Uncovering evidence: Transitioning from face-to-face to online learning

Katherine E Yerex*, MS, RDH; Dieter J Schönwetter§, PhD; Caroline Monnin†, MLIS

PRACTICAL IMPLICATIONS OF THIS RESEARCH

- Instructional designs that integrate multiple modalities (visual, auditory, kinesthetic, and verbal) can foster greater engagement and support diverse learner needs.
- Blended instructional models that combine online and face-to-face delivery can achieve comparable learning outcomes while enhancing flexibility in dental and dental hygiene education.
- Online lecture modules provide an efficient means of reallocating faculty expertise towards clinical teaching, supporting programs facing increasing demands on limited specialist resources.

ABSTRACT

Background: There is a need for evidence-based choices when integrating innovative teaching technologies into dental hygiene and dentistry education. Examining both the direct and indirect effects of these technologies can help to inform and enhance teaching practices. The aim of this study was to compare traditional lectures with online modules tailored to diverse learning style preferences, exploring how these approaches influence student engagement, retention, and recall. **Methods**: Second-year dental hygiene and first-year dentistry students were randomly assigned to 1 of 2 teaching conditions (in-person lecture, online lecture) in a common communications course. Baseline measures of content achievement, Edmonds learning style preferences, and comfort levels with learning online and in-person were recorded prior to the lecture using the pre-lecture assessment survey. Students completed post-lecture assessments immediately after the lecture and again 6 months later. **Results**: Regardless of the teaching condition, students showed significant improvement in their academic performance compared to the baseline measures. Their learning style preferences were found to be linked with higher engagement levels, a sense of accomplishment, and control over their learning environment. **Conclusions**: Teaching health sciences students presents challenges, especially when transitioning from traditional in-person classes to online learning, which may lack engagement for some. Accommodating diverse learning style preferences is crucial for maximizing technology's benefits in education and enhancing learning outcomes. A blended approach, combining face-to-face and online lectures, can optimize student learning experiences, emphasizing the importance of considering varied preferences in educational strategies, particularly in the post-pandemic era.

RÉSUMÉ

Contexte : Il faut faire des choix fondés sur des données probantes pour intégrer des technologies d'enseignement novatrices à l'éducation en hygiène dentaire et en dentisterie. L'examen des effets directs et indirects de ces technologies peut aider à éclairer et à améliorer les pratiques d'enseignement en formation dentaire. L'objectif de cette étude était de comparer les cours magistraux traditionnels à des modules en ligne adaptés à diverses préférences de style d'apprentissage, pour explorer la façon dont ces approches influencent l'engagement, la persévérance et le rappel des étudiants. **Méthodes** : Les étudiants de deuxième année en hygiène dentaire et de première année en dentisterie ont été affectés au hasard à 1 des 2 formats d'enseignement (cours magistral en personne, cours magistral en ligne) dans un cours commun de communication. Les mesures de référence sur la réalisation du contenu, les préférences en matière de style d'apprentissage fondé sur la méthode d'Edmonds et les niveaux de maîtrise de l'apprentissage en ligne et en personne ont été évaluées en amont du cours au moyen du sondage d'évaluation préalable. Les étudiants ont effectué des évaluations immédiatement après le cours et de nouveau 6 mois plus tard. **Résultats** : Quel que soit le format d'enseignement, les modules adaptés ont permis aux étudiants d'améliorer leur rendement de façon significative par rapport aux mesures de référence. Leurs préférences en matière de style d'apprentissage étaient liées à des niveaux d'engagement plus élevés, à un sentiment d'accomplissement et à une gouvernance relativement à leur environnement d'apprentissage. **Conclusions** : L'enseignement aux étudiants en sciences de la santé présente des défis, surtout lorsqu'il s'agit de passer de cours traditionnels en personne à l'apprentissage en ligne, qui peut se traduire par un manque d'engagement pour certains. Il est essentiel de tenir compte des diverses préférences en matière de style d'apprentissage pour maximiser les avantages de la technologie et améliorer les résultats d'apprentissage. Une approche mixte, combinant des cours magistraux en personne et en ligne, peut optimiser les expériences d'apprentissage des étudiants, en insistant sur l'importance de tenir compte des préférences variées dans les stratégies d'enseignement, particulièrement à l'ère post-pandémique.

Keywords: lecture; online learning; post-secondary education; student engagement; student learning; student learning style preferences; technology
CDHA Research Agenda category: capacity building of the profession

*Associate professor, School of Dental Hygiene, Dr Gerald Niznick College of Dentistry, Rady Faculty of Health Sciences, University of Manitoba, Winnipeg, MB, Canada
§Professor and director, Academic Services, Dr. Gerald Niznick College of Dentistry and School of Dental Hygiene, Rady Faculty of Health Sciences, University of Manitoba, Winnipeg, MB, Canada
†Health sciences librarian, Rady Faculty of Health Sciences, University of Manitoba, Winnipeg, MB, Canada

Correspondence: Katherine Yerex, MS, RDH; katherine.yerex@umanitoba.ca
Manuscript submitted 12 June 2024; revised 15 October and 29 November 2024; accepted 17 January 2025

BACKGROUND

Although higher education institutions adopted teaching technologies during the COVID-19 pandemic to improve the effectiveness and quality of teaching and learning, dedicated research is needed to support evidence-based decisions regarding the use of innovative technologies. Previous research that focused on technology and direct student learning outcomes and student engagement provided a foundation for the current study.[1-5] A review of that research, which identified specific technology tools to enhance dental hygiene and dentistry student learning during COVID-19, revealed a need to assess both their direct and indirect impacts.[6] As seen in the literature review that follows, research often emphasizes the indirect benefits of technology, such as student and teacher self-reported perceptions of satisfaction and engagement. However, this focus too often comes at the expense of examining concrete, measurable learning outcomes.

