Evaluation of computer-aided learning in orthodontics

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Introduction: Studies of computer-aided learning (CAL) in orthodontics have documented both objective and subjective outcomes; however, to date, no studies have attempted to correlate these 2 outcome measures.

Methods: The main objective outcome measured was performance on a written test covering material in the orthodontic diagnosis electronic tutorial (ODET) administered to 92 fourth-year undergraduate dental students. The main subjective outcome measured was a 12-statement questionnaire to elicit students’ perception of the ODET and CAL as teaching modalities.

Results: In the male and female subgroups, a statistically significant difference in mean lecture test scores favoring women (72.46%) over men (67.08%) was observed ($P = 0.05$). This difference was not observed for mean ODET test scores ($P = 0.52$). Although responses to the questionnaire were mostly positive, the students are not prepared to replace lectures with CAL tutorials. Responses showed that male students preferred self-instruction as a mode of learning more than female students did ($P = 0.05$). When linking objective and subjective outcomes, the mean ODET test score had a statistically significant ($P = 0.025$), but weak, positive correlation ($r = 0.243$) with self-reported time spent reviewing the ODET but not with any other statement in the questionnaire.

Conclusions: Despite a difference in lecture test scores between male and female students, there was no difference in mean ODET test scores between the 2 subgroups. This might be explained by sex differences: male students preferred self-instruction more than female students did. Improved performance on the ODET test was noted for students who reported longer times spent reviewing the tutorial. Because students are not prepared to replace lectures with CAL tutorials, from their perspective, the ODET should continue to be used with traditional modes of learning. (Am J Orthod Dentofacial Orthop 2010;138:410-9)

Computer-aided learning (CAL) in dental education has become increasingly popular. By 2006, approximately 25% of North American dental schools had already implemented mandatory laptop programs for students. 1 CAL might no longer be considered a novel method for learning but a necessary tool in the arsenal of education.

A CAL program that is at least as effective as other methods of learning has several potential value-added advantages (depending on how the program is designed and the students’ ease of access to the CAL modules). Using a well designed CAL system, a student can learn at his or her own pace, review lessons numerous times, and access the system in a convenient, distraction-free environment. 2

A systematic review of CAL in orthodontics concluded that there is insufficient evidence to support the complete replacement of conventional teaching with CAL programs, supporting the notion that CAL should be used as an adjunct to conventional teaching or as a mode of self-instruction. 3 If CAL can elicit positive responses from students, it might motivate them to learn the orthodontic curriculum. With the documented shortage of orthodontic faculty in North America, used effectively, CAL could help overcome diminishing resources. 4

REVIEW OF THE LITERATURE

By following the same protocol outlined in our previous systematic review of CAL in orthodontics and updating a search of the literature to include articles up to the fourth week of August 2007, the objectives of this review were to build on our previously published...
systematic review and provide contemporary information regarding CAL in orthodontics. In this study, the updated review was not limited to the analysis of randomized controlled trials. Rigid quantitative scientific methods of controlled experimentation are not always valid in an environment such as a medical or dental school class, where the variables in the subject pool are almost as great as or greater than the subject pool itself.

It is most effective when evaluating the 10 studies included in this review to separate the quantitative and objective findings from the qualitative and subjective findings (Table I). As summarized in Table I, the following conclusions can be made.

1. Studies of CAL in orthodontics that met our inclusion criteria were split between no difference (4 of 7 studies), significant advantage of CAL over conventional teaching (2 studies), and significant advantage of conventional tutorial over CAL in terms of knowledge gained (1 study).

2. Studies measuring the amount of time spent on CAL by students showed no correlation between time spent using the computer program and improvements in test scores.

3. CAL programs in orthodontics, for the most part (5 of the 7 studies), elicit positive responses and attitudes from students toward learning.

