

Comparison between flipped classroom and team-based learning in fixed prosthodontic education

Original article

Abbreviated title

Comparison between flipped classroom and team-based learning

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Keywords

flipped classroom; team-based learning; dental education; prosthodontics; educational methodology

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1 **Abstract**
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4 Purpose: We previously investigated the effects of team-based learning (TBL) on fixed
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7 prosthodontic education and reported that TBL could have higher efficiency with high student
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10 satisfaction than traditional lecture. In the current report, we introduced flipped classroom to
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13 the fixed prosthodontic education and compared their effectiveness based on the final
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16 examination score in addition to TBL.
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20 Methods: Participants were forty-one students from XXXXXX University School of Dentistry
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23 who attended a fixed prosthodontics course. The first six classes adopted the flipped classroom
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26 style while the latter eight classes adopted TBL. To evaluate the relationship between learning
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29 styles and their effectiveness, we compared results from the term-end examination between the
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32 curriculum covered by flipped classroom and TBL-style classes. To draw comparisons, a
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35 referential examination with the same questions was conducted to eight faculty members who
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38 had not attended any of these classes.
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42 Results: Term-end examination results showed that TBL classes had slightly higher scores than
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45 flipped classroom classes. Referential examination results also showed higher scores for the
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48 same curriculum and no significant interaction was found between class formats and the
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51 term-end and referential examination scores. Analysis revealed no noticeable difference in the
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54 effectiveness of the class formats.
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58 Conclusion: Our previous study reported that TBL had higher efficiency than traditional style
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1 lecture. In the current study, there was no statistical difference in the examination score
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4 between flipped classroom and TBL. Therefore, we conclude that both styles are highly
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7 effective than traditional style lecture and constitute valid formats for clinical dental education.
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1 **1. Introduction**

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4 Active learning is an instructional method that requires students to search for questions and
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7 solve problems by themselves [1]. Classes employing active learning involve a variety of
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10 techniques such as problem-based learning (PBL), team-based learning (TBL) and flipped
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13 classroom [2-15]. PBL is typically performed in small classes and the tutor assigned to the
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16 class observes and assists in the group discussion [2]. For classes with a large number of
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19 students, TBL is more efficient as class members are divided into several teams to develop
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22 intra- and inter-group discussions [3-8]. We have conducted TBL in prosthodontic education in
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25 2013 and reported that TBL promotes study preparation and an active student attitude. TBL is a
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28 potentially more effective method of teaching than the usual style of classes [7, 8]. In that
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31 report, the term-end examination results showed significantly higher scores on the questions
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34 that covered the TBL-class material than those that had covered the traditional lecture-class
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37 topics.
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42 Currently, the increasing use of personal computers and mobile information platforms such as
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45 smartphones and tablet computers are reducing the information gap between each student. The
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48 development of these information and communication technologies has resulted in e-learning
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51 becoming part of higher education in many fields [9-11]. Flipped classroom is one of the
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54 blended learning methodologies that combine e-learning and face-to-face classroom technique.
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57 Typically, students first prepare for the classes by watching videos and subsequently, instead of
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1 a passive-style lecture, receive individual instruction and workshops that are conducted in the
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4 classroom [13].
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7 The advantages of these new learning methods have been widely researched, usually through
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10 questionnaires and/or examination results surveys [2–8, 14–16]. However, little research has
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13 compared the effectiveness of the different active learning methods. Our study aimed to
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16 evaluate and compare the quality of flipped classroom and TBL in prosthodontic education for
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19 fourth-year students at XXXXXX University School of Dentistry. Flipped classroom and
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22 TBL-style classes were both held during a semester on a fixed prosthodontics course and
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25 term-end examination performances were used to evaluate the effectiveness of the methods.
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32 **2. Materials and methods**

