Utilization of Blended Learning to Teach Preclinical Endodontics

Cristina Maresca, D.D.S., M.S.; Carlos Barrero, B.D.S., M.S.; Dereck Duggan, B.D.S., M.S.; Enrique Platin, D.D.S.; Eric Rivera, D.D.S., M.S.; Wallace Hannum, Ph.D., M.S.; Frank Petrola, B.A.

Abstract: Blended learning (BL) is the integration of classroom learning with an online environment. The purpose of this study was to determine whether dental students who experienced BL in a preclinical endodontic course demonstrated better manual skills, conceptual knowledge, and learning experience compared to those experiencing traditional learning. All eighty-one students (100 percent) in a preclinical endodontics course agreed to participate and were assigned to either the traditional or BL group. A root canal procedure was used to determine the level of manual skills gained by each group. Pre- and post-intervention quizzes were given to all students to evaluate conceptual knowledge gained, and the students' perspectives on the methods were evaluated with a survey. The BL group scored better than the traditional group on the manual skills exercise at a statistically significant level (p=0.0067). There were no differences in the post-intervention quiz scores between the two groups, and the students' opinions were positive regarding BL. With BL, the students were able to learn and demonstrate dental skills at a high level.

Dr. Maresca is a graduate resident, Department of Endodontics, University of North Carolina at Chapel Hill School of Dentistry; Dr. Barrero is Clinical Associate Professor, Department of Prosthodontics, University of North Carolina at Chapel Hill School of Dentistry; Dr. Duggan is Assistant Professor, Department of Endodontics, University of North Carolina at Chapel Hill School of Dentistry; Dr. Platin is Clinical Professor, Department of Endodontics, University of North Carolina at Chapel Hill School of Dentistry; Dr. Rivera is Associate Professor, Department of Endodontics, University of North Carolina at Chapel Hill School of Dentistry; Dr. Hannum is Associate Professor, University of North Carolina at Chapel Hill School of Education; and Mr. Petrola is Research Assistant, Department of Prosthodontics, University of North Carolina at Chapel Hill School of Dentistry. Direct correspondence and requests for reprints to Dr. Carlos Barrero, Department of Prosthodontics, University of North Carolina at Chapel Hill School of Dentistry, 333 Brauer Hall CB 7450, Chapel Hill, NC 27599; 919-537-3959; carlos_barrero@dentistry.unc.edu.

Keywords: dental education, blended learning, teaching methodology, endodontics

Submitted for publication 6/21/13; accepted 12/5/13

Traditionally, a preclinical endodontics course is taught using a face-to-face (synchronous) learning approach. In this method, the faculty member demonstrates a clinical technique using, most commonly, a PowerPoint presentation in a lecture hall. Students then perform the same technique in a simulated clinic environment. Such face-to-face learning can be problematic because information is delivered at only one time without any interactivity or opportunity for students to repeat all or even any of the lecture segments. Face-to-face learning is believed to be a passive learning approach. It is expected that all students will process the presented information in the same way and learn how to perform the technique without the opportunity to review important concepts from the presentation. In this learning environment, some students excel, most students eventually complete the task, and a few struggle.

A possible solution to address these issues is to teach the preclinical endodontics course using blended learning (BL): a combination of synchronous (face-to-face) and asynchronous (online technology-mediated learning modules) approaches.[1] A multimedia learning module that presents the information and demonstrates the skills allows students to access instructions not only when material is presented for the first time but also permits them to review the material later, when it is most convenient for them to concentrate, and multiple times if needed. Frequently, students need access to demonstration of the task even when practicing techniques during a laboratory session. For all these reasons, BL can provide a more effective teaching strategy for students' acquisition of knowledge and skill sets. It has been reported that this methodology can also help dental educators overcome such challenges as faculty shortages and limited funds and help reduce lecture time in a saturated curriculum.[2,3]

Many educators agree that e-learning plays an important role in the future of university education.[4] Evidence from previous studies indicates that online learning is as effective, and sometimes more effective, than traditional classroom instruction.[5-7] A recent

research project conducted by the U.S. Department of Education concluded that an online approach to learning, whether all online or in a BL environment, was more beneficial for students' learning than a face-to-face classroom setting.[8] E-learners often demonstrate increased content retention that results in improved knowledge, skills, and attitudes because students control their access to the content. Advancements in e-learning are establishing the groundwork for a revolution in graduate medical education, for example, by individualizing learning, enhancing learners' interactions with each other, and transforming the role of teachers from disseminators of information to facilitators of self-motivated learning.[9]

A variation of online teaching is BL, which may be the perfect teaching strategy for dental students in preclinical endodontics by allowing them to have multiple outlets of learning while retaining student-to-student and faculty-to-student interactions. BL is an instructional method that allows students to access various experts and materials, supplements traditional instructor-led training, and eases the strain of faculty shortages. BL may decrease the required hours in the classroom because it allows students to access outlets of study anywhere there is a computer and Internet access. BL may also decrease the time required for expert faculty members to be in the classroom, allowing them more time to answer student questions in office hours or via a chat room or to practice in a clinic. BL has been proposed as an alternative method for graduate orthodontic education,[10,11] but has not previously been proposed in the area of endodontics or in preclinical laboratory formats. As with other instruction, interaction is a key component in distance education. Researchers and practitioners agree that interaction increases learning satisfaction in distance education courses.[9,12,13]

