

# Team-Based Learning Using an Audience Response System: An Innovative Method of Teaching Diagnosis to Undergraduate Dental Students

Roberta Pileggi, D.D.S., M.S.; Paula N. O'Neill, M.Ed., Ed.D.

*Abstract:* A team-based learning (TBL) approach was used to facilitate student learning and performance in a sophomore preclinical endodontic course. TBL is based upon the division of a class into small groups of students using a problem-based learning approach. The purpose of this project was to improve student ability to diagnose diseases utilizing TBL combined with an audience response system (ARS). Three measures were used to assess the outcomes: 1) pre- and posttest scores, 2) a diagnostic skills assessment during the final examination, and 3) an attitudinal survey completed by the students. At the beginning of the course, second-year students (n=64) were evaluated to determine entry-level knowledge. Six groups of ten to eleven students each were pretested, followed by a parallel posttest following the implementation of the TBL experience. Students' performance on the posttest (63.4 percent) showed improved results when compared to the pretest (36.9 percent). Students also exhibited improved diagnostic skills with the final examination. The results of the students' attitudinal survey indicated an 80 percent agreement that TBL enhanced their powers of critical analysis.

Dr. Pileggi is Assistant Professor and Assistant Program Director of Graduate Endodontics, Department of Endodontics, College of Dentistry, University of Florida Health Science Center; she was Assistant Professor, Department of Endodontics, University of Texas Health Science Center at Houston Dental Branch at the time this project was conducted; Dr. O'Neill is Professor and Associate Dean, Educational Research and Professional Development, Department of Diagnostic Sciences, University of Texas Health Science Center at Houston Dental Branch. Direct correspondence and requests for reprints to Dr. Roberta Pileggi, University of Florida Health Science Center, College of Dentistry, Department of Endodontics, Room D10-37, P.O. Box 100436, Gainesville, FL 32610-0436; 352-273-5437 phone; 352-273-5446 fax; rpileggi@dental.ufl.edu.

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Dental pain is the most commonly reported form of oral-facial pain; thus, an effective and accurate diagnosis is the most critical step of our profession. Every year, approximately fifteen million working days are lost due to dental pain in the United States,<sup>1</sup> and about 90 percent of emergencies with pain are of pulpal and/or periapical origin.<sup>2</sup> Researchers have found reduced quality of life due to dental disease or pain.<sup>3</sup> Other researchers have demonstrated that oral conditions caused more workday loss than stroke and, in younger adults, as much work loss as all neoplasms combined.<sup>4</sup>

Commonly, one of our concerns as dental educators is to graduate students who are not only comfortable with techniques of clinical dentistry, but are also competent in diagnosis to improve the quality of life for their patients. A precise diagnosis can result only from the synthesis of scientific knowledge, clinical experience, and the ability to

correlate science with the patient's chief complaint. The preclinical endodontics curriculum at the University of Texas Health Science Center at Houston Dental Branch consists of twelve lecture hours accompanied by thirty-six hours of technique in the laboratory. Traditionally, students in the course have been assessed using quizzes, one midterm, and one final examination.

To improve student learning and performance in diagnosing dental disease in the preclinical endodontics course, a team-based learning (TBL) approach was implemented at the Dental Branch in 2005 for the first time in the entire undergraduate curriculum. Team learning is based upon the division of a class into small groups of students and uses a case-based approach.<sup>5,6</sup>

Some faculty may assume that TBL is similar to problem-based learning (PBL). There are similarities in that both TBL and PBL attempt to fully engage

learners, and both are designed to encourage high levels of interaction in the teaching and learning setting. The key distinction between the two is that PBL is learner-centered and conducted in small group classrooms without interaction with the large group as a whole. Students are presented with the problem prior to studying relevant concepts and are asked to problem-solve over the course of several days while continuously receiving additional case-related materials.<sup>7</sup> TBL, on the other hand, is typically instructor-centered and conducted in a large classroom setting with students breaking up into small groups around the room and then coming together for assessment and feedback multiple times during instructional sessions. Students typically receive content information first and then are asked to use that information to solve problems by working through application exercises.<sup>8,9</sup>

