Use of Technology in Dental Education

Dental Students’ Preferences and Performance in Crown Design: Conventional Wax-Added Versus CAD

R. Duane Douglas, D.M.D., M.S.; Christa D. Hopp, D.M.D.; Marcus A. Augustin, Ph.D.

Abstract: The purpose of this study was to evaluate dental students’ perceptions of traditional waxing vs. computer-aided crown design and to determine the effectiveness of either technique through comparative grading of the final products. On one of two identical tooth preparations, second-year students at one dental school fabricated a wax pattern for a full contour crown; on the second tooth preparation, the same students designed and fabricated an all-ceramic crown using computer-aided design (CAD) and computer-aided manufacturing (CAM) technology. Projects were graded for occlusion and anatomic form by three faculty members. On completion of the projects, 100 percent of the students (n=50) completed an eight-question, five-point Likert scale survey, designed to assess their perceptions of and learning associated with the two design techniques. The average grades for the crown design projects were 78.3 (CAD) and 79.1 (wax design). The mean numbers of occlusal contacts were 3.8 (CAD) and 2.9 (wax design), which was significantly higher for CAD (p=0.02). The survey results indicated that students enjoyed designing a full contour crown using CAD as compared to using conventional wax techniques and spent less time designing the crown using CAD. From a learning perspective, students felt that they learned more about position and the size/strength of occlusal contacts using CAD. However, students recognized that CAD technology has limits in terms of representing anatomic contours and excessive occlusion compared to conventional wax techniques. The results suggest that crown design using CAD could be considered as an adjunct to conventional wax-added techniques in preclinical fixed prosthodontic curricula.

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Computer-based education methods facilitate interactive learning and have potential benefits as a teaching resource. Today’s dental students belong to a generation that has embraced digital media. Often referred to as Generation Y, Net Generation, Gen Next, or Millennials, these students have an affinity for interactivity and new technologies and prefer visual learning favoring graphics and images versus print. Dental students specifically have a higher preference for visual learning than does the general student population.

The visualization or spatial ability of students refers to their ability to form mental representations of forms, shapes, and positions and to manipulate them in their minds. High spatial/visual ability contributes to success in dental school. Spatial ability tests have been demonstrated to predict performance in preclinical technique courses, which teach psycho-motor skills involved in tooth preparation and restoration, such as building and shaping crowns and filling teeth. Because spatial ability is a better predictor of preclinical success than college grade point average (GPA), dental schools use the Perceptual Ability Test (PAT) to preselect students who demonstrate high spatial/visual ability (SVA).

Computer-assisted instruction can present spatial information using 3D modeling, thereby allowing students to visualize complex anatomical relationships by interacting with the models to visualize the 3D structures. Viewing dynamic 3D animations can improve students’ incomplete mental models. Virtual reality technologies that use 3D graphics have shown great potential to educate students in medicine, particularly in the anatomical sciences, radiology, and microbiology. Studies have demonstrated that high SVA students benefit more than low SVA students.
when learning using 3D visualization. Dentistry too has adopted computer-based education methods or e-learning technology for educating students in dental terminology, dental implantology, oral manifestations of systemic disease, geriatric dental care, tobacco cessation, diagnosis and treatment planning, clinical simulations, orthodontics, anatomy, dental morphology, pharmacology, radiology, and histology, as well as comprehensively in a dental curriculum.

Dental students have a strong desire for, and positive reaction to, interactive learning tools that include 3D graphics. In a recent study, dental and dental hygiene students showed their strongest preference for e-resources that included 3D graphics. In dental morphology, these educational resources are generally recognized as a great benefit in preparing for tests. Although many studies have investigated the use of computer-based digital interactive technologies that incorporate 3D graphics as an educational aid in teaching dental morphology, documentation of its application in fixed prosthodontics curricula is minimal. The skills and knowledge developed in dental morphology and occlusion are fundamental and prerequisite to learning fixed prosthodontics. Dental morphology courses have moved away from the presentation of foundation knowledge in lectures and textbooks to a more interactive, media-based education for teaching tooth anatomy to dental students. Psychomotor skills traditionally developed through two-dimensional drawings and carving teeth from blocks of wax are now replaced with clinically relevant waxing exercises based on restoring missing structure of articulated manikin teeth. Many preclinical fixed prosthodontics curricula require students to apply the skill set developed in dental morphology to the design and fabrication of full contour restorations. Yet there exists an apparent gap between the use of 3D graphics technology in dental morphology courses and crown fabrication in fixed prosthodontics courses.

