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The effect of a multimedia interactive tutorial on learning endodontic problem-solving

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New technology may create additional opportunities for learning in dental education. One of these new features is a multimedia approach, courseware combining sound, text, stills and video with interactive learning. A multimedia program was developed to train dental students and dental practitioners in decision making and problem solving in endodontics. This study compared the effects of the multimedia program with a more traditional approach consisting of written information, without interaction. 28, 4th-year dental students at the University of Kentucky in Lexington, KY, USA were randomly assigned to the multimedia or the text-based groups. They were given a written pre-test using 2 cases of dental pain and were instructed to study independently using either the multimedia program (group A) or the written information (group B). No restrictions were imposed on the amount of time to be invested, and the total study time was recorded for each student. 3 weeks after the pre-test, the students completed the post-test. A total of 18 students completed both the pre-test and the post-test and their scores were included in the final data. Statistical analysis of the average scores using paired t-tests revealed no significant difference between the performance of the students in either group, indicating that the multimedia approach to learning endodontic problem solving may successfully replace traditional learning strategies.

Key words: education, dental; pain-diagnosis; computer assisted learning; clinical decision making; compact-disk-interactive.

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Learning problem-solving is an important core-activity of modern dental curricula. A scientific approach to clinical dentistry emphasises the thinking process as an essential part of problem-solving. Dental students first need to make observations on patients in order to understand the nature of the dental problem. They have to examine, document and analyse the patient, his/her behaviour, previous treatments, the oral cavity and available radiographs. This information will lead towards the diagnosis of the medical and dental problems. The next step is to create a tentative treatment plan by matching standard treatment alternatives to the identified problems, and to modify these alternatives towards the individual case, including the patient’s desires. A definitive treatment plan is achieved by implementing additional wishes from the patient and suggestions from colleagues. After carrying out treatment according to plan, the problem-solving process will be completed by a critical appraisal of the treatment results, which, in fact, is a new observation possibly iterating the problem solving process. Recording observations, arriving at a diagnosis, constructing a treatment plan and evaluating the treatment results are important features of learning to resolve patient problems.

Modern technology such as the compact disc interactive (CD-i) and computers, can be very helpful in training dental students to acquire knowledge and skills in problem solving. One of the first references that appeared in the literature reporting on the application of multimedia technology to simulate dental patients and dental disorders stems from 1988 (1). The introduction of information technology in dental education has been addressed in more recent publications (2–5).

The Nijmegen College of Dental Science has a long tradition of innovative activities in dental education. In 1974, a curriculum revision was accomplished, based on problem-oriented self-paced learning (6). Problem-solving methodology in dental education has been studied extensively (7–8). Based on a predefined strategy for teaching dental problem solving, the simulation of dental pain using a multimedia approach was envisaged in 1994. In developing the multimedia program, the following strategy was applied:

1. Identify and define the dental problem to be simulated.
2. Select an appropriate clinical case.
3. Collect data and record data systematically on sheets, photographs, audiotape and videotape. Digitise the selected images.
4. Develop an interactive teacher-to-student dialogue to obtain questions and possible answers in the context of the various steps as defined in the problem-solving process.
5. Produce the multimedia courseware.
6. Test the first draft in various educational settings and various curricula. Modify the courseware according to the test results.
7. Implement the approach in the standard dental curriculum.

The multimedia program combined text, sound and images with the expert-system information as a decision-tree in a self-paced learning program. After steps 1–5 were accomplished, the measurement of the validity of the resulting program was envisaged. Therefore, the objective of the present study was to assess the validity of the produced multimedia program among a group of dental students.

Material and methods

28, 4th-year, dental students (15 male and 13 female) at the University of Kentucky in Lexington, KY, USA, consented to participate in the study. All students had completed the same course work prior to participation, comprising a course on endodontic techniques and dental pain diagnosis (72 h study load) in the 2nd year, followed by clinical and didactic endodontic courses in the 3 year (average of 20 and 19 h study load, respectively). The students were randomly assigned to either the multimedia group (6 female and 8 male) or the text-based group (7 female and 7 male).

A pre-test consisting of two representative case histories was taken simultaneously by all 28 students. No feedback was given to the students regarding the outcomes of the pre-test. Each group was subsequently instructed to use 1 of the 2 available educational options, the multimedia or the text-based course.

