ORIGINAL RESEARCH

Impact of COVID-19 on Teaching the Tooth Morphology Course to the New Generation of Learners: A Cross-sectional Study

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Abstract

Aim: The purpose of the study was two-fold. First, to evaluate students' learning style and relate it to their academic performance. Second, to highlight changes implemented in the tooth morphology (TOMO) course as a response to the coronavirus disease-2019 (COVID-19) pandemic.

Materials and methods: The study was performed during 2021–2022 with 101 dental students. Didactic lectures were delivered online and students challenged with nine quizzes and one final examination. Didactic score was calculated by averaging the scores of quizzes and the final exam. Lab score was a combination of five lab projects and the final competency. At course completion, students received a survey on their learning style and how they would like to receive feedback. Kruskal-Wallis test was used to assess differences in didactic and lab scores among groups.

Results: Many students perceived themselves as visual learners (39%) followed by kinesthetic (24%), aural (19%), and reader (18%). There was no difference among learning style groups in performance of didactic ($p = 0.340$) and lab scores ($p = 0.845$). Students preferred that the instructor talks them through the questions for feedback on quizzes (41%) while they preferred demonstrations when receiving feedback on their wax-ups (51%). Most students (75%) preferred a TOMO teacher that uses demonstrations. 2020–2021 marked the year of the pandemic where all lectures were delivered online and waxing projects were performed at-home. A postpandemic transformation occurred during 2021–2022, reverting to conventional in-person lab sessions while keeping online didactic lectures.

Conclusion: We conclude that TOMO should be delivered by using various teaching styles rather than focusing on a single method while providing more demonstrations.

Clinical significance: Teaching tooth morphology to the new generation type of learners efficiently will affect the clinical work of dental graduates.

Keywords: COVID-19 pandemic, Dental education, Generation Z, Learning style, Tooth morphology.

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Introduction

For many educational institutions, the coronavirus disease-2019 (COVID-19) pandemic compelled fundamental changes to existing ways of teaching. Faculty and staff needed to quickly adapt and develop online classes, remote-teaching plans, and novel strategies to meet students' learning goals. It also re-surfaced the importance of the learning environment and meeting new generation of students' learning preferences. Coping with COVID-19 challenges and recognizing the shift in new generation of dental students, provided the opportunity to evaluate the delivery of the dental curriculum from multiple aspects—as each generation has their unique characteristics with strengths and weaknesses, and thus, a different and unique style of learning.[1]

At Loma Linda University School of Dentistry (California, USA), tooth morphology (TOMO) is taught to the first-year dental students with the purpose of introducing students to the morphological characteristics of the human dentition. It was designed so that students can apply the didactic knowledge and develop psychomotor skills necessary to proficiently reproduce tooth contours in wax and be able to relate these skills in their future clinical practice.[2] A major transformation was made in the TOMO course in the academic year (AY) 2020–2021. Conventional classroom instructions were replaced with synchronous online lectures and laboratory (lab) sessions were converted to implementation of "at-home" waxing. The overall quality of students' waxing work was comparable to previous years; however, students overwhelmingly desired faculty feedback that was not available at home.[3] In response to students' feedback and the lifting of COVID-19 in-person restrictions, the course has gradually morphed to combine the benefits and students' preferences of online education and reverting to in-person lab sessions.

There is no doubt that the intensive TOMO course (1) reinforced the didactic knowledge of morphology through a focus on analyzing the form of teeth as they are developed in wax;

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(2) enhanced the ability to visualize the three-dimensional form of teeth; (3) allowed students to learn how to make precise movements with their hands.[3] However, there is a scarce information on how learning styles of new generation of learners can affect didactic and practical performance in the TOMO course. Therefore, the purpose of this study was to evaluate students' self-reported preference in learning and relate it to their academic performance. Learning style was adapted from VARK that measures four perceptual preferences: visual (V), aural (A), read/write (R), and kinesthetic (K).[4]

We hypothesized that there would be no difference in didactic and lab performance scores among students with different perceptual preferences. Another purpose of this study was to highlight changes implemented in the TOMO course over three academic years as a response to the COVID-19 pandemic and advocate future changes to meet the new generation of learners' preferences.

