Evaluation of a 3-D Interactive Tooth Atlas by Dental Students in Dental Anatomy and Endodontics Courses

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Abstract: Advances in information and communication technology continually offer innovations to assist faculty in their efforts to help students learn new information or develop new skills. However, faculty members are often hesitant to incorporate these innovations into their courses out of fear that these new methods may not provide the anticipated outcomes. Hence, students are often the subjects of educational trials to evaluate curriculum innovations by comparing a new teaching/learning method to traditional lecture-based instruction. The most typical finding is that students can learn equally well by either method. However, two questions that have not been studied extensively in dental education are whether dental students will actually use computer-based educational resources made available to them and whether students perceive these materials to provide a value-added learning experience. Accordingly, the goals of this study were to determine whether first-year dental students (D1), second-year dental students (D2), and third-year dental students (D3) would 1) use an interactive tooth atlas, available on a DVD, as a study aid and 2) perceive that the atlas provided sufficient value-added benefit for their dental anatomy (D1), preclinical laboratory endodontics (D2), and clinical endodontics (D3) courses to recommend adding it to their school’s comprehensive electronic resources. A low percentage of the students (14 percent; 40/289) voluntarily downloaded the atlas from a DVD to their laptops prior to the addition of incentives in the form of atlas-related examination questions. Even after incentives were added, only 43 percent of the students (126/289) downloaded the DVD. After using the atlas, students responded to the statement “Using the 3D Interactive Tooth Atlas was beneficial for me” on a 0 to 10 scale with 0 representing strongly disagree, 5 representing unsure, and 10 representing strongly agree. The mean rankings were 5.34 for D1s, 6.79 for D2s, and 7.28 for D3s. Students also responded to the statement “The atlas should be added to our school’s VitalBook” (digital library of curriculum materials). The mean rankings for this statement, using the same 0–10 scale, were 5.15 for the D1s, 6.63 for the D2s, and 7.26 for the D3s. Based upon these findings, the course directors decided not to add this atlas to the students’ electronic resources.

Electronic curriculum (e-curriculum or e-learning) refers to computer-assisted learning including educational materials available to students by CD or DVD; online courses and web mechanisms used to search the literature; electronic systems used to enhance academic programs such as e-mail; online testing and course evaluations; and various applications of instructional technology including providing laptops to students, multimedia projection systems, and Internet-compatible, wireless classrooms.1 Figure 1 provides a summary of the proposed advantages of e-curriculum.2-4 A study of dental school curriculum innovation conducted during the 2002–03 academic year by Kassebaum et al. found a high level of interest among dental educators in e-curriculum.3 Kassebaum et al. reported that 86 percent of North American dental schools had expanded use of instructional technology during the past three years for implementation of core curriculum and 82 percent of schools desired to increase their use of computer-based technology even further during the next three years. In 2004, Hendricson et al. found that virtually all North American dental schools had made substantial efforts to provide...
instructional technology resources to their faculty in the past several years, collectively investing millions of dollars, but also found use of twenty-two components and capacities of e-curriculum was limited except at schools that required students to purchase a laptop with bundled curriculum support software.6

This article focuses on one component common to e-curriculum: the use of DVDs by dental students to assist their acquisition of biomedical knowledge and skills. In health professions education, DVDs are typically designed to allow students to interact with the educational materials by image selection and manipulation. Many DVDs also allow students to make decisions in simulations, analyze the outcomes of these decisions, and respond accordingly much as “gamers” do with PlayStation, Xbox, and Wii. The use of DVDs as an educational tool has received considerable attention in dental education over the decade as more and more schools require students to matriculate with a laptop and associated curriculum-support software.

To explore whether an interactive DVD was a valuable study aid, we investigated dental students’ perceptions of the benefits of an interactive three-dimensional tooth atlas, accessible by DVD, and their utilization of this educational resource in a freshman dental anatomy course, a sophomore endodontics preclinical course, and a junior year clinical endodontics course at one U.S. dental school in the 2007–08 academic year.