4. The most complete evaluation studies of CAL as a teaching tool include both objective and subjective outcome measures, allowing for the evaluation of both effectiveness of the study and the student’s satisfaction with the learning program. These findings might contribute to student motivation.

5. There is insufficient evidence for the replacement of conventional teaching with CAL programs in orthodontics (only 2 studies). CAL is better used as an adjunct to conventional teaching or a mode of self-instruction in orthodontics.

6. CAL’s advantage is that it can present and preserve orthodontic study models, radiographs, and other visual diagnostic aids. Students can learn at an individualized pace when they are most alert. CAL allows immediate feedback on the presented material.

7. No studies have evaluated the correlation between subjective and objective outcome measures. This type of evaluation might provide insight regarding the role of motivation and learning style preference in modulating the effectiveness of CAL in orthodontics.

We found that evaluation studies of CAL in dental education focused on the measurement of objective outcomes such as test performance, with up to 17 well-designed randomized controlled trials available as of September 2007. Several of these studies also documented subjective outcome measures in the form of students’ responses to questionnaires eliciting their perceptions of the CAL program. There does not appear to be a study that correlates objective with subjective outcomes to elucidate a possible link between students’ intrinsic feelings and motivations toward the educational unit and their performance in formal evaluations.

The orthodontic diagnosis electronic tutorial (ODET), developed and used as part of the undergraduate orthodontic curriculum at McGill University in Montreal, Quebec, Canada, is being considered for similar use at the University of Toronto. As part of the formal evaluation before its implementation, an evaluation of the program through objective and subjective measurement tools was undertaken with additional

Table I. Summary of the effectiveness of CAL in orthodontics measured with objective and subjective approaches

<table>
<thead>
<tr>
<th>Study</th>
<th>Subject</th>
<th>Quantitative/objective findings</th>
<th>Qualitative/subjective findings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Favor CAL</td>
<td>No difference</td>
</tr>
<tr>
<td>Hobson et al (1998)</td>
<td>Diagnosis and treatment planning</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Irvine and Moore (1986)</td>
<td>Mixed dentition analysis</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Nurko and Proffit (2005)</td>
<td>Advanced clinical orthodontics</td>
<td>NA</td>
<td>X</td>
</tr>
<tr>
<td>Stephens and Dowell (1983)</td>
<td>Case assessment and treatment planning</td>
<td>NA</td>
<td>X</td>
</tr>
<tr>
<td>Total, 10 studies</td>
<td></td>
<td>2/7</td>
<td>4/7</td>
</tr>
</tbody>
</table>

NA, Not applicable.
insight into the undergraduate students’ attitudes and perceptions toward the ODET and CAL.

The objectives of this study were (1) to elicit and assess students’ perceptions of the ODET; (2) to assess whether there is a correlation between objective (test scores) outcome measures and subjective (questionnaire responses) outcome measures; and (3) to assess whether there are any differences in outcomes (test scores and responses to the questionnaire) between the subgroups of male vs female, and doctor of dental surgery (DDS) vs international dentist advanced placement program (IDAPP) undergraduate dental students.

MATERIAL AND METHODS

Ninety-two fourth-year undergraduate dental students (38 men, 54 women) participated in this study. The fourth-year class (designated 0T8 for the year of graduation) consisted of 67 DDS students and 25 IDAPP students.

The ODET was developed to give undergraduate dental students the skills to recognize, quantify, and properly diagnose a developing malocclusion. It was designed to introduce students to the practice of orthodontics as it applies to general dentistry and currently forms the basis for the orthodontic curriculum taught at McGill University. The objectives of the tutorial are for students to be able to recognize orthodontic patient problems including developing malocclusions, recognize nonorthodontic patient problems, identify the differences between standard norms and deviations in development, effectively diagnose a malocclusion using various diagnostic tools, and identify and apply the appropriate diagnostic tools using the outside-in approach (extraoral and soft-tissue findings are considered before intraoral and radiographic findings) to patient screening.

