E-Learning vs. Classroom Instruction in Infection Control in a Dental Hygiene Program

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Abstract: The purpose of this project was to evaluate e-learning versus classroom instruction in infection control by comparing outcomes of multiple-choice examination scores and clinical competency-based examinations (CBE) between two groups of first-year dental hygiene students (fall 2008 e-learning: n=26; fall 2009 classroom instruction: n=26). Contents of both instructional units were comparable and were developed by the Organization for Safety, Asepsis, and Prevention. All students in each group were required to complete infection control instruction as part of the preclinical curriculum (didactic and clinical) and were tested on the material using the multiple-choice examination and clinical CBE. Both groups’ scores on the multiple-choice examination ranged from 74 percent to 94 percent (n=26 to 33 of 35), with e-learning mean score=82.8 percent, n=29 of 35, and classroom instruction mean score=86.8 percent, n=30 of 35. A two-tailed independent samples t-test indicated a statistically significant difference between the two groups on the multiple-choice examination (p=0.11). The Fisher’s exact test indicated no statistically significant difference between the two groups on the first-time pass rate for the clinical CBE (p=0.668). Findings demonstrated little difference between the two methods for teaching infection control. Thus, either method may be chosen. Future research should examine a blended approach with larger samples and longitudinal data.

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Increased demands on faculty time, pressure from administrators to control costs and increase student enrollment, and students’ desire for convenient education have been identified as factors impacting decisions about classroom instruction.1,2 Utilizing e-learning technology may be one way to begin to address some of these issues. This program evaluation was designed to evaluate the use of e-learning versus classroom instruction in infection control in a dental hygiene program. It compared student outcomes related to infection control measured by written multiple-choice examination scores and clinical competency-based examinations (CBE) between two groups of first-year dental hygiene students.

Literature Review

E-learning (online or web-based education) has increased in higher education over the past decade, with 66 percent of two-year and four-year post-secondary institutions (N=1,600 weighted to represent 4,200 schools) offering some form of online education, hybrid, or other type of distance education in 2006–07.3 Ninety-eight percent of these institutions utilized asynchronous technology in which the learner does not need to be present at a certain time or place (75 percent to a large extent, 17 percent to a moderate extent, and 6 percent to a small extent). Potential advantages of e-learning reported in the literature include convenience for students, increased enrollment, flexibility, decreased cost, easy for faculty to update material, easier student tracking, and greater student retention of course information. Some disadvantages of e-learning discussed in the literature include technical difficulties, faculty time needed for development, lack of technical resources, and feelings of isolation/frustration for students.1,2,4-6

Most studies reported in the literature have suggested comparable outcomes for e-learning and classroom instruction.1,2,6-8 A 2006 meta-analysis by Sitzmann et al. suggested that e-learning and classroom instruction are equally effective when the content and learners are similar.7 Sitzmann et al. reviewed ninety-six studies comparing e-learning (web-based) and classroom instruction. A 2004 meta-analysis by Bernard et al. found classroom instruction and distance education (DE) were comparable to one another.8 Bernard et al. reviewed DE literature from 1985 to 2002 encompassing 232 studies of all types
of DE (synchronous and asynchronous, computer-based, multimedia, and teleconferencing). Bernard et al.'s findings suggested that classroom instruction was favored over DE when using the synchronous medium; however, the outcomes were comparable between synchronous classroom instruction and DE in the asynchronous medium. Bernard et al.'s review compared all types of DE, whereas the Sitzmann et al. review focused on use of e-learning (web-based) or asynchronous technology. E-learning (web-based) or asynchronous technology is the most current type of DE in use today.3

Web-based education in dentistry and dental hygiene has grown over the past decade.9-12 A study by Nunn et al. found that a severe shortage of dental hygiene educators exists and will continue to grow if solutions are not developed.12 One solution Nunn et al. suggested was to increase the use of distance technologies to teach dental hygiene students pursuing master’s degrees since they are likely to become educators. Distance technology was suggested for use in dental hygiene master’s degree programs in order to reach potential students who may be living far from urban areas or college campuses or those with current employment and/or family commitments since it would provide the flexibility of taking coursework at the student’s convenience. This use of e-learning was suggested as a means to help alleviate the problem of faculty shortages.

Information emerging from published studies on e-learning in dental education has indicated that a blended approach using both classroom instruction and e-learning may be best.9,13 Studies of five groups of dental and dental hygiene students (N=165) enrolled in a health informatics course were conducted to assess this learning modality.6 Online instructional modules were combined with in-person tutoring sessions with mandatory attendance. Follow-up questionnaires, student-led nominal group evaluations, and non-participant observations of student engagement found the online component was perceived as valuable by 65 percent of those responding (N=158). The major concern expressed by students in this study was a lack of online support and lack of advanced postings of online information.9 A follow-up study correcting for these concerns found that 75 percent of students participating found the course beneficial.13 These findings suggested that a combination of classroom teaching with the role of the teacher as a coach or facilitator may enhance asynchronous technology. An article by Bray et al. suggested use of an electronic conference platform with web camera, video, and live audio technology to create a virtual classroom in real time to augment online learning.14

Follow-up data over a three-year period found that students (N=27) were satisfied with blended instruction; however, challenges of time zone differences were a concern.15 Few studies in the dental literature examined a blended approach to learning, so further study is needed.