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36 This study was approved by the Research Ethics Committee of XXXXXX University Hospital
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39 (No. 1893). For the study, forty-one fourth-year students (thirteen males and twenty-eight
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42 females) at the XXXXXX University School of Dentistry attended the fixed prosthodontic
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45 course. Fourteen classes were held: the first six classes adopted the flipped classroom style
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48 while the latter eight classes adopted TBL. The TBL class used printed handouts for
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51 preparatory study and students have to receive these materials before the classes. The order of
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53
54 the TBL class was arranged after the flipped classroom in which e-learning system was adopted
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57 for preparatory study. In the initial flipped classroom and TBL class, introduction of the class
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1 formats and instructions for the study preparation were performed with visual aids through a
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4 video projector. Each class was sixty minutes in length.
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7 Figure 1 presents a summarized schema of the flipped classroom and TBL classes. Before
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9
10 attending the flipped classroom classes, students were provided with the teaching materials
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12 through the e-learning system. Students accessed the e-learning system using their own ID and
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14 password and prepared for the classes at home using a personal computer and/or smartphone.
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17 The progress of each student's preparation was confirmed by multiple-choice questions that
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20 had been developed using Moodle (<http://Moodle.org/>) in the XXXXXX University Learning
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23 Management System (LMS). Five questions were assigned to each class, and students could
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26 check their test scores immediately after uploading their answers. However, they could not
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29 ascertain the correct answers until the actual class. This preparatory test was performed within
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32 one week or one day prior to each class. Before the class, the teacher reviewed each student's
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35 score and calculated the percentage of correct answers for each question. At the beginning of
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38 the class, the teacher gave feedback to the students about the questions and subsequently
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41 provided an explanation of the teaching materials and individual instruction.
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48 Details of the instruction for TBL format were described in our previous report [7, 8]. In
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51 summary, when starting TBL classes, students were given a preparatory handout for their home
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54 study, one week before each TBL class. At the beginning of each TBL class, students
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57 underwent an individual readiness assurance test (IRAT) in multiple-choice format to check
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1 their preparation level. Students were then divided into small teams of six or seven and took the
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4 group readiness assurance test (GRAT) after the group discussion, which had the same
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7 questions as the IRAT. Following teacher feedback with regard to the IRAT and GRAT
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10 questions, the students were given group assignment projects (GAPs), which involved clinical
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13 practical questions to test the students' ability to apply their learning to difficult clinical
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16 situations. Each group then presented its GAP findings to the class using number boards.
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19 Finally, a peer evaluation was performed by each student and scores were given to each of their
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22 group members.
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26 The effectiveness of the flipped classroom and TBL was assessed from the results of the
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29 term-end examination. Forty-seven multiple-choice questions, which included twenty-three
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32 questions from the flipped classroom and twenty-four questions from the TBL, were included
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35 in the examination. A referential examination with the same questions was given to eight
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38 dentists who belonged to the Department of Stomatognathic Function and Occlusal
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41 Reconstruction, XXXXXX University. The average age of these dentists was 30.9 ± 5.7 year
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44 old with more than two years clinical experience and none of them had attended any of these
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47 classes. The correct answer ratios for each question were calculated from the term-end and
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50 referential examinations and a two-way analysis of variance with two factors, class format and
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53 examinees, was conducted to evaluate the interaction between those factors.
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58 Besides the examination records, a student evaluation questionnaire for the e-learning and
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1 flipped classroom was conducted at end of the first six flipped classroom classes (Table 1) [7,
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4 8]. In this questionnaire, four questions about flipped classroom that asked about
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7 self-evaluation of the students' performance level across ten grades were investigated. Six
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10 questions that evaluated e-learning across five grades were also asked. These questionnaires
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13 were handed to students at the end of the last flipped classroom class and collected at the
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16 beginning of the next class day. Answer of each question was scored and treated as the
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19 numerical variable in the statistical analysis. The average and standard deviation from the score
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22 of each questionnaire item were calculated. The sums of the scores of the two questionnaires
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25 from each student were also obtained. Then, the correlation between the total scores of these
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28 questionnaires was calculated to verify whether there were any relationships between the
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31 students' assessment for e-learning and their performance in the flipped classroom. Spearman
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34 rank correlation coefficient was adopted to evaluate the association between these
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37 questionnaire scores. SPSS 15.0J was used for the statistical analysis and a p-value of <0.05
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40 was used as the level of statistical significance. Free comments from the students were also
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43 collected with the questionnaire describing the good and bad points of flipped classroom and
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46 e-learning from their perspective.
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55 **3. Results**

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58 In the term-end examination, the average correct answer ratio of the questions covered by the
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1 flipped classroom classes was 64.8% while that of TBL classes was 70.1%. The referential
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4 examination results were 66.8% for the flipped classroom and 73.4% for the TBL, for the same
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7 questions (Figure 2). The statistical analysis did not show any significant interaction between
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10 the class formats and the two examinations (Table 2, $F = 0.37$; $P = 0.848$). Therefore, the
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13 examination record indicated that there was no noticeable difference in the effectiveness
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16 between the flipped classroom and the TBL classes.
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20 Figures 3 and 4 shows the average and standard deviation of the responded scores for all items
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23 in the questionnaire. Both of these bar graphs present relatively high scores of the students'
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26 assessment for e-learning and their performance level in flipped classroom. E-learning
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29 questionnaire score has a comparatively large standard deviation which indicates a variety of
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32 individual student scores. Comparison of the questionnaires' score that evaluated student
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35 performance at the flipped classroom and student assessment for e-learning exhibited
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38 significantly positive correlation (Figure 5, $p = 0.0004$). Table 3 shows a summarized list of the
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41 free comments from the students for flipped classroom and e-learning.
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48 **4. Discussion**