**Description of 3D Interactive Tooth Atlas**

The 3D Interactive Tooth Atlas, Version 4.0, was created by Brown and Herbranson Imaging (http://ehuman.com/) as a teaching tool to provide a comprehensive database of human dentition. Users can access four types of images of every tooth: photographs, radiographs, serial cross-sections, and micro-CT scans. Photographs, cross-sectional views, and CT scans can be fully rotated and tilted 360 degrees in any direction and also enlarged for better visualization. The CT scans also allow users to peel away anatomical structure to view internal anatomy; users can literally navigate canals and roam around inside the tooth to explore structures in fine-grain detail. For example, external structures can be completely stripped away to reveal only the canals. Internal structures are highlighted in color to trace their pathway, and popup labels can be accessed.
on demand to identify and describe all structures and features, both internal and external. Users can compare side by side photographic, radiographic, and CT scan views of the same tooth and rotate them in sequence. In addition, users can request and view tooth-skull relationships and request various 3D images to review anatomical considerations for periapical surgery and implant placement.

The 3D tooth atlas contains an x-ray database of dozens of images of each tooth demonstrating numerous anatomic variations and an extensive collection of case studies showing numerous dental pathologies and anatomic variations for each tooth. These cases were submitted to Brown and Herbranson by dentists from all over the United States and internationally. For in-depth study of endodontics, the DVD includes examples and explanations of pulpal pathology that illustrate the pathway from normal to pulpal degeneration to periapical involvement. Students can review pulpal anatomy by rotating images and literally drill down through the tooth via the cross-sectional images. To produce the cross-sectional views, teeth were sliced into fifty to seventy sections and photographed. Other modules illustrate and label pulpal anatomy using the CT scans and allow exploration of periapical anatomy via cut-away techniques controlled by the user. Split screens combining photographs, radiographs, and CT scans visualize instrumentation and canal anatomy that create challenges for dentists.

The tooth atlas DVD also contains self-assessment quizzes that allow users to review correct and incorrect responses and an extensive glossary of terms, definitions, and concepts. Dentists and staff at Brown and Herbranson assisted the authors in development of the protocol described in the methods section.

### Methods

This was a prospective study performed at the University of Texas Health Science Center at San Antonio (UTHSCSA) in 2007–08. The research proposal was approved by the UTHSCSA Institutional Review Board. The research hypotheses explored in this study were that dental students 1) will utilize a three-dimensional interactive tooth atlas accessible via a DVD as a study aid when provided an opportunity to do so and 2) will perceive that the atlas is a beneficial educational resource. To test these hypotheses, we sought answers to four questions using an investigator-developed survey as the primary data collection method. Question 1 addressed the first hypothesis, and questions 2, 3, and 4 addressed the second hypothesis:

1. What percentage of first-year dental students (D1), second-year dental students (D2), and third-year dental students (D3) voluntarily used the 3D Interactive Tooth Atlas?
2. Did D1s, D2s, and D3s perceive that the atlas was beneficial?
3. To what extent did D1s, D2s, and D3s perceive that the atlas provided information, perspectives, radiographic images, and other learning opportunities that were otherwise not available?
4. Did D1s, D2s, and D3s recommend adding the atlas to a comprehensive electronic resource at this dental school that includes all textbooks and course manuals, plus many other instructional materials, for their entire curriculum?

Dental students in the freshman, sophomore, and junior years at the UTHSCSA Dental School participated in this study on a voluntary basis. The total enrollments for each class at the time of the study were ninety-five, ninety-three, and 101, respectively, although not all students elected to participate as indicated in the results section.

The surveys used in this study are displayed in the Appendix. Survey questions were developed by the authors based on the hypotheses to be explored. Several other faculty members reviewed the questions for clarity and appropriateness, given the purposes of the study, and provided suggestions for wording that were incorporated. The surveys were not validated.

An educational specialist received a copy of Brown and Herbranson’s 3D Interactive Tooth Atlas DVD and participated in several hours of training by one of the atlas marketers, as well as one of the dentists who participated in atlas development, about how to use the DVD to present the atlas to dental students in the dental anatomy and endodontics courses.