Dentistry and dental hygiene students spend numerous hours in lecture theatres and preclinic laboratories learning the theories and techniques required for clinical practice. Although many state-of-the-art technologies are now used in dentistry and dental hygiene clinics (e.g., electronic patient records, cone-beam scanners), teaching students relies heavily on in-person lectures.[9] This is surprising in that innovative technologies are improving the effectiveness and quality of teaching, such as telecommunications services,[10] communications or social software,[11] rich media in interactive training and learning,[12] webcasts[13] and podcasts,[14] virtual learning environments,[15] sophisticated communications,[16] and virtual reality with haptic devices[17].

Prior to the COVID-19 pandemic, academic institutions adopted innovative technologies to improve the effectiveness and quality of teaching and learning slowly and more methodically. If used, these technologies were implemented without fully considering their potential benefit for teaching and learning.[8] Pre-pandemic research in this area demonstrated the indirect benefits of innovative technologies for teaching and learning, relying on soft measures such as perceptions of students' and teachers' satisfaction[18] and student self-reports of attitudes, satisfaction, interest, and perceptions of learning and engagement,[19-26] rather than hard measures of student learning outcomes.[8]

As the COVID-19 pandemic swept across the world, dentistry and dental hygiene educators were forced to adapt quickly to remote learning,[27,28] implementing technology in the classroom in ways that had never been done before. However, there was little evidence to support the introduction of this technology in such a drastic manner.[28,29] One solution to move learning from the classroom to an online environment involved converting lecture content into online learning modules using voice-over PowerPoint presentations.[1] A 2016 study of voice-over PowerPoint presentations found that students benefitted from this content delivery format as assessed through recognition and recall.[1] However, student engagement with the content material was somewhat limited. What was missing was an online learning process that provided a full suite of options to present course content tailored to students' different learning preferences.[30-32] Learning preferences may be verbal or linguistic, auditory, visual or spatial, and kinesthetic or physical.[33] Incorporating online content that caters to different learning preferences may better engage students, enhancing their overall learning experience.

Three important needs drove the current study. First, to find an effective way of putting course material online that improves teaching by transitioning from in-person lectures to online learning, while also enhancing students' learning experience. Second, to help dental hygiene and dentistry administrators find ways of maximizing access to scarce subject-matter experts who are in high demand globally as fewer experts are accepting academic careers.[7] The ultimate goal is to maximize specialists' skills on the clinical floor while ensuring that their students receive a quality education in lecture halls and preclinical laboratories.[8] Lastly, the study aimed to tackle the present and upcoming obstacles in education in the context of pandemics such as COVID-19.

Therefore, the aim of this study was to evaluate the direct and indirect impacts of innovative teaching technologies on student learning, specifically focusing on engagement, retention, and recall. To achieve this, a traditional face-to-face lecture on nonverbal communication was compared with an online module on the same topic, designed to cater to diverse learning style preferences. The comparison assessed teaching approaches in terms of their effects on "hard" learning measures (e.g., retention and test performance) and "soft" learning measures (e.g., student engagement and satisfaction).

METHODS

This study received ethics approval from the University of Manitoba Research Ethics Board HS22845. All participants provided written informed consent.

Baseline assessment

In order to examine how the impact of teaching conditions on student learning is affected by student differences, student demographics (gender and program of study) as well as Edmonds' learning preferences[1] were identified. Several critical baseline measures were included to control for confounding effects. The students' awareness of the content material being presented, their perceived comfort level with both traditional and online teaching formats, and their perceptions of whether technology could enhance their learning—key indicators of indirect or soft learning measures—were assessed using 5-point Likert scale questions (Appendix).[34,35]

It was crucial to assess students' prior knowledge of the lecture content (a direct or "hard" learning measure). Given that self-reported knowledge can be unreliable, a pre-assessment test was administered.[34,35] The test consisted of 2 parts: a 5-minute free association task where students listed any words they associated with the term "nonverbal communication," followed by a 21-item multiple-choice test, designed to evaluate 3 of Bloom's levels of cognition: knowledge, comprehension, and application, with 7 questions in each category.[36]

Post-lecture assessments

After the lecture, a 5-minute recall test was conducted to assess the students' understanding of the key concepts presented. The same recognition test given during the pre-assessment was given again after the lecture.

Student behavioural, emotional, and intellectual engagement was also assessed using 5-point Likert scale questions (Appendix).[37] Behavioural engagement was established by students' self-reports of time-on-task during the lecture; emotional engagement was established by students' satisfaction with the lecture and their recommendation to refer other students to the learning session.[37] Cognitive engagement was inferred through student achievement on various measures of recognition and recall.[37] The more a student was able to recognize and recall, the more attentive they would have been during the lecture. A self-report measure of cognitive engagement was also used.

All pre- and post-assessments were administered in person under supervision.

Lecture conditions

Two teaching conditions were created: 1) the traditional face-to-face PowerPoint lecture presentation; 2) the online learning module. Both conditions were designed to accommodate the following 4 primary learning preferences:

- **Visual learning**: In the face-to-face condition, visual learners benefitted from slides with diagrams and models of nonverbal communication presented in PowerPoint. Similarly, the online module featured models created on an electronic whiteboard using a Surface Pro, enhanced through Adobe After Effects and animated via Camtasia Studio.
- **Auditory learning**: For auditory learners, the face-to-face lecture included verbal explanations and opportunities to ask questions and engage in discussion. The online module included voice recordings, YouTube videos, and whiteboard animation videos.
- **Kinesthetic learning**: In the face-to-face setting, kinesthetic learners engaged with physical gestures and body language demonstrated by the instructor, which reinforced the nonverbal communication topic. In the online module, students interacted with the content by selecting "hot boxes" that linked to additional resources, such as YouTube videos and glossaries, providing a more hands-on approach to learning.
- **Verbal learning**: Verbal learners were supported in the face-to-face condition through the instructor's verbal presentation and the written content on the slides. The online module also catered to this style by providing written text on each slide, reinforcing the verbal learning style.

