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Interactive Computer-Assisted Instruction vs. Lecture Format in Dental Education

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Purpose. The purpose of this study was to compare computer-assisted instruction (CAI) with lecture format using recent hardware and software advances. A pre- and post-test was used to determine student performance and instructional preference. In addition, a post-instruction survey was used to determine student learning preferences.

Methods. Seventy-five first-year University of North Carolina (UNC) dental students who were registered for the introductory radiology course were asked to participate. All agreed and were randomly placed in one of three groups: interactive CD only, interactive CD and lecture, and lecture only. The content of the multimedia instruction focused on intraoral radiography. A pre- and post-test was administered to determine if there was a significant difference between interactive CD and lecture formats, and an evaluation instrument was used to determine if there was a student learning preference between CAI and lecture format. Analysis of covariance and the sign test were used to determine significance ($p<.05$).

Results. There was no significant difference between pre- and post-test outcomes, indicating that similar learning took place using the interactive CD and/or lecture format. However, students preferred CAI to lecture format.

Keywords: Computer-assisted instruction, lecture, multimedia, intraoral radiography

Introduction

Lectures are the predominant means of delivering dental and dental hygiene instruction and are often complemented by handouts, notes, and assigned readings. Popular lecture aids include film or computer slide shows, overhead transparencies, blackboards, chalkboards, and video presentations. These teaching formats make it difficult for students to review and navigate material freely without having to search for specific content.

Electronic media, the World Wide Web, and computer-assisted instruction (CAI) have created more flexibility since they use a non-linear approach.[1,2] Computers became influential in dental instruction in the mid-1980s,[3] and since then, CAI has been used to teach all areas of dentistry.[4-9] A 1997 survey of a dental school revealed that 85% of the faculty had access to and used a personal computer.[10] For example, at the University of North Carolina (UNC) School of Dentistry, where an office of information technology has been established, all faculty, graduate, dental, dental assisting, and dental hygiene students own or have access to a personal computer. In fact, students are required to purchase laptop computers.

Instructional presentation software allows instructors to conveniently enhance and change content, and it provides opportunities for animation and placement of materials on a server. Once on the server, students have access to the material at all times. Ludlow and Platin found that while 71% of students preferred online instruction, the preference appeared to be related to the ease of using the technology and facilitation of flexible learning styles, rather than improved didactic performance.[13] Plasschaert et. al found no significant difference between the performance of the students using multimedia for endodontic problem-solving.[14] Presently, the ability to store large volumes of information on a CD-ROM disk, transmit large files over the Internet, and use authoring, imaging, and video software makes interactive instruction readily available to instructors.

Purpose

The purposes of the study were to determine if student performance varied whether students participated in a CAI learning activity using new software or a lecture supplemented with PowerPoint, and to determine student preference between these two delivery methods.

Methods and Materials

Approval of this study was obtained from the Committee on Research Involving Human Subjects (Institutional Review Board for the UNC School of Dentistry). Seventy-five first-year dental students (class of 2003) who were enrolled in the fundamentals of dental radiology course were asked to participate. All agreed and were randomly placed in one of three groups of instruction. The groups were identified as CAI (the group studying the multimedia-presented material only), CAI + lecture (the group studying the multimedia-presented material and the lecture material), and lecture (the group studying material presented by lecture only).

A 20-question pre-test was administered to determine which students had previous experience using the XCP (extension cone paralleling) instrument. The questions were formatted in a PowerPoint presentation, which emphasized beam-guiding device construction recognition, radiographic film nomenclature, and film placement in a full series mount. Ten students participating in the study were absent during the administration of the pre-test.

Director 8 authoring software (Macromedia Inc., San Francisco, CA) was used to create an interactive presentation. The content of the multimedia instruction focused on intraoral radiography emphasizing the use of the XCP instrument and the exposure, development, and mounting of intraoral radiographs. After introducing the advantages of beam-guiding devices for intraoral radiography, the presentation was divided into three sections: instrument armamentarium, exposure technique, and film mounting. Instrument armamentarium covered instrument assembly for posterior, anterior, and bitewing radiographs. Technique was divided into three sections—or, anterior, and bitewing radiographs—with each section covering anatomical landmarks, clinical use of the instrument, film processing, and nomenclature. Finally, a film mounting exercise tested the student's ability to correctly place a full series of radiographs into a film mount.

Video clips were created using QuickTime (Apple Computers, Inc., Cupertino, CA) with a JVC DVL 9500 digital camcorder (JVC Company of America, Wayne, NJ) and Adobe Premier 5.1 video editing software (Adobe Systems Incorporated, San Jose, CA) to capture, edit, and export digital video. Photographs were taken using a Kodak DC 120 digital camera (Eastman Kodak Company, Rochester, NY), and images were enhanced with Adobe Photoshop 5.5 and LivePix 2.0 (Roxio, Inc., Milpitas, CA). The multimedia program was constructed using a workstation or personal computer that met or exceeded the processor speed, RAM, and hard drive storage requirements of the software.