Ten DVDs containing the tooth atlas were provided by Brown and Herbranson to the dental school to lend to requesting students. Students acquired the DVD by requesting it from an administrative assistant in the Department of Restorative Dentistry. The names of requesting students and request dates were recorded. All UTHSCSA students purchase either a Macintosh laptop computer (Mac) or personal laptop computer (PC) at the time of their matriculation into dental school as part of their tuition. Requesting students installed the tooth atlas DVD onto their laptop computers in the immediate vicinity and im-
mediately returned the DVD to the administrative assistant, who observed the students as they loaded the DVD onto the laptops. Consequently, we have a high level of confidence that the recorded students were the only ones who placed the atlas on their computers, although more than one student could view the atlas from one student’s computer. Students were not provided registration numbers for the atlas, but it was programmed to allow computers to run it for a two-week period without being registered. Students could uninstall and reinstall the program to obtain another two-week viewing period.

Near the beginning of the freshman year dental anatomy and occlusion course, the educational specialist demonstrated the tooth atlas DVD to show these students the purposes of this study; the components, features, and potential advantages of the atlas to assist their learning of external tooth anatomy; and how to access this educational resource. After two months, only eleven of the ninety-five D1s had requested the DVD from the administrative assistant, so the students were informed that four questions about the atlas would be placed on their next examination. These questions appear in Figure 2 with the correct answers highlighted in bold. Students were informed that these four questions would be included in calculation of their test score and were equal in value to all other items on their examination. After receiving notification about these four questions and prior to the examination, seventy-three of ninety-five D1s (77 percent) requested the DVD to install on their computers.

Near the beginning of the sophomore year preclinical (laboratory) endodontics course, the educational specialist also oriented students in this course about the research study and the atlas. Students were informed that the four atlas-related questions would be included in calculation of their test score and were equal in value to all other items on their examination. Prior to the examination, twenty-six of the ninety-three D2s (28 percent) requested the DVD from the administrative assistant.

1. When entering the 3D Interactive Tooth Atlas, you are requested to select one of three choices. These three choices are
   A. Photography, tomography, and x-ray
   B. Crown anatomy, root anatomy, and internal anatomy
   C. Dental anatomy, supportive tissues anatomy, and oral anatomy
   D. Enamel structures, dentinal structures, and pulpal structures

2. From the options below, what is the best answer to this question: which of the following were NOT in the 3D Interactive Tooth Atlas?
   A. Third molars
   B. Primary teeth
   C. Palmer and international nomenclature
   D. None of the above were in the atlas
   E. A, B, and C all were in the atlas

3. Which of the following options indicates how you select a tooth to view on the 3D Interactive Tooth Atlas?
   A. Table of listed teeth
   B. Maxillary pie chart and mandibular pie chart
   C. Teeth over a picture of the lower face
   D. Typodont identical to the one our students have

4. Which of the following were on the 3D Interactive Tooth Atlas?
   A. View of skulls
   B. A quiz that assessed understanding of information communicated in the atlas
   C. A quiz with sample National Board Dental Examination Part 1 dental anatomy questions
   D. All of the above

Figure 2. Questions related to the 3D Interactive Tooth Atlas DVD that were added to the dental anatomy examination (correct answers in bold)
Near the beginning of the year-long D3 clinical endodontics course, the educational specialist also oriented third-year students about the research study and the atlas. The students were informed that prior to appointing a patient to the endodontic clinic to perform their first endodontic procedure, their course director required that they use the atlas to review the internal tooth anatomy of the tooth to be treated. During the fall semester, three of the 101 D3s requested the DVD. To encourage installation and review of the atlas, junior students were informed that the four previously described questions (Figure 2) about the atlas would be placed on their first examination in this course during the spring semester. Prior to the examination, twenty-seven D3s (27 percent) requested the DVD from the administrative assistant.