The electronic tutorial is focused on the orthodontic examination comprising facial, functional, and dental examinations; cephalometric and panoramic analyses; and classifications of malocclusions. The content of each section is described through text and figures. Words explaining key concepts are highlighted in blue and act as hyperlinks for animation and other visual teaching tools that appear on the screen (Fig 1). At the end of each section, students can evaluate their understanding of the material by completing exercises providing immediate feedback. As they progress through the exercises, the students can easily return to the content sections by using a drop-down menu on the upper left side of the screen. Navigation through the tutorial can be done nonlinearly, giving the user full control of the learning (learner-controlled program). Students can rely on their personal learning preferences without having to comply with the structure of the electronic tutorial.

Objective outcome measures

The orthodontic lecture term test (OLTT), developed by the undergraduate orthodontic course coordinator (J.P.), includes several short-answer questions to
assess the students’ ability to diagnose and analyze an orthodontic patient by answering several knowledge and application questions from lecture material. An answer key for the test was prepared before administration of the test and used to mark all tests. If an answer was provided by students that could have been correct but was not included in the answer key, consensus was reached between the 2 principal researchers (H.R. and J.P.) regarding its inclusion in the answer key and considered when marking all tests.

The ODET was developed by the undergraduate coordinator (J.P.) and the principal researcher (H.R.); this test matched the lecture test in level of difficulty while encompassing the topics included in the ODET. Questions in the test can be categorized as “knowledge” questions (testing students’ familiarity and understanding of the material) and “application” questions (testing students’ ability to apply concepts presented in the ODET). Both the ODET test and OLTT were administered one after the other. The assessment was administered in a manner similar to that of the OLTT. Questions were discarded if they yielded a successful response percentage of less than 25% for the entire class for both tests, eliminating any potential source of ambiguity.

**Subjective outcome measures**

A 12-statement questionnaire adapted from a previous study was prepared to assess dental students’
perceptions and impressions of the electronic tutorial (Fig 2). Response options for the statements were “strongly disagree,” “disagree,” “uncertain,” “agree,” or “strongly agree.” The 92 students responded using the following scoring for the Likert scale: strongly agree (5), agree (4), uncertain (3), disagree (2), and strongly disagree (1). Statements in the questionnaire were meant to reflect students’ perception of the (1) usability and acceptability of the tutorial (statements 1 and 2), (2) educational quality (statements 3-5), (3) acceptability of CAL (statements 6 and 7), and (4) students’ learning style preferences (ie, preference of CAL over traditional learning methods; statements 8-10). The last 2 statements were meant to assess students’ motivation to use the electronic tutorial (statement 11) and students’ self-reported time spent on the tutorial (statement 12). For statement 12, students were asked to estimate the amount of time that they spent reviewing the tutorial by circling one of the following: <1 hour, 1-3 hours, 4-6 hours, 7-10 hours, or >10 hours. A higher frequency of responses agreeing with statements 1 through 11 indicated positive student perceptions of the ODET and CAL. Students were invited to provide input regarding features of the electronic tutorial that they liked, disliked, or would improve. Once completed, questionnaires were coded to be able to correlate the responses (subjective outcome measures) with ODET and OLTT scores (objective measures).

### Statistical analysis

All statistical analyses were performed by using SPSS for Windows (version 15.1, SPSS, Chicago, Ill). Differences in OLTT vs ODET mean test scores were analyzed by using paired-samples t tests. Differences in test scores for the various subgroups were analyzed by using independent-samples t tests and univariate analysis of variance (ANOVA). Statements in the questionnaire regarding learning style preferences (questions 8-10) were trichotomized into “disagree,” “uncertain,” and “agree.” Differences between male and female responses were assessed by using independent-samples t tests. Correlations between mean ODET test scores and mean level of agreement on the questionnaire for each response were calculated by using the Spearman rank correlation coefficient.