The objective of this project was to determine if there were differences in acquiring manual skills and conceptual knowledge of a particular skill, such as completion of a maxillary endodontic root canal therapy, by second-year dental students after the use of BL in a preclinical endodontics course as compared to those who did not experience the BL approach. The online modules employed in our study, designed to maximize the learning experience, allowed students to review endodontic concepts and develop dental skills at their own pace without face-to-face interaction. In addition, this study tested the hypothesis that a blended learning course can develop students' competence in both preclinical laboratory and didactic learning with less direct supervision than with our past traditional methods. Knowledge gained from this research might also help shape future guidelines for the development of preclinical courses in our dental school.

Materials and Methods

This study was approved by the Institutional Review Board of the University of North Carolina. Permission was granted to test a BL module as a method of teaching preclinical endodontics at the University of North Carolina at Chapel Hill (UNC) School of Dentistry. A series of four lectures and six videos that were part of the preclinical endodontics course for second-year students were redesigned, updated, and recorded (Figure 1).

Videos and narrated lectures were created and edited by university staff experts on development of educational material for professional schools. Final Cut Pro Photoshop and Panopto software were used to develop instructional materials that fulfilled all standards of quality. At UNC, eight endodontic residents, five faculty members from the Department of Endodontics, one faculty member from the Department of Radiology, and one faculty member from the Department of Prosthodontics were asked to provide feedback regarding the completeness and detail of the learning modules. Also, two faculty members from the University of Houston were consulted. After reviewing critiques and feedback forms from these individuals, further improvements and corrections were made to all educational material, and the preclinical course director granted final approval.

The course management system used to test and deliver the experiment was SAKAI. Two platforms were created for the course: one for the traditional group and one for the blended learning group. For students to access their SAKAI accounts, they were given a unique username by the university. Each student then password-protected his or her account, giving that student access to only that specific SAKAI platform.

For the BL group, the six narrated videos and the four lectures were uploaded to the SAKAI platform. Only the BL group had access to these recorded resources, and students were not told beforehand what documents would be in their SAKAI platform. When students logged in, they had access to only what was linked to each's SAKAI identity. The SAKAI platform for the BL students contained links to reading assignments, four interactive prerecorded

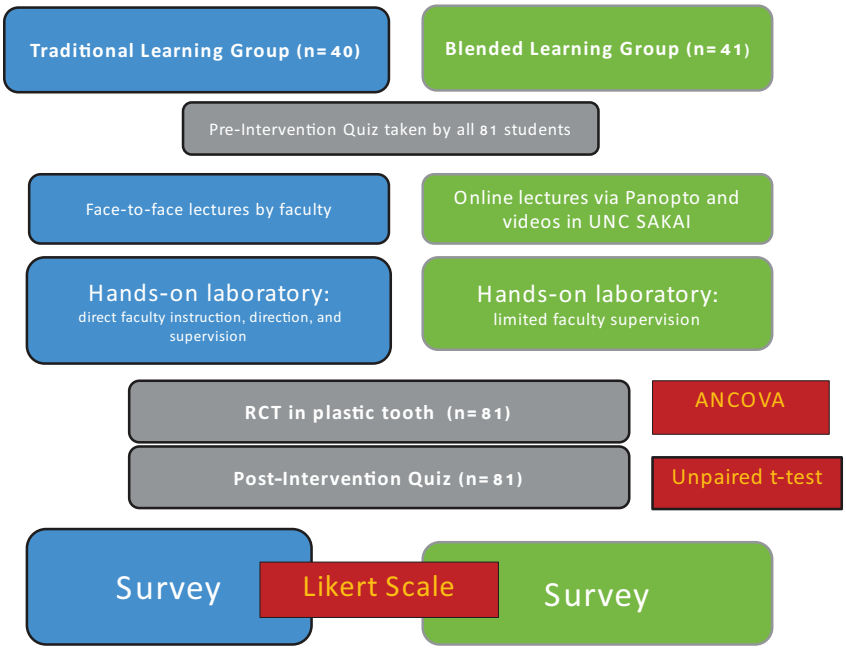

Figure 1. Design of this study

lectures pertaining to the content in PowerPoint using Panopto, two quizzes corresponding to the prerecorded lectures, and six narrated videos.

For the traditional group, the SAKAI preclinical course platform contained links to reading assignments, two quizzes corresponding to the traditional lectures, and live faculty lectures. Those lectures were in the following topics: knowledge of pulp morphology, internal anatomy access, negotiation initial working length, crown down and final working length, apical enlargement, shaping errors, endodontic radiography and radiographic interpretation, endodontic instruments, medicaments, filling, and coronal seal.