Near the end of the freshman dental anatomy course, all D1s (n=95) received a survey titled “Dental Anatomy and 3D Interactive Tooth Atlas” (see Appendix) to evaluate the atlas as an added benefit to their current course material, which consisted of a 315-page manual developed by the course director and two dental anatomy textbooks. Near the end of the sophomore preclinical endodontics course, all D2s (n=93) received a survey titled “Endodontics and 3D Interactive Tooth Atlas” (see Appendix) to evaluate the atlas as an added benefit to their current course material, which consisted of a manual developed by the course faculty and two endodontics textbooks. Near the end of the junior clinical endodontics course, all D3s (n=101) received the same survey as the sophomores to evaluate the atlas as an added benefit to their current course material (two clinical endodontics textbooks). Students in each class were provided time to complete the survey in a paper and pencil format during regularly scheduled class time.

The nonparametric Mann-Whitney procedure was used to perform pairwise statistical comparisons among the three groups for each question. All testing was two-sided with null hypotheses rejected at the 0.05 level of statistical significance. The reported p-values were adjusted by the Bonferroni method to control for inflation of the Type 1 error rate due to multiple comparisons.

Results

A total of 235 students (eighty-four D1s, seventy-one D2s, and eighty D3s) completed surveys for response rates of 88 percent, 76 percent, and 80 percent respectively. The total number of students who responded to each question varied. Findings for each of the four questions that framed the study are reported in this section.

1. **What percentage of first-year dental students (D1), second-year dental students (D2), and third-year dental students (D3) voluntarily used the 3D Interactive Tooth Atlas?** Two sources of data were available to answer this question: the number of students who acquired the DVD for laptop installation and the students’ self-reported use of the atlas on the survey. For actual checkout, departmental records indicate that eleven D1s (12 percent; 11/95) requested the DVD prior to the addition of the four atlas-related examination questions in the dental anatomy course, and a total of seventy-three D1s (77 percent) obtained the DVD by the time of the examination. For the D2s, twenty-six (28 percent; 26/93) requested the DVD for laptop installation. Among the D3s, three of the 101 students (3 percent) requested the DVD prior to the addition of the four atlas-related questions on the clinical endodontics examination, and a total of twenty-seven (27 percent) obtained the DVD by the time of the examination. A summary of the students who acquired or reported viewing the DVD appears in Table 1.

Among the students who completed the survey, seventy-four of eighty-four D1s (88 percent), forty-nine of seventy-one D2s (69 percent), and thirty-eight of eighty D3s (47 percent) reported that they had viewed the 3D Interactive Tooth Atlas. The self-reported usage of the atlas by the D1s is consistent with the DVD checkout records, but the self-reported usage by D2s and D3s is substantially higher than indicated by the checkout roster for these classes. The primary reasons students reported for not viewing the atlas were problems running it on their computers (especially with Macintosh laptops) and being too busy with other schoolwork. Among the students who attempted to utilize the atlas on their computer, 19 percent (30/154) indicated they could not run it.

2. **Did D1s, D2s, and D3s perceive that the atlas was beneficial?** Only those students who viewed the DVD were asked to respond to the survey item designed to elicit their perceptions of benefit, which was stated as “Using the 3D Interactive Tooth Atlas was beneficial for me.” Students responded to this item using an eleven-point scale ranging from 0 to 10 with the anchors of 0 representing strongly disagree with the statement, 5 representing unsure, and 10 representing...
strongly agree. A summary of the D1 students’ assessment of the atlas’s helpfulness for their dental anatomy course is in Table 2. Summaries of the D2 and D3 assessments of the atlas’s helpfulness for their preclinical laboratory endodontic course and clinical endodontic course are in Table 3. For D1s, the weighted mean ranking for this statement was 5.34 with a standard deviation (SD) of 2.24, while the mean scores were 6.79 (SD=1.64) for D2s and 7.28 (SD=1.56) for D3s. The weighted mean rankings of the D1 and D2 classes were significantly different from each other (p=0.002) and the rankings of the D1 and D3 classes were also significantly different (p<0.001), but the rankings were not significantly different (p=0.636) between the D2 and D3 classes.