To control for lecture presentation differences, items on nonverbal communication were presented in both sessions. To maintain consistency across both teaching conditions, the same 2 instructors were responsible for delivering the content in the face-to-face traditional lecture and the online asynchronous module. The lecture content was identical for both conditions, ensuring that students in each group received the same material. The final version of the online learning module was uploaded to the Learning Management System (LMS) and made available to students during the experiment.

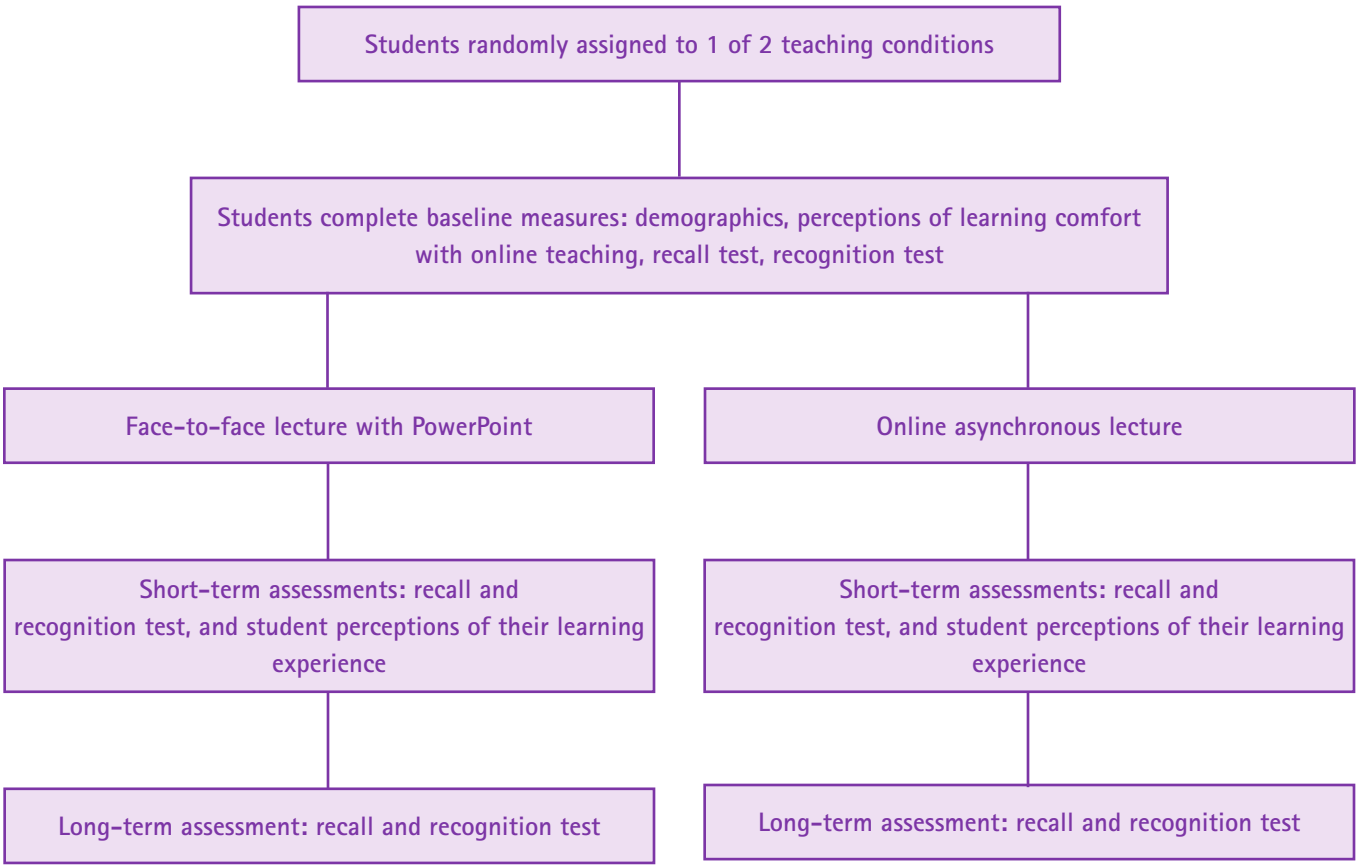
Classroom analog

The theatre for the face-to-face lecture and the theatre for students viewing the online lecture on their individual laptop were designed to provide realistic and controlled learning environments. Participants are often more motivated to perform when assessments are conducted in a realistic classroom setting.[34,35]

Procedure

There were 26 second-year dental hygiene students and 29 first-year dentistry students enrolled in the mandatory nonverbal communication course. Of that number, 25 dental hygiene students and 27 dentistry students consented to participate in the study, specifically the pre- and post-analysis, which was voluntary. As seen in Figure 1, all students met in one theatre for the scheduled lecture. For the first 20 minutes, they completed the pre-lecture assessment. Students were then randomly assigned (using a randomization table) to 1 of 2 teaching conditions: a face-to-face traditional lecture in the lecture theatre or an online learning module in a different theatre where students accessed the online asynchronous module via their personal laptop with headphones. The hired research assistant facilitated the online asynchronous session to ensure that students had no technological challenges. Both sessions were conducted at the same time and for exactly 1 hour. Following the session, all students completed the post-lecture assessments and were debriefed on the details of the study. Six months later, the students completed post-lecture recall and recognition tests.

Figure 1. Linear flow diagram of the procedure



Statistical analyses

Because this was an exploratory study, a Pearson correlation was conducted on all variables. One-way (lecture, online) ANOVAs were conducted on dependent variables representing the pre-, post-lecture, and 6-month post-lecture assessments. Student *t*-tests were employed to compare differences among these 3 lecture assessment times.

RESULTS

Demographics

A total of 25 second-year dental hygiene and 27 first-year dentistry students (32 females and 20 males) participated in the study. Twenty-six students were randomly assigned to each of the 2 teaching conditions.

Baseline assessment: controlling for confounding effects

To control for any prior maturation effects, pre-lecture recognition test items in which all students got the correct answer would be removed. However, none were identified; thus, all questions were retained in the final analysis.