The study was explained to all eighty-one students registered for the course DENT 220 Endodontics Preclinical Laboratory. Participation in the study was voluntary, and all eighty-one agreed to participate. The participants were assigned to two groups: the traditional group consisted of students who experienced the conventional face-to-face learning (n=40; last name M-Z); and the BL group consisted of students exposed to the BL methodology (n=41; last name A-M). To prevent cross-contamination between the groups, the students were advised that there would be sanctions for cheating or sharing information of the resources in their individual SAKAI accounts. Also, recordings on the SAKAI website could not be saved and transferred. In addition to this protocol, records were maintained of how many times each of the students in the BL group launched the videos and the duration of each viewing session.

Assessment Quizzes and Laboratory Exercises

All eighty-one students were assigned a pre- and post-intervention quiz. The pre quiz took place during the first introductory lecture. Its purpose was to assess the baseline knowledge of the two groups. The post quiz was presented in similar fashion after completion of the laboratory exercise, which followed the first introductory lecture. Students were asked to complete the post quiz within an hour of completing the laboratory exercise. The content of both quizzes was approved by the course program director. To prevent testing contamination, students in the traditional group did not have access to the

SAKAI BL platform. Students in the experimental (BL) group who failed the post quiz would be given a remediation tutorial and retested. Students in the traditional group who failed the post quiz would keep that score.

For the laboratory exercises, the two groups were assigned to two different laboratories. Students in the traditional group (the conventional face-to-face format) experienced a live narrated demonstration of the access, instrumentation, and filling of a maxillary central incisor, all of which the students observed on their assigned lab bench monitors. This face-to-face demonstration took approximately thirty minutes prior to the student's performing the technique on a typodont tooth. The laboratory was staffed with six faculty members who provided additional explanations if students had questions. Faculty members in the traditional group lab were considered to be expert faculty, meaning they had multiple years of experience practicing endodontics. By contrast, students in the BL group experienced the online modules and were instructed to immediately begin accessing, instrumentation, and filling a maxillary central incisor on a typodont tooth. Since this group had prior access to the videos, no live narrated demonstration was given. Students used headphones in the laboratory and were asked to work independently by following the directions and demonstration in the videos. The BL laboratory session had a limited number of instructors present, and these instructors were endodontic residents. The BL students were given an additional thirty minutes of practice since this group had not received a face-to-face faculty demonstration.

In both groups, instructors were present in the laboratory to answer students' questions and evaluate performance. The student/instructor ratio was 10:1 for both groups. However, in the BL group, faculty-level assistance was limited, and endodontics residents rather than expert faculty served as instructors. To measure this limited assistance for the BL group, all instructors had a custom table that allowed them to record the number of interactions and types of questions asked. The questions were classified as simple or complex. Simple questions were related to technical procedures that took the instructor less than a minute to address or were necessary check steps. Complex questions were those that required additional one-on-one demonstrations to communicate the information.

Post-Intervention Quizzes and Manual Skill Grading

For the two post-intervention quizzes, all students were present in their corresponding laboratories. The quizzes were uploaded to the SAKAI platform for both groups, were password-protected, and had a record specifying the log-in time and date. Fifteen minutes after initial quiz launching, quizzes from both groups were retrieved from the platform, and students were no longer granted access. The content of the two quizzes was identical for the two groups and contained the same content as the pre-intervention quizzes. The only difference between the pre and post quizzes was the order of questions and randomization of answers. The results for both groups for the pre and post quizzes were statistically compared with ANCOVA.

After the laboratory sessions were completed, all the typodont teeth from both groups were collected for grading, and the students were dismissed from their corresponding laboratory. At the end of the experiment, students who had difficulty learning to perform the skills were tutored until they mastered the technique, regardless of which group they had been a member. All students were also then given access to the SAKAI BL platform in case they needed to review specific items of the technique.

The eighty-one plastic maxillary incisors typodont teeth were labeled, coded, and mixed in a single container so the graders did not know the students' names or assigned group. The graders—eight endodontic residents—determined the total number of error points based on a set of prespecified criteria. The graders were calibrated and masked to the identity of each group. Each focused on one specific criterion to grade. After the grader gave a score for that criterion, the tooth was passed on to the next evaluator to grade his or her criterion. CITA (Council of Interstate Testing Agencies, Inc.) performance criteria were used to evaluate the endodontic treatment on the maxillary tooth. Unpaired t-tests were used to determine whether there was a statistically significant difference between the traditional and BL test groups in the exercise.

Survey

All eighty-one students were surveyed after completing the exercise and allowing the BL group the opportunity to participate in the traditional methodology and the traditional group the opportunity to

access the online material. Two sets of surveys were developed for the traditional and BL groups using the online software Qualtrics. The eighteen-question survey included both multiple-choice and open-ended questions. The students rated their perceptions of the learning experience, assessment of their skill level, and confidence in performing the skills taught. Their perceptions regarding the recorded seminar, reading materials, technology, and post-seminar discussions were measured on a five-point Likert scale (1=strongly disagree to 5=strongly agree). The surveys were developed in consultation with the UNC Department of Education based on previously published research and feedback from thesis committee advisors.