3. To what extent did D1s, D2s, and D3s perceive that the atlas provided information, perspectives, radiographic images, and other learning opportunities that were otherwise not available? Using the same eleven-point scale, the weighted mean ranking for this statement was 6.64 (SD=2.29) for the D1s (Table 2), 7.35 (SD=2.01) for the D2s, and 7.85 (SD=1.76) for the D3s (Table 3). The rankings of the D1 and D2 classes were not significantly different (p=0.033), the rankings for the D1 and D3 classes were significantly different (p=0.026), and the rankings for the D2 and D3 classes were not significantly different (p=0.927).

4. Did D1s, D2s, and D3s recommend adding the atlas to a comprehensive electronic resource at this dental school that includes all textbooks and course manuals, plus many other instructional materials, for their entire curriculum? UTHSCSA dental students purchase the software program “Vital Curriculum,” which is bundled with their laptop computer, from VitalSource Technologies. Vital Curriculum, typically called VitalBook by our students, enables them to view all of the textbooks that dental school faculty selected for course reading lists as well as course manuals, syllabi, and other educational resources submitted by course directors including videos and PowerPoint presentations. On the survey, the statement designed to elicit students’ perceptions related to this question was “The atlas should be added to our school’s VitalBook.” The weighted mean ranking for this statement, using the eleven-point scale, was 5.15 (SD=3.08) for the D1s, 6.63 (SD=2.99) for the D2s, and 7.26 (SD=2.66) for the D3s. The rankings of the D1 and D2 classes were significantly different (p=0.019), the rankings of the D1 and D3 classes were also significantly different (p=0.001), but the rankings were not significantly different (p=0.912) between the D2 and D3 classes.

The last survey question for all levels of students requested additional information the students wanted to provide about the atlas. Write-in comments were received from all eighty-four D1s who completed the survey, from thirty-six of the seventy-one D2s, and from forty-two of the eighty D3s. Consistent with their other survey responses, the D3 students’ written comments were more favorable than the D2 class followed by the D1 remarks, which were the least favorable. The most common responses across all three classes of students were related to the atlas’s cost and problems encountered running the DVD, primarily on Mac laptops. Other common responses were that the atlas was more relevant for students in clinical practice and that it was fun to manipulate the images on their computers.

The same four examination questions to assess awareness of the format and components of the atlas were given to the D1, D2, and D3 students. The averages of students in each class selecting the correct answers to all four questions combined were 91, 73, and 72 percent respectively for the D1s, D2s, and D3s. These scores correspond roughly with the percent of

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<td><strong>Checked out atlas prior to knowing questions would be on examination (55 D1s and 101 D3s)</strong></td>
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the class who reported they viewed the atlas: D1, 88 percent; D2, 69 percent; and D3, 47 percent—i.e., if a higher percentage of the class viewed the atlas, the class’s average score was higher.

In spite of the fact that the three courses each addressed internal pulpal anatomy, the D3 students followed by the D2 students rated the atlas as having greater value. In an informal setting, D3 students were asked the reason for this difference. They related that students need experience to be able to interpret and appreciate the information provided in the atlas and that students in the preclinical laboratory or clinical phases of dental school have greater clinical interests and the atlas provides these students with a different perspective about clinically meaningful information.

### Discussion

The use of DVDs and their predecessor, CDs, has been extensively described in the literature of health professions education, usually in conjunction with descriptions of computer-assisted learning (CAL) systems. A 2002 literature review identified seventy-six English-language articles published from 1996 to 2002 that described the development and/or use of educational materials that students accessed by viewing CDs or DVDs, typically in conjunction with CAL or as an adjunct to lectures and web-based modules. The following sources were reviewed to identify this body of literature: PubMed, Cochrane Database of Systematic Reviews, and Cochrane Database of Abstracts of Reviews of Effectiveness.
A follow-up review was conducted by the authors in 2008 using these three sources and Google encompassing the search terms compact disc, DVD, interactive digital video, medical education, dental education, and nursing education. The 2008 review identified an additional sixty-four English-language articles published between 2000 and 2008 that described the instructional use of CDs or DVDs as components of multimedia modules run on computers or in conjunction with web-based learning. Twenty-four of these articles described educational uses of DVDs and CDs for dental students.