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52 The examination results did not confirm any differences in the effectiveness between the
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55 flipped classroom and the TBL. Our previous study reported the validity of TBL for fixed
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58 prosthodontic education. In that research, we discussed that TBL demands advance preparation
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1 to which students have responded positively, and this resulted in the improvement of
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4 examination performance. Advantages of TBL than normal style lecture for dental clinical
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7 education were also reported by other studies [4-6]. The flipped classroom format also requires
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10 students to do preparatory study at home in advance of the actual classes and preparatory tests
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13 confirmed the individual study level. So we think that this preparation test with Moodle in
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16 XXXXXX University LMS was similar to the individual readiness assurance test of TBL class.
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19 The validity of flipped classroom for dental clinical education was reported by Faraone et al.,
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22 who utilized a DVD for complete denture prosthodontics education [15]. Furthermore, Aly et
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25 al. reported the advantages of flipped classroom for orthodontics education [16]. In our study,
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28 we did not find any differences between the effectiveness of the flipped classroom and TBL
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31 from the results of the term-end examination. Therefore, by taking into account previous
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34 reports, both the flipped classroom and TBL formats could be more effective in clinical
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37 education than traditional lecture-style classes.
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42 To evaluate the effectiveness of the different class formats, setting an adequate control group is
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45 a very important issue. In this research, we evaluated scores of the reference examination as the
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48 control data. Since none of the examiner for the reference examination attended both the
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51 flipped classroom and TBL classes, the result of the reference examination had no relation with
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54 class formats. But because those examiners were not dental students, there was a chance that
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57 individual ability resulted in some bias for the examination results. So further considerations
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1 will be required for the design of the control data in future studies.

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4 Both class formats were performed as two-step lessons; preparation study and face-to-face
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7 classwork. Flipped classroom preparation was done using e-learning, while the TBL classes
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10 were done by giving student handouts of the teaching material. Results of the student
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13 questionnaire exhibited higher scores for the questionnaire items that asked for the
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16 effectiveness of e-learning for preparation study and self-evaluation of student attitude in
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19 flipped classroom (Figures 3, 4). Since standard deviations of the scores in the e-learning
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22 questionnaires were relatively large, it could be suspected that students' preference for
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25 e-learning study depends on a variety of individual dispositions. Since the sum of the
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28 e-learning questionnaire item scores, which indicates the students' assessment of the e-learning,
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31 exhibited positive correlation with their self-evaluation of the flipped class performance
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34 (Figure 5), students who adapt to the study preparation with the e-learning system could have
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37 better performance in the flipped classroom classes.
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41 Teaching materials for e-learning requires internet connection and students could access these
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44 materials through personal and/or tablet computer and smart phone as well. One of the
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47 advantages of the e-learning system is high mobility without losing quality and many students
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50 seem to prefer smart phones as a preparatory study device. The popularity of smart phones
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53 among these students could also accelerate this tendency. So we think that a suitable teaching
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56 material for preparatory study should be designed for smart phone users.
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1 Free comments from students (Table 3) were “I could study any time at my own pace in any
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4 place.” and “Many pictures and graphics were helpful to understand for preparation study”. So
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7 the convenience and accessibility of visual aids in the e-learning system might prompt a
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10 positive attitude for students who readily accept e-learning study. However, other comments
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13 indicated that students wanted a handout of the teaching materials and these students seemed to
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16 prefer a learning style based on a paper text rather than on a computer screen. Some of the free
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19 comments from the students indicated that some technical terms in the study material were
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22 rather difficult to understand. So it could be said that, active learning that attaches importance
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25 to preparatory study requires that the quality and accessibility of the preparatory materials be at
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28 an acceptable level for the target students.
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31 **5. Conclusion**

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39 Flipped classroom and TBL were introduced into a fixed prosthodontics clinical education
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42 course for Japanese dental students. The term-end examination did not demonstrate any
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45 differences in the scores for the questions covered by both classes. Our previous report
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48 regarding TBL and the results of the current study indicate that both these active learning
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51 classes are highly effective and constitute valid formats for clinical dental education.
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54 **Conflict of interest**

1 The authors declare that they have no conflicts of interest with respect to their authorship or the
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4 publication of this article.
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1 **Figure Legends**

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4 Table 1. Student questionnaire items for flipped classroom and e-learning