### RESULTS

The class of 0T8 comprised 92 students, all of whom took both tests. Of the 92 students, 25 were IDAPP students (13 men and 12 women). The other 67 students were DDS students (25 men and 42 women). The mean OLTT score for the entire class (n = 92) was 70.2% (38.6 of 55 marks). For this test, 2 questions (4 marks) yielded a successful response percentage of less than 25% and were discarded. The mean ODET test score for the entire class was 72.7% (33.4 of 46 marks). One question (2 marks) yielded a successful response of less than 25% and was discarded. No statistically significant difference was found between the OLTT and ODET test scores (P = 0.08) for the entire class, although there was a significant difference (P <0.001) in mean ODET knowledge scores (79.6%) vs ODET application scores (67.4%). Among the male and female subgroups (Table II), a statistically significant difference was found (P = 0.005) in mean OLTT score favoring the women (72.5%) over the men (67.1%). This difference was not observed for mean ODET test scores (P = 0.52). There was no significant difference in ODET test mean knowledge scores (P = 0.71) and mean application scores (P = 0.47) between the sexes. When analyzing the DDS vs IDAPP subgroups in the class (Table III), a statistically significant

### Table II. Mean test scores for male and female subgroups

<table>
<thead>
<tr>
<th>Outcome measure</th>
<th>Subgroup</th>
<th>Mean score % (SD)</th>
<th>T test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture test</td>
<td>Male (38) Female (54)</td>
<td>67.1 (8.4) 72.5 (9.6)</td>
<td>Statistically significant difference (P = 0.005)</td>
</tr>
<tr>
<td>ODET test</td>
<td>Male (38) Female (54)</td>
<td>73.6 (9.5) 72.0 (12.9)</td>
<td>No difference (P = 0.517)</td>
</tr>
<tr>
<td>ODET knowledge</td>
<td>Male (38) Female (54)</td>
<td>80.1 (9.0) 79.2 (11.9)</td>
<td>No difference (P = 0.71)</td>
</tr>
<tr>
<td>ODET application</td>
<td>Male (38) Female (54)</td>
<td>68.9 (14.3) 66.4 (18.4)</td>
<td>No difference (P = 0.47)</td>
</tr>
</tbody>
</table>

### Table III. Mean test scores for DDS and IDAPP subgroups

<table>
<thead>
<tr>
<th>Outcome measure</th>
<th>Subgroup</th>
<th>Mean score % (SD)</th>
<th>T test</th>
</tr>
</thead>
<tbody>
<tr>
<td>OLTT</td>
<td>IDAPP (25) DDS (67)</td>
<td>64.7 (11) 72.3 (12.3)</td>
<td>Statistically significant difference (P = 0.003)</td>
</tr>
<tr>
<td>ODET test</td>
<td>IDAPP (25) DDS (67)</td>
<td>72.9 (7.9) 72.6 (11.4)</td>
<td>No difference (P = 0.93)</td>
</tr>
<tr>
<td>ODET knowledge</td>
<td>IDAPP (25) DDS (67)</td>
<td>79.9 (11.6) 79.4 (10.5)</td>
<td>No difference (P = 0.83)</td>
</tr>
<tr>
<td>ODET application</td>
<td>IDAPP (25) DDS (67)</td>
<td>66.6 (14.3) 67.7 (17.7)</td>
<td>No difference (P = 0.75)</td>
</tr>
</tbody>
</table>
Table IV. Students’ responses to the questionnaire