These twenty-four articles in the dental education literature either proposed development and assessment guidelines/techniques, curricular applications, and best practice heuristics for this type of educational material or reported the results of evaluations of the effectiveness of these educational materials by one or more of the following: 1) comparison of pre- to post-training learning gains among students who used DVDs and CDs alone or in combination with other CAL techniques, sometimes in comparison to passive controls (no training) or active controls (students who learned by other methods, usually lectures); 2) appraisal of students’ perceptions of the value and usability of the educational materials; 3) measurement of changes in students’ attitudes about a particular health care issue or their confidence concerning a specified topic or skill; and 4) assessment of students’ satisfaction with the DVD-based learning experience and/or their preference for studying by DVD versus other methods. Dental applications described in these articles included educational modules on implantology,8 dental care for special needs patients,9 oral health care for children with Down Syndrome,10 cross-infection control,11 dental care for geriatric patients,12 tobacco cessation,13 anatomy,14,15 therapy for partially edentulous patients,16 radiology,17,18 patient assessment, diagnosis, and treatment planning in periodontics and endodontics,19,21 orthodontic appliances,22 case-builder templates for assessment and treatment planning simulations,23,24 blended learning modules combining CDs or DVDs with other learning materials in several disciplines,25-27 and orthodontics.28-31 Four studies involving combinations of CAL and DVD-based materials in orthodontics instruction were described in a review article by Rosenberg et al.32 Johnson and Schleyer33,34 and Eaton et al.35 reviewed guidelines and methods for developing, evaluating, and effectively using educational software including interactive DVDs.

Nine of these articles reported outcomes of evaluations of students’ knowledge comprising a total of twelve studies. Seven studies reported statistically significant enhancements in dental students’ knowledge,8,10,12,13,27,32 four reported no statistically significant knowledge gains between pre- and post-tests or equivalent performance to students who learned the same material by other methods,17,18,22,32 and one reported lower pre- to post-test knowledge gains for students studying materials presented via DVD modules than students who attended classroom lectures.32 Three studies explored outcomes other than knowledge acquisition. Littlefield et al. assessed dental students’ diagnostic accuracy for endodontic problems without comparison to controls.21 Shittek et al. observed the history-taking skills of dental students who did and did not learn via a virtual learning environment that allowed students to interact with patient data in simulations and concluded that the media-based group of students performed more complete patient interviews than students who had received standard teaching.19 Pahinis et al. assessed the extent of information sharing among dental students in a blended-learning course created to promote student interaction and concluded that this learning experience did not stimulate high levels of student collaboration.25

Twelve studies assessed dental students’ satisfaction with educational experiences that incorporated DVDs or CDs alone or in combination with other educational methods and/or assessed students’ preference for media-based learning versus standard classroom lecture.8,10,14-22,26 All of these articles reported that students were satisfied with their alternative, non-lecture learning experiences or preferred interactive media-based learning to conventional teaching. Two studies investigated changes in dental students’ attitudes concerning specific health care issues and reported positive changes for students who completed interactive patient simulations.13,27 Sanders et al. reported that dental students’ comfort and confidence in treating a patient with congenital deafness and blindness increased after studying an interactive CD module.17 Three studies investigated students’ perceptions of the utility and usability of interactive DVDs or CDs: Kleinert et al. reported positive student perceptions,10 while Gray et al. and Pahinis et al. reported less positive student perceptions.11,25