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7 Questionnaire was administered at the end of the final flipped classroom class

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12
13 Table 2. Comparison of term-end and referential examinations results from the flipped
14 classroom and TBL classes (two-way ANOVA test)

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23 Table 3. Free comments from the students for flipped classroom and e-learning

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29 Figure 1. Flipped classroom and team-based learning (TBL) formats

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32 Both of these class formats have two-step lessons; preparations for classes and face-to-face
33 classwork. For the preparations, flipped classroom adopted the e-learning system while TBL
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39 used printed handouts of the teaching material. In the flipped classroom classes, the students
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42 received an explanation of the teaching materials following feedback of the individual test. In
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45 TBL classes, the students took IRAT and then made small teams to perform group works.

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47
48 LMS = Learning Management System, XXXXXX University; IRAT = Individual
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52 Readiness Assurance Test; GRAT = Group Readiness Assurance Test; GAP = Group
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55 Assignment Project

1 Figure 2. Comparison of term-end and referential examinations results from the flipped
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4 classroom and TBL classes

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7 Each bar graph represents the average value and standard deviation of the correct answer ratio
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9 of the questions in the examination. A referential examination was given to eight dentists who
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11 did not attend any of the flipped classroom and TBL classes. A significant difference was not
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14 found between examiners (students/dentists) and also between class formats (flipped
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17 classroom/TBL). Since there was no significant interaction between the class formats and the
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20 examiners, any difference of the correct answer ratio between flipped classroom and TBL
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23 questions was not found in the both examiner groups.
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33 Figure 3. Flipped classroom questionnaire scores

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36 Note: n = 41; Score: 0 (Poor) – 9 (Excellent)

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39 This questionnaire was performed at the end of the last flipped classroom class. Each bar graph
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42 represents average value and standard deviation of student's self-evaluation of their
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45 performance in flipped classroom classes.
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52 Figure 4. E-learning for the flipped classroom questionnaire scores

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55 Note: n = 41; : 0 (Poor) – 9 (Excellent)

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58 Each bar graph represents the average value and standard deviation of student's evaluated
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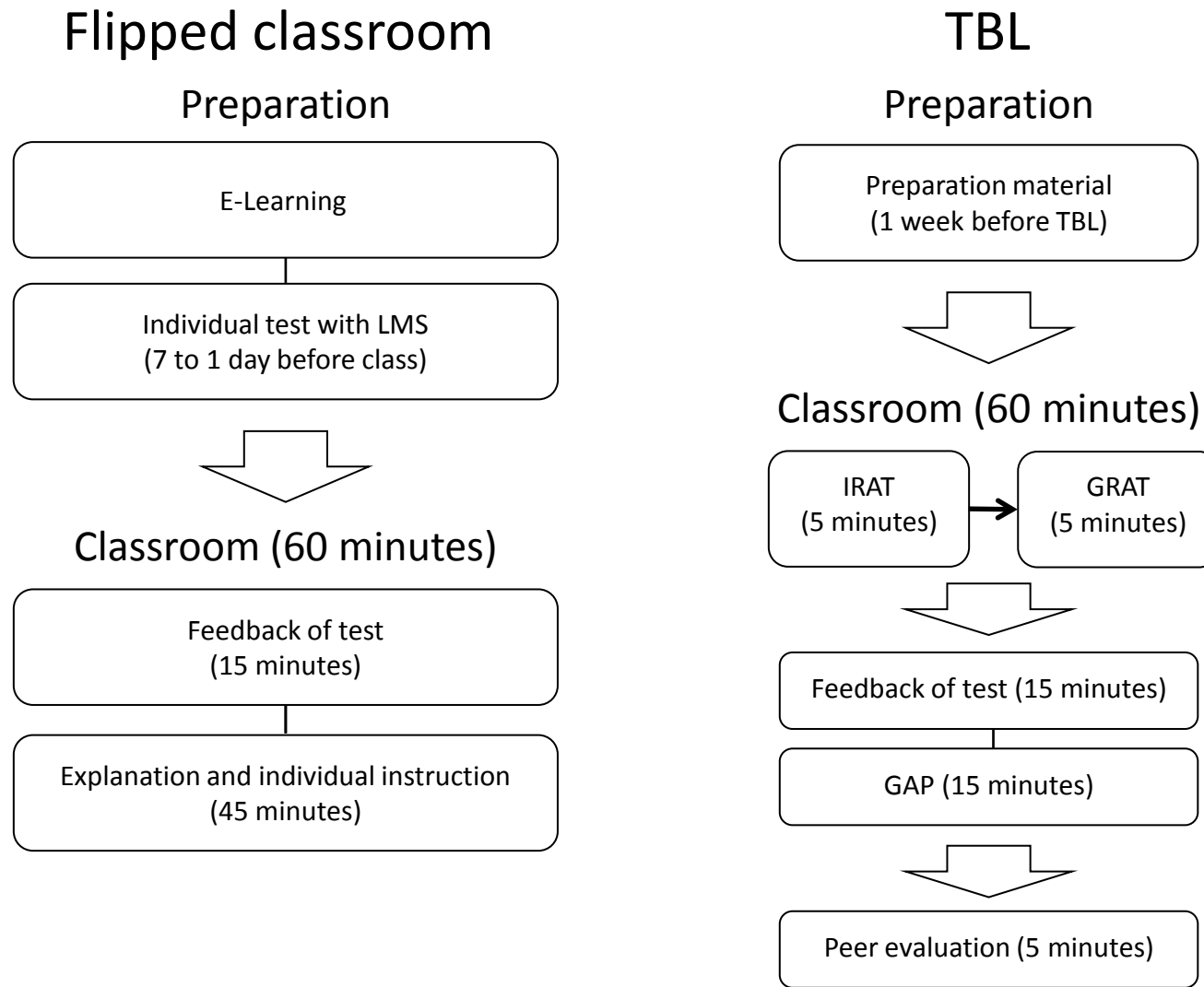