To control for potential confounding effects, statistical tests were done on students' awareness of and experience with the content presented and their perceived comfort level in learning from innovative technology. One-way ANOVAs (traditional versus online lecture) were conducted on each of the dependent variables (Table 1). No differences were found in students' self-reported awareness of "nonverbal communication." A recall and recognition test on the content was completed by students prior to the lecture.[19,38] Again, no differences were identified between the 2 groups, indicating that students in both conditions had similar minimal content knowledge. Further, no differences were found in the students' perceived comfort level in learning from face-to-face lectures or an online format, or in their perceptions that technology can enhance learning. Thus, the potential confounding variables identified in this study were controlled by randomly selecting students to the 2 teaching conditions.

Correlations

A Pearson correlation was conducted on all variables. Statistically significant correlations are reported below. First, Edmonds Learning Styles (LS) subscales Reading and Feeling ($r(51) = -0.53$, $p < 0.01$), as well as Auditory and Kinesthetic ($r(51) = -0.39$, $p < 0.05$), were inversely related. Students scoring high on one subscale tended to score lower on the other. Second, high Visual scores correlated directly with student satisfaction with the presentation of the learning module ($r(51) = 0.40$, $p < 0.01$), student perceptions of being successful with ($r(51) = 0.29$, $p < 0.05$)

Table 1. Between group comparison of students' soft and hard learning measures

Variable	ANOVA *p* value	Online group	Traditional lecture group
Post-teaching assessments			
Perception that the presentation enhanced their learning	$p = 0.03$	M = 3.19, SD = 0.75	M = 3.85, SD = 0.73
Students' satisfaction with the presentation	$p = 0.05$	M = 3.54, SD = 1.07	M = 4.00, SD = 0.57
Recommendation to encourage other students to attend a similar type of presentation in the future	$p = 0.05$	M = 3.54 , SD = 0.95	M = 4.00, SD = 0.75
Students' self-report on the extent to which they feel engaged in the presentation	$p = 0.05$	M = 3.19, SD = 1.23	M = 3.77, SD = 0.86
Students' perception of success	$p = 0.04$	M = 3.19, SD = 0.85	M = 3.65, SD = 0.69
Students' perception of control	$p = 0.05$	M = 2.88, SD = 1.07	M = 3.42, SD = 0.90
Students' cognitive engagement self-report	$p = 0.05$	M = 3.42, SD = 0.95	M = 3.85, SD = 0.54

p = alpha level; M = mean; SD = standard deviation

Table 2. ANOVAs conducted across teaching conditions on hard measures of learning

Variable	ANOVA *P* value	Baseline (a) Mean (±SD)	Post-learning (b) Mean (±SD)	Long-term learning (6 months later) (c) Mean (±SD)	LSD comparisons
Recall	$p < 0.0001$	3.67 (±1.54)	9.98 (±3.41)	3.38 (±5.68)	a vs b: $p < 0.001$ a vs c: $p < 0.001$ b vs c: $p < 0.001$
Knowledge MCQs	$p < 0.0001$	2.90 (±1.10)	5.71 (±0.97)	4.51 (±1.33)	a vs b: $p < 0.001$ a vs c: $p < 0.001$ b vs c: $p < 0.001$
Comprehension MCQs	$p < 0.05$	2.33 (±0.96)	2.82 (±0.89)	2.49, (±1.14)	a vs b: $p < 0.01$ a vs c: $p < 0.42$ b vs c: $p < 0.09$
Application MCQs	$p < 0.0001$	1.90 (±1.27)	3.18 (±1.13)	2.49 (±1.14)	a vs b: $p < 0.01$ a vs c: $p < 0.01$ b vs c: $p < 0.01$
MCQs total	$p < 0.0001$	7.23 (+2.11)	11.73 (±2.02)	9.49 (±2.96)	a vs b: $p < 0.01$ a vs c: $p < 0.01$ b vs c: $p < 0.01$

LSD = Fisher's Least Significant Difference test; MCQs = multiple-choice questions; *t*-tests were used for comparisons between each of the 3 achievement times

and control of their learning (r(51) = 0.32, $p < 0.05$) as the result of the learning module, feelings of general (r(51) = 0.50, $p < 0.01$) and cognitive engagement (r(51) = 0.37, $p < 0.01$), the extent to which they would refer other students to attend the learning module (r(51) = 0.39, $p < 0.01$), higher recall (r(51) = 0.42, $p < 0.01$), and lower cognitive MCQs scores (r(51) = 0.31, $p < 0.05$). Third, higher Reading scores were inversely correlated with recall scores (r(51) = -0.35, $p < 0.05$), whereas Auditory scores were inversely correlated with knowledge based MCQs (r(51) = -0.39, $p < 0.05$).

Perceptions of pre-lecture content knowledge correlated with comprehension-based MCQs (r(51) = 0.65, $p < 0.01$). Student perceptions of their comfort level with the way the content was presented correlated with knowledge-based MCQs (r(51) = 0.32, $p < 0.05$) yet were inversely correlated with post-lecture comprehension-based MCQs 6 months later (r(51) = -0.34, $p < 0.05$).

Student perceptions of learning enhancement correlated directly with their perceptions of satisfaction (r(51) = 0.48, $p < 0.01$), perceived success (r(51) = 0.38, $p < 0.01$), and control with and in their learning (r(51) = 0.38, $p < 0.01$), the referral of the learning module to other students (r(51) = 0.45, $p < 0.01$), and feelings of being engaged generally (r(51) = 0.60, $p < 0.01$) as well as cognitively (r(51) = 0.37, $p < 0.01$). However, student perceptions of learning enhancement indirectly correlated with long-term performance on comprehension (r(51) = -0.31, $p < 0.05$) and application MCQs (r(51) = -0.31, $p < 0.05$). Student perceptions of satisfaction correlated directly with perceived success (r(51) = 0.59, $p < 0.01$), and control (r(51) = 0.52, $p < 0.01$), with and in their learning, the referral of the learning module to other students (r(51) = 0.57, $p < 0.01$), and feelings of being engaged generally (r(51) = 0.75, $p < 0.01$), as well as cognitively (r(51) = 0.69, $p < 0.01$).