To announce the surveys, an email was sent to all eighty-one students through Qualtrics. To encourage feedback, email addresses were not linked with individual responses, and participants in the survey were awarded three percentage points on their final grade for the course. The deadline for completion of the surveys was approximately three weeks following the date of the first email. A second email reminder was sent two weeks after the first one. Data were collected from Qualtrics and imported into an Excel spreadsheet for analysis. Descriptive statistics such as percentages, means, and standard deviations were used to analyze findings.

Results

Eighty-one students (100 percent of the class) participated in the study: forty in the traditional group and forty-one in the blended learning group. The outcomes measured were the students' ability to complete a maxillary anterior endodontic treatment in an acrylic simulation maxillary central incisor and the students' scores on the pre- and post-intervention quizzes.

Analysis of Covariance (ANCOVA) was used to compare the two groups' post quiz scores using the pre quiz score as a covariate and included interaction between the traditional and BL groups. The level of significance was set at 0.05. The mean grades on the two quizzes are shown in Figure 2. There was no statistically significant interaction in the pre quiz scores between groups, indicating that the pattern of pre quiz scores was similar for the two groups and the two groups were similarly distributed (p=0.59). After we controlled for the pre quiz scores, there was no statistically significant difference in the post quiz score mean grades between the two groups (p=0.92).

However, the students' mean grades in the manual skill exercise (which served as an indicator of the acquisition of manual dexterity) showed a significant difference between the two groups (p=0.0067).

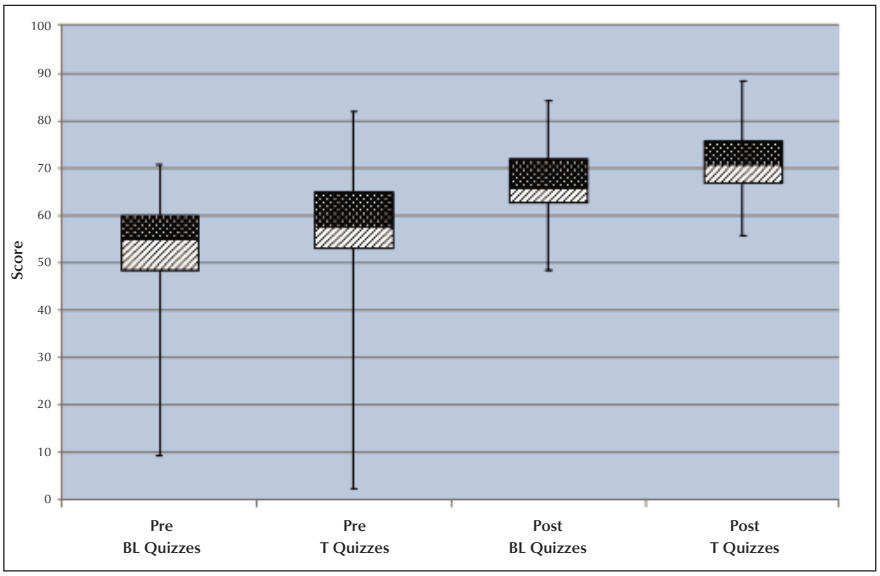

Figure 2. Mean and box plot of grades for the pre- and post-intervention quiz scores of blended learning (BL) and traditional lecture (T) groups

On average, the BL group scored higher than the traditional group on the exercise (x=42.5, s=14.4 vs. x=34.2, s=12.1, respectively; Figure 3).

All eighty-one students (100 percent) participated in the survey. Survey results demonstrated that a high percentage of the students learned appropriately, were attentive, and comprehended the videos sufficiently to complete the exercise (Figure 4). Almost all students responded positively when asked if they had liked the BL techniques. Regard-

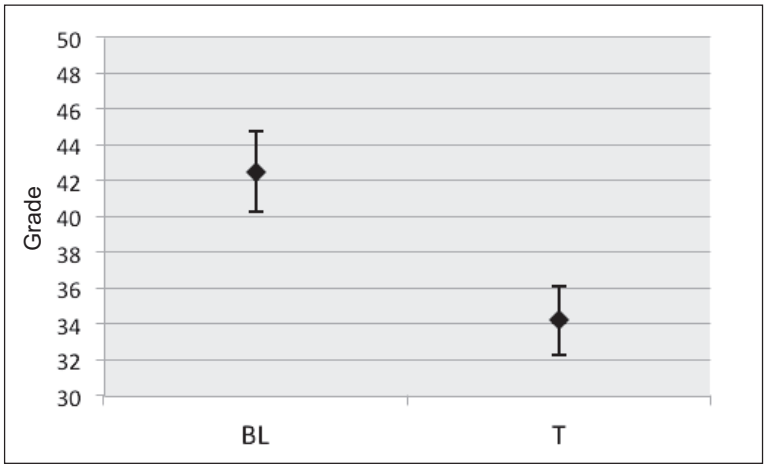

Figure 3. Manual skills root canal therapy grades: mean and standard error of blended learning (BL) and traditional lecture (T) groups