Figure 1. Flipped classroom and team-based learning (TBL) formats

Both of these class formats have two-step lessons; preparations for classes and face-to-face classwork. For the preparations, flipped classroom adopted the e-learning system while TBL used printed handouts of the teaching material. In the flipped classroom classes, the students received explanation of teaching material following feedback of the individual test. In TBL classes, the students took IRAT and then made small teams to perform group works.

LMS = Learning Management System, XXXXXXX University; IRAT = Individual Readiness Assurance Test; GRAT = Group Readiness Assurance Test; GAP = Group Assignment Project

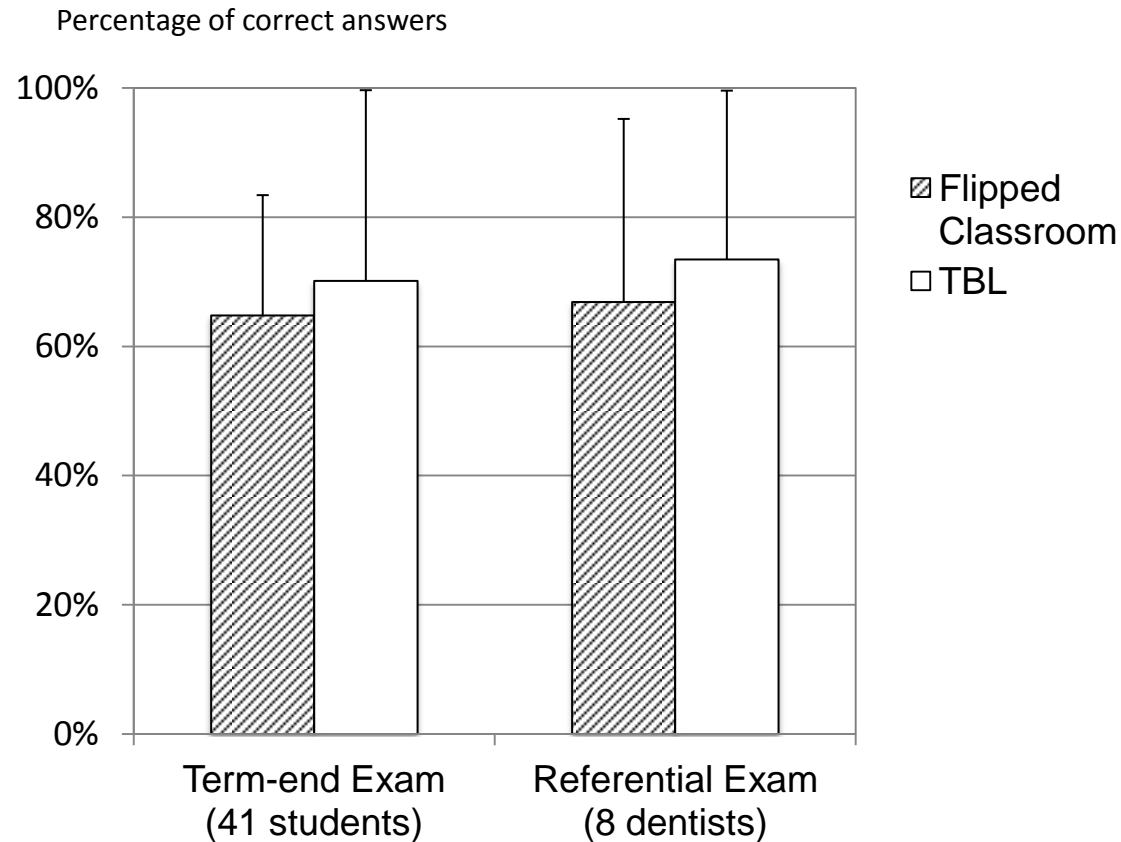


Figure 2. Comparison of term-end and referential examinations results from the flipped classroom and TBL classes

