no difference between with and without video in terms of the correct answer rate for the term-end examination. A previous study reported that there was no significant difference between the types of auxiliary (with and without video) [2] although the previous study and our current study showed that the students liked the video in the study material [22]. Our students' answers to the questions regarding the favorable responses of FC and TBL showed that the students liked the video. Chen et al. also reported that generally, video teaching and lecturing were equally effective, with video achieving slightly better results [2]. Based on the previous studies and our current study, the video in FC pre-class may not have a very strong impact than slides, but the students liked the video in the study materials.

The students' comments on the favorable responses of FC are that they could learn good study habits and the video contents were good. The students' comments on the unfavorable responses of FC are mainly on study materials. The student' comments showed that the effect of class preparation might improve their study habits through active learning.

Conclusions

There is no statistical difference between FC and TBL on term-end examination scores for each year and the combined data. There was no interaction between the test period and the participants (students or dentists), and the test period and class format.

Abbreviations

FC: flipped classroom

TBL: team-based learning

IRAT: Individual Readiness Assurance Test

GRAT: Group Readiness Assurance Test

GAP: Group Assignment Project

LMS: Learning Management System

ANOVA: Analysis of variance

Declarations

Ethics approval and consent to participate: Blinded processing of information ensured the anonymity of participation. Participation in this questionnaire was voluntary. In obtaining consent, the person in charge of the research explained the contents of the research. The consent was given verbally and was also considered given if they answered the questionnaire. No medical information was collected and no medical intervention was performed. This study, including the consent method, was approved by the Tokushima University Hospital Clinical Research Ethics Committee (No. 1893).

Consent for publication: Not applicable.

Availability of data and materials: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Figures

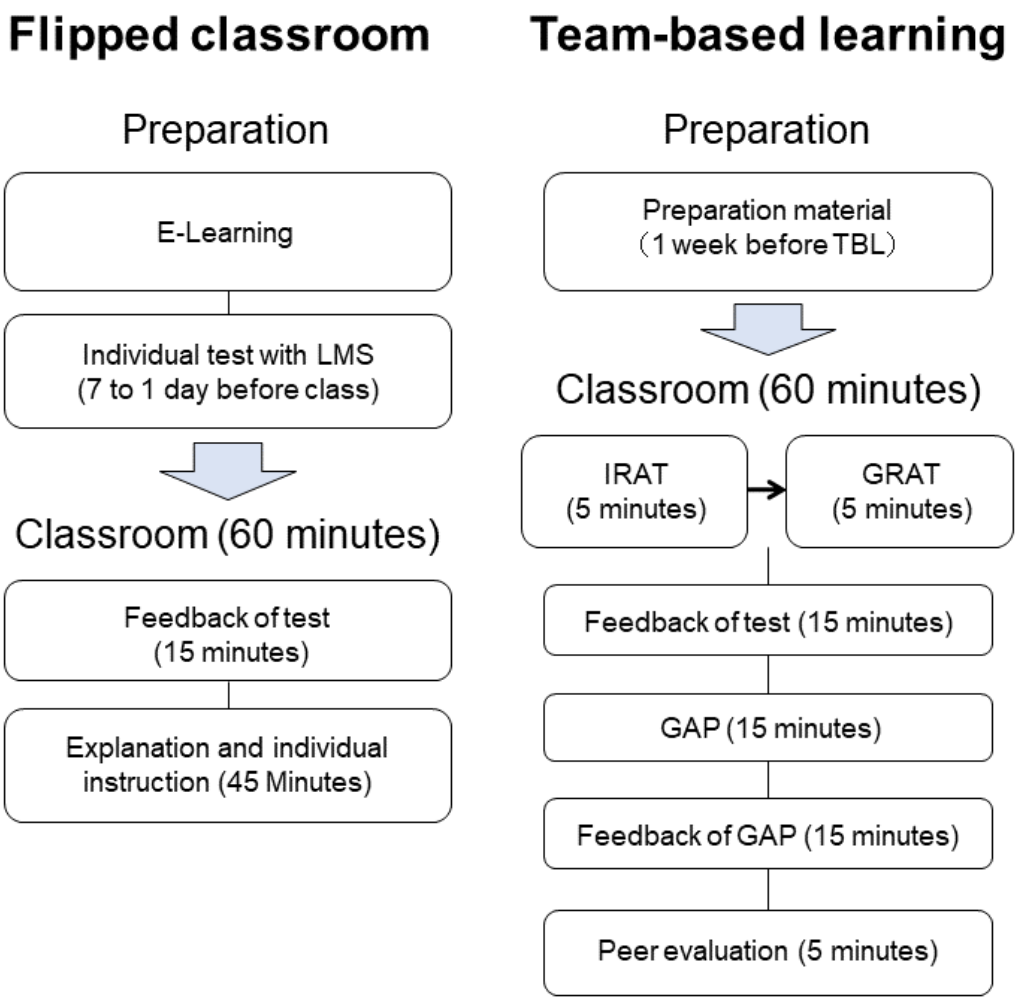

Fig. 1

Figure 1

Flipped classroom and team-based learning formats. Both class formats have two-steps; preparations for the classes and classes. For the preparations, FC used the e-learning system, and TBL used printed handouts for the teaching materials. In the FC, the students received the feedback of the individual tests and the explanation of the teaching materials. In TBL, the students took IRAT and GRAT, then performed

group works (GAP). LMS: Learning Management System, Tokushima University, IRAT: Individual Readiness Assurance Test, GRAT: Group Readiness Assurance Test, GAP: Group Assignment Project.