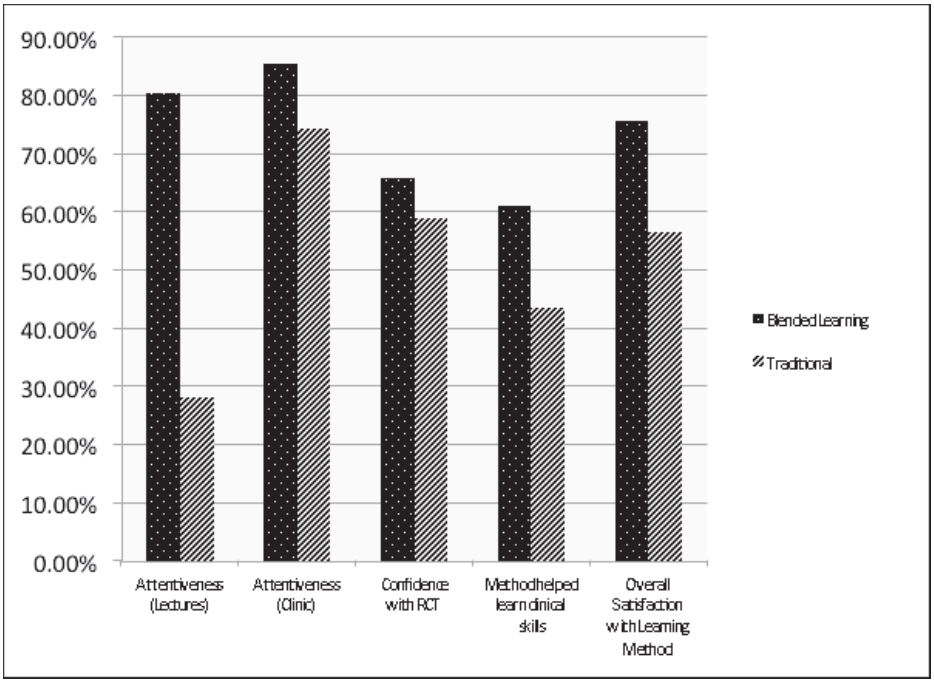

Figure 4. Students' satisfaction with course, by percentage of each group who agreed or strongly agreed

ing learning a clinical skill such as performing a root canal, a higher percentage of students in the BL group (61 percent) showed a preference for their method of learning than did the students in the traditional group, of whom 42 percent showed a preference for the traditional method. Also, 68 percent of the BL group agreed that its method helped them learn the content versus 38 percent in the traditional group. The BL and traditional groups reported a similarly high level of attentiveness (85 percent and 74 percent, respectively) while participating in their learning method. However, some students in the traditional group said that the ability to remain attentive in a large lab varied greatly depending on where the student sat (front of lab versus back).

The traditional group attended a traditional lecture given by a live faculty member, while the BL group watched a prerecorded lecture on Panopto. Participants in the BL group reported a much higher level of attentiveness during lectures (81 percent) than did the traditional group (27 percent). This can be attributed to the BL students' ability to rewind or fast-forward the lecture, pause and take notes, and choose a preferred time to watch the video. The two groups were almost identical in responding that the use of technology was not a distraction: only 18 percent of the traditional group agreed that the use of technology was a distraction, while 19 percent of the BL group did. Although a majority in both groups reported a high level of satisfaction with their respective method of receiving lectures, the BL group reported a higher level of satisfaction (75 percent) than the traditional group (56 percent). However, three students in the BL group complained that they could not receive immediate answers to their questions during a lecture and also during or after watching online videos; this amounted to 7 percent of the BL group who were unhappy about not receiving an immediate response The BL students had to submit questions to an online forum and wait hours or days for a response, whereas traditional group students could simply ask the faculty member during or immediately after the lecture.

The majority of both groups reported feeling confident in their ability to perform root canal therapy after completing their respective teaching methods: traditional group=59 percent vs. BL group=66 percent. However, a higher percentage of both groups agreed they would require additional faculty help in performing root canal therapy: 77 percent of the traditional group vs. 71 percent of the BL group. The two groups asked roughly the same number of questions in the laboratories; however, many of the questions from the traditional group were more basic in nature than those of the BL group. Typical examples of questions asked by the traditional group were "How many accessory cones should I place?," "Which instrument should I use?," and "Is my access too big? Too small?" The BL group questions were more related to conceptual definitions such as AGF (Apical Gauge File) vs. MAF (Master Apical File).

The BL group reported a markedly higher level of satisfaction than the traditional group with their learning method: 85 percent of students in the BL group said they would like to have subsequent seminars taught using this method. In addition, 85 percent of the same group said they would recommend this method to other students taking the same course. However, it should be noted that many students commented that, although they preferred viewing lectures and skills demonstrations using the online method, they also said it was imperative to have faculty in the lab to allow for direct interaction.

