

Evaluation of Team-Based Learning and Traditional Instruction in Teaching Removable Partial Denture Concepts

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Abstract: The aim of this study was to evaluate the effectiveness of team-based learning (TBL) methodology on dental students' retention of knowledge regarding removable partial denture (RPD) treatment. The process of learning RPD treatment requires that students first acquire foundational knowledge and then use critical thinking skills to apply that knowledge to a variety of clinical situations. The traditional approach to teaching, characterized by a reliance on lectures, is not the most effective method for learning clinical applications. To address the limitations of that approach, the teaching methodology of the RPD preclinical course at the University of Florida was changed to TBL, which has been shown to motivate student learning and improve clinical performance. A written examination was constructed to compare the impact of TBL with that of traditional teaching regarding students' retention of knowledge and their ability to evaluate, diagnose, and treatment plan a partially edentulous patient with an RPD prosthesis. Students taught using traditional and TBL methods took the same examination. The response rate (those who completed the examination) for the class of 2013 (traditional method) was 94% (79 students of 84); for the class of 2014 (TBL method), it was 95% (78 students of 82). The results showed that students who learned RPD with TBL scored higher on the examination than those who learned RPD with traditional methods. Compared to the students taught with the traditional method, the TBL students' proportion of passing grades was statistically significantly higher ($p=0.002$), and 23.7% more TBL students passed the examination. The mean score for the TBL class (0.758) compared to the conventional class (0.700) was statistically significant with a large effect size, also demonstrating the practical significance of the findings. The results of the study suggest that TBL methodology is a promising approach to teaching RPD with successful outcomes.

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The process of learning removable partial denture (RPD) design requires that dental students first acquire a knowledge base and then use critical thinking skills founded on evidence to apply that knowledge to a wide variety of clinical patient care situations. U.S. graduating seniors in 2013 did not identify removable prosthodontics as a major concern in terms of preparedness for practice, with only 2.4% reporting they felt underprepared and 15.9% somewhat underprepared in that area.¹ However, we are among the dental faculty members who recognize that not all students are adequately

prepared in RPD design when they graduate. Clinical studies have also found a deficiency in the level of dental graduates' technical knowledge about removable prostheses.^{2,3} During the 2011 annual senior exit interviews, enough students at the University of Florida College of Dentistry stated they felt underprepared at graduation in RPD treatment to prompt faculty members to consider ways to improve students' level of understanding and clinical performance.

To address this issue, the faculty decided to change the teaching methods used for RPD from a passive to an active learning approach. In summer

2012, the RPD preclinical course was revised so that most traditional lectures and lab exercises were reduced and a team-based learning (TBL) approach was added. Current educational research in the health sciences supports the use of TBL to inspire, engage, and motivate students to learn.^{4,5} The goals for revising the course were to improve the students' knowledge base of component parts and design principles while enhancing their critical thinking skills to use in clinical patient care. The aim of this study was to evaluate the effect of this change on student outcomes through the use of an examination administered in the final semester of the course.

Team-Based Learning

TBL is a dramatic cultural shift for students and faculty members who are accustomed to passive learning methods. In the passive learning model, faculty members are in charge of delivering information to students based on their knowledge, research, and reviews. The student is expected to listen to the information, understand, and retain it for future applications. In contrast, TBL is designed to create mature, confident, and knowledgeable professionals with the aim of developing skills as lifelong learners.^{6,7} Placing the responsibility for learning on students enhances their learning ability and allows more time for instructors to teach at levels beyond basic knowledge comprehension and understanding.

TBL is a well-defined instructional strategy used in business and science courses.⁸ TBL brings

together theoretically based strategies that support the effectiveness of small groups which work independently during class time with high student-faculty ratios (up to 200:1). As an instructional method, TBL consists of repeating sequences of three phases: preparation, readiness assurance, and application of course concepts (Figure 1 and Figure 2).⁸ In Phase 1, outside of scheduled class time, students independently learn material that is related to the course objectives. In Phase 2, individual students take a multiple-choice exam to ensure their readiness to apply their knowledge. Once all individual members of each team (typically six or seven students) complete their exams, they re-take the same examination as a group. However, during this process, they must reach consensus on their answers for immediate scoring and posting. In Phase 3, teams complete in-class application assignments that promote collaboration, use of knowledge, and identification of deficiencies.