Materials and Methods

The study was determined to be an exempt study by Loma Linda University Institutional Review Board (IRB #5210464). Dental freshmen students (LLUSD DDS Class of 2025) were enrolled in the 4-week TOMO course during the AY 2021–2022 this study was carried out. The didactic lectures ($N = 11$) were delivered synchronously via Zoom (Zoom Video Communications, San Jose, California) by one instructor throughout the course. Lecture materials included the use of 3D Human Tooth Atlas 9 (eHuman, Fremont, California) PowerPoint slides and selected video clips. Students were challenged with nine quizzes (10 questions/quiz) and one final examination (40 multiple choice questions) that were administered through an ExamSoft software (ExamSoft, Dallas, Texas).

During the lab session, students received a complete series of images showing the sequential step-by-step "heights of contour" waxing technique for each of five teeth that the students would be completing during the course. Each tooth had missing surfaces: the facial surface of the maxillary central incisor; distal surface of the maxillary canine; mesial surface of the maxillary first premolar; lingual surface of the maxillary first molar; and distal surface of the mandibular first molar. The students were also provided with videos that showed the actual step-by-step waxing of each tooth the students were required to complete. In addition to the teaching materials, students received conventional face-to-face instruction with a student faculty ratio of approximately 16:1. The competency consisted of a wax-up of the maxillary first molar with missing mesial surface. Students were allowed a total of 2 hours to complete their competency projects, and then handed them in at the grading room, along with a completed self-evaluation form that contains a checklist of eight criteria that is also used during the instructor's visual grading.

At the end of the course, students received a 4-question survey on their learning preferences and how they would like to receive feedback on their quizzes and wax-ups. The learning preference was determined by having students select one of the four perceptual preferences that were adapted from VARK: visual (V), aural (A), read/write (R), and kinesthetic (K). Visual learners prefer to learn from materials that are presented in charts, graphs, and other symbolic devices instead of words. Aural learners prefer if somebody walks them through the information by talking over the material. Read/write learners prefer to learn from reading, while kinesthetic learners prefer to learn through direct practice and hands-on materials.[4]

The TOMO course was taught by three different instructors over 3 years (AY 2019–2020 to 2021–2022) and each instructor filled out the course content and delivery method for their respective academic year.

Data Analysis

Descriptive statistics were generated to characterize students' perceptual learning preferences and didactic and practical scores. The mean didactic score was calculated by averaging the scores for the nine quizzes and the final exam. The mean lab score was a combination of five lab projects and the final practical competency. The nonparametric Kruskal-Wallis test was used to assess differences in didactic and lab scores among groups with different perceptual learning preferences. All analyses of data were performed with Jamovi version 1.6 (Jamovi, Sydney, Australia).[5] Throughout, the level of significance was set at $\alpha = 0.05$.

Results

The DDS class of 2025 consisted of 101 students with a mean age of 24 years ($N = 101$; age range 20–36 years; male: 56%, female: 44%). A total of 95 students responded to the learning style preference questionnaire (Response rate: 94%). Descriptive data of mean didactic and lab scores for the overall class and further categorized by perceptual learning preferences are shown in Table 1. Based on the Kruskal-Wallis test, there was no evidence that the four perceptual learning style groups differed in performance for didactic scores ($p = 0.340$) or for lab scores ($p = 0.845$). The distribution of the didactic and lab scores by perceptual learning style is illustrated as boxplots in Figures 1 and 2, respectively.

Responses to the 4-question survey on students perceptual learning style (Q1), how they would like to receive feedback on their quizzes (Q2), waxed teeth (Q3), and what type of instructions they would prefer for TOMO (Q4) are illustrated in Figure 3. Many students perceived themselves as a visual learner (39%) followed by kinesthetic (24%), aural (19%), and reader (18%). When receiving feedback on their quizzes, students preferred that the instructor talks them through the questions (41%). Students preferred that the instructor uses demonstrations on the model when providing feedback on their waxed tooth (51%). A vast majority of students (75%) preferred a TOMO teacher that uses demonstrations, models, or practical sessions.