Computer-aided design (CAD) and computer-aided manufacturing (CAM) technologies have been used to fabricate full contour and partial coverage restorations at chair-side and in commercial dental laboratories. As the use of CAD/CAM fabrication of dental restorations continues to increase in the practice of dentistry, many dental schools are incorporating the technology into their clinical and preclinical curricula. CAD/CAM uses similar 3D modeling to that of 3D interactive tooth atlases used as e-resources for dental morphology courses. This presents an opportunity to incorporate some of the same principles outlined in the development of dental morphology curricula into preclinical and clinical fixed prosthodontic restoration design.

Currently, the preclinical fixed prosthodontics courses at Southern Illinois University School of Dental Medicine require that students manually design crowns using a conventional wax-added technique and virtually design crowns using CAD techniques. The aim of this study was to compare student experiences with the traditional method of crown design to computer-aided design and manufacturing of a full contour crown. Students’ perceptions of traditional versus computer-aided crown design were also evaluated, and the effectiveness of both techniques was determined through comparative grading of the final products. The null hypothesis for this study was that the type of crown design technique (wax-added or CAD) would have no influence on the number of occlusal contacts, the grade for dental morphology, the time needed to complete the project, or the students’ preferences.

Methods

This research was approved by the Institutional Review Board of Southern Illinois University Edwardsville. At the beginning of the second-year spring semester, all fifty students in the Year II (D2) class were given an informed consent to explain and request participation in the study.

CAD/CAM Crown Design Project

In 2012, the Fixed Prosthodontics II curriculum was modified to include the fabrication of an all-ceramic crown using CAD/CAM technology (CEREC 3D, Sirona Dental Systems, Charlotte, NC, USA). The exercise consisted of one three-hour laboratory session to acquire the digital impression and design the restoration and a second three-hour laboratory session to finish, polish, and lute the milled restoration. Two one-hour supporting lectures were also given to instruct students on digital impressions and crown design using the CEREC acquisition unit. The course laboratory manual was revised to include step-by-step instructions on using the CEREC system to make a digital impression and design the crown. The manual included fifty-three screen shot images and was designed to permit students to design their restorations outside of assigned laboratory time using computers provided by the dental school. Sessions with the course director were scheduled in
Although this is primarily an additive technique, a certain amount of carving occurs as well to achieve a suitable crown design that matches the model manikin tooth. Because the intent of this study was to compare different crown design techniques, the students were not required to cast the wax patterns.

**Evaluation of Crown Design Projects**

On completion of each project, students submitted their crown designs (WAX and CAD) on the manikin tooth identified solely by their anonymous student numbers. To prevent any bias introduced by the order of the projects and to improve the logistics of computer access, half the class started with the CAD/CAM design project and half the class started with the wax design project. Each project had an equal grade value in the course syllabus. Projects were immediately evaluated for occlusion by three faculty members who marked the crowns with articulating paper and then independently counted the number of occlusal contacts and indicated the existence of supraocclusion. Faculty evaluators reconciled all projects with critical errors (zero occlusal contacts or supraocclusion greater than 0.5 mm at the cuspid region) and any project in which there was a discrepancy of greater than one occlusal contact between the highest and lowest occlusion evaluations.

Prior to grading the projects for morphologic form, manikins with each of the crown designs were duplicated and poured in dental stone to blind the evaluators as to which crown designs were wax vs. CAD/CAM ceramic. Each student’s tooth with the wax crown design was inserted into the corresponding maxillary arch and duplicated using vinyl-polysiloxane impression material and a plastic stock impression tray. Stone models were fabricated from Type IV dental stone and immediately compared to the original wax crown/manikin to verify that no visible distortion had occurred during making of the impression or the model fabrication. All students then adjusted occlusion and contours, polished and luted their restorations during the same laboratory session, and submitted the projects for grading.