Discussion

This study assessed the educational effectiveness of blended learning using three major measures: acquisition of knowledge assessed by students' academic performance on quizzes; gain of dexterity and ability measured by students' manual skills in completing root canal therapy using a resin maxillary central incisor; and course satisfaction gauged by asking students to complete post-course surveys. Both knowledge and skill assessments came from the students' grades, while their satisfaction levels regarding the course were derived from the surveys. This methodology has been used similarly in other studies.[14-16]

Regarding students' performance, our study found a statistically significant difference between mean grades on the practical test (anterior root canal therapy) between the traditional and the BL groups. The results indicated that students in the BL group performed better than students assigned to the traditional group. Regarding the pre- and post-intervention quizzes, using the pre quiz score as a covariate, there was no statistically significant difference between the two test groups based on the average post quiz scores.

Although a great deal of evidence has shown no significant differences in student performance between distance learning and traditional classroom

instruction, there remain significant differences in the way online learning experiences are perceived by participating students. According to Chodorow, multiple studies have found that students from BL courses demonstrate increased content retention, resulting in improved acquisition of knowledge, skill, and attitude because they have control over access to the content.[17] In our study, since students in the BL group had limited contact with instructors, some of the dynamics and interaction that come with synchronous (face-to-face) teaching was lost, which could possibly explain why the BL group did not outperform the traditional group on the post quiz.

The BL group reported a markedly high level of satisfaction with the blended learning techniques: 85 percent said they would like to have subsequent seminars taught using the BL method, and 85 percent said they would recommend the BL method to other students taking the same course. However, it should be noted that many of these students commented that although they preferred viewing lectures and skills demonstrations using the online method, they also said it was imperative to have faculty in the laboratory to allow for direct interaction. This may indicate that students and faculty do not see BL as replacing traditional instructor-led training but as a complement to it,[9] especially for training in skills that students are learning to perform in the laboratory.

The students' performance and satisfaction seemed to be at their height when a blended learning technique was implemented. These results directly relate to the U.S. Department of Education meta-analysis that showed a blended learning methodology resulted in students' performing better when compared to a traditional face-to-face style of teaching.[8] Giving students access to educational tools via online videos, lectures, and tutorials allows them to have more time reviewing concepts and, unlike face-to-face lectures, does not confine them to learning only in the classroom. The students in our study thought it imperative to have faculty interaction along with the online teaching—a combination consistent with findings in the Department of Education meta-analysis.

Students' satisfaction with the course in our study was notably high at 85 percent, based on their answers to the survey. In particular, students from both groups remarked on the high quality of the videos, lectures, organization of the course, and the educational content. Their perceptions reflected the fact that the BL course content was based on distance learning principles and organized to enhance self-paced learning. In addition, the course material was developed by content professionals specifically for this course. Therefore, the material did not resemble any existing, probably outdated written or electronic material created in the past. The quality of the e-learning material and positive student evaluations are important factors in determining the success of blended learning courses in higher education—dentistry in particular. Studies by Tan et al. in radiology,[18] Linjawi et al. in orthodontics,[19] and Gibbard and Salajan in prosthodontics,[20] in which traditional courses were converted into e-learning courses, found that the e-learning courses could be fully implemented into curricula based on students' positive responses and the quality of the content.

Technological challenges can be very frustrating for learners and can negatively impact their perception of electronic learning materials.[21] Students in our endodontics BL study strongly agreed they were not distracted from learning because of the technology. However, to truly advance online education, maximum efforts need to be applied to reducing technological difficulties. In previous studies done in the orthodontics department at the UNC dental school, technological issues were the most frequent criticism.[5,16,21] Residents and faculty members in those studies were most concerned with the need for better editing, need for more frequent visual aids, the slow pace of the seminars, and the video/sound quality. The high satisfaction rate with the BL approach in our study was due mainly to the quality of editing, visual aids, detailed instruction, and sound of the online material.

Currently, the UNC School of Dentistry is fortunate to have access to the university's Center for Educational Development and Informatics, whose professionals provide faculty members with support for making videos, recording lectures, and creating platforms using state-of-the-art technology and equipment not present in other dental schools. For example, Panopto is a program that allows for multiple windows to be viewed simultaneously. This allows the viewer to observe both the presenter and the presentation at the same time, with the added ability to pause, skip, and rewind. The high definition of the videos, fabricated with Final Cut Pro Photoshop, as well as the clear sound, contributed to the high level of satisfaction reported by the students in our study.

The students in the BL group also reported being attentive during the online lectures since they were able to pause and write notes throughout the lectures to avoid missing any part. They could also rewatch part of the videos around their personal

schedules and at their own pace. One student commented, "It prevents me from losing focus and surfing the Internet as I would in class." Another student with a learning disability and short attention span noted, "I can pause the video and refocus and begin again when I am ready. I am also in a more comfortable environment without distractions [from] other classmates." Another student stated that the online video "levels the playing field: everyone learns the same material and reviews it as much as necessary. When faculty lecture or demonstrate in the lab, not everyone can see or hear equally, and different faculty members share different pieces of information."