Table 1: Didactic and lab performance by perceptual learning style

	Overall (N = 95)		*Visual (N = 37)*		*Aural (N = 18)*		*Reading (N = 17)*		*Kinesthetic (N = 23)*	
	Didactic	*Lab*	*Didactic*	*Lab*	*Didactic*	*Lab*	*Didactic*	*Lab*	*Didactic*	*Lab*
Mean	82.0	84.7	83.4	84.7	82.9	85.5	79.6	84.6	80.7	84.1
SD	8.4	3.2	6.9	3.2	10.9	3.9	9.5	3.3	7.4	2.7
Min	57.8	76.5	68.9	79.0	64.4	79.0	57.8	79.5	66.7	76.5
Max	98.9	95.5	96.7	91.5	98.9	95.5	96.7	93.0	96.7	88.0

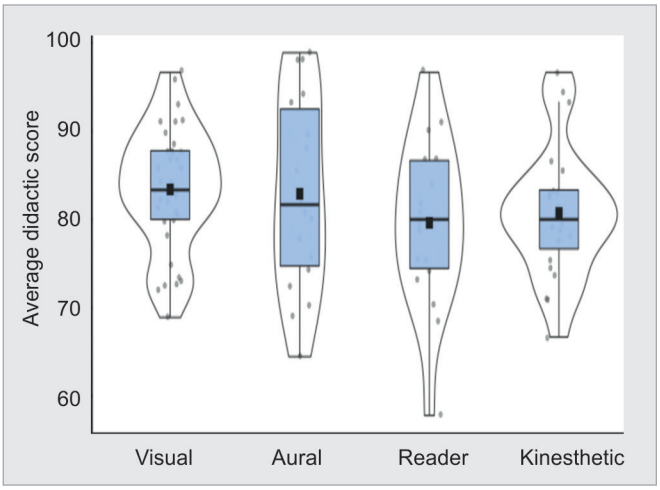

Fig. 1: Average didactic scores by students with different perceptual learning styles

The delivery method and content for the TOMO course is summarized in Table 2. AY 2019–2020 highlights the conventional method of teaching TOMO with classroom teaching and lab sessions that span over a full quarter which generally consisted of 11 weeks. AY 2020–2021 marks the year of the pandemic where curriculum changes became a necessity to comply with the state's social distancing and stay-at-home orders. Substantial curricular modifications were implemented by transitioning from in-person to online presentations and compressing the course from a full quarter to an intensive 4-week course. Due to strict COVID-19 related regulations, the practical waxing lab sessions had to be removed and all lab works were done "at-home" by the students without direct supervision of faculty. For the "at-home" waxing, all students were provided with a kit of student-purchased lab armamentarium that included wax, a set of teeth, a waxing block, a Boley gauge for making measurements, and two hand instruments. Additionally, there was no practical competency during that year. AY 2021–2022 was the result of merging the benefits of pre- and postpandemic teaching. The online didactic presentations were continued as it