Conventional Wax-Added Crown Design Project

For the conventional wax-added design exercise (WAX), students were given a second duplicate maxillary first molar preparation. The students used the preparation as a die to wax a crown for tooth #3 using traditional methods. The students could insert the tooth into the manikin to develop contours, proximal contacts, and occlusion. Prior to the wax design project, students had waxed a full contour crown for tooth #3 three times for graded projects (D1-Dental Morphology, D1-Occlusion, and D2-Fixed Prosthodontics I) using Peter K. Thomas waxing instruments. The Peter K. Thomas technique employs the strategic placement of wax cones or drops to establish cusp tips and marginal ridges and wax struts to create heights of contour and triangular ridges.
of the anatomy of a model tooth. A grade of 100, 95, 85, 75, 65, or 55 was assigned independently by each faculty member using a grading rubric that assessed the following criteria: finish, occlusal view, cusp ridge anatomy, fossa/groove anatomy, buccal view, lingual view, interproximal view, and embrasures. An average of the three grades was determined. Grading rubrics at this school generate a failing grade if less than 70. Similar to the occlusion evaluation, each failing project or project that had a range of evaluations greater than 10 percent was reconciled by the evaluators until consensus was achieved.

**Evaluation of Students’ Perceptions**

Students’ perceptions of and learning associated with the two crown design projects were assessed with an eight-question survey instrument. The instrument was distributed in paper form to all members of the class who indicated a willingness to participate on their informed consent. The students were advised verbally and via written informed consent that their participation was voluntary and that their grades would not be affected by their responses or participation in the survey. The students were identified on their surveys by a participant number generated from their informed consents by an independent party not involved in the study. Therefore, survey responses were anonymous to the investigator. For questions asked on students’ perception of one design technique compared with the other design technique, the order of the comparators was reversed on each consecutive question.

Each survey item was a statement to which the students responded based on a five-point Likert scale with 1=strongly disagree, 2=disagree, 3=neither agree nor disagree, 4=agree, and 5=strongly agree. Throughout the exercises, each participant recorded on a time sheet provided to them the number of minutes spent on each of the various elements of the CAD project (acquisition, design, and adjusting/polishing) and for the total time spent for the WAX project.

**Data Analysis**

Qualitative and quantitative analyses were used as a basis for evaluating the data in this study. A paired t-test was used to determine if there were significant differences between the projects for grades and the number of occlusal contacts for the two design group projects. A p-value of equal to or less than 0.05 was considered statistically significant. A Fisher exact test was used to test for significant difference in the proportion of total failures between the two crown design groups and for difference in reason for failure (no occlusion vs. supraocclusion) between the two crown design groups.

Results for survey responses were reported as summary statistics. Results for questions 7 and 8 were compared for significant difference using a Wilcoxon signed rank test to determine if a significant difference existed in preference of one design project over another. All statistical computations were made using Minitab 16 Statistical Software (State College, PA, USA).

**Results**

The primary outcomes measured were the project grades and the number of occlusal contacts realized. Detailed results are presented in the figures and tables.

**Project Grades**

The numbers of occlusal contacts for the CAD and WAX projects are shown in Figure 1, and the descriptive characteristics are shown in Table 1. Of the fifty students who participated in the study, one student was unable to complete the project on time, so that student’s projects were excluded from the study. Total occlusal contact distributions for the WAX project group yielded a mean of 2.9 contacts versus a mean of 3.9 contacts for the CAD project group. There was a statistically significant difference in the number of occlusal contacts between the two groups (t-value=2.40, p=0.02).

Critical errors (0 contacts or supraocclusion >0.5 mm) resulting in a failed project were 16 percent for CAD group and 20 percent for the WAX group. Although there was no significant difference in the number of failures between the two project groups, there was a significant difference in the mode of failure. For the WAX project, students who failed due to not having any occlusal contacts were significantly higher than the CAD project. Conversely, for the CAD project, of the students who failed, those who failed for supraocclusion were significantly higher than the manual wax-added project. The difference in proportion of failures due to no occlusal contacts versus supraocclusion between the two projects was significant (p=0.025).

Project grade results for morphology of conventional wax added and CAD/CAM crown designs are shown in Figure 2, and the descriptive character-
Item 1 focused on a comparison of the amount of time students spent on each project. The responses indicated that the majority of students (86 percent) spent more time on the waxing project than on the CAD project. Student logs (Table 4) corroborated this, revealing that the mean time students spent for the entire CAD project was 127.7 minutes compared to 160.6 minutes for the WAX project. Item 2 indicated that students found it harder to design a crown using the wax technique than the CAD technique, with over 80 percent disagreeing or strongly disagreeing with the statement.