<table>
<thead>
<tr>
<th>Item (n)</th>
<th>Frequency distribution (%) and response frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 and 2, usability of tutorial; 3-5, educational quality; 6 and 7, acceptability of CAL; 8-10, preference of CAL over traditional learning; 11, motivation to use the tutorial</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>1. The content of the material in the electronic tutorial was interesting (89)</td>
<td>2.2%</td>
</tr>
<tr>
<td>2. The electronic tutorial was simple to use (89)</td>
<td>2.2%</td>
</tr>
<tr>
<td>3. The information presented in the electronic tutorial was useful (89)</td>
<td>2.2%</td>
</tr>
<tr>
<td>4. The electronic tutorial was an effective learning method (89)</td>
<td>3.4%</td>
</tr>
<tr>
<td>5. The electronic tutorial made the information in the course easier to understand (88)</td>
<td>2.3%</td>
</tr>
<tr>
<td>6. I would like to see more computer-aided tutorials in other classes (89)</td>
<td>3.4%</td>
</tr>
<tr>
<td>7. I enjoy classes that use a combination of teaching methods: ie, lectures, labs, and electronic tutorials (89)</td>
<td>1.1%</td>
</tr>
<tr>
<td>8. I would prefer using the electronic tutorial rather than studying from a textbook (89)</td>
<td>2.2%</td>
</tr>
<tr>
<td>9. I prefer learning on my own rather than having material taught to me (88)</td>
<td>17.0%</td>
</tr>
<tr>
<td>10. I would replace lectures/seminars with computer tutorials (88)</td>
<td>17.0%</td>
</tr>
<tr>
<td>11. I was highly motivated to use the computer-aided tutorial (88)</td>
<td>6.8%</td>
</tr>
<tr>
<td>Self-reported time spent reviewing the tutorial</td>
<td>&lt;1 h</td>
</tr>
<tr>
<td>12. In your estimation, how much time did you spend reviewing the tutorial since you received it? (85)</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

(P = 0.003) difference in mean OLTt score was found favoring the DDS class (72.3%) over the IDAPP class (64.7%). This difference between the 2 subgroups was not observed for mean ODET test scores (P = 0.93) with neither mean knowledge scores nor mean application scores differing significantly (P = 0.83 and 0.75, respectively). Furthermore, after controlling for sex, the difference in test scores between the IDDAP and DDS subgroups was statistically significant for the OLTt (F ratio = 12.5; P = 0.001) but not for the ODET test (F ratio = 0.002; P = 0.97).

Eighty-nine of the 92 students (96.7%) responded to most statements in the questionnaires. Responses regarding usability and acceptability of the ODET, educational quality, and acceptability of CAL had 526 positive responses (strongly agree or agree) of a possible 622 for statements 1 through 7 (Table IV). The frequency distribution showed a definitive shift to the right, indicating a high frequency of agreement (Fig 3). For the usability of the tutorial (statements 1 and 2), most students (79 of 89; 88.8%) agreed that the material presented was interesting, and most (84 of 89; 94.4%) agreed that it was simple to use (Fig 3). With respect to the educational quality (statements 3-5) of the electronic tutorial, most students (81 of 89; 91%) agreed that the information presented was useful, most (71 of 89; 79.8%) agreed that the tutorial was an effective learning method, and many (66 of 88; 75%) agreed that the electronic tutorial made information in the course easier to understand. Responses to statements regarding students’ acceptability of CAL as a mode of learning (statements 6 and 7) were also positive, with most (69 of 89; 77.5%) students noting that they would like to see more CAL tutorials in other classes, and with most students (76 of 89; 85.4%) noting that they enjoyed classes that used a combination of teaching methods. Responses for statements regarding students’ learning style preferences (ie, preference for CAL over more traditional modes of learning in statements 8-10) showed less positive results. Although many students (59 of 89; 66.3%) would prefer using the ODET rather than studying from a textbook, they were less enthusiastic about the prospect of self-instruction and even less so about replacing lectures and seminars with CAL.
Only a few students (25 of 88; 28.4%) preferred learning on their own (self-instruction) rather than having material taught to them, and even fewer (21 of 88; 23.9%) were ready to replace lectures and seminars with CAL. When trichotomizing the responses for learning style preferences into disagree, uncertain, and agree, a frequency distribution shift to the right was seen for statement 8, whereas responses for statements 9 and 10 showed a clear shift to the left (Fig 4). Student responses showed that more than half (50 of 88; 56.8%) were highly motivated to use the ODET, but there was still variation in motivation levels (Table IV). The median self-reported time spent on the tutorial was 4 to 6 hours. Comments added in the questionnaire by students showed that they would have liked to have had the tutorial in their junior years of the DDS program and been able to have used it throughout the 4-year DDS program. Suggestions for improvements of the ODET included a more detailed table of contents to enhance navigation and overall compatibility with Macintosh computers.