The structure of TBL requires that individuals on each team discuss their responses and come to judgments and decisions. With proper implementation of TBL, individuals and teams are able to explain the rationale for their decisions and why they excluded other treatment options. The process of discussion and debate within teams and between teams teaches students they must provide a defensible rationale for clinical judgment, a strategy that is used to promote critical thinking as they engage deeply with the content. Because TBL utilizes the principles of constructivist learning, it has been shown to foster critical thinking skills when students work in high-functioning teams.⁹ The instructional principles that

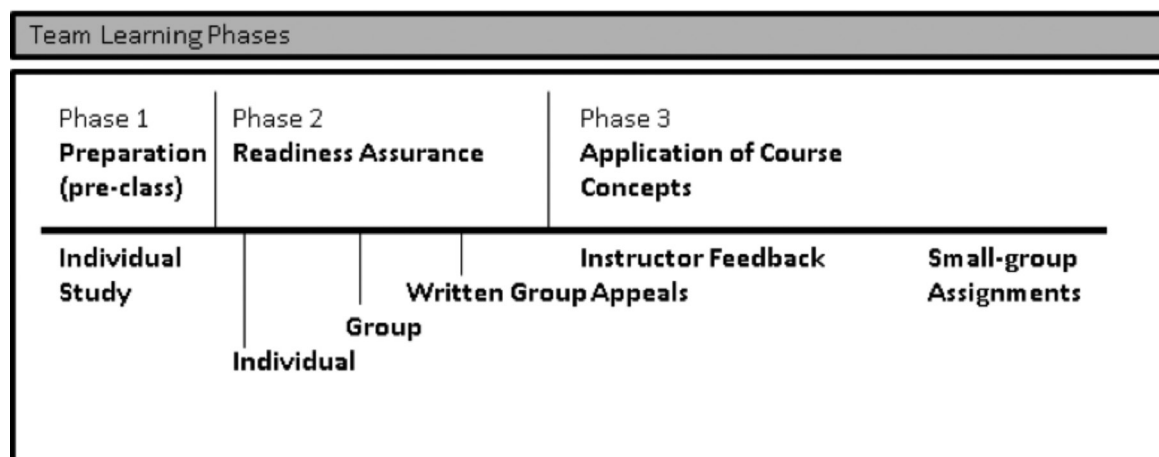


Figure 1. Instructional phases of team-based learning

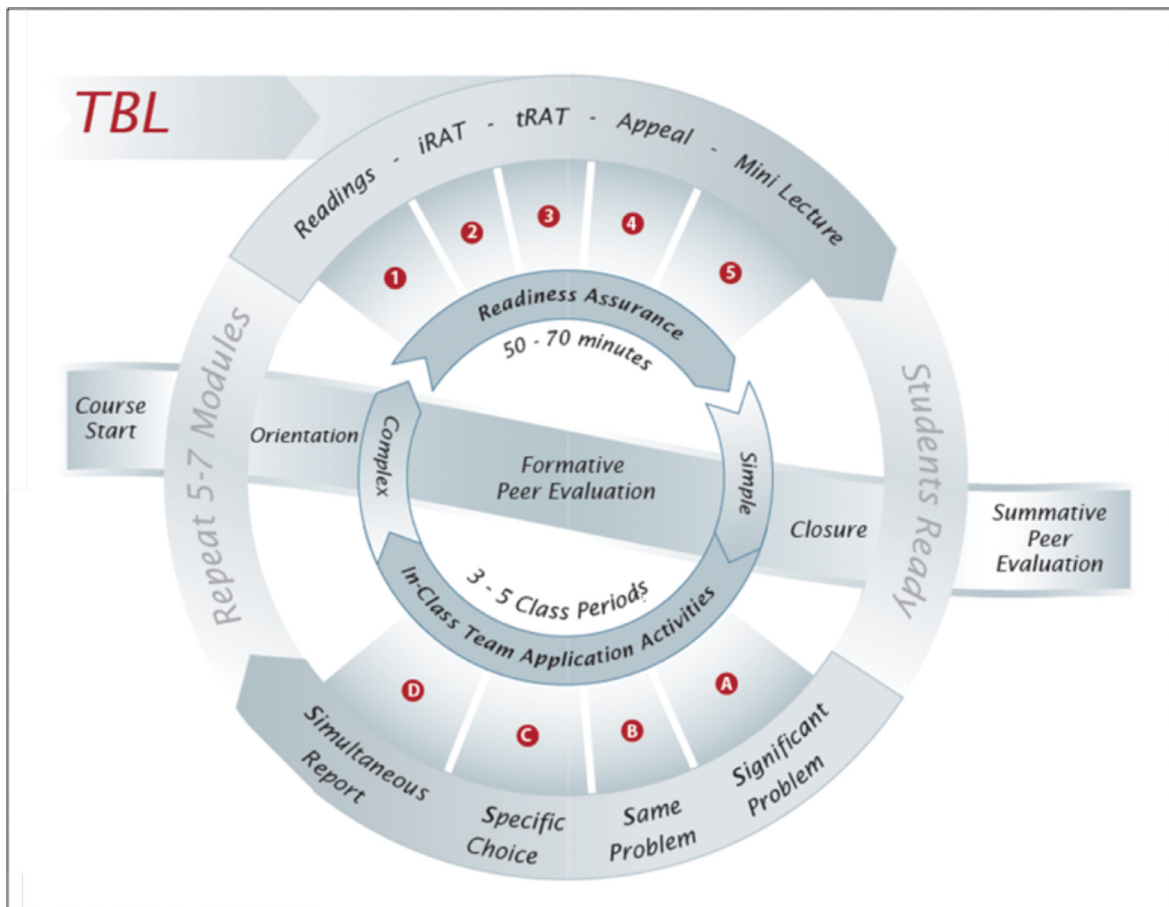


Figure 2. Team-based learning methodology by Jim Sibley and Sophie Spiridonoff, University of British Columbia

Source: Figure created by Jim Sibley and used with his permission.

support the use of TBL are stressing the importance of prior preparation and learning of established objectives, holding peers accountable for attending class, and participating in course assignments. TBL emphasizes three keys to effective active learning: individual and group accountability; need and opportunity for group interaction; and motivation to engage in give-and-take discussions.¹⁰

Current educational research in the health sciences supports the use of TBL as a process that inspires, engages, and motivates students to learn,¹¹⁻¹⁴ while conventional lectures and quizzes (a passive methodology) do not necessarily motivate student learning.¹⁵⁻¹⁷ Characteristics that distinguish TBL from passive learning are placing the onus for learning on the students and using collaboration.

TBL encourages student preparation before class. While in the classroom, students work in as-