Overall, the findings from these studies are consistent with the substantial body of research
from many areas of higher education pertaining to the learning outcomes of educational activities that employ DVDs or CDs as students’ primary means of information acquisition, alone or in combination with web-based learning. The collective evidence found that instructors who use DVDs or CDs to communicate information can expect students’ performance to be equivalent to what is typically achieved by classroom lectures and can anticipate that most, but not all, students will express satisfaction with these materials. One of the most commonly expressed advantages of CAL is the programming technology that allows students to interact with the information presented in educational modules by answering questions and learning the accuracy of responses, manipulating images, selecting the sequencing of modules (versus being forced to study the information in a pre-set sequence), and managing patient care simulations by making decisions and responding to the consequences of these decisions. Cognitive psychologists have contended that such “learner-control” enhances student motivation and improves the quality of learning. Learner-control does appear to enhance motivation and satisfaction, but the research findings to date concerning the influence of learner-control in CAL on overall performance have been inconsistent. In one of the few studies to assess the influence of student control over computer-based learning modules in health professions education, Aly et al. compared interactive multimedia modules in orthodontics that allowed student control of how the materials were studied to a preprogrammed module that communicated the same information and images to students who could not interact with the material. These investigators found no differences in performance between students completing interactive learner-controlled and programmed (noninteractive) versions of this educational module.

Given that the learning outcomes of computer-assisted learning, including modules that use interactive DVDs, have produced persistent findings of equivalent outcomes in comparison to lectures and other methods, we focused on the intertwined issues of whether dental students perceive this type of educational material to be valuable in their learning process and whether they will actually use an interactive DVD when provided the opportunity. As noted, interactive DVDs and other forms of CAL have been associated with enhanced student motivation. However, the findings of the laptop study at fourteen U.S. dental schools where students were provided with substantial DVD-based learning materials indicated that these resources were not perceived to be vital study aids and were not extensively utilized by students.

To further explore the utilization issue, we investigated dental students’ perceptions of the benefits of an interactive three-dimensional tooth atlas, accessible by DVD, and their utilization of this educational resource in a freshman dental anatomy course, a sophomore endodontics preclinical course, and a junior clinical endodontics course at one U.S. dental school in the 2007–08 academic year.

This study tested two hypotheses: dental students will 1) utilize the 3D Interactive Tooth Atlas accessible via a DVD as a study aid when provided an opportunity to do so, and 2) will perceive that the atlas is a beneficial educational resource. Our study found minimal support for the first hypothesis. Prior to addition of an incentive in the form of DVD-related questions on course examinations, only 14 percent (40/289) of the first-, second-, and third-year students voluntarily checked out the DVD for installation on their laptops. Even after incentives were applied, only 43 percent of the students checked out the DVD (126/289). We have no way of determining the extent to which the students actually reviewed the DVD or the extent of the interactive features they investigated although the students’ answers to the four exam questions about atlas features suggests that a majority of students at least superficially scanned it. These findings are consistent with the students’ perceptions from a study of fourteen dental schools with laptop/bundled software programs. In that study, dental students indicated they made minimal use of educational software provided with their laptops. The most frequent explanation was that students did not perceive that the materials meaningfully contributed to their capacity to perform well on course examinations.

The data from our study are somewhat more supportive of the second hypothesis. Students’ perceptions of the educational benefits of the atlas increased year by year culminating in a rating of 7.28 (on a scale ranging from 0=strongly disagree, 5=unsure, to 10=strongly agree) for the junior students. Students’ responses to the questions about “unique opportunities” and “add to their VitalBook collection” also increased incrementally from class to class. The relatively low (i.e., midscale) ratings of the freshmen (5.34, 6.64, and 5.15 respectively) to the three benefits questions could be interpreted in a couple of ways. First-year students may have paid attention to the scale, which had a center point of 5=unsure, and accordingly responded that they were uncertain
about the value of the atlas. Another explanation is that they did not perceive that the atlas added value to the educational resources they already possessed for the dental anatomy course, and they may have felt that the atlas provided information and features they were not yet ready to use given their level of knowledge of tooth structure and lack of patient care experience. If the later explanation is correct, it could be speculated that the freshmen did not have the insight into anatomical considerations and complications that arise during dental care to appreciate the potential value of the images and other educational resources incorporated into the atlas. A more speculative explanation for freshmen’s lukewarm responses to the benefits questions is that first-year students sensed that the atlas provided information and learning opportunities that were above and beyond what was needed to perform well on examinations in the dental anatomy course. The news that many students, especially those with Macs, were having difficulty running the DVD probably spread through the class and may have dissuaded some students from downloading the atlas. The company that produces the atlas now has a 3D Interactive Tooth Atlas Mac Patch v2.1, which may help with the problems students experienced when attempting to run the atlas on Mac laptops.