Each bar graph represents the average value and standard deviation of the correct answer ratio of the questions in the examination. A referential examination was given to eight dentists who did not attend any of the flipped classroom and TBL classes. A significant difference was not found between examiners (students/dentists) and also between class formats (flipped classroom/TBL). Since there was no significant interaction between the class formats and the examiners, any difference of the correct answer ratio between flipped classroom and TBL questions was not found in the both examiner groups.

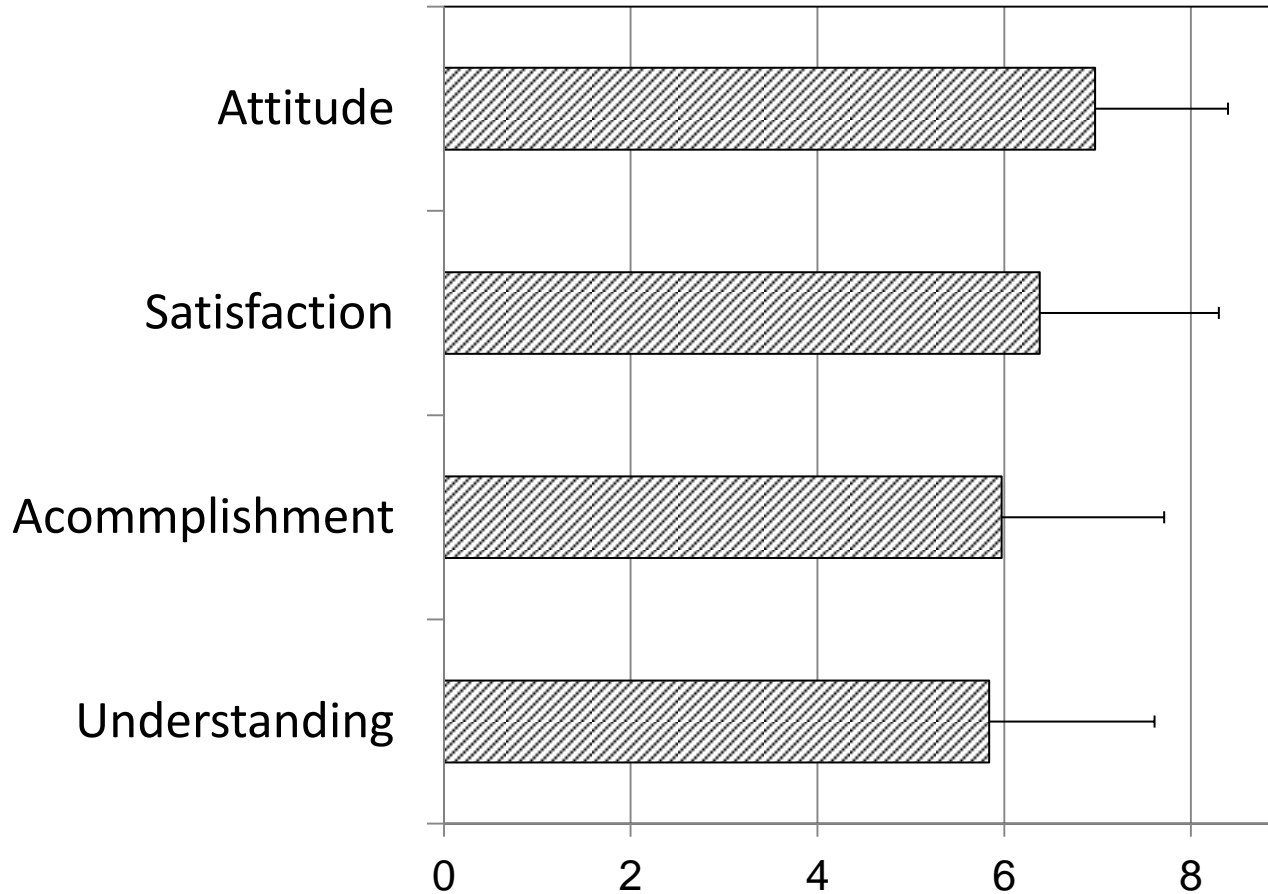


Figure 3. Flipped classroom questionnaire scores

Note: n = 41; Score: 0 (Poor) – 9 (Excellent)

This questionnaire was performed at the end of the last flipped classroom class. Each bar graph represents average value and standard deviation of student's self-evaluation of their performance in flipped classroom classes.