Student perceptions of success were directly correlated with perceptions of control in their learning ($r(51) = 0.74$, $p < 0.01$). Students perceptions of success and control were correlated with the referral of the learning module to other students ($r(51) = 0.59$, $p < 0.01$; $r(51) = 0.48$, $p < 0.01$), feelings of being engaged generally ($r(51) = 0.57$, $p < 0.01$; $r(51) = 0.57$, $p < 0.01$), and application-based MCQs ($r(51) = 0.33$, $p < 0.05$; $r(51) = 0.36$, $p < 0.01$), yet were inversely correlated with baseline recall scores ($r(51) = -0.31$, $p < 0.05$; $r(51) = -0.46$, $p < 0.01$). The referral of the learning module to other students was correlated with students' perceptions of being engaged generally ($r(51) = 0.57$, $p < 0.01$). Perceptions of general engagement were correlated with specific cognitive engagement ($r(51) = 0.68$, $p < 0.01$), yet inversely with total long-term recognition test scores ($r(51) = -0.29$, $p < 0.05$). Perceptions of specific cognitive engagement correlated inversely with baseline recall scores ($r(51) = -0.28$, $p < 0.05$).

Post-teaching assessment: short and long term

A one-way ANOVA (traditional face-to-face lecture versus online lecture) demonstrated no statistically significant differences in the short-term recall test (Table 1) or the recognition test, which assessed knowledge, comprehension, and application.

Affective engagement was inferred by students' satisfaction with the presentation and their recommendation to encourage other students to attend a similar type of presentation in the future. Statistically significant differences were found between the 2 conditions in terms of students' satisfaction and recommendations (Table 1). Students in the traditional face-to-face lecture had higher scores than those in the online lecture condition. Behavioural engagement was measured by students' self-reports of the extent to which they paid attention to the presentation during the full hour. Students in the traditional face-to-face lecture condition reported higher levels of behavioural engagement than those in the online lecture condition. Cognitive engagement was inferred by students' perception of success and control over their learning as the result of the presentation and more specifically by a self-report on the extent to which the presentation impacted their cognitive engagement with the topic material. Once more, students in the traditional face-to-face lecture, as compared to the online lecture condition, reported higher scores of cognitive engagement.

The third research question focused on the long-term learning impact of the teaching methods. A one-way ANOVA (traditional face-to-face lecture versus online lecture) demonstrated no differences in long-term recognition test scores or between baseline and long-term recognition test scores (see Table 1). A closer look at most hard achievement measures shows a slight gain pattern for the online learning condition.

Overall learning across teaching methods

Given that minimal differences were observed between the 2 teaching conditions, the question remains whether students learned from the lecture, regardless of teaching condition. To test for this question, comparisons of the baseline, post-learning module (immediately following the lecture) and long-term (6 months later) assessments of recall and recognition were conducted by combining the teaching condition (face-to-face & online) assessment information. The unit of analysis was the achievement performance across the 3 testing times. As seen in Table 2, differences were observed in terms of students' learning regardless of the teaching conditions. The pattern is consistent: the post-learning module produces the highest achievement, followed by the long-term achievement test. Only in one case was the difference between the baseline and the long-term achievement test not statistically significant: comprehensive MCQs.

DISCUSSION

This study compared a traditional face-to-face lecture with an online module on nonverbal communication. It incorporated student learning preferences into soft and hard measures of achievement and student engagement. This study focused on the interplay between student learning preferences and online/traditional teaching differences.[30,32,39] Although there were no statistically significant findings in either type of teaching condition, correlations were found. When it comes to student learning preferences, being a visual learner was related to satisfaction with the presentation, higher perceptions of success and control in the learning environment, higher levels of general and cognitive engagement, and higher referrals to others. Being more of a visual or verbal (read/write) learner was related to higher recall scores, but lower cognitive and knowledge-based test item performance for visual and auditory learners, respectively.

While this study incorporated various teaching methods to address different learning preferences, it is important to acknowledge the ongoing debate over the validity of the learning preferences. Research has raised questions about the effectiveness of tailoring instruction to individual learning styles, suggesting that there is limited evidence to support the idea that such an approach improves learning outcomes.[40] That said, educators still find value in diversifying instructional methods to engage students through multiple modalities: visual, auditory, kinesthetic, and verbal. This diversification ensures that all students are exposed to a richer learning environment that can enhance engagement and understanding.[41]

When it comes to the 2 teaching conditions, the data reveal strong patterns of higher scores among the online learning group on most of the hard measures of achievement. However, none of these findings were significant either in the correlations or the teaching condition comparisons. The students did learn from both

teaching conditions. Hence, online teaching produced similar learning outcomes to the traditional face-to-face lecture on the various assessments of recall, recognition in terms of knowledge, comprehension, and application-type exam questions.[1]

The COVID-19 pandemic prompted a swift transition to online learning in most academic institutions. Fortunately, recent studies have shown that students can learn effectively in both traditional and online teaching settings.[29,42] Additionally, online teaching can help academic faculty by giving them more time to focus on their clinical academic responsibilities and improving work–life balance.[43,44] Recent studies have shown that, while faculty initially reported an increased workload arising from online learning, many prefer it significantly over face-to-face instruction because of student enthusiasm.[45]

There were several noteworthy findings in terms of students' perceptions of their own achievement. These "softer" indicators were shown to have statistical significance in many cases. First, students reported higher behavioural and cognitive engagement with the face-to-face lecture versus the online teaching format. This result differs from many of the pre-COVID-19 research findings[14-52] and is surprising given that students have more control over their learning because of the ability to stop, go back, move ahead, and/or replay the online teaching module. It is possible that face-to-face lectures positively impacted the students' perceptions. The COVID-19 pandemic forced didactic teaching of dentistry and dental hygiene students to move to an online format. Online learning and teaching, asynchronous and synchronous, perceptually lack student engagement, and not all students are satisfied with this teaching environment.[46-48] However, the technology allowed students to attend classes during the pandemic, and some preferred the autonomy of this learning environment.[48] Perhaps the best way moving forward would be to consider a blended approach that includes both face-to-face lectures and online synchronous and asynchronous lectures.[46,49,50]

Study limitations

This study has several limitations. First, a small sample size provided less than ideal power for the study. As seen in terms of differences in means, there were patterns of higher scores among the online learning group on most of the hard measures of achievement, yet higher scores by the traditional learning groups on soft measures supporting their perceptions of achievement. A larger sample size would be needed to tease out these differences.