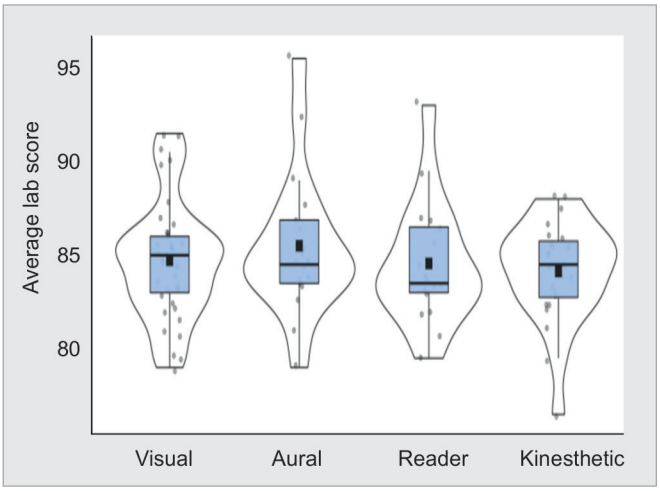

Fig. 2: Average lab scores by students with different perceptual learning styles

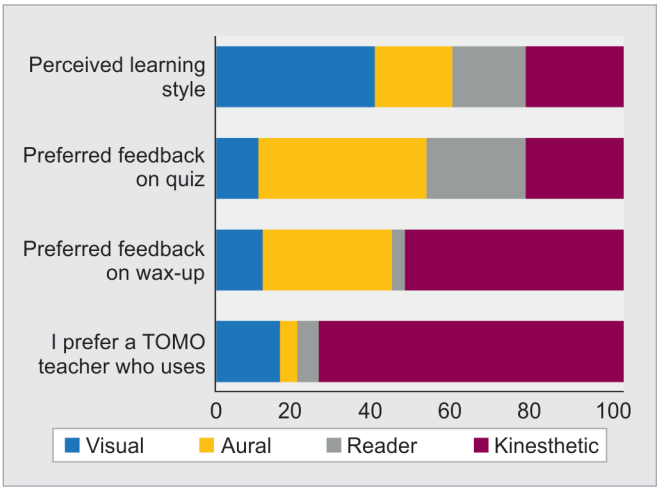

Fig. 3: Distribution of students' perceptual learning style and type of feedback preferences (%)

Table 2: Changes in delivery and content of the tooth morphology course over the years

AY	*Length*	*Didactic*	*Tests*	*Lab*	*Lab projects*	*Lab competency*
Pre-COVID	11 weeks	20 in-person lectures	10 quizzes, 1 midterm, 1 final exam	20 sessions	13 lab projects 7 teeth with missing surfaces 6 full contour wax-ups Tooth identification	Yes
2020–2021	4 weeks	11 zoom lectures	9 quizzes and 1 final exam	At-home	5 lab projects 1. facial surface of the Mx central incisor 2. distal surface of the Mx canine 3. mesial surface of the Mx first premolar 4. lingual surface of the Mx first molar 5. distal surface of the Mn first molar	No
2021–2022	4 weeks	11 zoom lectures	9 quizzes and 1 final exam	4 sessions	5 lab projects as in 2020–2021	Yes

alleviated the problem of classroom shortage while lab sessions were reinstated to provide the needed faculty feedback.

Discussion

As one of the first classes directly related to teeth and oral function, tooth morphology plays a vital role in first year dental students' foundational knowledge acquisition and hand skills development. Furthermore, it is an impactful time to plant visions and shape valuable attributes of an oral healthcare provider in students. As we look ahead, recognizing unique learning styles and preferences of new generation of learners is an important issue that needs to be considered prior to adopting new and innovative ways in teaching future dental students.[6]

This study specifically aimed to address the lack of information on perceptual learning preferences of the new generation and their academic performance. The mean age of the class of 2025 was 24 years which based on generation typology would fit into Generation Z (Gen Z), that are born after 1995 and tend to be immersed in technology and thus stay highly connected.[7] In terms of learning style, Gen Z have become wired to complex visual imagery, and as a result, the part of the brain responsible for visual ability is far more developed, making visual forms of learning more effective.[8,9] This is in accordance with our results where majority of students identified themselves as visual learners. This is also supported by another study that reported that visual learning was one of the most preferred unimodal styles of dental students.[10] It is important to note that in our questionnaire, we limited the selection of learning styles to one choice, as we tried to identify the most dominant learning style. According to studies that analyzed dental students' learning style, common learning styles identified were unimodal, bimodal, and multimodal.[4,10–14] Therefore, it is recommended that dental educators direct attention to match the learning preferences of as many students as possible by using various teaching styles rather than focusing on a single method of delivering the course.[15] Interestingly, there was no difference in academic achievement for both didactic and lab scores for students with different learning styles. Based on the results we accepted our null hypothesis that didactic and lab performance scores among students with different perceptual preferences would not be different. Our results were comparable with other studies that reported no relationship between learning style and academic achievement.[12,14]

In contrast to our results, a study by Nasiri and others reported that there was a relationship between learning style and academic achievement in dental students. They found that visual learners had significantly higher exam scores.[13]