Analysis of responses regarding students’ learning style preferences (or preference of CAL over traditional methods of learning) demonstrated a statistically significant difference in mean response between the sexes for statement 9, “I prefer learning on my own rather than having material taught to me.” A higher mean response for men was found compared with women ($P = 0.05$). The other 2 statements in this category (8 and 10) did not show these sex differences ($P = 0.088$ and 0.252, respectively).

A statistically significant ($P = 0.025$) but weak positive correlation ($r = 0.243$) was observed between mean ODET test scores and self-reported time spent...
reviewing the ODET. The mean ODET score was not significantly correlated with any other responses to statements in the questionnaire. Although not correlated with ODET scores, motivation (statement 11) had a significant correlation with responses in the questionnaire regarding usability \( (r = 0.57, P < 0.0001) \), educational quality \( (r = 0.48, P < 0.0001) \), acceptability \( (r = 0.59, P < 0.001) \), learning style preference \( (r = 0.46, P < 0.001) \), and self-reported time spent \( (r = 0.21, P = 0.049) \).

**DISCUSSION**

Many studies have evaluated the effectiveness of CAL in dental education, with up to 17 higher-quality randomized controlled trials as of September 2007 all focusing on the effectiveness of CAL vs traditional modes of learning by comparisons of objective outcome measures (usually test scores). Some reported qualitative outcomes with students’ responses to CAL questionnaires. None attempted to correlate objective with subjective outcomes. In our updated review of CAL in orthodontics, we noted that, to date, no studies evaluated the correlation between subjective and objective outcome measures and concluded that such an evaluation could provide insight into the role of subjective measures such as motivation and learning preference in modulating the effectiveness of CAL. An attempt was made to correlate these outcomes by coding completed questionnaires, allowing for the correlation of test scores with students’ responses. Of all of the possible correlations between ODET test scores and responses to the 12 statements in the questionnaire, increased self-reported time spent on the ODET was the only statement for which responses significantly correlated with improved performance on the ODET test \( (r = 0.243, P = 0.025) \). Although the correlation was weak, this trend suggests that students who spent more time reviewing the tutorial performed better on the ODET test. As logical as this finding might seem (the longer a student spends studying, the better he or she will perform on a test), this correlation was not found in 2 other studies.\(^6,^8\) The correlation might be due to the students’ self-reported time spent on the tutorial, leading to potential biases such as failure to recall or to strong students attributing their good understanding of the material to committing a substantial time reviewing the tutorial. In comparison, the other 2 studies relied on objectively measured time spent on the CAL program. In this study, because the CAL program was available to students on a take-home compact disc, reliable monitoring of the time spent on the ODET was not possible. Time-spent data could have been improved if students had been given monitoring diaries, although this approach relies totally on their compliance. Objective time measurement could also be improved through an on-line version of the ODET. The accuracy of an on-line approach is still less than ideal if a student has the program running but does not interact.

Interestingly, increased motivation to use the ODET correlated positively with responses to all other statements in the questionnaire. Students reporting higher motivation to use the tutorial were more positive about its usability and educational quality, and about the acceptability of CAL as a learning tool and the preference of CAL over traditional learning methods; they reported longer times spent reviewing the tutorial. This finding highlights the importance of motivation in the learning process. CAL can be enhanced by its documented advantages of allowing students to learn at their own pace when they are motivated to do so, providing immediate feedback about their understanding of the presented material, eliminating their potential fear of making mistakes or asking questions when clarification might be required, and allowing for personal instruction that is time-consuming and not always possible in a traditional setting.