The TBL methodology has been successfully utilized in medicine in preclinical through residency programs,<sup>5-10</sup> but to date there is no report of its application in peer-reviewed journals related to dental education other than in faculty development workshops at the American Dental Education Association's Annual Sessions.<sup>11,12</sup>

Based upon the approach developed by Hunt et al.,<sup>9</sup> the primary goal of TBL is to ensure that students have the opportunity to practice using course concepts. This approach results in using the majority of class time for teamwork on application-focused assignments. The TBL strategy involves four basic principles: 1) groups must be properly formed and managed; 2) students must be made accountable for their learning; 3) team assignments must promote both learning and team development; and 4) students must receive frequent and immediate feedback.

A critical aspect of this innovative teaching methodology is designing and implementing effective group assignments. Michaelsen et al.<sup>8</sup> argue that, to obtain the utmost effect on learning, the assignments must be characterized by the "3Ss":

- Same problem: individuals and groups should work on the same problem.
- Specific choice: individuals and groups should utilize the course concepts to make their choices.
- Simultaneously reported: the choices should be simultaneously reported by the individuals and groups, avoiding letting them change their minds based on another group's solution.

The TBL methodology has been found to foster more interactivity and a higher level of cohesiveness

and to be a very efficient teaching methodology.<sup>8-10</sup> This method has also been found to have economic advantages over other small group methods since it can be conducted in a large class of students with only one facilitator.<sup>8</sup> In a study conducted in several courses at Baylor College of Medicine, TBL was found to stimulate out-of-class study, higher levels of engagement, and higher levels of student knowledge-based performance.<sup>5</sup> In another study, TBL was used with pre-health sciences students and found to be very effective, enhancing HIV/AIDS interprofessional role perception, increasing positive attitudes towards collaboration and interprofessional care, and fostering confidence in teamwork skills.<sup>13</sup>

During the TBL learning sessions, groups are given PBL scenarios that stimulate discussion among students and promote a change from the traditional lecture-based format. Positive educational outcomes associated with the use of PBL have been reported in the dental education literature.<sup>15,16</sup> Both TBL and PBL encourage reflective thinking skills that are important in learning environments as they foster engagement. It is our experience that well-designed case problems will generate interest among students if the case correlates effectively with clinical practice. Rich et al. reported that PBL in the preclinical periodontics curriculum resulted in student performance in nonsurgical periodontics skills at a level equal to or greater than that of the conventional approach,<sup>14</sup> and a study of PBL conducted at Harvard School of Dental Medicine found an increase in extracurricular activities such as research.<sup>15</sup>

The goal of our project was to improve students' ability to diagnose pulpal and periapical pain using a TBL approach along with an audience response system (ARS) to provide immediate feedback and encourage team engagement and student interaction—thus enhancing learning. Our objectives to support this goal were the following:

1. Modify the curriculum to incorporate the innovative TBL approach to teaching pulpal and periapical diagnosis;
2. Bring faculty on board to support this approach to teaching;
3. Implement TBL in the sophomore second-year endodontics curriculum; and
4. Evaluate the impact of the TBL experience through the use of pre- and posttests and attitudinal surveys completed by students.

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## Methodology for Implementation

The second-year preclinical endodontics course was revised by the investigators, who reviewed the existing medical literature on TBL to provide guidance for effective uses of this innovative instructional strategy. To gain support and buy-in, meetings of departmental faculty were held during the revision process in order to discuss and evaluate the possible introduction of TBL into the course. Once the revisions were completed, the course was then presented to the department chair and other endodontic faculty for their approval, which was received. The revised course was then presented to the Dental Branch Curriculum Committee, which also approved it.