Despite the value of the online modules, the face-to-face meetings in the laboratories were rated as highly important by most of the students. This finding supports the idea that there is still a high preference among students for face-to-face communication with the teacher and social interaction with colleagues. A previous study found that students generally had a positive response to web-based instructional formats, but that classroom interaction and participation were perceived as a necessary component to learning.[22] Another study reported students preferred online modules to be used as a complement to face-to-face learning, not in place of it.[23]

In our study, the most reported disadvantage in the open-ended questions of the survey was students' inability to ask questions and receive immediate feedback while using the online teaching tool. Even though a forum was provided to post questions, only a few students used this feature in the SAKAI platform. Rather, students preferred asking the faculty member directly during the laboratories and/or emailing faculty members. As one student stated, "SAKAI takes too many clicks to get to the forums and it may be easier to ask a nearby faculty. The problem with online interaction is sometimes faculty may not be as readily accessible as one would like." This challenge represents a disadvantage in online learning since the BL students could miss out on the potential learning opportunities offered via other students' questions. On the other hand, some students reported that when the faculty member was asked questions during the face-to-face lecture, the instructor tended to lose track of the presentation, thus inadvertently adding confusion.

According to Klein et al.'s study,[21] a discussion format is the most effective way of learning material but not the most time-efficient since it includes a lot of dead time or empty pauses while participants think about what they want to say. Also, lectures that are not rehearsed, according to Klein et al., can potentially negatively affect their acceptance. On the other hand, many faculty members and residents in our study reported to us anecdotally that having residents participate in the video of the recorded seminars would be beneficial. They agreed that it would have been more interesting and could have provided a better learning experience for students to watch the interaction between residents and faculty members in the recorded seminar video as opposed to seeing the faculty member lecture alone. However, the lectures were rehearsed and recorded in a non-noise environment to improve the audiovisual experience. As a result, a majority of the students still reported being satisfied with the short and concise lectures despite having only a single faculty member narrating the videos.

It cannot be expected that the current generation of students learn in the same way previous generations did. Members of the Millennial generation, or Generation Y, were born between 1980 and 2000 and currently comprise nearly a quarter of the world's population.[24] They are the first generation to grow up surrounded by digital media: two-thirds of them used computers before the age of five, and they are constantly connected to friends, parents, information, and entertainment. Accustomed to being surrounded by technology that offers much potential, they have high expectations and clear goals. They are willing to work hard and expect to have the support they need to achieve their objectives. Millennials are multitaskers and can easily engage in a multitude of activities at the same time, such as text messages, email, blogs, and interpersonal dialogue. They comprise the current and next generations of dental students for whom educational institutions have to adapt their curricula to successfully mold into future dentists. Blended learning methods can ameliorate the challenge of keeping up with this paradigm shift since the techniques are more in line with educational needs of today's students.

BL can also facilitate the distribution of faculty resources in highly specialized areas, resulting in greater cost effectiveness by lowering the teaching load of experienced and specialized faculty and making educational resources more widely available to students. Initially, faculty members using BL will have an increase in workload prior to class commencing because they will have to prepare their coursework and online materials. However, their daily workload during the semester will decrease, allowing more time for clinic

work or to aid students. With increasing teaching demands on many endodontic faculty members and the need to better integrate and decompress dental curricula, BL is an option that can be implemented in many programs at predoctoral and graduate levels to help with these issues. Although distance education cannot be expected to replace traditional classroom instruction, our study confirms that BL can be a useful complement. In some cases, BL has proven to be at least as good as traditional approaches, found to be particularly beneficial and useful in teaching basic concepts that underlie clinical practice in a preclinical setting.[25] According to Bednar et al.'s study, BL learning offers two potential benefits: it alleviates problems associated with shortages of experienced full-time faculty, and it reduces dependence on expert faculty for demonstrations during laboratory sessions by allowing junior faculty to take a leading role in teaching intensive preclinical courses.[25] For example, in many instances, high-quality narrated presentations and videos can be moderated by junior faculty during a laboratory session, even if expert faculty are not available. It seems highly likely that these benefits would also broadly impact other areas of dental education as well as continuing dental education.

The majority of BL research has concentrated on determining if the gain of conceptual knowledge can be the same or better compared to distance learning and traditional classroom instruction.[1-3,15] In dental education, BL has been tested in the areas of orthodontics and prosthodontics, where it has been shown that learning via a virtual interactive asynchronous environment can be significantly improved with the presence of a tutor.[16,19-21] However, very little research has been done previously in the area of acquiring manual skills, particularly in endodontics and especially in a preclinical course, so our study moves the research forward in this area in particular.