Second, a topic area that is totally new to students would be ideal to test. Even though controls were put in place to adjust for prior knowledge on effective nonverbal communication, testing students who have no prior knowledge would provide a better indication of the impact of traditional versus technology-enhanced presentations.

Finally, this study was conducted at a single university, which may limit the generalizability of the findings. The educational environment and student demographics may not fully reflect those of other institutions, which could affect the applicability of the results in broader contexts.

Applications for future education

The current shortage of clinical specialists teaching in dentistry and dental hygiene requires institutions to find new means of capturing their expertise for student learning. Fewer health sciences specialists are interested in working in academia given the much greater financial rewards of private practice. Further, the demands on these specialists' time in clinical settings are often in direct conflict with their classroom and clinical teaching, as they are often called away to emergency and operating wards. Hence, finding ways to maximize their teaching time and make their expert knowledge accessible to students 24/7, potentially through online learning formats, is paramount in health sciences education.

Applications for future research

As teaching through technology becomes the norm, discovering the specific elements that impact and enhance student online learning based on the various types of students enrolled is key. More research is needed on different learning style preferences and how to match technologies to those preferences. Research also needs to move away from student perceptions of learning in favour of hard measures of recall and recognition. Moreover, traditional recognition tests that assess knowledge, comprehension, and application should be replaced with tests that measure the impact of learning in terms of higher levels of learning including analysis, synthesis, and creativity.

CONCLUSIONS

Teaching students in the health sciences is a challenge that needs to encompass and support the variety of learning style preferences, especially when considering migrating courses from the traditional face-to-face format to online learning. In doing so, the efficiencies of teaching with technology can be more fully realized and the learning of students enhanced. It remains to be seen how technology in the classroom will continue to evolve in the post-pandemic world.

CONFLICTS OF INTEREST

The authors have declared no conflicts of interest.

APPENDIX: Survey questions used during the study

Learning Preferences (Pre-learning condition)

Please complete the following questions in preparation for the upcoming lecture on nonverbal communication

Comfort Level Learning New Material in Different Learning Formats

Instructions: Circle the best answer for each of the following.

1. What is your perceived comfort level in learning from lectures presented in the traditional classroom?
   i. Very uncomfortable
   ii. Uncomfortable
   iii. Neutral
   iv. Comfortable
   v. Very comfortable
2. What is your perceived comfort level in learning from lectures presented in an online format?
   i. Very uncomfortable
   ii. Uncomfortable
   iii. Neutral
   iv. Comfortable
   v. Very comfortable
3. To what extent do you think that technology can enhance student learning?
   i. Not at all
   ii. Minimally
   iii. Somewhat
   iv. Quite a lot
   v. Very much so

Previous Knowledge About the Learning Content

4. What best describes your awareness of the term "nonverbal communication"?
   i. No awareness
   ii. Limited awareness
   iii. Some awareness
   iv. Knowledgeable
   v. Very knowledgeable
5. If you are at all aware of this term, your awareness comes from (please circle):
   i. Previous lecture material: no yes
   ii. Textbook material: no yes
   iii. Personal experience: no yes
   iv. Website material: no yes
   v. Other: _____ no yes

Previous Knowledge (Pre-learning condition)

In the next 5 minutes and in the page provided, record all the key words that you know concerning the term "nonverbal communication" for healthcare providers.

Learning Style Preferences (Pre-learning condition)

Instructions: This exercise is designed to identify how individuals learn most easily and most efficiently. This is not a test. There are no right or wrong answers. You will hear 20 common English words. As you hear each word, observe your own immediate reaction – notice what goes on inside of your head. For each word, you will probably have one of four responses:

1. *You will see a picture of some object or activity.*
2. *You will picture the word spelled out in your mind.*
3. *You will hear the word and understand its meaning based on the sound.*
4. *You may have some physical or emotional feeling about the word, such as tightening of a muscle or a feeling such as warmth, etc.*

This is not a test of word association. It is not important what other word you think of. Rather the nature of your own immediate and instantaneous response to the word itself is important. For each word, circle only one of the four possibilities below.

Edmonds' Learning Style Identification Exercise

1.	Picture	Spelling	Sound	Feeling
2.	Picture	Spelling	Sound	Feeling
3.	Picture	Spelling	Sound	Feeling
4.	Picture	Spelling	Sound	Feeling

Continued...

5.	Picture	Spelling	Sound	Feeling
6.	Picture	Spelling	Sound	Feeling
7.	Picture	Spelling	Sound	Feeling
8.	Picture	Spelling	Sound	Feeling
9.	Picture	Spelling	Sound	Feeling
10.	Picture	Spelling	Sound	Feeling
11.	Picture	Spelling	Sound	Feeling
12.	Picture	Spelling	Sound	Feeling
13.	Picture	Spelling	Sound	Feeling
14.	Picture	Spelling	Sound	Feeling
15.	Picture	Spelling	Sound	Feeling
16.	Picture	Spelling	Sound	Feeling
17.	Picture	Spelling	Sound	Feeling
18.	Picture	Spelling	Sound	Feeling
19.	Picture	Spelling	Sound	Feeling
20.	Picture	Spelling	Sound	Feeling
Total: _____		_____	_____	_____

Nonverbal Communications Lecture Reflection (Post-learning condition)
Please complete the following questions based on the lecture on Nonverbal Communication.

