An Educational Experiment Resulting from COVID-19: The Use of At-Home Waxing and Webinars for Teaching a 3-Week Intensive Course in Tooth Morphology to First Year Dental Students

Charles J. Goodacre, DDS, MSD,1 Reema Younan, DDS,2 Vaughn Kearbey,2 & Michael Fitzpatrick3

1Advanced Education Program in Implant Dentistry, Loma Linda University School of Dentistry, Loma Linda, CA
2Division of General Dentistry, Loma Linda University School of Dentistry, Loma Linda, CA
3International Dental Program, Loma Linda University School of Dentistry, Loma Linda, CA

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Abstract
Purpose: To report the outcomes of presenting a 3-week intensive course in tooth morphology to first year dental students using “at-home” waxing projects and webinars.

Materials and Methods: Students were provided with the instrumentation and materials required to complete 5 waxing projects at home during the 3-week course. In the same time period, the didactic content was presented via 11 webinar sessions. A postcourse survey provided student perspectives regarding this new experience.

Results: Students were able to effectively complete high-quality waxing projects at home by using step-by-step images and videos but the survey indicated an overwhelming preference for in-person faculty feedback. Webinars based on the students having studied the 3D Tooth Atlas and an instructor reviewing content in the Atlas was effective in teaching the didactic aspect of tooth morphology as evidenced by the student grades and survey results. However, most of the students indicated a preference for physically going to class and being able to interact with faculty and classmates as opposed to online webinars. The condensed 3-week version of the course was part of an expanded 4-week student orientation and worked well, allowing other clinical precursor courses to occur before their usual time in the curriculum, thereby allowing students to begin earlier patient treatment.

Conclusions: The at-home waxing exercises produced very good results by having the students use step-by-step images and videos in the 3D Tooth Atlas. However, the students indicated a strong preference for personal faculty feedback that was not available at home. Students effectively learned the didactic aspects of tooth morphology through the webinars with accompanying use of the 3D Tooth Atlas but again most students prefer physically going to class and being able to interact with faculty and classmates. These preferences for contact with classmates and faculty supports the natural human desire for personal interactions with other human beings.

It has been stated that “modifying a dental school curriculum is similar in difficulty to moving a cemetery.” However, given the educational challenges produced by the COVID-19 pandemic, curriculum changes became a necessity with dental schools introducing substantial modifications. So now it might be appropriate to state “it takes a pandemic to make substantive curriculum changes in dental education.” For indeed, the presence of a crisis oftentimes stimulates innovation and change.

A major change in dental education has been the use of distant learning and webinar-based presentations in place of traditional classroom lectures. While the introduction of such presentations required change, the difficulties are easier to manage than teaching laboratory courses where students have traditionally been present in a physical facility in close approximation to other students along with close interaction with faculty. As a result, laboratory courses present unique challenges due to the need for social distancing so as to provide appropriate protection for students, faculty, and staff. In addition, available laboratory space in many schools has prevented required separation of an entire class of students at the same time. One method
used to resolve this challenge is to teach laboratory courses in smaller groups of students that permit appropriate spacing between students in existing physical facilities. However, while this process can work, it requires increased faculty time due to the multiple sessions. Also, even with physical separation of students in the laboratory, it can be difficult to adhere to social distancing when students need faculty assessment of their procedures and when faculty need to sit down and demonstrate while students observe.

Due to the challenges associated with the COVID-19 pandemic, a significant change was made in the tooth morphology course that involved the use of “at-home” waxing in conjunction with webinar presentations rather than classroom instruction. This experiment produced interesting results and the purpose of this paper is to describe the materials and methods used in the course along with the results.

**Materials and methods**

The first-year dental student course covering the topic of tooth morphology was presented over a 3-week period of time as part of an extended 4-week orientation program for first year students. The laboratory portion of the course involved “at-home” waxing projects with webinars being used in place of classroom presentations.