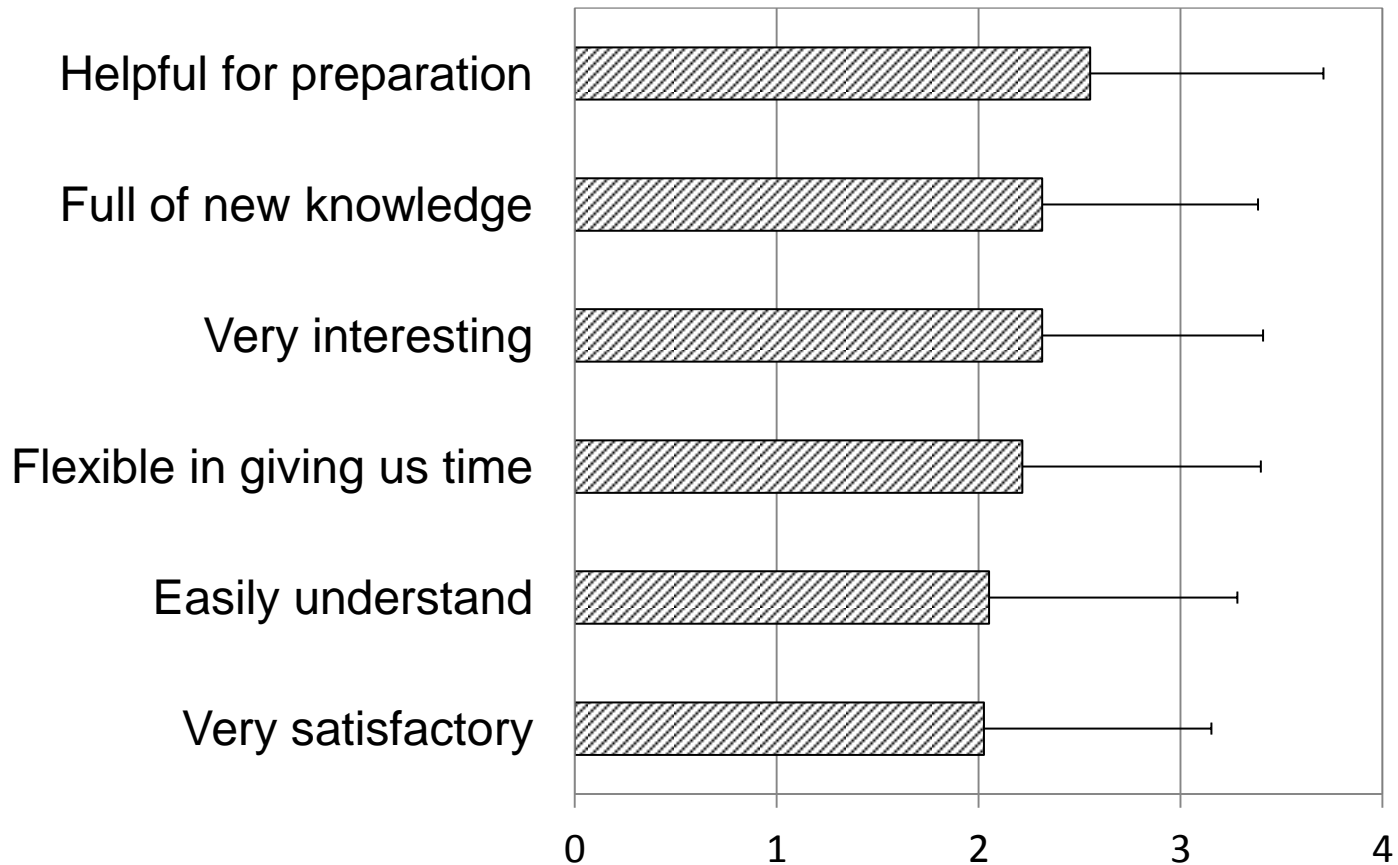


Figure 4. E-learning for the flipped classroom questionnaire scores

Note: n = 41; Score: 0 (Poor) – 9 (Excellent)

Each bar graph represents the average value and standard deviation of student's evaluated scores for e-learning used in the flipped classroom classes