Although the number of studies on the effectiveness of e-learning in dentistry and dental hygiene is not extensive, they have found e-learning to be as effective as classroom instruction; thus, their results have shown promise for continued study. Grimes reported no statistically significant difference (p=.453) between the scores on a final examination in a dental terminology course (n=4 web-based students, n=14 traditional classroom students).4 Bearden et al. found no statistically significant differences in course averages (p=0.1992) or National Board Dental Hygiene Examination (NBDHE) scores (p=0.8436) between online (n=30) and on-campus (n=24) students in a dental hygiene nutrition course.16 A longitudinal study by Olmstead compared student performance (GPA, course averages, and NBDHE scores) for distance learners (n=115) and on-site learners (n=105) in the first undergraduate dental hygiene program offering its didactic curriculum completely via distance education and found no statistically significant differences.17 Gallagher et al. found students in a web-based gerontology course (n=12; 67 percent dental hygiene combined with other health professions) had higher scores on tests, graded assignments, and projects and greater retention of material than the classroom instruction group (n=32).18 The limitations of these studies (small sample size and/or non-probability samples) demonstrates the need for further development and study of e-learning in dental and allied dental education.

Infection control education may be conducive to e-learning. Traditionally, students learn the didactic portion of infection control via classroom instruction and then apply their knowledge in the clinical setting. Infection control education and compliance have been mandated by the Commission on Dental Accreditation (CODA) for all dental, dental hygiene, and other allied dental education programs, with two CODA standards specific to infection control education for dental hygiene programs (2-12 and 5-1).19 The Occupational Safety and Health Administration (OSHA) has recommended that components of infection control education must include materials that are 1) appropriate for the learner’s knowledge level, 2)
specific and not generic, 3) completed initially and updated annually, and 4) interactive so the learner can ask questions. In addition, OSHA requires that educators be knowledgeable and that documentation of the education be kept.20-24 For many years, students and practitioners also have been educated about the Centers for Disease Control (CDC) guidelines, a set of professional standards related to infection control, and site-specific information about the facility in which they are working.

No reports were found in the literature of web-based infection control education in dental hygiene. One study of practicing dentists in England found that a CD-ROM for infection control continuing education was successful as measured by increased satisfaction and knowledge level. The authors suggested that future training of this nature should be accessible via e-learning.25 Results of an evaluation of an online continuing education program indicated that e-learning is a worthwhile addition to onsite courses to meet the needs of dental hygiene practitioners at sites distant from urban areas.26

Review articles of the nursing literature have suggested that e-learning is equally as effective as classroom instruction.1,2,6 Nursing educators also have examined the use of technology for infection control education. In 2000, a study of computer-assisted learning (CAL) available for nurses (n=25), third-year medical students (n=23), and infection control personnel (n=3) practicing in a London hospital found the interactive CAL was frequently accessed, easy, and enjoyable to use. Medical students’ gain in infection control knowledge from using the CAL was equally as effective as formal lecture (p<0.0001).27 A report of nursing students’ learning infection control in a Wales hospital found an increase in infection control assessment results before and after using a CAL program and recommended future use of CAL to reinforce good standards of infection control.28 More recently, the focus has been on e-learning. A study published in 2008 of nursing students (N=141) divided into two groups compared online infection control instruction for the surgical class and classroom instruction for the medical class.29 The post-instruction multiple-choice exam resulted in higher scores for the classroom instruction group in epidemiology and preoperative preparation (p=.01). No significant difference between the two groups was found in exam scores related to protocols and guidelines (p=.53), standard precautions to prevent infection (p=.91), and isolation of patients with infections (p=.35). A majority of all students (70 percent) were satisfied with the teaching method, whether e-learning or lecture, and there was no significant difference between groups in study time (p=.67).

In my study, an e-learning approach to infection control education was examined to assess its potential for future application in dental and dental hygiene education.