For the “at-home” waxing experiment, each of the 99 students was provided with a kit of student-purchased laboratory armamentarium that included wax, a set of teeth, a waxing block, a Boley gauge for making measurements, and two hand instruments (a surface carver and a groove carver) (Fig 1). The set of teeth included 12 specially designed life-size teeth with one of the tooth surfaces missing along with the same 12 teeth that were intact so students could see what the missing surface should look like. Five of the 12 teeth were used by the students in the course with grades assigned for each of these 5 teeth (Fig 2). The remaining teeth could be used by the students to practice their skills in reproducing the morphology of various missing surfaces of these teeth. The students also received an electric waxer provided by the school for a rental fee and a complete series of images showing the sequential step-by-step “heights of contour” waxing technique for each of 5 teeth that the students would be completing during the course. These images could be downloaded by students and placed on their phones or tablets for easy viewing as they were waxing the teeth. As an example, the students were given 30 images that showed the process of waxing the mesial surface of the maxillary first premolar (Figs 3–5). The students were also provided with videos that showed the actual step-by-step waxing of each tooth the students were required to complete and videos that showed evaluation of each completely waxed tooth by rotating the tooth and demonstrating the reflection of light off the wax surface to show heights of contour; and each student had a copy of the eHuman 3D Tooth Atlas installed on their laptop or tablet. This program contains the complete series of images for all the 5 teeth waxed as part of this course as well as the videos described above to help guide students during their at-home waxing. The waxing video used by the students...
At-Home Waxing and Webinars for Tooth Morphology

The top pictures show forming the mesiofacial and distofacial line angles and then adding wax to establish the facial and lingual contours. The bottom pictures show the wax added to develop the mesial contour of the crown and root along with the cervical line.

The missing aspects of these teeth included the cervical line and a portion of the root so students gained a perspective regarding the form of the cervical line as well as root morphology during the waxing processes.

The didactic portion of the course included 11 webinar-based sessions. Except for the first and last webinar presentations, online quizzes were given at the beginning of each class period covering the material presented in the previous webinar session. A one-hour online 40 question multiple choice final examination was given following a comprehensive review session during the last webinar.

Students completed a postcourse survey using 5 possible responses to 15 statements (strongly agree, agree, neutral, disagree, and strongly disagree). The survey also included 4 open-ended questions (Table 1). The intent of the statements and open-ended questions was to gain the student’s perspective regarding the use of webinars, use of online quizzes and examination, use of the computer-based program entitled 3D Tooth Atlas as the focus of the webinars and source of their study, and completion of “at-home” waxing projects.

Results

To the surprise and pleasure of the faculty, the overall student performance in the “at-home” waxing experiment was very good as evidenced by the quality of the waxed teeth. Also, there was improvement in the scores as the 99 students progressed through the 5 teeth from the maxillary central incisor to the mandibular first molar. For the maxillary central incisor, A grades were given to 32 students, B grades to 27 students, C grades to 32 students, and a D grade to 8 students. The maxillary canine was the next tooth that was waxed and there were 38 A grades, 32 B grades, 27 C grades, and 2 D grades. For the maxillary first premolar there were 59 A grades, 34 B grades, 2 C grades, and 4 D grades.
### Table 1: Student perceptions regarding 15 statements and 4 open-ended questions with response data