The authoring multimedia instruction consisted of 27 separate movies that incorporated techniques such as cursor rollover, cast member exchange, sprite tweening, onion skinning, and video clip insertion to allow the student to interact freely with the information. Three faculty members from the Oral and Maxillofacial Radiology Section, two graduate oral and maxillofacial radiology residents, and a second-year dental student who had completed the course the preceding year reviewed the completed multimedia program. Following the review process, suggestions for changes were incorporated, and the multimedia material was placed on CD-ROM disks. Equivalent information for the lecture format was incorporated

into a PowerPoint presentation. Care was taken to assure that the lecture content was similar to CAI. The video clips and film mounting exercise sections were not included in the PowerPoint presentation because insufficient time was allotted during the lecture presentation. The PowerPoint presentation was divided into three lectures and was provided by a senior radiology instructor.

To determine the difference in outcomes between CAI and lecture format, the CAI group was given a CD-ROM disk and asked to not attend the lectures. The CAI + lecture group received the CD-ROM disk and was asked to attend the lecture. The lecture group did not receive a CD-ROM disk and was specifically asked not to borrow the CD-ROM disk from their classmates. Students using the CD-ROM disk were instructed to review the instructional material as often as they wished, and e-mails were sent every three days to reinforce its use. All students used the same model laptop computer to play the CD-ROM. Therefore, those students in groups who received CAI only, or those who received the CD-ROM and attended lecture, were able to view the media on similar hardware.

Two weeks after the third and final lecture, a 20-question PowerPoint post-test was administered. The format was identical to the pre-test and was administered at one time to the entire class. The post-test score was factored in toward their final course grade. Before the post-test was administered, 33 of the 75 participating students reported having used the XCP instrument in a clinical setting. The post-test scores of those 33 students were analyzed to determine if there was a significant difference between their scores and the others who did not have previous experience using the XCP instrument. Following the post-test, an evaluation instrument using a five-point Likert scale was administered to students in Group 2—those who had received CAI and attended lecture—to determine if there was a preference for CAI compared to lecture format. The information recorded on the evaluation form was anonymous.

To determine the effectiveness of each intervention, (CAI only, CAI + lecture, and lecture only), the median scores for the pre-test and post-test were compared using the Wilcoxon signed rank test. Ten pre-test scores were missing, as listed in Table I. The level of significance was set at .05, and analysis of covariance (ANCOVA) was used to determine whether there was a significant difference in learning between the CAI format and the lecture format. The three groups (CAI only, CAI + lecture, and lecture only) were the categorical variables, and the dependant variables were the post-test scores.

Table I. Comparison of Pre-test and Post-test scores by Treatment Group

	Variable	N	Mean	Median	STD	P-Value
CAI only	Pre-test	*24	4.083	1	5.919	<0.0001
	Post-test	26	17.000	17	1.414	
CAI + lecture	Pre-test	*23	4.261	1	5.762	<0.0001
	Post-test	25	16.880	17	1.856	
Lecture only	Pre-test	*18	2.167	1	3.854	<0.0001
	Post-test	24	16.5	17	2.414	

Wilcoxon signed rank test was used to determine significance between pre-test and post-test scores in each group.
*Ten students in the study were absent for the pre-test.

Pre-test scores were divided into five categories indicating the range of correct answers and labeled 0, 1, 2, 3, and 4 (Table II). Five categories were chosen because 10 of the subjects had missing pre-test values and would have been excluded from the analysis. The number of correct questions answered out of 20 were: Category 0 = student absent; Category 1 = zero answers correct; Category 2 = one answer correct; Category 3 = two to nine answers correct; and Category 4 = greater than nine answers correct. The number of correct answers per category was designed to allow for at least 10 students per category, fulfilling the assumption that the data is parametric, or normal (i.e. representing a normal population).

Table II. Pretest Scores by Assigned Categories

Categories	Number correct, out of 20 questions	Number of students
0	student absent	10
1	score = 0	23
2	score = 1	16
3	score = 2 to 9	15
4	score = > 9	11

The pre-test scores co-vary with the dependent variable and are called the "covariate." A is a statistical test, using means, which tests the effects of categorical groups by comparing a dependent variable after controlling for the covariate. In this study, ANCOVA tested the mean post-test scores of the three treatment groups after adjusting or controlling for pre-test groups. The null hypothesis was that there was no significant difference in post-test scores of the three treatment groups (after controlling for pre-test category). The level of significance for ANCOVA was set at = .05.