Materials and Methods

The sample for this program evaluation included two groups of all first-year students in a two plus two baccalaureate degree dental hygiene program. The two groups were similar in baseline characteristics, with the students’ having successfully completed all prerequisite dental hygiene courses and being accepted into the professional program. All first-year students in the fall 2008 semester had web-based modules (n=26), and all first-year students in the fall 2009 semester had classroom instruction in infection control (n=26). The contents of the two instructional units were comparable, based upon either written or online instructional materials developed by the Organization for Safety, Asepsis, and Prevention (OSAP).21,24 All students in each group completed infection control instruction as a required component of the dental hygiene preclinical course with a thirty-five-item multiple-choice examination constituting 5 percent of the final course grade. Each item had one correct response, and the scores were based on a possible score of 100 percent. The same examination was used for both groups. An exemption for this program evaluation was granted from the institution’s Human Subjects Committee.

The author became the sole infection control instructor in the fall of 2008 when the e-learning modules were implemented. The question arose as to whether one of these two modalities was more effective than the other. Thus, a classroom instruction approach provided by the same instructor was implemented for comparison in the fall of 2009.

All incoming first-year students in the fall semester of 2008 (n=26) were assigned web-based (e-learning) modules in infection control. In early June 2008, instructions about the modules were mailed to students in their orientation packets prior to the start of the academic year in late August. Students had the
entire summer to work on the modules. They were instructed to access and complete all of the web-based infection control modules developed by OSAP and were given the course instructor’s e-mail address for assistance or questions. The OSAP modules contained the same information as the OSAP textbook, designed by experts in infection control following CDC and OSHA guidelines. Both were designed to be used by students, professionals, or anyone with an interest in infection control. The online modules are available free of charge; however, there is a $150 fee for professional continuing education credits. The modules could be accessed as many times as the students desired. There were eight modules to complete and no time limit in which to complete them. Students were on the honor system and were not required to prove they finished the modules because proof of completion would have required paying the continuing education fee. These students were incoming first-year students into a professional dental hygiene program and were motivated to learn the material because they were informed that they would be tested on it on the first day of class. In late August, a question and answer session was held during orientation on the Friday before classes began to allow students to ask questions and receive clarification on the online modules completed during the summer. Students took the multiple-choice examination on the first day of class, the Monday following orientation.

All first-year students in the fall semester of 2009 (n=26) had classroom instruction in infection control. They had assigned readings from the OSAP textbook prior to the lectures and four hours of classroom instruction over two sessions during the first week of classes. The classroom instruction included a PowerPoint lecture presentation, a ten-minute video, and a brief learning activity (“What’s wrong with this picture?” involving identifying infection control errors in a photograph). This group was also given the opportunity to ask questions and get clarification prior to the examination. Students took a multiple-choice examination at the end of the second lecture session on Friday of the first week of classes. It was the same examination used for the e-learning group the year prior. Table 1 shows the timeline of the methodology.

Outcomes also were compared from clinical competency-based examinations (CBE) for the same two groups of students. The CBE is a hands-on clinical examination that students complete in their preclinical course early in the fall of the first year (during the fourth week of classes in mid-September for both groups). The evaluation instrument consists of nineteen criteria to test students’ performance of protocol for proper setup of a dental unit according to infection control standards. Performance is observed by a clinical faculty member according to established criteria known to the student. This examination is evaluated as satisfactory (all nineteen criteria evaluated as satisfactory) or unsatisfactory and may be repeated until a satisfactory performance is achieved with interim remediation instruction available. Students must demonstrate satisfactory performance in all CBEs to achieve a passing course grade. This CBE remained the same for both groups of students included in this evaluation.

An independent samples t-test was used to compare mean multiple-choice examination scores of the students in the two groups. A Fisher’s exact test was used to test for relationships between these

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**Table 1. Methodology timeline**

<table>
<thead>
<tr>
<th>Classroom Instruction Group</th>
<th>E-Learning Group</th>
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<tr>
<td>• Readings assigned first day of class (Monday)</td>
<td>• Online modules assigned early June prior to classes starting</td>
</tr>
<tr>
<td>• Four hours of lecture during first week of classes</td>
<td>• Early June through late August students had the opportunity to work on modules</td>
</tr>
<tr>
<td>• Question and answer session at the end of last lecture</td>
<td>• Question and answer session late August prior to first day of classes</td>
</tr>
<tr>
<td>• Multiple-choice examination given at end of first week of classes (Friday)</td>
<td>• Multiple-choice examination given on first day of class</td>
</tr>
<tr>
<td>• One week of contact time with course material prior to multiple-choice examination</td>
<td>• Variable contact time (1 to 3 months) with course material prior to multiple-choice examination</td>
</tr>
<tr>
<td>• Clinical examination given during week four of classes</td>
<td>• Clinical examination given during week four of classes</td>
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two groups in categorical first-time satisfactory/unsatisfactory performance on the CBE.