signed teams.¹⁸ During TBL, the teacher acts as an expert facilitator who points out any inconsistencies between students' current understanding and new experiences. Using TBL, students are accountable for their own performance and individual contributions to the team.¹⁹ The processes underlying TBL have been instrumental in stimulating development of mental frameworks built upon previous knowledge.⁹ During the group sessions, teamwork skills are strengthened by focused reflection on new experiences and feedback to group members.

Medical and health sciences educators are increasingly employing TBL to develop students' abilities to use self-managed learning teams in medical and dental education. TBL is a learner-centered, small-group instructional strategy.¹⁹ Some research shows that TBL has positive academic outcomes and the potential to address professional competencies

that are critical for the practice of medicine.¹⁸ For clinical cases, TBL was found in that study to improve clinical reasoning ability among students who had PBL experience yet had limited clinical exposure.

In a study by Haj-Ali and Al Quran, the implementation of TBL in a preclinical removable denture prosthesis module was shown to improve student performance.²⁰ Student examination scores on TBL sessions were higher than their conventional written examination scores, and rates of student satisfaction for those using TBL were nearly the entire class with 72% reporting satisfied and 22% reporting partially satisfied. The instructors reported a higher level of student engagement and less demand on contributing faculty members. Using TBL as the primary instructional strategy, another group of researchers examined changes in team emotional intelligence (EI) during a third-year clerkship.²¹ Team EI increased significantly from pre to post clerkship for three of the four areas of EI: awareness of own emotions ($p=0.018$), recognizing emotions in others ($p=0.031$), and ability to manage other's emotions ($p=0.013$). No change in ability to control own emotions was observed ($p=0.570$).