| Statement                                                                 | Response Data                                                                                   |
|--------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
| 1. The webinar presentations were effective in helping me learn tooth morphology. | Result: 58 of 86 students agreed or strongly agreed whereas 8 students disagreed or strongly disagreed with 19 neutral responses. |
| 2. I would prefer traditional classroom lectures over the use of webinars.  | Result: 47 students agreed or strongly agreed with the statement whereas 14 disagreed or strongly disagreed with 25 neutral responses. |
| 3. I think the webinar format made it more comfortable for me to provide answers to instructor questions during the webinars than if we were in a traditional classroom setting. | Result: 25 of 86 students agreed or strongly agreed whereas 29 students disagreed or strongly disagreed with 32 neutral responses. |
| 4. I think the online quizzes and an online examination were easy for me to use. | Result: 58 of 86 students agreed or strongly agreed whereas 17 disagreed or strongly disagreed with 11 neutral responses. |
| 5. I think use of the “3D Tooth Atlas” during the webinars helped me learn tooth morphology. | Result: 55 of 86 agreed or strongly agreed whereas 12 students disagreed with 19 neutral responses. |
| 6. I used the “3D Tooth Atlas” outside of the webinar session. | Result: 79 students agreed or strongly agreed with 4 disagreeing or strongly disagreeing and 3 neutral responses. |
| 7. I think the “Self-Assessment Examination” in the synopsis section of the “3D Tooth Atlas” with its pictures of different teeth that I needed to identify helped my knowledge of tooth morphology. | Result: 62 of 86 students agreed or strongly agreed whereas 13 students disagreed or strongly disagreed with 11 neutral responses. |
| 8. I think the “Sample Quiz/Examination Questions” in the “3D Tooth Atlas helped me learn tooth morphology. | Result: 50 of 86 students agreed or strongly agreed with 20 students disagreeing or strongly disagreeing and 16 students selecting a neutral response. |
| 9. I think the “3D Tooth Atlas” helped me develop my 3-dimensional visualization skills (ability to visualize the 3-dimensional shape of teeth). | Result: 62 of 86 students agreed or strongly agreed whereas 9 students disagreed or strongly disagreed with 15 neutral responses. |
| 10. I think the “3D Tooth Atlas” provided me with better learning materials than traditional classroom lectures and textbooks. | Result: 49 of 86 students agreed or strongly agreed with 16 students disagreeing or strongly disagreeing and 21 selected a neutral response. |
| 11. I think the waxing images and videos present in the “3D tooth Atlas” allowed me to visualize the required “at-home” waxing projects and be able to complete them. | Result: 51 of 86 students that agreed or strongly agreed whereas 18 students disagreed or strongly disagreed and 17 selected the neutral response. |
| 12. I think the “at-home” waxing projects enhanced my knowledge of tooth morphology. | Result: 58 of 86 students agreed or strongly agreed whereas 13 students disagreed or strongly disagreed with 15 neutral responses. |
| 13. I think the “at-home” waxing projects helped me develop my 3-dimensional visualization skills (ability to visualize the 3-dimensional shape of teeth). | Result: 65 of 86 students agreed or strongly agreed with 8 disagreeing and no students strongly disagreeing with the statement. There were 13 neutral responses. |
| 14. I think the “at-home” waxing projects helped develop my ability to make small, precise movements with my hands. | Result: 69 of 86 students agreed or strongly agreed whereas 8 disagreed or strongly disagreed and 9 students chose a neutral response. |
| 15. I think the “at-home” waxing projects helped prepare me for future clinical applications of tooth morphology. | Result: 67 of 86 students agreed or strongly agreed whereas 8 disagreed or strongly disagreed and 11 selected a neutral response. |

**Open-ended questions**

1. What do you think was the most useful aspect of the tooth morphology webinars?
   Result: Of the 61 responses, 26 related to the positive value of the 3D Tooth Atlas and the instructor going through the atlas and reviewing each tooth along with explanations. There were 8 comments about the value of the recorded lectures, 5 comments about being comfortable with asking questions during the webinars and 3 students appreciated being home and not having to spend time getting ready and traveling to class.

2. What do you think were the biggest limitations of the tooth morphology webinars?
   Result: Many of the 61 responses had similar themes such as “preferring to physically go to class”, “lack of personal interaction and class bonding”, “not being able to meet with the instructors”, “not being able to ask questions of the instructors”, and “being disconnected from classmates and instructors”.

3. What do you think were the biggest limitations of the “at-home” waxing?
   Result: 58 of the 69 responses were related to the lack of feedback as to how they were doing.

4. What suggestions do you have for improving the course?
   Result: There were 63 comments that included “more feedback”, need for “zoom office hours”, “making the class be an in-person experience”, “making the class on-ground”, “in-person instruction cannot be replaced”, “more information about how to differentiate teeth on the left side from those on the right side”, “leaving the class online but having an in-person laboratory”, and “better communication between the instructors”.

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The results of the more difficult molar waxing projects were very encouraging. For the maxillary first molar there were 39 A grades, 53 B grades, 6 C grades, and 1 D grade. The final waxed tooth was the mandibular first molar and there were 58 A grades, 35 B grades, 5 C grades, and 1 D grade. Examples of the completed teeth are shown in Figures 7–9.

The condensed course, based on 11 webinar-based sessions, was presented over a 3-week period of time as part of an extended orientation program for first year students. In this way, the entire course was completed before the beginning of the fall academic quarter, thereby opening time in the fall quarter for a preclinical course in operative dentistry to be presented earlier in the curriculum.

