Effectiveness of an Electronic Histology Tutorial for First-Year Dental Students and Improvement in “Normalized” Test Scores


Abstract: The effectiveness of an electronic histology tutorial (EHT) as a mode of learning was assessed by comparing performance on two term tests for an EHT class of sixty-nine students and five prior classes (n=347) who learned by traditional methods. The aims of this study were to 1) develop and introduce a self-instructional, computer-aided approach to guide student learning in the first-year histology course at the University of Toronto Faculty of Dentistry; 2) evaluate the effectiveness of the self-study electronic histology tutorial by comparing students’ test scores for the EHT group to students’ scores in previous years; and 3) evaluate students’ acceptance of this novel mode of learning by means of a satisfaction questionnaire. The EHT group performed significantly better on both the general histology and oral histology term tests than the five prior control years (p<0.001), yet there were no significant differences in overall GPA between the groups, suggesting that the improvement was specific to the EHT/histology course grades (p=0.1 to 0.47). A statistically significant improvement in performance per unit overall GPA was noted in the test group, which demonstrated an increase in this test score normalized ratio (TSNR) of 3-18 percent in the general histology term test and 7-21 percent in the oral histology term test over the control groups. In addition to determining the effects of the EHT on grade performance, this study sought to evaluate students’ acceptance of this alternative mode of learning in comparison to the standard teaching model by means of a satisfaction questionnaire. Overall, students’ responses to the questionnaire were positive with an overall mean level of agreement for all ten responses of 4.5 out of 5 (90 percent).

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Several studies have documented changes in student grades in histology when the approach for teaching this topic was modified from traditional utilization of microscopes to computer-aided learning (CAL) that essentially represents a “virtual” histology course.1-8 Most of these studies3-5,7,8 focused their evaluation of the educational units by measuring students’ attitudes toward CAL via responses to questionnaires. One study also utilized academic performance as an outcome measure, reporting no difference in academic performance between the computer group and the control group. Overall, these studies have demonstrated positive changes in students’ responses towards this new mode of learning. Similarly, in a review of the literature on the effectiveness of CAL in dental education, results showed that CAL can be used as a means of self-instruction, thereby providing a more flexible approach to learning while at the same time motivating students to learn more than they might have otherwise.3 Yet this review also suggested that data reported in controlled trials of CAL in dental education show effects ranging from none (i.e., no difference between CAL and traditional methods) to significant advantages of CAL over conventional teaching modalities in terms of knowledge gained by the students.3

At the University of Toronto Faculty of Dentistry, first-year histology has traditionally been taught by means of lectures in which students are shown Kodachrome™ slide reproductions of prepared histological sections and directed to areas of interest by the instructors. To reinforce learning, students participate in histology laboratories following lectures, in which they use microscopes to study the actual slides under...
the supervision of a team of experienced tutors. The academic year 2004-05 marked a significant change in the delivery of this histology educational program because first-year students in the graduating class of 2008 (designated 0T8) were given an electronic version of the histology slides with an associated study book for use in lectures.

Given this newer approach to teaching histology, the aims of this educational research project were to 1) develop and introduce a self-instructional, computer-aided approach to guide student learning in the first-year histology course at the University of Toronto Faculty of Dentistry; 2) evaluate the effectiveness of the self-study electronic histology tutorial by comparing students’ test scores for the EHT group (class of 0T8) to students’ scores in previous years; and 3) evaluate students’ acceptance of this novel mode of learning by means of a satisfaction questionnaire.

Materials and Methods

Process and Participants

The process of digitizing the histological glass slides required several steps. Histological glass slides were created using standard histological preparation techniques, were photographed at the microscopic level, and were then made into 35 mm Kodachrome slides. The Kodachromes were then recorded digitally to produce appropriate electronic versions. The digital images were subsequently enhanced with computer software and cropped to actual size. The finished digital images were then transferred into Microsoft PowerPoint slideshow and organized according to lecture topic. Annotations (figure legends and other descriptive text) were added using textboxes and arrows. To assist in the learning process, students were given workbooks containing black and white printouts of the lecture slides, along with space to add notes during lectures; this constituted the electronic histology tutorial (EHT). The EHT is therefore an atlas (workbook and CD) that combines lecture material, course notes, and laboratory slides. It features complementary material from the lecture with annotated notes covering both the general histology and oral histology elements of this undergraduate course.