Materials and Methods

The University of Florida Institutional Review Board approved this study (Protocol # 2012-U-1348). An experimental study was conducted to compare two teaching methodologies in a removable partial denture (RPD) course: a conventional approach (lectures, quizzes, and preclinical laboratory sessions) and a TBL approach. This study was conducted with senior dental students in the class of 2013 who were trained using the conventional approach and senior dental students in the class of 2014 who were trained using a TBL approach. An RPD examination was prepared and administered to each class five semesters after completion of the RPD preclinical course and without preparation or prior knowledge of the content or subject material of the assessment. The test grades for each class were compared using a t-test.

Course Revision

To transition students from passive to more active learning, the teaching methodology in the DEN 7413 removable partial denture preclinical course was changed from traditional lecture and lab exercises to a TBL approach. Course hours in the traditionally taught conventional course were changed for the team-based learning design. In the

conventional course, the class of 2013 ($n=84$) RPD education consisted of 14 lecture hours and 33 lab hours in the junior year under the guidance of four or five faculty members. In the TBL course, the class of 2014 ($n=82$) RPD education consisted of two lectures, 18 lab hours, and ten (2.5-hour) in-class application assignments under the guidance of two faculty members. Overall, the TBL-designed course required fewer faculty members and reduced student contact hours by two. The goals for the revised course were to 1) provide students' self-learning content through selected textbooks, articles, recorded lectures/presentations, and videos; 2) improve students' knowledge base of component parts and design principles; 3) allow students to discuss content and judgment through team learning application assignments; and 4) have students apply critical thinking skills through case-based design.

The TBL instructional methodology was followed in the course revision. All of the lecture hours were changed to a Readiness Assurance Process (RAP) and Application Assignments (App). Students were given a series of objectives, recorded lectures, videos, presentations, and reading assignments as part of their individual preparation outside class. While in class, individual students took a multiple-choice examination that consisted of five to eight case-based questions to ensure their readiness to apply their knowledge. After all individual members of each team (six or seven students per team) completed their individual Readiness Assurance Test (iRAT), they took the same examination as a team: the team Readiness Assurance Test (tRAT). However, during the team process, they had to reach consensus on their answers, which in and of itself promotes discussion, debate, and learning. Once the team members decided on what they thought was the right answer, they scratched off the Immediate Feedback Assessment Technique card (IFAT) for immediate scoring. Each time the team did not find the correct answer, members returned to the question for further discussion and consensus. Following the tRAT, the teams were encouraged to appeal incorrect answers, which pushed the team back into discussions and review of the reading material. Once the appeals process was completed, the instructor provided a targeted mini-lecture on the most troublesome concepts in order to resolve any confusion.

The course material was divided into six RPD topics with specific objectives. These topics were covered on six RAPs and eight in-class Application Assignments/Examinations (Apps), some including

laboratory exercises. Each member of the team was required to complete the laboratory work as well as help each other. At the end of the session, team members evaluated their work and chose the best one for the final team grade. The application assignments promoted critical evaluation, collaboration, use of knowledge, accountability, and identification of deficiencies.

The application examinations also consisted of open-book assignments in which the teams discussed and solved relevant clinical scenarios. These activities followed the 4 Ss principle (Significant problem, Same problem, Specific Choice, and Simultaneous Report) (Figure 2). These assignments gave the individuals, the teams, and the entire class opportunities to discuss cases and receive feedback on the specifics of their rationale. The simultaneous reporting allowed students to engage with a diverse set of perspectives and approaches to problem-solving and to treatment planning for removable partial dentures.

The course evaluation was also revised following TBL methodology. For each student's grade, individual performance (combination of 50% iRAT and 50% final written examination) counted for 50%; the team performance (combination of 50% tRAT and 50% application examinations/assignments) counted for 40%; and 10% was the result of peer evaluation. The peer evaluation was also an important aspect of TBL as it promotes students' accountability, workload distribution, and participation. Each member evaluated the contributions of all of the other team members by assigning an average of ten points to the other team members. Each member had 60 points (teams of seven) or 50 points (teams of six) to assign. They were not allowed to split the points equally. They had to select the strongest and the weakest of the team and assign at least one score of 11 to 15 and at least one score of 9 or lower. The scores were averaged for final grade calculations.