No formal overall grades were given for the tooth morphology course as it is part of the Dental Fundamentals course that continues through the fall quarter. Grades will be given at the end of the fall quarter that includes tooth morphology and operative dentistry. However, calculations were made of the performance in the tooth morphology section of the Dental Fundamentals course to provide faculty with insight into the performance of students without direct faculty interaction. The class average was 87 with a range from 62.5 to 96.3 for the combined didactic and laboratory portions of the course.

The survey results provided insight into the student’s perspective regarding “at-home” waxing, webinar-based presentations, and use of the 3-D Tooth Atlas. Of the 99 students in the class, there were 86 responses to the survey and all 86 students responded to each of the 15 statements.

The responses to the 15 statements are summarized as follows:

The first statement was “The webinar presentations were effective in helping me learn tooth morphology” with 59 of 86 students agreeing or strongly agreeing whereas 8 students disagreed or strongly disagreed and 19 selected the neutral response. Regarding responses to the contrasting statement “I would prefer traditional classroom lectures over the use of webinars,” there were 47 students who agreed or strongly agreed with the statement whereas 14 disagreed or strongly disagreed with 25 neutral responses.

The third statement focused on whether or not students would feel more comfortable responding to questions posed during class than a traditional classroom session. The class responses to this statement included 25 of 86 students who agreed or strongly agreed that the webinar format made them more comfortable responding whereas 29 students disagreed or strongly disagreed with 32 neutral responses. Fifty-eight of 86 responses indicated the quizzes and online examination were easy to use whereas 17 disagreed or strongly disagreed and there were 11 neutral responses.
Regarding the statement “I think use of the 3D Tooth Atlas during the webinars helped me learn tooth morphology,” 55 of 86 responses indicated the 3D Tooth Atlas helped with learning tooth morphology whereas 12 students disagreed or strongly disagreed and 19 students were neutral. The statement “I used the 3D Tooth Atlas outside the webinar session” resulted in 79 students agreeing or strongly agreeing whereas 4 students disagreed or strongly disagreed and 3 students selected a neutral response.

For the statement “I think the Self-Assessment Examination in the synopsis session with its pictures of different teeth helped my knowledge of tooth morphology,” 62 of 86 students agreed or strongly agreed whereas 13 students disagreed or strongly disagreed with 11 neutral responses. The statement “I think the Sample Quiz/Examination questions in the ‘3D Tooth Atlas’ helped me to learning tooth morphology” resulted in 50 of 86 respondents agreeing or strongly agreeing and 20 students disagreeing or strongly disagreeing with 16 neutral responses.

Relative to the statement “I think the 3D Tooth Atlas helped me develop my 3-dimensional skills (ability to visualize the 3-dimensional shapes of teeth),” 62 of 86 students agreed or strongly agreed whereas 9 students disagreed or strongly disagreed and 15 neutral responses were recorded. For the statement “I think the 3D Tooth Atlas provided me with better learning materials than traditional classroom lectures and textbooks,” 49 of 86 students agreed or strongly agreed with 15 students disagreeing or strongly disagreeing and 21 selected a neutral response.

Regarding the question “I think the waxing images and videos present in the 3D Tooth Atlas allowed me to visualize the required At-Home Waxing Projects and be able to complete them,” there were 51 of 86 students that agreed or strongly agreed whereas 18 students disagreed or strongly disagreed and 17 selected the neutral response. Five students commented that the videos were not good quality and were blurry. There were 58 of 86 students who felt the “At-Home Waxing Projects” enhanced their knowledge of tooth morphology whereas 13 disagreed or strongly disagreed with the value of these at-home projects. Responses to the statement, “I think the At-Home waxing projects helped me develop my 3-dimensional visualization skills” resulted in agreement or strong agreement from 65 of 86 students with 8 disagreeing and no students strongly disagreeing with the statement. Regarding the statement, “I think the At-Home waxing projects helped develop my ability to make small, precise movements with my hands,” 69 of 86 students agreed or strongly agreed with the statement whereas 8 disagreed or strongly disagreed and 9 students chose the neutral response. Relative to the statement about the At-Home waxing projects helping to prepare you for future applications of tooth morphology, 67 of 86 students agreed or strongly agreed whereas 8 disagreed or strongly disagreed and 11 were neutral.