Results

The Shapiro-Wilk test of normality determined that the multiple-choice exam scores were distributed normally (p=0.477), and the Levene’s test for equality of variances indicated equal variance on the test scores (p=0.449); therefore, a t-test could be used for data analysis. A two-tailed independent samples t-test was used to compare the mean multiple-choice exam scores of students in the classroom group versus the e-learning group at a significance level of p≤.05. The e-learning group's mean score was 82.8 percent (n=29 of 35), with a range of 74 percent to 94 percent (n=26 to 33). The classroom instruction group’s mean score was 86.8 percent (n=30 of 35), with the same range of 74 percent to 94 percent (n=26 to 33 of 35). The two-tailed independent samples t-test indicated a statistically significant difference existed between the two groups’ mean scores on the multiple-choice examination (p=0.011). Table 2 shows the mean score multiple-choice exam results for both groups.

The Fisher’s exact test used to analyze the clinical competency-based examination scores indicated no statistically significant difference between the two groups (p=.668). In the e-learning group, 84.6 percent (n=22 of 26) passed on the first attempt with 100 percent passing after two attempts. In the classroom instruction group, 92.3 percent (n=24 of 26) passed this clinical examination on the first attempt, with 100 percent passing after two or three attempts. Remediation occurred prior to the second and third attempts for students in both groups. Table 3 shows the results of the clinical competency-based examinations.

Discussion

This program evaluation compared outcomes of classroom instruction and e-learning (web-based modules) in infection control education between two groups of students. No studies of e-learning in infection control education were found in the dental literature.

Gaining additional time in the beginning of the curriculum would be beneficial for both students and faculty members if the two approaches were comparable in outcomes. The literature has shown that e-learning is equally as effective as classroom instruction.1,2,6-8 Use of e-learning prior to enrollment for infection control education could benefit faculty members and students by gaining additional classroom time early in the first semester for orientation, lecture, and activities.

<table>
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<th>Table 2. Multiple-choice examination results</th>
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<td>Group</td>
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<td>---------------------------------------------</td>
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<tr>
<td>Classroom Instruction (n=30 of 35)</td>
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<tr>
<td>E-Learning (n=26)</td>
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* p≤0.05

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<th>Table 3. Clinical competency-based examination results</th>
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<td>Group</td>
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<td>Classroom Instruction (n=26)</td>
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<td>E-Learning (n=26)</td>
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No statistically significant difference existed between the two groups on the clinical CBE. This result could be due to the small sample size (n=26 in each group) since nominal data such as pass/fail scores often require larger samples for increased statistical power. More students in the classroom instruction group passed the clinical CBE on the first attempt (n=24 out of 26) than the e-learning group (n=22 out of 26). However, one student in the classroom instruction group needed three attempts to pass, one more attempt than any in the e-learning group.

The classroom instruction group scored slightly higher on the multiple-choice exam. The difference in multiple-choice exam scores was statistically significant; however, there appears to be no practical significance because these scores were similar and the two groups did equally well on the clinical CBE. The difference between the two groups may be due to additional information at the end of the lecture for the classroom instruction group. After the lecture material, the classroom instruction group watched a brief ten-minute video and identified errors in infection control on a photograph. The e-learning group did not. Another factor that may have contributed to the difference was group dynamics. The classroom instruction group asked many questions after the lecture, whereas the e-learning group asked very few questions. Both groups were given the opportunity to ask questions and receive clarification. Perhaps this point needed to be highlighted or stressed further in the orientation packet and instructions sent prior to the start of the semester for the e-learning group. There was only a brief mention of the opportunity to ask questions in the orientation packet. The extra ten-minute video for the classroom instruction group may have provided a slight advantage. Another advantage for the classroom group may have been that the students were in closer contact with the content before the examination was given. Although the difference between the two groups was statistically significant, the mean examination scores only differed by one point, four percentage points, with an identical range of scores (74 percent to 94 percent) indicating little difference in actual knowledge of infection control as measured by the examination.

Dental hygiene educators have to determine whether this small difference would impact a student’s general infection control knowledge and clinical application. With minimal difference, it appears that e-learning could be a viable alternative for teaching infection control. When assigned after admission to the program but prior to the first day of class, the time saved with e-learning in infection control could be beneficial.

One of the limitations of this program evaluation is the small sample size. Further study should include larger samples from various locations and longitudinal data. The findings are not generalizable to all dental hygiene students because of the use of a non-randomized sample. This study did not utilize a student survey. Student surveys should be used in future studies of this nature to examine variables such as satisfaction level with the delivery method (e-learning, classroom, or blended approach) and the amount of time and effort required to complete the coursework.

The findings of this program evaluation contribute to the literature on e-learning in dental hygiene education. These findings, although based upon a small non-randomized sample, demonstrated very little difference between e-learning and classroom instruction for infection control content. Thus, either method may be chosen as an interchangeable educational methodology. It also examined the effectiveness of an online educational module in dental infection control developed by OSAP. Future research should include the examination of a blended approach with larger and more varied samples and longitudinal data.

**REFERENCES**