Comfort Level Learning New Material in Different Learning Formats

1. What was your perceived comfort level in learning from today's presentation?
    i. Very uncomfortable
    ii. Uncomfortable
    iii. Neutral
    iv. Comfortable
    v. Very comfortable
2. To what extent do you think the format of the presentation today enhanced your learning?
    i. Not at all
    ii. Minimally
    iii. Somewhat
    iv. Quite a lot
    v. Very much so

Previous Knowledge About the Lecture Material

3. Now that you have received the lecture on the term "nonverbal communication", how aware were you of this content material prior to the lecture?
    i. No awareness
    ii. Limited awareness
    iii. Some awareness
    iv. Knowledgeable
    v. Very knowledgeable
4. Your satisfaction with the presentation is best described as:
    i. Poor
    ii. Adequate
    iii. Average
    iv. Good
    v. Excellent
5. How successful do you feel over your learning as the result of the presentation?
    i. No success
    ii. Minimal success
    iii. Some success
    iv. Quite a lot of success
    v. Very much success
6. How much control do you feel over your learning as the result of the presentation?
    i. No control

Continued...

ii. Minimal control
iii. Some control
iv. Quite a lot of control
v. Very much control

7. To what extent would you encourage other students to attend the presentation on "nonverbal communications"?
   i. Not at all
   ii. Minimally
   iii. Somewhat
   iv. Quite a lot
   v. Very much so
8. Did you feel engaged in the presentation?
   i. Not at all
   ii. Minimally
   iii. Somewhat
   iv. Quite a lot
   v. Very much so
9. The extent to which the presentation impacted your cognitive engagement with the topic material is best described as:
   i. Not at all
   ii. Minimally
   iii. Somewhat
   iv. Quite a lot
   v. Very much so

Nonverbal Communications Lecture Recall (Post-learning condition)

In the next 5 minutes and in the page provided, record all the key words that you know concerning the term "nonverbal communication" for healthcare providers.

REFERENCES

1. Schönwetter DJ, Gareau-Wilson N, Cunha RS, Mello I. Assessing the impact of voice-over screen-captured presentations delivered online on dental students' learning. *J Dent Educ*. 2016;80(2):141–48.
2. Glockner S, Payer M, Kirnbauer B, Mischak I, Subbalekha K, Mattheos N. Evaluation of dental education during the pandemic of COVID-19—Results from an online survey among dental students. *Eur J Dent Educ*. 2024;28(2):538–47.
3. Bashary NZ, Levine MH. Teaching strategy adaptations in undergraduate dental education during the COVID-19 pandemic. *J Dent Educ*. 2024;88(6):865–71.
4. Chilton JK, Hanks S, Watson HR. A blended future? A cross-sectional study demonstrating the impacts of the COVID-19 pandemic on student experiences of well-being, teaching and learning. *Eur J Dent Educ*. 2024;28(1):170–83.
5. Mucke K, Busch C, Becker J, Drescher D, Becker K. Is online-only learning as effective as blended learning? A longitudinal study comparing undergraduate students' performance in oral radiology. *Eur J Dent Educ*. 2024;28(1):236–50.
6. Luce C, Kirnan JP. Using indirect vs. direct measures in the summative assessment of student learning in higher education. *Journal of the Scholarship of Teaching and Learning*. 2016;16(4):75–91.
7. Wilson NHF, Jones ML, Pine C, Saunders WP, Seymour RA. Looking forward: Educating tomorrow's dental team. *Eur J Dent Educ*. 2008;12(3):176–99.
8. Schönwetter DJ, Reynolds PA, Eaton KA, De Vries J. Online learning in dentistry: An overview of the future direction for dental education. *J Oral Rehabil*. 2010;37(12):927–40.
9. Keck DB, Rutkauskas JS, Clothey RA. Evaluating the need for alternative didactic learning options in pediatric dental residency training. *J Dent Educ*. 2009;73(6):706–717.
10. Feeney L, Reynolds PA, Eaton KA, Harper J. A description of the new technologies used in transforming dental education. *Br Dent J*. 2008;204(1):19–28.
11. Reynolds PA, Mason R, Harper J. The many faces of interaction. *Br Dent J*. 2008;204(10):565–70.
12. Eaton KA, Reynolds PA, Cox MJ. Top of the pops—CD-ROM and DVDs in dental education. *Br Dent J*. 2008;204(4):203–207.
13. Reynolds PA, Mason R, Eaton KA. Webcasting: Casting the web more widely. *Br Dent J*. 2008;204(3):145–49.
14. Walmsley AD, Lambe CS, Perryer DG, Hill KB. Podcasts—an adjunct to the teaching of dentistry. *Br Dent J*. 2009;206(3):157–60.
15. Reynolds PA, Harper J, Dunne S, Cox M, Myint YK. Portable digital assistants (PDAs) in dentistry: Part II—Pilot study of PDA use in the dental clinic. *Br Dent J*. 2007;202(8):477–83.

16. Wagner I-V, Ireland RS, Eaton KA. Digital clinical records and practice administration in primary dental care. *Br Dent J.* 2008;204(7):387–95.

17. Eaton KA, Reynolds PA, Grayden SK, Wilson NHF. A vision of dental education in the third millennium. *Br Dent J.* 2008;205(5):261–71.

18. Mitchell TV, Gadbury-Amyot CC, Bray KK, Simmer-Beck M. Advanced degree seeking students' satisfaction with online courses at UMKC—an early investigation. *J Dent Hyg.* 2007;81(3):62.

19. Rush BR, Hafen M, Jr., Biller DS, Davis EG, Klimek JA, Kukanich B, et al. The effect of differing Audience Response System question types on student attention in the veterinary medical classroom. *J Vet Med Educ.* 2010;37(2):145–53.

20. Harper BE. I've never seen or heard it this way! Increasing student engagement through the use of technology-enhanced feedback. *Teaching Educational Psychology.* 2009;3(3):1–8.

21. De Gagne JC. The impact of clickers in nursing education: a review of literature. *Nurse Educ Today.* 2011;31(8):e34–e40.