Conclusion

This study evaluated a blended learning methodology for teaching endodontics to predoctoral dental students, and the results showed it was viable to teach the preclinical endodontics course using this method. The blended learning approach was well received by the dental students with no major problems or issues. Concerning performance, students in the blended learning group performed significantly better on the manual skills assessments and similarly for the conceptual knowledge compared to their colleagues in the traditional group. With the utilization of the blended learning environment, the students were able to learn and perform the specified dental procedure with a 30 percent reduction in lecture time.

These students also evaluated the course components positively. Students in both groups highly appreciated the content, organization, educational material, and design. Overall, the students' attitudes towards blended learning courses were positive: they reported that blended learning was effective and motivating and that it promoted active engagement and enhanced self-study and self-assessment. In particular, students in the blended learning group liked the combination of online and face-to-face teaching in the laboratories, finding it effective and enjoyable. However, the students did not want to see a BL approach replacing traditional instructor-led training, but rather as a complement to it.

REFERENCES

1. Graham CR. Handbook of blended learning: global perspectives, local designs. San Francisco: Pfeiffer, 2005.
2. Cornell R. The onrush of technology in education: the professor's new dilemma. Educ Technol 1999;39(3):60-3.
3. Garrison DR, Kanuka H. Blended learning: uncovering its transformative potential in higher education. Internet Higher Educ 2004;7:95-105.
4. Johnson DW, Johnson RT, Smith KA. Active learning: cooperation in the college classroom. Edina, MN: Interaction Book Co., 1991.
5. Bednar ED, Hannum WM, Firestone A, et al. Application of distance learning to interactive seminar instruction in orthodontic residency programs. Am J Orthod Dentofacial Orthop 2007;132:586-94.
6. Cook DA, Levinson AJ, Garside S, et al. Internet-based learning in the health professions: a meta-analysis. JAMA 2008;300:1181-96.
7. Schmid RF, Bernard RM, Borokhovski E. Technology's effect on achievement in higher education: a stage I meta-analysis of classroom applications. J Comput Higher Educ 2009;21:95-109.
8. Evaluation of evidence-based practices in online learning: a meta-analysis and review of online learning studies. Washington, DC: U.S. Department of Education, Office of Planning, Evaluation, and Policy Development, 2010.
9. Ruiz JG, Mintzer MJ, Leipzig RM. The impact of e-learning in medical education. Acad Med 2006;81:207-12.
10. Trotman C, Bennett E, Scheffler N, Tulloch JC. Faculty recruitment, retention, and success in dental academia. Am J Orthod Dentofacial Orthop 2002;122:2-8.
11. Eaton KA, Reynolds PA, Grayden SK, Wilson NHF. A vision of dental education in the third millennium. Br Dent J 2008;205:261-71.
12. Zhang D. Interactive multimedia-based e-learning: a study of effectiveness. Am J Distance Educ 2005;19:149-62.
13. Wanstreet C. Interaction in online learning environments. Q Rev Distance Educ 2006;7(4):399-411.

14. Neuhaus KW, Schegg R, Krastl G, et al. Integrated learning in dentistry: baseline data and first evaluation at the Dental School of Basel. Eur J Dent Educ 2008;12:163-9.
15. Woltering V, Herrler A, Spitzer K, Spreckelsen C. Blended learning positively affects students' satisfaction and the role of the tutor in the problem-based learning process: results of a mixed-method evaluation. Adv Health Sci Educ 2009;14:725-38.
16. Bednar ED, Hannum WM, Firestone A, et al. Application of distance learning to interactive seminar instruction in orthodontic residency programs. Am J Orthod Dentofacial Orthop 2007;132(5):586-94.
17. Chodorow S. Educators must take the electronic revolution seriously. Acad Med 1996;71:221-6.
18. Tan PL, Hay DB, Whaites E. Implementing e-learning in a radiological science course in dental education: a short-term longitudinal study. J Dent Educ 2009;73(11): 1202-12.
19. Linjawi AL, Hamdan AM, Perryer DG, et al. Students' attitudes towards an online orthodontic learning resource. Eur J Dent Educ 2009;13:87-92.
20. Gibbard LL, Salajan F. A novel interactive online module in a traditional curriculum through a blended learning approach. Electron J e-Learn 2009;7:301-8.
21. Klein KP, Hannum WM, Koroluk LD, Proffit WR. Interactive distance learning for orthodontic residents: utilization and acceptability. Am J Orthod Dentofacial Orthop 2012;141(3):378-85.
22. Ginns P, Ellis R. Quality in blended learning: exploring the relationships between online and face-to-face teaching and learning. Internet Higher Educ 2007;10:53-64.
23. Durham JA, Brettell S, Summerside C, McHanwell S. Evaluation of a virtual anatomy course for clinical undergraduates. Eur J Dent Educ 2009;13:100-9.
24. Eckleberry-Hunt J, Tucciarone J. The challenges and opportunities of teaching "Generation Y." J Grad Med Educ 2011;3(4):458-61.
25. Bednar ED, Hannum WM, Firestone A, et al. Application of distance learning to interactive seminar instruction in orthodontic residency programs. Am J Orthod Dentofacial Orthop 2007;132(5):586-94.