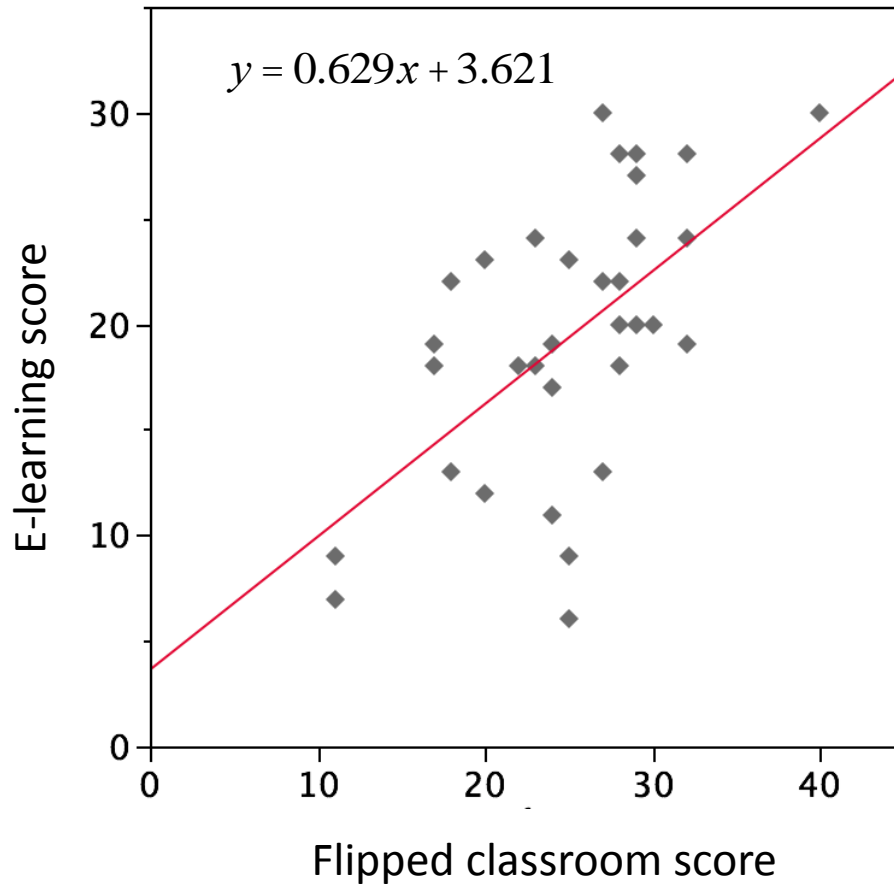


Figure 5. Correlation of the e-learning and flipped classroom questionnaire scores.

Vertical line represents the sum of the six-item scores for e-learning questionnaire for each student. Horizontal line represents the sum of the four-item score for flipped questionnaire. Significant correlation was found between these two questionnaires' scores (Spearman rank correlation coefficient = 0.5464, $P = 0.0004$)

Table 1. Student questionnaire items for flipped classroom and e-learning
Questionnaire was administered at the end of the final flipped classroom class

On a scale of 0 (Poor) to 9 (Excellent), score yourself in a flipped classroom classwork for the following items:

What was the level of your attitude in this class?

What was the level of your satisfaction in this class?

What was the level of your accomplishment for the study object in this class?

What was the level of your understanding in this class?

On a scale of 0 (Poor) to 4 (Excellent), score e-learning in this class for the following items:

E-learning was helpful in making us easily understand the study subjects.

E-learning was helpful in making us prepare for the class.

E-learning in this class was full of new knowledge.

E-learning was flexible in giving us time to prepare.

E-learning in this class was very interesting.

E-learning in this class was very satisfactory over all.

Table 2. Comparison of term-end and referential examinations results from the flipped classroom and TBL classes (two-way ANOVA test)

Source	Type III sum of square	df	Mean square	F	Significance
Examinees	0.017	1	0.017	0.67	0.417
Class Format	0.083	1	0.083	0.755	0.389
Class Format / Examinees Interaction	0.001	1	0.001	0.037	0.848

Table 3. Free comments from the students for flipped classroom and e-learning

Good Points

This course got me into habit of preparation study.

I could study any time with my own pace in any place.

Many pictures and graphics were helpful to understand for preparation study.

Preparation material made the course substance clear.

Bad points

It was difficult to understand the technical term in the preparation material.

I thought that this e-learning was useful for review of the classroom, but rather difficult for preparation study.

More detailed descriptions and instructions were necessary to understand.

It was hard to print out all preparation materials.

I want the digest of the material that was handy to print out.