Given the challenges produced by the COVID-19 pandemic, substantial modifications were made in the delivery of the TOMO course during the AY 2020–2021. First, all in-person didactic presentations were delivered synchronously through webinars with accompanying use of the 3D Tooth Atlas. Second, there were no lab sessions instead students were provided with the instrumentation and materials to complete five waxing projects at home. Our institution had long before discussed implementation of online courses to overcome some classroom shortages; however, it was the presence of the crisis that prompted and forced the change from in-person to online classes. We had anticipated that students would appreciate having classes from the comfort at home. However, most students indicated a preference for physically going to class and being able to interact with faculty and classmates as opposed to online webinars. Furthermore, students indicated a strong preference for personal and immediate faculty feedback during their waxing projects that was not available at home.[3] During the AY 2021–2022, social distancing guidelines were lifted and students could return to school under certain circumstances. A modified version was adopted where lab sessions re-opened to in-person classes while didactic lectures were kept as synchronous online presentations. This helped to avoid physical limitations of needing actual classrooms and helped in managing student schedules. A major change that our school implemented during the pandemic was the change from the two 4-hour sessions a day (8 am–12 pm and 1 pm–5 pm) to three 3-hour sessions a day (7 am–10 am, 10:30 am–1:30 pm and 2 pm–5 pm). The new schedule allowed the school to add one more lab/clinic session, per day, which significantly increased the overall experience level for students. This also made it possible to not only distribute the students out over a more teachable group size (50 vs. 100 students), but it also allowed to distribute faculty more evenly throughout the various clinical and lab sessions. Thus, the tooth morphology lab was performed on Wednesday three times for three different groups.

A systematic review by de Azevedo on how TOMO is taught suggested that there is no standard method that is widely used for teaching dental anatomy but that combining traditional teaching technique and a method of using software may be promising. The review included five articles that met the inclusion criteria of research involving dental students, studies using sculpture as a methods of learning assessment, and reporting teaching methodology for the practice of dental sculpture.[16] Reflecting on the feedback, students appreciated to have the instructor go through the questions aurally and show how to fix their wax-up using demonstrations on models. This reflects one characteristic of Gen Z in favoring personal interaction and immediate feedback by the instructor.[8] It has been further reported that Gen Z appreciates interactive games, collaborative projects, advance organizers, and challenges that mark milestone achievements.[8] Considering Gen Z preferences, our TOMO team which consists of three faculty and three dental students discussed changes that could be implemented without major investment in faculty or equipment. The team identified some potentially engaging teaching methods that would be better accepted by Gen Z to improve their learning experience.

First, to challenge Gen Z and engage them in a collaborative project, students can choose or be assigned to work in groups to answer a question such as: "What is your favorite tooth and why" by creating a short video clip. Having this open-ended question encourages students to review the didactic content and re-create knowledge in a more creative way. Videos can be submitted on Canvas Studio and uploaded on a discussion board where other classmates can view and comment on each other's posts. Classmates can review and vote for their classmate's videos based on creativity which can create a milestone achievement for students. Second, interactive games are well appreciated by Gen Z, as it promotes fun activities while testing one's knowledge. The Zoom (Zoom Video Communications, San Jose, California) platform which is used at LLUSD allows to incorporate a variety of games such as Kahoot! (Oslo, Norway) or Jeopardy. Implementing games concurrently during lectures can help reestablish learning points and can be used as checkpoints to address topics that students may struggle more on. Third, a timed puzzle game to organize teeth in their correct location in their typodont could be a fun project for students to apply their knowledge in tooth morphology.

This is the first study that evaluated the learning preferences and academic performance of the new generation type of learners in the tooth morphology course. Limitations included the lack of validity of categorizing learning preferences into four modes: visual, aural, reader, and kinesthetic. Additionally, students were not given the choice of selecting multiple learning preferences. Lastly, the study included students of one institution which makes the results not generalizable to all dental students.

Conclusion

There is no doubt that the COVID-19 pandemic brought about many challenges and prompted faculty to be more flexible and creative in delivering the course material. Within the limitations of this study, we conclude that to match the learning preferences of as many students as possible, tooth morphology should be delivered by using various teaching styles rather than focusing on a single method of delivering the course while making it interactive and providing more hands-on demonstrations.

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