First-year students in the graduating class of 2008 (designated 0T8) were each provided with the EHT, and although the histology laboratory was still available for these students, attendance was not mandatory. Rather, students were free to use the EHT on their own time. It was felt that the provision of nonmandatory attendance to weekly histology labs did not make this onerous to the students, as they could use this time to review the EHT, while at the same time the availability of the lab also provided a safety net for any students who might have problems with this newer form of teaching.

The experimental group consisted of sixty-nine first-year students in the graduating class of 2008 (0T8) who were exposed to the EHT tutorial. The control group consisted of sixty-seven, seventy-two, sixty-eight, seventy-one, and sixty-nine first-year students in the graduating classes of 2007 (0T7), 2006 (0T6), 2005 (0T5), 2004 (0T4), and 2003 (0T3), respectively, who were taught histology via traditional lectures and the use of microscopes in a laboratory setting.

Outcome Measures

First-Year Dental School GPA of Comparison Groups. Homogeneity in terms of academic skill for each comparison group was determined by comparing the mean first-year dental school GPA for each group. This provided a mechanism to rule out differences in test scores that could theoretically have been related to overall differences in academic performance between comparison groups as opposed to effects of the EHT.

Scores on Term Tests. The guiding assumption for assessing student performance was that if the course content for the experimental group was not different from that received by control group students in previous years, any differences in outcomes (as measured by students’ grades) could reasonably be attributed to the method of delivery, particularly if there is no difference in overall GPA scores between the test groups. The effectiveness of the self-study EHT was measured as the difference in students’ test scores between the pilot study year (2004-05) and scores obtained by students in the classes of the five preceding years (which served as the control group). The test scores on the two histology term tests, consisting of a general histology term test (GHTT) and an oral histology term test (OHTT), were compared between experimental and control groups. In these tests, students were graded for their ability to correctly identify specific structures from the slides that they studied over the course of the term. The tests included sixty randomly chosen slides for general histology and thirty randomly chosen slides for oral
Results

Effects of the EHT on General Histology and Oral Histology Term Tests Scores

The classes of 0T7, 0T6, 0T5, 0T4, and 0T3 (control groups) were taught the histology course via lectures and weekly microscope labs, while the class of 0T8 (EHT group) used the electronic histology tutorial at their leisure and on their own time to augment course content. The traditional microscope lab was still available to the students, but attendance was not mandatory. Results on the outcome measures of mean first-year dental school GPA, mean GHTT scores, and mean OHTT scores are summarized in Table 1. The EHT group’s scores in the general histology term test were significantly better than those of students in the prior classes. The EHT group scored 11.2 percent higher on this test than the 347 students in the prior classes combined (p<0.0001). Similarly, the OHTT scores of the EHT group were 11.6 percent higher than the controls (p<0.0001).

Homogeneity in terms of academic skill for each comparison group was determined by comparing the mean first-year dental school GPA for each group. There was no statistically significant difference in first-year dental GPA between the Class of 0T8 (EHT group) and the Classes of 0T7 (p=0.19), 0T6 (p=0.09), 0T5 (p=0.1), 0T4 (p=0.47), and 0T3 (p=0.38). In fact, when the data were normalized against overall GPA, incremental improvement in performance per unit overall GPA was noted in the test group, which demonstrated an increase in the test score normalized ratio (TSNR) of 3-18 percent in the general histology term test and 7-21 percent in the oral histology term test over the control groups. With the exception of the GHTT/GPA ratio between the EHT group and the class of 0T7 (p=0.33), differences in GHTT/GPA ratio and OHTT/GPA ratio were statistically significant for all comparisons, favoring the EHT group over the control groups (Figure 1).