In the implementation phase, sixty-four second-year dental students in the preclinical endodontics course were selected to be participants in this study. Because the assessments to be undertaken in the course were considered normal practice in an educational setting by the Committee on Human Subjects, no Institutional Review Board (IRB) action was necessary.

Course faculty were given an orientation to TBL, including an overview of the pretest and two other assessment instruments known as the Individual Readiness Assurance Test (I-RAT) and Group Readiness Assurance Test (G-RAT). Based upon the TBL model developed by Michaelsen et al.,<sup>8,10</sup> three measures were developed by course faculty for this study: the pretest, the I-RAT, and the G-RAT. Each of the

tests developed was reviewed by other departmental faculty to ensure content validity prior to administration and was revised as necessary prior to its use.

Generally, as educators, we are guided by assumptions of how much students know or do not know, but in reality we lack evidence to prove or disprove our assumptions. Therefore, initial data for this study were gathered from the sixty-four students via the administration of a pretest to determine their entry-level knowledge. The pretest consisted of a twenty-five-item, multiple-choice exam of concepts from problem-based cases that would be reassessed later through the I-RAT and G-RAT (see Figure 1 for example of questions).

The I-RAT was used to determine whether students had completed the preclass reading assignments in preparation for the class. During each three-hour TBL session, students were given the I-RAT based upon previously given reading assignments with the purpose of determining individual knowledge level and comprehension related to diagnosis and treatment at that point in the course. To assist students in developing enhanced diagnostic skills, the cases included details of patients' chief complaints, medical history, and information from the clinical and radiographic examination. In addition, the questions were focused on the biology associated with the clinical findings.

The I-RAT was comprised of twenty-five questions, including multiple-choice, fill-in-the-blank, and short PBL cases using short answer responses indicating appropriate differential diagnosis or treatment planning (up to three sentences each) that

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A 35-year-old male, while playing basketball, had his central incisor exarticulated from the socket. Since he was more worried about the game than his injury, the tooth was kept in a paper towel and left in his pocket for approximately 3 hours before he saw his dentist. The best treatment of choice for this tooth is:

- a. splinting for 4 weeks, then pulpectomy and calcium hydroxide as an interim dressing for six months
- b. root canal therapy either extra-orally or intra-orally and splint for 2 weeks
- c. pulpectomy, calcium hydroxide, and then splint for 3 weeks
- d. splinting for 2 weeks and pulpotomy
- e. none of the above

**Figure 1.** Example of questions included in pretest

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helped to determine whether students had a basic understanding of key concepts based upon an assigned set of readings for the class. The I-RAT was a closed-book test.

Following the I-RAT, the students were divided into six groups of ten to eleven students each. Taking Michaelsen et al.'s approach,<sup>8,10</sup> the opportunity was given to the students to be assigned to the same group they had been with for the past semester during their laboratory exercises. Each group was provided with an audience response system (ARS) to enhance individual and group interaction. The system we used is called an OptionFinder (Option Technologies Interactive), which enables the creation of an interactive environment in which students receive instant feedback about their responses or answers to critical points in the TBL experience. Students were given an overview and demonstration of how to correctly use the ARS, prior to using it in the course.

After students were divided into groups, they were again presented with the same case-based patient differential scenario, but now they were expected to respond to a parallel test (G-RAT) consisting of concepts presented in readings and on the I-RAT. (Tests are considered parallel whenever

their information functions are identical.) The student groups then used the ARS only after reaching a group consensus about each answer. The G-RAT was immediately scored electronically in class using the ARS. This system allowed the faculty member to project group scores on a large screen at the front of the classroom for all students to see; groups could thus monitor their progress and compare their scores with their colleagues'. This approach allowed for immediate feedback and discussion by the entire class, led by the course director and facilitated by three other endodontics faculty. The intragroup and intergroup interaction was rich and probed the depth and breadth of the topics when there was any disagreement among the groups.