From the statements used to determine whether students preferred the use of CAI, Questions 4 and 5 were the most relevant. For each question there were five possible answers (strongly agree, agree, undecided, disagree, and strongly disagree). The sign test was used because of the possibility of a non-normal distribution of data. The sign test is a test of the probability of a median value above or below the expected value—in this case, 0. The p-value is an indication of the significance of the deviation of the group response median above or below a neutral (0) response. Again, the significance level was set at a = .05. In this test, each possible response was given a value as follows: strongly agree = - 2; agree = - 1; undecided = 0; disagree = 1; and strongly disagree = 2. The null hypothesis was that there was no difference in frequency for those who agree and those who disagree. In other words, the null hypothesis was that there would be an equal number of answers above and below zero.

Results

To determine whether each intervention—CAI only, CAI + lecture, and lecture only—improved scores, the level of significance comparing pre-test and post-test scores for each test group was less than 0.0001 (). Therefore, the median pre-test and post-test scores for each group were different, suggesting that each intervention helped improve scores.

Mean post-test scores,15.5 to 17.5, did not vary from pre-test scores. Post-test score means fell within two standard deviations of the pre-test categories 0, 1, 2, and 3. Therefore, regardless of group (CAI only, CAI + lecture, and lecture only) or pre-test category, post-test score means were not significantly different.

Group analysis: To determine whether post-test score means in the three treatment groups were significantly different after adjusting for pre-test category, p = 0.9819. There was no significant difference in post-test outcomes in the three treatment groups, regardless of their pre-test category.

Pre-test analysis: To determine whether post-test score means in the five pre-test categories were significantly different after adjusting for the three treatment groups, p = 0.1371. There was no significant difference in post-test outcomes among the five pre-test groups, regardless of the treatment group.

Confounder analysis: Thirty-three of the 75 students had prior experience using the XPC instrument before the post-test. ANCOVA revealed no difference in post-test outcomes among the three test groups when adjusting for pre-test category and prior experience in using the XCP instrument (p = 0.9187).

There was no difference in post-test outcomes among the five pre-test groups, adjusting for test group and prior experience with the XCP instrument (p = 0.2427). There was no difference in post-test means among those with prior experience with the XCP instrument, adjusting for test group and pre-test category (p = 0.1092). The p-values convey that post-test scores of students with prior experience with the XCP instrument were not significantly different, regardless of treatment group or pre-test category.

From the evaluation questions given to students in the second group, (CAI + lecture), Questions 4 and 5 inquired about students' preferences for the CAI or lecture format. Table III demonstrates the cumulative percentage responses and the signed test p-values for statements 4 and 5. For Question 4, students significantly agreed that it was advantageous to review the XCP instrumentation by CAI, as compared to the PowerPoint lecture format ($p < .0001$). Finally, for Question 5, students significantly agreed that they preferred learning the XCP content from the interactive CAI, compared to the PowerPoint lecture format ($p < .0001$).

Table III. Students' Preference for Teaching Methods

	Responses	Cumulative %
4.	It was advantageous to review the XCP Instrumentation on CD compared to the lecture format (PowerPoint lecture):	
	strongly agree	68%
	strongly agree + agree	92%
	strongly agree + agree + undecided	96%
		Sign test p < .0001
5.	I prefer learning the XCP content from the interactive CD media compared to lecture format:	
	strongly agree	52%
	strongly agree + agree	64%
	strongly agree + agree + undecided	92%
		Sign test p < .0001

Discussion

The use of a CD for CAI is a departure from traditional lecture format. An effort was made in this study to not only place the lecture material on a CD for CAI, but also to integrate content into a variety of interactive methods—animated diagrams, video clips, and full series mounting exercises, for example—which may accommodate a wider range of learning styles and promote greater learning satisfaction than lecture alone. The CAI content did not include student testing and feedback because these tasks required software skills that dental educators may not have acquired, such as data base construction and server input language.

Previous reports have found similar results of no significant difference in post-test outcomes using CAI compared to lecture format.[11-13] This study was different, however, in that it used recent advances in authoring software to which dental educators have been and will be exposed in the future. Guidelines for developing CAI should be instituted so that student learning preference is not biased by CAI quality. In this study, specific student learning styles or preferences were not taken into account and should be further studied.

A limitation in the design of this study was that students were not blinded to group assignment. Although students in each group were instructed not to communicate with each other regarding their assigned groups, crossover was not specifically monitored, and it is possible that students interacted with each other. While students receiving CAI were e-mailed several reminders, it was not determined how often they viewed the CD.

Creating interactive learning material for teaching purposes is not an endpoint. Guides for teaching, testing, and data analysis can also be used in distance learning. Guides created for distance learning would allow practitioners to earn credit for continuing education in their home locations. Further research regarding CAI and its role in distance learning should be initiated to determine the effectiveness of CAI when compared to traditional methods.

Conclusion

This study demonstrated no differences in student learning outcomes between lecture and CAI. However, study results indicate that students preferred the interactive instructional program because of its convenience and ease of navigation. Results of this study support the notion that, in dental education, CAI has the potential of being as equally successful a tool as linear instruction. Readily available tools were used to produce this program, indicating that the same approach can be used to include other content areas.

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Notes

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