This course revision followed the four paradigm shifts defined by Jim Sibley and Sophie Spiridonoff at the University of British Columbia (Figure 2). The course goals shifted from knowing to applying; the teacher shifted from "sage on stage" to "guide at side"; the students shifted from passive to active; and responsibility for learning shifted from instructor to student.

Examination Administration

An examination designed for the study as an outcomes measure of the effectiveness of instruction

was administered during a senior-level course (DEN 8462, Advanced Topics in Prosthodontics) in the last semester of the senior year. By the time the examination was administered, students had completed all of their required prosthodontic courses and had been treating patients in the clinics for five semesters. Students were notified four weeks in advance that this examination was a required activity in the course but were not given prior knowledge of the content or subject materials of the assessment. The students had one hour to complete the examination, which was proctored by faculty members. The identical clinical case-based scenario examination was administered to students in the class of 2013 in January 2013 and to students in the class of 2014 in January 2014.

The examination was comprised of nine questions (laboratory prescription, multiple choice, and essay). For laboratory prescription, a question required students to create an RPD design for a partially edentulous mandibular arch with survey crowns opposing a maxillary complete denture based on a clinical scenario (diagram and laboratory prescription). Seven multiple-choice questions related to the fabrication steps of the prosthesis. The topics were use of the altered cast technique, sequence for fabricating survey crowns in RPD treatment, determination of the occlusal vertical dimension, determination of occlusal scheme for the exam scenario, techniques and records used to record maxillomandibular relations and wax try-in, sequence for denture insertion, and post-insertion care. Finally, there was an essay question about patient education and instructions when delivering a mandibular RPD opposing a maxillary complete denture prosthesis. This question asked students to describe important factors to consider when educating patients to achieve stable long-term prognosis and improved health outcomes. Correct responses had to include the following areas: a) function: both dentures should be worn at all times, except when out overnight or for cleaning; b) biomechanics: patient should eat with both sides at the same time; c) eating: start with soft food and increase the hardness over time; d) cleaning dentures; e) hygiene of remaining natural teeth; f) removal of both dentures every night to allow soft tissue rest; g) proper insertion and removal; and h) recall visit encouraged and planned.

Grading

Following completion of the second class's examination, faculty members identified assessment

criteria and graded both examinations. The grading process was blind, as each exam was assigned a randomized study ID number. Meeting the criteria was scored as 1 and not meeting the criteria was scored as 0. Each student received a total grade for each section.

The first section, RPD laboratory prescription writing, was graded by three independent evaluators (board-eligible or -certified prosthodontist faculty members). The RPD design drawing was evaluated on the following criteria: retainers, major connector, acrylic retention, rest seats, guide planes, clarity of drawing, and congruence (agreement between diagram and written description). The RPD design written description was evaluated on the following criteria: major connector, tooth numbers, retainer type, retention undercut, reciprocation, rests, and guide planes. For each criterion, the score was either correct (1) or incorrect (0). Each student received a total grade for the section. The maximum number of points for this section was 14 points. The grades of the three reviewers were averaged.

The multiple-choice items required a single correct best answer. Each student received a total grade for the section, and the maximum number of points for this section was seven. The authors verified the key as identifying the single best answer choice. The essay section was graded by three independent evaluators (a general dentist prosthodontics faculty member, a non-dentist educator, and a non-dentist/non-dental educator). Each student received a total grade for the section, and the maximum number of points for this section was eight. The grades of the three reviewers were averaged.

The maximum number of points for the entire examination was 29. After a weighted percentage was assigned to the average grade for each section,

a total grade for each student was calculated. The percentages for each section were 70% for RPD design/laboratory prescription, 15% for multiple-choice questions, and 15% for essay question. Data were entered into Excel, then exported into SPSS v2 (IBM Corp., Armonk, NY, USA). Examination grades for the two class years were tested for statistical significance using the t-test, and the proportions of each class's passing/failing were statistically tested by chi-square.

Results

The response rate (those who completed the examination) for the class of 2013 was 94% (79 students of 84) and for the class of 2014 was 95% (78 students of 82). The results showed that the Q-Q plot supported the normal distribution of grades. Thirty-eight students (48.1%) in the class of 2013 (conventional methodology) passed the examination with a minimum grade of 72 or higher; grades ranged from 87 to 47. In contrast, 56 (71.8%) students in the class of 2014 (TBL methodology) passed the examination (Table 1). This was an absolute 23.7% improvement by the 2014 class in the proportion of passing grades ($p=0.002$). The odds ratio for passing under the conventional instructional methodology demonstrated a 2.75-fold increased likelihood of failing compared to TBL ($OR=2.746$).