Overall, students were positive with respect to the acceptability and usability of the electronic tutorial, the educational quality of the tutorial, and the acceptability of this novel mode of learning. However, they remained uncertain regarding replacing conventional lectures with CAL tutorials alone, a finding also reported by others.\(^13,^30\) Students’ reluctance to replace lectures with CAL tutorials might be explained by the fact that students are accustomed to attending traditional lectures, which represent a familiar comfort zone.

Although in this study the ODET was used by undergraduate students, its use could be extended to graduate orthodontic programs, especially early on. Because of the often diverse orthodontic undergraduate dental education of residents entering graduate programs, the ODET could be used to give orthodontic residents a consistent baseline with respect to orthodontic knowledge. Future studies could focus on evaluating the effectiveness of the ODET in graduate orthodontic programs. Additional future directions could involve an evaluation of the effectiveness of the ODET once the program is implemented into the curriculum, the impact of motivation in learning, and the influence of differing learning style preferences in the process of learning.

A method to improve student motivation and performance is to adapt teaching approaches to meet the different learning style preferences for individual students.\(^31\) Knowing the students’ learning style
preferences will aid in the development of the most effective teaching approaches. Students in the sciences have a variety of learning style preferences, and the 2 sexes have significantly different learning styles. We determined that men preferred self-instruction more often than did women. Although this difference in learning style had marginal statistical significance \( P = 0.05 \), it might explain why male students performed significantly worse than female students on the OLTT but had similar ODET test scores.

The VARK system for assessing learning styles categorizes learning based on the student’s sensory preference. These sensory preferences are divided into 4 categories: visual (V-learners: drawings, pictures, diagrams, animations), aural (A-learners: lectures, seminars, recorded lectures), read-write (R learners: reading textbooks, making notes), and kinesthetic (K-learners: physical activities that include touching, performing an activity). Student learners generally use all of these sensory modes of learning but often have an individual preference or set of preferences in which 1 mode is dominant. For example, it has been documented that dental students prefer visual learning at a higher percentage than a sample population measured in the VARK website. Coincidentally, in the context of the undergraduate orthodontic curriculum, students who are visual learners might benefit the most from the ODET. Incorporation of the ODET into the curriculum to complement lectures and seminars (A-learners), clinical practice and screening (K-learners), and textbooks (R-learners) will provide a tool to complete the 4 sensory learning-style preferences for an all-encompassing approach to learning.

**CONCLUSIONS**

1. Despite a difference in lecture test scores between male and female students, there was no significant difference in mean ODET test scores between the 2 subgroups; this might be explained by the sex differences in terms of learning style preferences, with men preferring self-instruction more than women.
2. Similarly, despite a difference in lecture test scores between the IDAPP and DDS students, there was no significant difference in mean ODET test scores between those subgroups.
3. Responses to the questionnaire were for the most part positive with respect to acceptability and usability of the electronic tutorial, educational quality of the tutorial, and acceptability of this novel mode of learning. Students are not prepared to replace lectures with CAL tutorials. Thus, from the students’ perspective, the ODET should continue to be used with traditional modes of learning.
4. Increased self-reported time spent reviewing the tutorial was weakly correlated with improved ODET test scores.
5. Students reporting higher motivation to use the tutorial were more positive about its usability and educational quality, the acceptability of CAL as a learning tool, and the preference of CAL over traditional learning methods. They reported more time spent reviewing the tutorial, thereby placing emphasis on the importance of motivation in the learning process.

We thank Dr. Jean Marc Retrouvey for providing the ODET and allowing us to perform this evaluation study, and Dr. Shoroog Agou for her help with the statistical analyses. This paper is dedicated to the memory of Dr. David Locker.

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