Items 3 and 4 assessed the students’ learning preferences about the value of the CAD technique as compared to the conventional wax-added technique (WAX) for assessing occlusal contact position and strength. Half of the students (50 percent) agreed or strongly agreed that they learned more about the position of occlusal contacts using CAD technique compared to 22 percent who disagreed or strongly disagreed. A smaller percentage of students who

Figure 1. Number of occlusal contacts generated for conventional wax-added and CAD/CAM crown design projects

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Max</th>
<th>Min</th>
<th>Mean</th>
<th>Standard Error of Mean</th>
<th>Total Failures</th>
<th>No Occlusal Contacts</th>
<th>Supra-Occlusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wax-added</td>
<td>49</td>
<td>8</td>
<td>0</td>
<td>2.9*</td>
<td>0.33</td>
<td>10</td>
<td>7*</td>
<td>3*</td>
</tr>
<tr>
<td>CAD/CAM</td>
<td>49</td>
<td>9</td>
<td>0</td>
<td>3.9</td>
<td>0.29</td>
<td>8</td>
<td>1</td>
<td>7</td>
</tr>
</tbody>
</table>

*Significant difference p<0.05

Student Survey
Fifty students (100 percent of the class) completed the survey. Data from the student survey are shown in Table 3. Responses to survey items 1 and 2 evaluated the ease of use of the CAD design compared to the WAX design technique. Item 1 focused on a comparison of the amount of time students spent on each project. The responses indicated that the majority of students (86 percent) spent more time on the waxing project than on the CAD project. Student logs (Table 4) corroborated this, revealing that the mean time students spent for the entire CAD project was 127.7 minutes compared to 160.6 minutes for the WAX project. Item 2 indicated that students found it harder to design a crown using the wax technique than the CAD technique, with over 80 percent disagreeing or strongly disagreeing with the statement.

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Indicated a preference (44 percent) disagreed or strongly disagreed that they learned more about the size and strength of occlusal contacts using WAX vs. CAD compared to 26 percent who agreed or strongly agreed with the statement. When assessing crown contours (item 5) and occlusal interferences (item 6), student preferences favored the conventional wax-added technique over the CAD technique.

The overall student response to the use of the CAD technique for crown design was positive, with 90 percent of the respondents agreeing or strongly agreeing that they enjoyed designing a full contour crown using the CAD technique (Table 3). This finding was in contrast to response to the same question about the conventional wax-added technique, with which only 13 percent of the students agreed or strongly agreed. This difference was statistically significant (p<0.001).

Discussion

The use of technology in the dental classroom and preclinical laboratory helps convey information to students in innovative and novel ways. Because today’s dental students have a preference for visual learning and a digital interface, many of the computer-based techniques introduced in dental curricula are well received by students.30-42,52,53 Evaluating students’ perceptions of their ability to learn from new teaching modalities including those that utilize 3D graphics is essential in the evolution of dental education. However, student preference for one teaching resource over another may not necessarily translate to a positive educational outcome.

Although the students in this study overwhelmingly preferred to design a crown using the CAD technology as opposed to the conventional wax-added technique, the dental morphology grade distributions for the two projects were not significantly different (Table 2). However, outcomes for the CAD projects were shown to have a significantly higher number of occlusal contacts than the WAX projects (Table 1). On the surface, it may appear that although the students preferred the CAD technique, they performed equally using the WAX and CAD techniques. However, the students’ prior experiences with the two techniques for crown design were not
the same and likely confounded the results. At the
time of the study, these second-year students had been
in four laboratory courses over 1.5 years that used
wax-added crown design techniques. In contrast, the
CAD project in this study was the first exposure for
the students to 3D computer-aided design. Despite
the imbalance of prior knowledge and experience
between the two techniques, students spent less
time designing and fabricating a crown with CAD
than fabricating a wax pattern, ultimately obtaining
similar grades. Other studies have demonstrated that
students using virtual reality simulation arrive at the
same level of performance faster than students using
conventional learning.54,55

Grade distributions for the WAX project
showed a wider range at both ends of the spectrum
than did the distribution for the CAD projects.
Variability with the WAX technique would be
expected to be higher as the technique employs a
more artistic skill set to fabricate and design a wax
pattern from scratch. The CAD technique generates
a computer-driven proposal based on surrounding
tooth morphology that acts as a foundation, allow-
ing student operators to modify it where necessary.
Deficiencies noted by the evaluators that resulted in
major deductions differed for the two projects. For
the WAX projects, the reasons most frequently cited
for major deductions were non-anatomic form and
excessive contours, while the CAD projects gener-
ally received major deductions for marginal ridge
height discrepancy and cusp level discrepancy (too
tall). CAD project deficiencies may have resulted

from failure by the students to adequately manipulate
the 3D images to allow for comparison between the
anatomy of their design and that of adjacent teeth.