The mean grade for the class of 2014 was 0.758 ($SD=0.083$); for the class of 2013, the mean grade was 0.700 ($SD=0.092$). Results of the t-test showed that the class of 2014 higher average grade was statistically significant ($p<0.001$) with an effect size of 0.62 (Table 1, Table 2, and Figure 3).

Table 1. Distribution of pass-fail grades by classes of 2013 (conventional) and 2014 (TBL)

		Class of 2013	Class of 2014	Difference
Passed	Number	38	56	18
	Percentage of class	48.1%	71.8%	23.7%
	Highest grade	87	92	5
Failed	Number	41	22	-19
	Percentage of class	51.9%	28.2%	-23.7%
	Lowest grade	47	51	4
Total	Number	79	78	-1
	Average grade	68	75	7

Chi-square; $p=0.002$

Note: Grades are on scale from 0 to 100.

Table 2. Removable partial denture examination grades for classes of 2013 (conventional) and 2014 (TBL)

Class	Number	Mean	Standard Deviation	p-value
2013	79	0.700	0.092	<0.001
2014	78	0.758	0.083	

Discussion

In this study, team-based learning methodology, which requires active student participation, was employed to improve dental students' ability to apply principles learned to treatment plan and design a removable partial denture. The results showed the TBL methodology had a positive and statistically significant impact on the students' learning outcomes, knowledge retention, and ability to evaluate, diagnose, and treatment plan a partially edentulous patient with an RPD prosthesis.

The results of the examination showed that students who learned RPD treatment through the TBL

methodology had a statistically significant greater knowledge and retention of the concepts than the students who had traditional instruction. Students' knowledge retention and understanding were maintained more than one year after they completed the RPD course, suggesting that they had developed competence in RPD theory and treatment. However, it is important to note that the high overall failure rate for both classes was due to the fact that students did not know the content or subject material of the examination in advance so they did not prepare for this assessment. By completing this assessment without studying, it was our intent to measure the effectiveness of the training method (combined to a certain extent with their clinical experience). If the students had been advised that this was a high stakes exam and would count a percentage of the course grade, they would have studied for it, possibly negating assessment of the effect of the conventional training methodology. So with no preparation for the exam, we would expect lower scores overall. The large effect size also demonstrates the practical significance of using TBL.