Responses to the open-ended questions resulted in some common themes as noted below.

There were 61 responses to the question “What do you think was the most useful aspect of the tooth morphology webinars?” Twenty-six of the responses were related to the positive value of the 3D Tooth Atlas and the instructor going through the atlas and reviewing each tooth along with explanations. There were 8 comments about the value of the recorded lectures and being able to go back and review them. There were 5 comments indicating these students were comfortable asking questions during the webinars and using the chat feature where questions could be posed. There were 3 comments about the comfort of being home and not having to spend time getting ready and traveling to class. There were even positive comments about demonstrating the morphology of teeth by holding up the giant teeth during the webinars.

The question “What do you think were the biggest limitations of the tooth morphology webinars?” produced 61 responses. Many of these comments had similar themes and included “preferring to physically go to class,” “lack of personal interaction and class bonding,” “not being able to meet with the instructors,” “not being able to ask questions of the instructors,” and “being disconnected from classmates and instructors.” Students also mentioned factors such as “being harder to pay attention during a webinar as opposed to in-person class,” “becoming distracted when you are by yourself,” and “unavoidable technology issues.”

There were 69 responses to the question “What do you think were the biggest limitations of the at-home waxing?” Almost all of the responses (58) were related to the lack of feedback as to how they were doing. Other responses related to not being able to see how other students are doing. Also, 5 students indicated the waxing videos should have higher quality.

The question “What suggestions do you have for improving the course?” resulted in 63 comments. There were many good suggestions that included “more feedback,” “need for ‘zoom office hours,’” “making the class be an in-person experience,” “making the class on-ground,” “in-person instruction cannot be replaced,” “more information about how to differentiate teeth on the left side from those on the right side,” “leaving the class online but having an in-person laboratory,” “better communication between the instructors.” Also, there were several comments about “correcting the errors present in the sample quizzes in the atlas” since there were a few questions where the answer had been incorrectly programmed and a few questions where the wording could be improved for better understanding of the questions.

**Discussion**

It was surprising how well the students waxed the teeth without any direct faculty instruction. They only used the series of images (Fig 4) and the videos that demonstrated the actual teeth the students were waxing at-home.

There are several possible reasons why the results were positive. One reason could be the fact that without direct faculty interaction the students had to rely on the images and videos and therefore they must have closely followed the step-by-step procedures outlined in the images and videos. Another proposed reason for the success was the requirement that the students email images to the faculty of the step-by-step waxing they performed, thereby documenting that they followed the prescribed technique.

A third reason could have been the time available as students spent varying amounts of time on the waxing projects, probably much more time than they would have spent if they were
in a laboratory with other students. When students are together in a laboratory setting, they often feel pressured to complete a project faster than they should because they observe classmates who are already finished and they feel like they are falling behind. Also, there is typically a specific amount of time assigned to a laboratory project with deadlines and oftentimes students feel obliged to "get it done and turn it in." With the at-home waxing, students were able to spend as much time as needed on the projects. This varying time brings up a concern some might have as they would say grading is not fair if some students spent more time than others. Perhaps true but that is actually what happens to some degree even in faculty supervised laboratory sessions. An important factor to consider relative to the time students spend on a project is the benefit gained by doing the project as well as possible the first time regardless of the time it takes since the hand skills of each student develop at a different pace. So obtaining the best possible result regardless of the time it takes can be a good process to learn and then develop increased speed.

Some dental educators have an interesting perspective regarding students waxing teeth. They believe students should not be taught to wax teeth. In fact, some schools have stopped including waxing teeth as part of the education of their students. A common reason for deleting waxing from the curriculum is the perspective that students will not be waxing teeth after they graduate and may not even use wax to form patterns for restorations as part of their clinical dental school education. While these statements are correct, this perspective overlooks some important factors. The authors of this paper place importance on waxing teeth for the following reasons: (1) Waxing teeth reinforces the didactic knowledge of tooth morphology through a concentrated focus on analyzing the form of teeth as they are developed in wax; (2) There is enhancement of manipulation of instruments, thereby allowing students to learn how to make small, precise movements with their hands, an important precursor to using dental instrumentation in the treatment of patients; and (4) Wax is an easy material to make additions and corrections to as needed.