As a part of the G-RAT, Michaelsen et al.'s approach<sup>8,10</sup> allows students to appeal any missed questions based upon the readings and use of evidence to support their contention that their answer is correct. This approach allowed for immediate oral feedback and reinforcement by the faculty members.

As a final part of the study, a short four-item attitudinal survey was administered to students regarding their perceptions of this teaching and learning strategy. The survey questions appear in Figure 2.

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A. Was worthwhile: 83% agreement

<i>Strongly Disagree</i>	<i>Disagree</i>	<i>Neutral</i>	<i>Agree</i>	<i>Strongly Agree</i>
5	1	3	31	16

B. Helped improve my diagnostic skills: 83% agreement

<i>Strongly Disagree</i>	<i>Disagree</i>	<i>Neutral</i>	<i>Agree</i>	<i>Strongly Agree</i>
3	0	3	29	18

C. Enhanced my powers of critical analysis: 80% agreement

<i>Strongly Disagree</i>	<i>Disagree</i>	<i>Neutral</i>	<i>Agree</i>	<i>Strongly Agree</i>
2	1	9	26	17

D. Enhanced our ability to work as a team: 70% agreement

<i>Strongly Disagree</i>	<i>Disagree</i>	<i>Neutral</i>	<i>Agree</i>	<i>Strongly Agree</i>
2	1	8	25	18

Figure 2. Results from attitudinal survey of students regarding the TBL strategy

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## Results

The evaluation outcomes assessed in this study included a pretest, I-RAT and G-RAT, student attitudinal survey, and diagnostic skills assessment with final examination. The I-RAT and G-RAT results were statistically analyzed with a T-test significance level of  $p < 0.05$ . Pretest results indicate that students in general had minimal entry-level knowledge. The class mean was 36.9 percent. No student scored higher than 50 percent correct on the pretest. However, students performed dramatically better on the G-RAT (63.4 percent), on which they responded collectively as groups.

When the numbers of missed questions by each individual student were compared, the G-RAT showed significantly superior results when compared

to the I-RAT ( $p < 0.01$ ) (Table 1, Figure 3). Seventy to 80 percent of students agreed/strongly agreed with each of the statements about the benefits and value of TBL.

Finally, students obtained higher scores at final examination on the diagnostic questions as compared to the two previous years. In 2003, the class average of correct questions on diagnosis in the final examination was 56 percent; in 2004, it was 69 percent; and in 2005, it was 75 percent.