The responses of the third-year students, now in the clinical phase of their education, presumably reflects their growing awareness that anatomical variations in tooth structure among patients play a substantial role in planning and implementing treatment. It is possible that responses to the question about adding the atlas to the school’s VitalBook collection may have been economically driven for some students who were hesitant to increase the price of the software that came with their laptops. Some of the students’ write-in comments reflected financial considerations.

**Conclusion**

A low percentage of students (14 percent) voluntarily downloaded the tooth atlas from DVD to their laptops prior to the addition of incentives in the form of atlas-related examination questions. Even after application of incentives, only 43 percent of students downloaded the DVD. The 3D Interactive Tooth Atlas was most appreciated as a useful resource by the junior dental students, who were in the clinical phase of their education and presumably had the strongest incentive to explore it as an aid to assessing patients’ dental problems and planning treatment strategies. The interactive features and extensive inventory of images that could be manipulated by students for in-depth study of normal and abnormal anatomy may have been too sophisticated for the learning needs of the freshman students. Based upon these findings, the course directors decided not to add the atlas to the students’ VitalBook program.

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**REFERENCES**


APPENDIX

Dental Anatomy and 3D Interactive Tooth Atlas Survey

Over the past year, you had the opportunity to use the 3D Interactive Tooth Atlas DVD. This is a research survey and completing it is voluntary. You can choose to not answer any or all of the questions. Please do not put your name on the survey. Thanks in advance for your time and consideration.

1. Did you view the 3D Interactive Tooth Atlas DVD?
   Yes ___ Please answer only questions 3–7.
   No ___ Please answer only questions 2 and 7.

2. If you did NOT use this atlas, please write the reasons and then skip to question 7.
   ______________________________________________________________________________
   ______________________________________________________________________________

3. Did the program run on your computer?
   Yes ___
   No ___ Please explain the problem:
   ______________________________________________________________________________

4. Using the 3D Interactive Tooth Atlas was beneficial for me. (Circle one.)

   Strongly Disagree 0 1 2 3 4 5 6 7 8 9 10 Strongly Agree

5. The 3D Interactive Tooth Atlas provided information, images, perspectives, or other opportunities for learning dental anatomy that were otherwise not available to me. (Circle one.)

   Strongly Disagree 0 1 2 3 4 5 6 7 8 9 10 Strongly Agree

6. The atlas should be added to our VitalBook. (Circle one.)

   Strongly Disagree 0 1 2 3 4 5 6 7 8 9 10 Strongly Agree

7. What additional information would you like to tell your faculty about this atlas?
   ______________________________________________________________________________
   ______________________________________________________________________________
   ______________________________________________________________________________
You had the opportunity to use the 3D Interactive Tooth Atlas DVD. This is a research survey and completing it is voluntary. You can choose to not answer any or all of the questions. Please do not put your name on the survey. Thanks in advance for your time and consideration.

1. Did you view the 3D Interactive Tooth Atlas DVD?
   Yes ___ Please answer only questions 3–7.
   No ___ Please answer only questions 2 and 7.

2. If you did NOT use this atlas, please write the reasons and then skip to question 7.

3. Did the program run on your computer?
   Yes ___
   No ___ Please explain the problem:

4. Using the 3D Interactive Tooth Atlas was beneficial for me. (Circle one.)

   Strongly Disagree 1 2 3 4 Unsue 5 6 7 8 9 Strongly Agree 10

5. The 3D Interactive Tooth Atlas provided information, images, perspectives, or other opportunities for learning endodontics, radiographic images, and dental anatomy that were otherwise not available to me. (Circle one.)

   Strongly Disagree 1 2 3 4 Unsue 5 6 7 8 9 Strongly Agree 10

6. The atlas should be added to our VitalBook. (Circle one.)

   Strongly Disagree 1 2 3 4 Unsue 5 6 7 8 9 Strongly Agree 10

7. What additional information would you like to tell your faculty about this atlas?