Table 1. Comparison of EHT group (0T8) mean first-year dental school GPA, general histology term test (GHTT) scores, and oral histology term test (OHTT) scores versus prior classes

<table>
<thead>
<tr>
<th>Comparison Group</th>
<th>First-Year Dental School Mean GPA Out of 4.0</th>
<th>Mean GHTT Score Out of 30</th>
<th>Mean OHTT Score Out of 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>0T8 EHT Group (n=69)</td>
<td>3.38 (sd 0.46)</td>
<td>27.94 (sd 1.4)</td>
<td>18.82 (sd 0.98)</td>
</tr>
<tr>
<td>0T7 Group (n=67)</td>
<td>3.31 (sd 0.49)</td>
<td>26.7 (sd 2.47)</td>
<td>16.59 (sd 1.59)</td>
</tr>
<tr>
<td><em>p=0.19</em></td>
<td>p=0.0002</td>
<td>p&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>0T6 Group (n=72)</td>
<td>3.26 (sd 0.55)</td>
<td>24.25 (sd 2.9)</td>
<td>14.42 (sd 1.97)</td>
</tr>
<tr>
<td>*p=0.09</td>
<td>p=0.0001</td>
<td>p&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>0T5 Group (n=68)</td>
<td>3.47 (sd 0.43)</td>
<td>25.46 (sd 2.6)</td>
<td>17.82 (sd 1.65)</td>
</tr>
<tr>
<td>*p=0.1</td>
<td>p&lt;0.0001</td>
<td>p&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>0T4 Group (n=71)</td>
<td>3.37 (sd 0.51)</td>
<td>23.09 (sd 3.9)</td>
<td>15.99 (sd 2.35)</td>
</tr>
<tr>
<td>*p=0.47</td>
<td>p&lt;0.0001</td>
<td>p&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>0T3 Group (n=69)</td>
<td>3.40 (sd 0.42)</td>
<td>23.43 (sd 3.8)</td>
<td>17.68 (sd 1.24)</td>
</tr>
<tr>
<td>*p=0.38</td>
<td>p&lt;0.0001</td>
<td>p&lt;0.0001</td>
<td></td>
</tr>
</tbody>
</table>

*p-values correspond to the differences in outcome measures between each group and the EHT group.
Perception of the EHT

All sixty-nine students taking the EHT-based course completed the satisfaction questionnaire. One student did not answer question 7. Overall, student responses were positive, with a mean score for students’ responses (MLA) of ≥4.4 for nine out of the ten statements (Table 2) and an overall mean level of agreement for all ten responses of 4.5 out of 5 (90 percent). Overall, the students’ responses to the EHT-based course were positive, with 526 out of a possible 690 responses consisting of “strong agreement or agreement” with the statements. In contrast, only forty students’ responses were not in agreement with the statements. Students, for the most part, reported that the EHT was an effective learning method (MLA=4.8), they would prefer using the EHT than viewing slides with a traditional microscope (MLA=4.9), and they found the EHT simple to use (MLA=4.9). Responses to the questionnaire, however, reveal a lower mean level of agreement for the replacement of conventional lectures with CAL tutorials (MLA=3.1).

Discussion

Traditionally, the evaluation of different modes of learning in medical and dental education has involved a comparison of outcome measures (such as scores on a multiple choice test) between randomly allocated experimental (e.g., CAL group) and control groups. It has been argued that rigid quantitative and controlled experimentation cannot be considered valid in an environment where the variables of the subject pool are almost as great as or greater than the pool itself. Furthermore, the blindness involved in randomization becomes corrupted in an educational context since there are rarely placebos in education. Recently, there seems to be a shift from the use of the randomized controlled trial (RCT) design to a more qualitative but still measurable approach by using students’ own perceptions to assess modes of teaching. Such results have been documented alone or in conjunction with more traditional quantitative results, as we have done here, even though this particular investigation was not randomized.
Although an RCT approach was not utilized in this study, its principal objectives were fulfilled—namely, to change the mode in which the histology course is taught without compromising students’ motivation to learn and perform in the course. In fact, the students’ response to the EHT model of teaching/learning was very positive. Moreover, in comparing performance on the basis of GPA, it was possible to demonstrate statistically and practically significant improvements in scores for both general histology and oral histology tests by the group using the EHT as compared to the control group, comprised of previous classes. Importantly, differences in test scores were most likely related to use of the EHT since there were no differences in overall GPA amongst all groups—a finding supported by improvements in the term test/GPA ratio or test score normalized ratio (TSNR) described above. Hence, our findings correlate well with several previous investigations. Such normalization of test scores may have an impact on prior evaluative CAL studies that have documented no difference in test scores between CAL and control groups. However, these studies documented positive responses from students towards CAL.