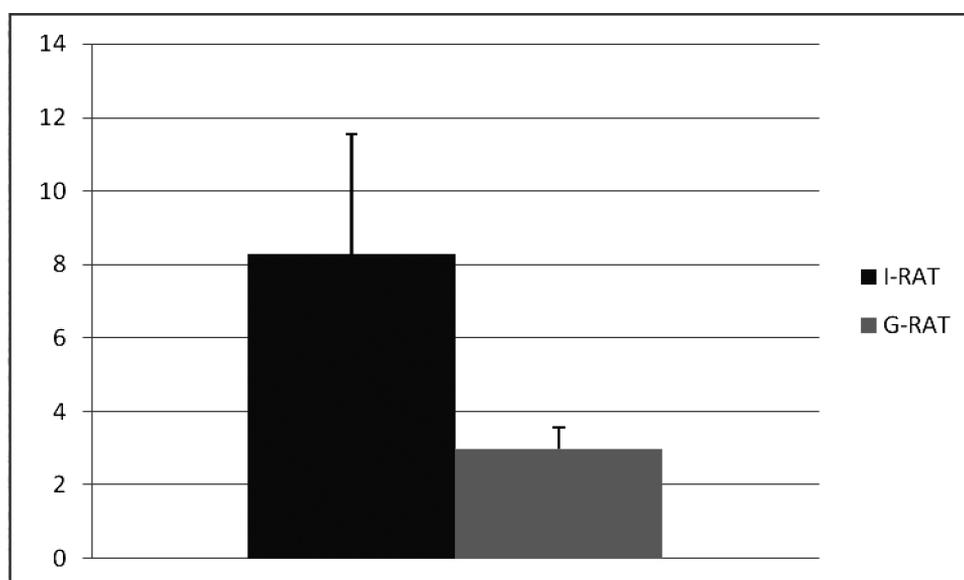
## Discussion

Team-based learning has been used in such educational areas as medicine and business. For example, TBL was utilized by a large group of interprofessional health care leaders in the National Academy of Practice (NAP), which resulted in a very positive outcome related to learning important skills for interprofessional collaboration.<sup>16</sup> However; the effectiveness of a TBL approach in dental education had not been investigated before our study, which was a catalyst for our efforts.

At the Dental Branch, we did not encounter problems with the formation of groups or number of students in the groups, perhaps because the faculty made the decision to maintain the original sophomore

**Table 1. Number of missed questions on the I-RAT and G-RAT**

	I-RAT	G-RAT
Mean	8.29	2.98
Standard deviation	3.26	0.57
Standard error	0.40	0.07



**Figure 3. T-test comparing number of missed questions between I-RAT and G-RAT ( $p < 0.01$ )**

laboratory groups and the number of students per group.<sup>10,11</sup> This strategy of keeping groups intact from other classroom or laboratory experiences has also been successfully used by others.<sup>10</sup> Our endodontics faculty were strongly supportive of using TBL as an innovative approach to teaching diagnosis and treatment concepts at the preclinical level. Since we only utilized TBL for diagnosis and the resulting treatment options, the six hours we committed to TBL appeared to be adequate for this content as can be seen by reviewing the posttest scores.

The TBL pretest demonstrated that students had little entry-level knowledge, with no score higher than 50 percent correct, indicating to the faculty that it was important to address diagnosis and the resulting treatment options in more detail. On the G-RAT, students' achievement level was at 64 percent, indicating a twofold increase in knowledge from the I-RAT regarding diagnosis and treatment planning during this midcourse experience. On the final examination, the students achieved a 75 percent correct response rate on the diagnosis and treatment planning questions compared to 56 percent on the final examination two years prior. The I-RAT and G-RAT were new experiences for the students, who were more accustomed to responding to multiple-choice questions than using the higher order thinking skills required for both the I-RAT and G-RAT. For this reason, these tests were not used in a summative manner, but instead as data points averaged into their overall grades. Anecdotally, clinical faculty stated that they observed that students seemed to have improved diagnostic ability while in the clinic. Based on these outcomes, the course faculty believe that this methodology improved students' didactic knowledge as well as their diagnostic skills when in clinic. By comparing the engagement in PBL and TBL in the medical field, we see the amount of learner-to-learner engagement was similar and much greater than in lectures with greater faculty input.<sup>16</sup> Engagement of learners to learners in our study is supported by both the observations of peer reviewers in the TBL classes and the outcomes on the attitudinal survey in their engagement as a team (see Figure 2).

We successfully used the ARS to provide immediate and direct feedback to the students linked to interactive learning objectives. Additionally, the use of the ARS enabled us to present immediate feedback to the entire class that facilitated group engagement and strengthened the learning of important concepts.

We believe that using TBL enhanced our students' skills on differential diagnosis and hopefully prepared them for success in their daily clinical education experience. In addition, it appears that using TBL strengthened teamwork and fostered some students' development of critical thinking, thus influencing students' perceptions of this approach to teaching.<sup>6</sup> However, we would recommend that other dental schools implement and study this innovative approach to teaching in their schools, since this report only reflects the experiences in one school.

In conclusion, this study was not only the first to introduce TBL to dental education, but also the first to incorporate the use of an ARS with TBL as a more innovative way of teaching diagnosis. In the future, we hope to demonstrate over time an increase in diagnostic skills and compare analyses of perception for students and faculty.

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