22. Thomas CM, Monturo C, Conroy K. Experiences of faculty and students using an audience response system in the classroom. *Comput Inform Nurs.* 2011;29(7):396–400.

23. Kay RH. Examining gender differences in attitudes toward interactive classroom communications systems (ICCS). *Computers and Education.* 2009;52(4):730–40.

24. Pahinis K, Stokes CW, Walsh TF, Tsitrou E, Cannavina G. A Blended learning course taught to different groups of learners in a dental school: follow-up evaluation. *J Dent Educ.* 2008;72(9):1048–1057.

25. Zary N, Johnson G, Fors U. Web-based virtual patients in dentistry: Factors influencing the use of cases in the Web-SP system. *Eur J Dent Educ.* 2009;13(1):2–9.

26. Bartsch R, Murphy W. Examining the effects of an electronic classroom response system on student engagement and performance. *J Educ Comput Res.* 2011;44(1):25–33.

27. Hung M, Licari FW, Hon ES, Lauren E, Su S, Birmingham WC, et al. In an era of uncertainty: Impact of COVID-19 on dental education. *J Dent Educ.* 2021;85(2):148–56.

28. Kurtulmus-Yilmaz S, Önöral Ö. Effectiveness of screen-to-screen and face-to-face learning modalities in dental anatomy module during COVID-19 pandemic. *Anat Sci Educ.* 2022;15(1):57–66.

29. Zheng M, Bender D, Lyon C. Online learning during COVID-19 produced equivalent or better student course performance as compared with pre-pandemic: Empirical evidence from a school-wide comparative study. *BMC Med Educ.* 2021;21(1):495.

30. Doyle NW, Jacobs K. Accommodating student learning styles and preferences in an online occupational therapy course. *Work.* 2013;44(3):247–53.

31. Hughes JM, Fallis DW, Peel JL, Murchison DF. Learning styles of orthodontic residents. *J Dent Educ.* 2009;73(3):319–27.

32. Montgomery SM. Addressing diverse learning styles through the use of multimedia. *Proceedings Frontiers in Education 1995 25th Annual Conference. Engineering Education for the 21st Century*, 1–4 November 1995, Atlanta, Georgia. Vol 1, pp. 3a2.13–3a2.21. doi: 10.1109/FIE.1995.483093.

33. Fleming N, Baume D. Learning styles again: VARKing up the right tree! *Educational Developments.* 2006;7(4):4–7.

34. Schönwetter DJ. Effective instruction and student differences in the college classroom [dissertation]. Winnipeg (MB): University of Manitoba; 1996.

35. Schönwetter DJ, Clifton RA, Perry RP. Content familiarity: Differential impact of effective teaching on student achievement outcomes. *Research in Higher Education.* 2002;43(6):625–55.

36. Bloom BS, editor. *Taxonomy of educational objectives: The classification of educational goals. Handbook 1, Cognitive domain.* London (UK): Longmans, Green and Co, Ltd; 1956.

37. Fredricks JA, Blumenfeld PC, Paris AH. School engagement: Potential of the concept, state of the evidence. *Rev Educ Res.* 2004;74(1):59–109.

38. Martyn M. Clickers in the classroom: an active learning approach. *Educause Quarterly.* 2007;30(2):71–74.

39. Murphy RJ, Gray SA, Straja SR, Bogert MC. Student learning preferences and teaching implications. *J Dent Educ.* 2004;68(8):859–66.

40. Pashler H, McDaniel M, Rohrer D, Bjork R. Learning styles: concepts and evidence. *Psychol Sci Public Interest.* 2008;9(3):105–119.

41. Alrashdi A, Alshammari M, Alduraywish T, Alenazi F, Alharbi J, Alobaidly A, et al. Visual, auditory, reading/writing, and kinesthetic: Which learning style predicts academic success in nursing? *International Journal of Advanced and Applied Sciences.* 2024;11(2):35–40.

42. Boonmak S, Plailaharn N, Sripadungkul D, Somjit M, Gaysonsiri D, Boonmak P. A randomized controlled, non-inferiority trial of Moodle online learning for basic life support training on learning outcomes among dental students. *J Dent Educ.* 2023;87(1):110–17.

43. Schlenz MA, Schmidt A, Wöstmann B, Krämer N, Schulz-Weidner N. Students' and lecturers' perspective on the implementation of online learning in dental education due to SARS-CoV-2 (COVID-19): a cross-sectional study. *BMC Med Educ.* 2020;20(1):354.

44. Mosquera P, Albuquerque PC, Picoto WN. Is online teaching challenging faculty well-being? *Administrative Sciences.* 2022;12(4):147.

45. Elshami W, Taha MH, Abuzaid M, Saravanan C, Al Kawas S, Abdalla ME. Satisfaction with online learning in the new normal: Perspective of students and faculty at medical and health sciences colleges. *Med Educ Online.* 2021;26(1):1920090.

46. Maragha T, Dempster L, Shuler C, Lee V, Mendes V, von Bergmann H. Exploring students' perspectives from two Canadian dental schools toward online learning experiences. *J Dent Educ.* 2023;87(7):1047–1056.

47. Pratheebha C, Jayaraman M. Learning and satisfaction levels with online teaching methods among undergraduate dental students: a survey. *J Adv Pharm Technol Res.* 2022;13(Suppl 1):S168–S172.

48. Nguyen VH, Patel T. Influence of the COVID-19 pandemic on learning preferences and perspectives of generation Y and Z students in dental education. *Int J Dent Hyg.* 2023;21(2):487–94.

49. McMillan DG, Kalloo OR, Lara RA, Pavlova M, Kritz-Silverstein D. Factors affecting dental students' comfort with online synchronous learning. *Dent J (Basel).* 2022;10(2).

50. Yu-Fong Chang J, Wang LH, Lin TC, Cheng FC, Chiang CP. Comparison of learning effectiveness between physical classroom and online learning for dental education during the COVID-19 pandemic. *J Dent Sci.* 2021;16(4):1281–1289.