The process of presenting a course in a condensed time frame where it is not spaced over an entire academic quarter or semester is not new. However, completing a foundational course such as tooth morphology as part of an extended student orientation program presented an interesting opportunity. It allowed the operative dentistry course to occur earlier in the curriculum at the beginning of the fall quarter. In this way, courses that are precursors to patient treatment can be moved forward in the curriculum, allowing students to begin treating patients earlier in their program.

The majority of the students (59 of 86) indicated the webinar presentations were effective in helping them learn tooth morphology but 47 indicated a preference for traditional classroom lectures. These results coupled with the comments made in the open-ended question about the biggest limitations of the webinars indicates students prefer having personal interaction with their instructors and classmates. While webinars proved to be effective in this course, they were not preferred by most students over the natural human desire for personal interactions.

As faculty, it was assumed that the webinar format might make students more comfortable responding to questions posed during the webinars since past experience indicates responding in class has not been a comfortable experience for most students when everyone is in a classroom together. However, 25 of 86 students agreed or strongly agreed that the webinar format made them more comfortable responding whereas 29 students disagreed or strongly disagreed relative to them being comfortable responding to instructor questions. In addition, 32 students selected a neutral response, indicating these students were not sure if the webinar format made them more comfortable asking questions during a webinar. Most of the students indicated the quizzes and online examination were easy to use, presumably because the process used in the course was reasonably straightforward.

The "3D Tooth Atlas" was judged to be effective in teaching tooth morphology since only 12 students disagreed or strongly disagreed. Also, 79 of 86 students used the program outside of class. The majority of the students also felt the self-assessment aspects of the program were helpful and that it helped them visualize the 3-dimensional shapes of teeth. It was interesting to note that 49 of the 86 respondents felt the program provided them with better learning materials than traditional classroom lectures and textbooks whereas 16 did not feel that way. In addition, there were 21 neutral responses, indicating these respondents were not sure. Since these first-year students had not been taught tooth morphology using traditional classroom lectures and textbooks, one would assume their responses may have been based on past experiences with traditional lectures and textbooks during their pre-dental years of study.

Most of the students felt the "at-home" waxing projects helped them learn tooth morphology, develop 3-dimensional visualization skills, develop the ability to make precise hand movements, and helped prepare them for future applications of tooth morphology. But the open-ended question about the limitation of the "at-home" waxing was overwhelmingly described as a lack of feedback. In other words, the students didn’t know how they were doing even though their actual projects were judged by the grading faculty to be as good as previous waxing projects where there was faculty input. These responses indicate the importance of personal human interactions even though pictures and videos can show how to complete the projects. Therefore, it seems reasonable to conclude that the combination of using the pictures and videos in the "3D Tooth Atlas" along with personal faculty feedback is likely to be the best method of providing laboratory instruction.

Conclusions

The overall quality of the completed waxing projects indicated "at-home" waxing was successful without direct faculty
interaction by the students using series of step-by-step images and videos present in the “3D Tooth Atlas”. However, students overwhelmingly desired faculty feedback that was not available at home. The students felt the webinars were effective in learning tooth morphology but a large number of students expressed a preference for traditional classroom lectures. Students indicated the biggest limitation of the webinars was not physically going to class and being able to personally interact with faculty and classmates, responses that document the natural human desire for personal interactions with others.

The 11-session webinar-based presentations presented over 3 weeks as part of an extended first year student orientation program allowed the operative dentistry course to be presented earlier in the curriculum. This process allows courses that are precursors to patient treatment to be moved forward in the curriculum, providing students with earlier access to patient treatment.

Most students indicated use of the “3D Tooth Atlas” helped them learn tooth morphology and almost all of the students used it outside of the webinar sessions. Most students felt the visual self-assessment examination with its pictures of teeth in the “3D Tooth Atlas” helped their knowledge of tooth morphology as did the sample quiz/examination questions. Students also indicated the “3D Tooth Atlas helped with their ability to visualize the 3-dimensional shape of teeth and most of the students also felt the atlas provided them with better learning materials than traditional classroom lectures and textbooks.

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