Although attendance in the microscope lab was not obtained for any of the classes (EHT or control classes), a marked decrease in attendance for the EHT group was noticed by the course director. Students have never been forced to attend the microscope labs but have traditionally attended these labs with a very high frequency as these labs were their main resource for viewing histological slides. Nevertheless, an accurate record of the number of students attending the microscope lab and time spent on the EHT would allow for a more meaningful assessment of the effects of the EHT as compared to traditional methods. A follow-up study is planned in which self-reporting of time spent studying, attendance in microscope labs, and responses to student satisfaction questionnaire for traditional educational measures will be assessed. Assessment of such outcome measures has the potential to make a contribution to our understanding of the effectiveness and efficiency of CAL as an alternative means of learning.

**Figure 2. Oral histology term test (OHTT)/GPA ratios for all classes**
Although students clearly preferred using the EHT over textbooks and viewing slides with the aid of a traditional optical microscope, they were still uncertain regarding the concept of replacing conventional lectures in favor of CAL tutorials alone, a finding also reported by others.19,24 It might be conjectured that students’ reluctance to replace lectures with CAL tutorials may be explained by the fact that students are accustomed to attending traditional lectures and have become accustomed to this specific learning environment. Yet, it is also noteworthy that, with the aid of the EHT, their performance in a specific course could be improved and that, overall, this approach to learning was perceived to be effective by the students. The EHT might prove to be a good model for similar courses (e.g., histopathology) as dental curricula move further into the twenty-first century.

**Conclusions**

Students who were provided the EHT had significantly better term test scores than students in previous classes who learned the material via traditional methods. Yet there were no statistically significant differences in first-year dental school overall GPA between the groups, resulting in a test score normalized ratio (TSNR) that was significantly higher for the EHT group.

The electronic histology tutorial (EHT) elicited positive responses from first-year dental students. This positive attitude towards such a mode of learning can motivate students to learn.

Although responses to the questionnaire were overwhelmingly positive (overall mean level of agreement for all ten responses of 90 percent), students are not prepared to replace lectures with CAL tutorials. Thus, from the students’ point of view, the EHT is perceived to be valuable but should be used as an adjunct to conventional teaching in histology.

The EHT has the added advantages of preservation of good-quality slides, elimination of searching for structures under a microscope, and allowing students to learn on their own time (not restricted by lab hours).

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**Table 2. Student satisfaction questionnaire**

<table>
<thead>
<tr>
<th>Item</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Uncertain</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Mean Level of Agreement</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The content of the material in the EHT was interesting.</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>35</td>
<td>29</td>
<td>4.4</td>
<td>0.61</td>
</tr>
<tr>
<td>2. The information presented in the EHT was useful.</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>18</td>
<td>49</td>
<td>4.7</td>
<td>0.59</td>
</tr>
<tr>
<td>3. The EHT was an effective learning method.</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>12</td>
<td>56</td>
<td>4.8</td>
<td>0.51</td>
</tr>
<tr>
<td>4. I would like to see more CAL tutorials in other classes.</td>
<td>0</td>
<td>1</td>
<td>7</td>
<td>16</td>
<td>45</td>
<td>4.5</td>
<td>0.74</td>
</tr>
<tr>
<td>5. I would replace lectures with CAL tutorials.</td>
<td>9</td>
<td>16</td>
<td>18</td>
<td>12</td>
<td>13</td>
<td>3.1</td>
<td>1.31</td>
</tr>
<tr>
<td>6. The EHT made the information in the course easier to understand.</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>16</td>
<td>51</td>
<td>4.7</td>
<td>0.58</td>
</tr>
<tr>
<td>7. I would prefer using the EHT rather than viewing slides with a traditional microscope.</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>64</td>
<td>4.9</td>
<td>0.41</td>
</tr>
<tr>
<td>8. I would prefer using the EHT rather than studying from a textbook.</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>7</td>
<td>55</td>
<td>4.6</td>
<td>0.8</td>
</tr>
<tr>
<td>9. The EHT was simple to use.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>65</td>
<td>4.9</td>
<td>0.24</td>
</tr>
<tr>
<td>10. I enjoy classes that use a combination of teaching methods including traditional lectures, labs, and electronic tutorials.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>23</td>
<td>43</td>
<td>4.6</td>
<td>0.63</td>
</tr>
</tbody>
</table>
REFERENCES