More students preferred the use of CAD
crown design compared to students preferring
conventional wax-added design for learning about
position of occlusal contacts as well as size and
strength of occlusal contacts. Their preferences may
be corroborated by a significantly higher number of
occlusal contacts obtained using the CAD design
compared with the wax design. These students also
found that the CAD design was more time-efficient
than the wax design. This finding was borne out in
the student logs, which demonstrated that students
on average spent a half hour more on WAX projects
than CAD projects. Time is a precious commodity
to dental students and likely explains the large ma-
jority of them who indicated that the CAD project
was easier than the WAX project—this was despite
the fact that the students had much more experience
in the conventional wax-added technique than the
CAD technique.

Table 3. Students’ responses on survey questions (n=50)

<table>
<thead>
<tr>
<th>Statement</th>
<th>1 Strongly Agree</th>
<th>2 Agree</th>
<th>3 Neutral</th>
<th>4 Disagree</th>
<th>5 Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I spent more time designing and milling the crown using CAD/CAM than</td>
<td>2%</td>
<td>6%</td>
<td>6%</td>
<td>46%</td>
<td>40%</td>
</tr>
<tr>
<td>I spent waxing the crown.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Designing the full contour crown in wax was easier than in CAD.</td>
<td>6%</td>
<td>4%</td>
<td>10%</td>
<td>53%</td>
<td>27%</td>
</tr>
<tr>
<td>3. I learned more about the position of occlusal contacts using CAD than</td>
<td>4%</td>
<td>46%</td>
<td>28%</td>
<td>14%</td>
<td>8%</td>
</tr>
<tr>
<td>the wax-added technique.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. I learned more about the size and strength of occlusal contacts using</td>
<td>2%</td>
<td>24%</td>
<td>30%</td>
<td>34%</td>
<td>10%</td>
</tr>
<tr>
<td>the wax-added technique than CAD.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. I learned more about tooth contours using CAD than the wax-added</td>
<td>2%</td>
<td>26%</td>
<td>30%</td>
<td>34%</td>
<td>8%</td>
</tr>
<tr>
<td>technique.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. I learned more about excursive occlusion/interferences using the</td>
<td>10%</td>
<td>54%</td>
<td>20%</td>
<td>16%</td>
<td>0</td>
</tr>
<tr>
<td>wax-added technique than CAD.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. I enjoyed designing a full contour crown using the wax-added technique.</td>
<td>3%</td>
<td>10%</td>
<td>20%</td>
<td>32%</td>
<td>35%</td>
</tr>
<tr>
<td>8. I enjoyed designing a full contour crown using CAD.</td>
<td>18%</td>
<td>72%</td>
<td>10%</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 4. Student log data for steps of wax-added and CAD/CAM projects (in minutes)

<table>
<thead>
<tr>
<th>Step</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wax-added</td>
<td>160.6</td>
<td>52.7</td>
<td>45</td>
<td>300</td>
</tr>
<tr>
<td>CAD acquisition</td>
<td>12.1</td>
<td>11.6</td>
<td>3</td>
<td>60</td>
</tr>
<tr>
<td>CAD design</td>
<td>50.6</td>
<td>28.7</td>
<td>15</td>
<td>160</td>
</tr>
<tr>
<td>CAD adjust/polish</td>
<td>65</td>
<td>32.6</td>
<td>45</td>
<td>200</td>
</tr>
</tbody>
</table>
Of the students who indicated a preference, the majority felt they learned more about tooth contours and excursive interferences in the WAX project than the CAD project. The CEREC software and acquisition technique renders little information about adjacent teeth below their heights of contour. As such, it is expected that students would find the conventional wax-added technique with hands-on models to be preferable to the virtual model. The CEREC 3.8 software does not support a virtual articulator function and therefore renders no information about excursive interferences. Again, it was expected that the majority of the students would agree or strongly agree that they learned more about excursive occlusion/interferences using wax-added techniques than CAD, and 63 percent of them did. This question can be viewed as a validation question indicating that the majority of the students read the question and understood the limitations of the CAD software.