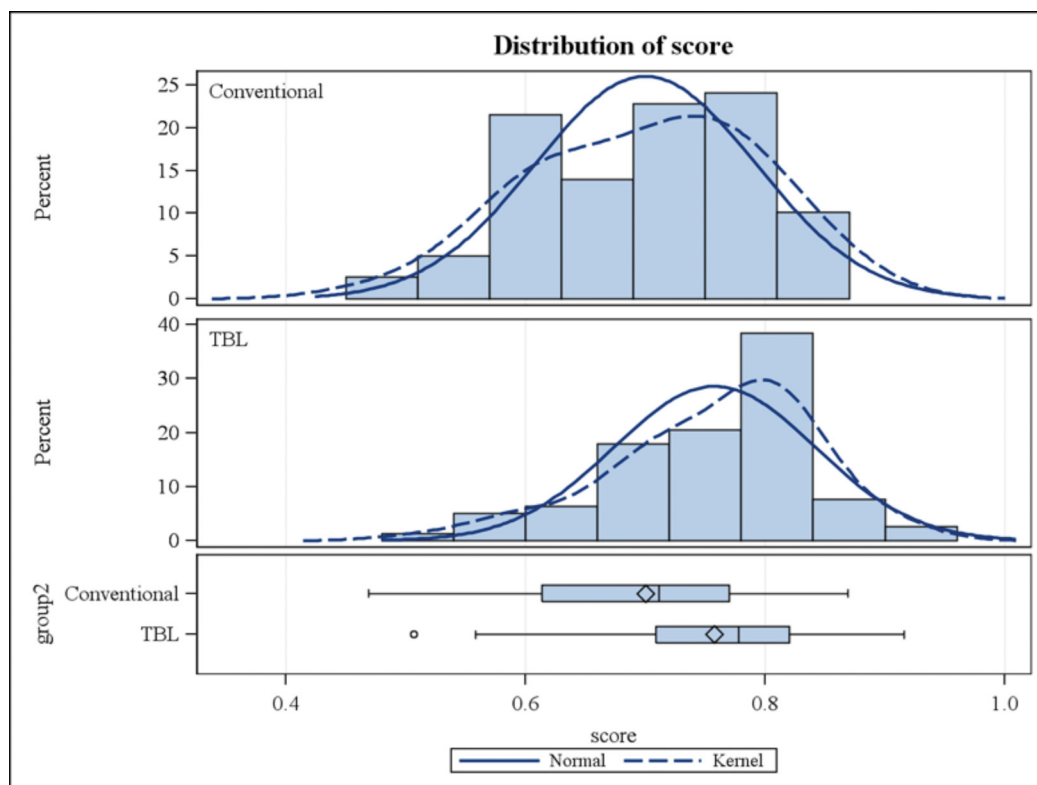


Figure 3. Distribution of scores for conventional and team-based learning (TBL)

Using the TBL methodology, the students were more actively engaged than in the traditionally taught RPD course, and fewer faculty members were needed to teach course content and lead the discussions. This was definitely beneficial to the department and the dental college. One limitation of this study is that test scores from two independent classes do not control for variations between the two classes. A productivity report of RPD cases, illustrating the representative clinical outcomes for the two classes, could be added. However, it is important to recognize that the results of clinical outcomes are highly dependent on the patient pool, clinical requirements, and students' interest in RPD treatment, whereas the assessment of didactic preclinical knowledge is not dependent on those factors.

Other researchers have pointed out the disadvantages of TBL, suggesting that it can be implemented in varied ways;⁹ however, TBL must be implemented with fidelity. If researchers fail to describe how TBL has been implemented, this omission can cause confusion, and it may be difficult to understand, critique, replicate, or compare outcomes. Although previous research has reported the cognitive benefits of TBL,^{6,7} benefits beyond knowledge retention are not routinely measured. Understanding how TBL might augment thinking, problem-solving, or unraveling complex problems has mostly come from evaluation or established test measures. Thus, the only conclusions that can be drawn to date are related to the cognitive benefits. Other areas that call for investigation include determining why students tend to be more engaged in TBL compared to traditional forms of teaching.¹⁹

This RPD preclinical course revision took approximately three weeks for the initial planning and required continuous changes as the course moved along. The Readiness Assurance Tests (RATs) and application examinations (Apps) were developed throughout the course as it takes approximately four hours to create a five-question RAT or a clinical scenario for the Apps. It is critical that these tests and applications are well constructed so that they can promote students' interactions, their exchange of knowledge during the team RATs, and resolution of the applications assignments and resulting knowledge gain.

Preliminary results of this revised RPD preclinical course design were evaluated through three methods. In peer observation of working teams, two faculty members from other disciplines observed the teams and described their findings this way:

“students were actively engaged in teaching each other and working toward consensus in designing their assigned RPD treatment plan” and “students asked process and clarification questions rather than content questions.” Regarding the second method—quality of student comments from previous and current course evaluations—the quality of student course evaluations changed from comments like “she is an excellent teacher” and “this was a good course” to “I learned how to defend my answers better and reason through things” and “there are many ways to deal with the same case and it is important to think critically on every case.” Student responses to a critical thinking feedback form, the third method, resulted in the following: 88% agreed with the statement “found myself actively engaged in thinking about difficult questions for which we still need to find answers”; and 89% agreed with the statement “the assignments forced me to think things through in order to determine what to believe or do in a given situation.”

Conclusion

This study found that using a team-based learning methodology in a removable partial denture course was more effective and led to greater retention of knowledge than the traditional methodology. Instructors who desire to engage students in the classroom while delivering factual information and to move them from passive to active learning can benefit from using TBL as seen in the comments made by the course director and instructors who facilitated this course. Findings from this study support the statistical and practical significance of using TBL in teaching predoctoral dental students the principles, theory, and practice of removable partial dentures treatment.

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