Because items 7 and 8 were identically worded except for the project variable (CAD or WAX), a differential statistical analysis could be employed to test for statistical differences in preference of one design project over another. This analysis showed a strong statistical preference for designing a full contour crown using CAD/CAM versus the conventional wax-added. Preferences for working in virtual reality could be related to a number of factors. The respondents indicated that they spent less time designing the crown using the CAD/CAM compared with the conventional technique; however, the amount of time spent designing the crown with the wax-added technique was only thirty-three minutes on average more than the time spent designing in virtual reality. The students may also have perceived that the learning curve for designing in virtual reality was easier than for the conventional wax-added technique. In fact, the students’ grades for the two projects were not significantly different despite the large discrepancy in experience the students had with wax-added technique over the CAD technique. Lastly, dental students are a part of a generation that has a predilection for digital media, and as such they tend to prefer visual learning.

Several areas exist for bias to confound the results of this study and may be considered limitations. Because the survey compared one technique with another, there was a potential for habituation and acquiescence to affect the survey results. Habituation occurs when respondents get in the habit of selecting the same answer when presented with survey questions with same response options. With acquiescence, the respondents passively agree with a survey question, giving the response they think is the “right” answer. In an attempt to avoid these response biases, the order of the comparators for each consecutive statement was alternated. One statement compared the wax technique to the CAD technique, and the next compared the CAD technique to the wax technique. Additionally, the potential for respondent bias by the grades received was removed by administering the survey before project grades were released.

Grading bias was another potential study limitation. Projects were graded in a single session with all three evaluators having greater than five years of experience in dental morphology grading. Projects were duplicated and poured in dental stone to blind the evaluators as to which project they were evaluating during the morphology grading. Unfortunately, three WAX projects fractured during the duplication, and those students’ projects (both WAX and CAD) were removed from the data sets for morphologic grading. Evaluators could not be blinded for the grading of occlusion, however, as the duplication process and subsequent articulation would introduce too many sources for error and confounding variables. Therefore, the potential for grading bias during the occlusion evaluation cannot be discounted. Duplication of the projects also introduces the potential of distortion of models due to air entrapment or tray movement during the impression stage or due to disruption of the setting dental stone during pouring of the model fabrication. Although each model was compared to the original to cross check for any visible difference, undetected distortion of the stone replica remains a potential confounding variable for grading.

Other limitations of this study are that it was a small sample group of fifty dental students who did not have equal experience with the two techniques. The study was undertaken at one dental school, and the timing of the study coincided with the first year the CAD/CAM technology was introduced in the preclinical course curriculum using an older version of the CEREC software than currently available. Lastly, evaluators could not be blinded for the occlusion evaluation of the projects. Further research is needed to expand the sample size.

The application of CAD/CAM technology to replace both conventional impression techniques and the fabrication of restorations through conventional techniques performed by a dental technician is rapidly increasing in both dental practices and dental laboratories. The latest available estimates (from 2010) indicate that over 27,000 CEREC units were
installed in dental offices in over fifty countries, and 4,500 inLab units were used by commercial dental laboratories. From 1985 to 2010, dentists placed more than 20 million restorations using CEREC technology alone. As the use of this technology continues to increase in the clinical practice sector, it is imperative that dental schools incorporate CAD/CAM technology into their curricula.

Conclusion

Today’s dental students are the product of a rapidly expanding technological society. They are preselected for high spatial/visual ability and have a preference for digital learning. CAD/CAM technology offers an avenue to educate students through 3D visualization. The survey data from this study support prior observations about the enthusiasm students have for visual learning. These students had a statistically significant preference for CAD design projects compared to wax-added projects. Based on the results of this study, the students appeared eager to digitally design crown forms using CAD/CAM technology in preclinical fixed prosthodontics courses. The students also recognized that this technology has limits in terms of representing anatomic contours of adjacent teeth and excursive occlusion compared to conventional wax techniques. The quantitative data indicate that their performance in morphologic evaluation using these two techniques was not significantly different; however, a significantly higher number of occlusal contacts resulted from the use of the CAD/CAM technique. While the inclusion of computer-aided design as an adjunct to conventional wax-added crown design appears warranted, additional studies are needed to substantiate these findings and determine effective ways to implement CAD/CAM technology into dental school curricula.

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REFERENCES