Students in the multimedia group used 5 out of 10 simulated cases from the experimental CD-i programme PAINDENT (PAIN-analysis in DENTistry, University of Nijmegen and Wigant Interactive Media, 1994). The cases were selected such that 5 different causes of dental pain were represented. Students were permitted to use all features of the multimedia program including full interactive and self-paced learning. Each case had the same format and combined both audio and visual aids. Simulated patients are referred to the student and have taken a seat in the “waiting room”. By using the mouse or joystick to select a patient, the problem solving process started. First, the patient is introduced by a narrator and the patient explains the nature of his/her problem. Thereupon, a choice can be made to explore one of the following sections: patient history, extra-oral examination, intra-oral examination, radiographic examination, diagnosis, treatment, and evaluation/feedback. Each of these sections offers a set of options such as questions and diagnostic tests to collect relevant information, and diagnostic and treatment alternatives to allow for the entry of diagnostic and treatment decisions. The objective is to select only those options which are relevant to resolving the problem. Options and sections may be omitted, when thought to be irrelevant to the case. Students may also select “neutral” options which are neither helpful nor harmful to resolving the case. After having selected an option, the information is displayed immediately, e.g., in the form of an audible answer by the patient (patient history), as the result of a test (pulp test, etc.) in text and audio, still images such as radiographs, occasionally illustrated by fade-over video images. After completion of the case, the evaluation/feedback section provides feedback on the effectiveness of the student’s problem solving approach. This assessment section displays for each part of the program the % of correct and incorrect choices made.

The scores obtained for all sections were averaged and linearly converted to a grade on a scale from 1, indicating a very poor problem solver, to 100, an excellent problem solver.

Students in the text-based group received information on the same 5 cases as the multimedia group in a format containing text and images. Details of patient history and examinations were provided and a diagnosis had to be selected from a number of choices. No op-

<p>| TABLE 1. Descriptive results of the multimedia and text-based pre-tests and post-tests (means, standard deviations and medians are expressed in %) |
|------|------|------|------|------|</p>
<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th>Post-test</th>
<th>Pretest</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>multimedia group</td>
<td>text-based group</td>
<td>multimedia group</td>
<td>text-based group</td>
</tr>
<tr>
<td>no. students</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>no cases</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>mean</td>
<td>45.06</td>
<td>59.94&lt;sup&gt;a&lt;/sup&gt;</td>
<td>43.44</td>
<td>55.44&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>standard deviation</td>
<td>19.62</td>
<td>14.89</td>
<td>17.51</td>
<td>13.11</td>
</tr>
<tr>
<td>median</td>
<td>43.50</td>
<td>59.00</td>
<td>41.00</td>
<td>58.00</td>
</tr>
</tbody>
</table>

<sup>a</sup> Significant difference between pretest and post-test means within the multimedia group (t-test; p<0.05).
<sup>b</sup> Significant difference between pretest and post-test means within the text-based group (t-test; p<0.05).
portunities for interactive learning were given. Each case was accompanied by a written epilogue which presented the nature of the problem, the correct diagnosis, and the most appropriate treatment. Students were asked to study independently, to keep track of their study time, and to record the number of hours taken. All students were encouraged to use the prescribed textbook whenever they felt this could be helpful. After a 3-week period, students were asked to fill out a questionnaire, and a written post-test was completed, comprising the same 2 cases used in the pre-test. All post-tests were again scored using the multimedia program. Eighteen students completed both the pre-test and post-test and only their results were used in the statistical analyses.

The answers for the pre-test and post-test were entered into the multimedia program to obtain objective measurements of knowledge pertaining to problem solving and treatment planning. Paired t-tests were used to test the differences between the groups for statistical significance. The results of the questionnaire were compared by unpaired t-tests.

**Results**

9 students in the text-based group and 9 students in the multimedia group completed both the pre-test and the post-test. The results are contained in Table 1. No significant differences were found between the pre-test scores of the multimedia group and pre-test scores of the text-based group ($p>0.05$), nor between the post-test scores of the multimedia group and post-test scores of the text-based group ($p>0.05$). Significant differences were observed between the pre-test and post-test results within both the multimedia group and the text-based group ($p<0.05$). The results of the questionnaire are contained in Table 2. Students in the multimedia group found their learning material to be significantly less repetitive and more clearly presented than did the students in the text-based group ($p<0.05$). Students in the multimedia group reported to have spent on average 98 minutes (s.d.=37 min) and students in the text-based group spent 131 minutes (s.d.=98 min).

**Discussion**

The number of students enrolled in this study was estimated to provide sufficient power in statistical testing. Drop-out of students in studies focused on the assessment of educational changes is difficult to prevent, as the participating students may choose to cancel their participation at any time. A reduction to only 9 students taking the post-test in both the experimental and the control group has caused the applied statistical tests to be less powerful. However, the applied pre-test/post-test design of this study secures that the results can be interpreted, although with caution, towards to the population of dental students in Western dental schools.

The results from this study indicate that the problem-solving skills of the students increased following a period of study, regardless of the learning material used. From the absence of a statistically-significant difference between the post-test scores of the multimedia group and the text-based group, it must be concluded that the multimedia program was responsible for an increase in problem-solving skills which was comparable to a more traditional teaching method, indicating that the multimedia program demonstrated criterion validity. This is an important finding in view of the rapidly growing quantity of courseware becoming available.

The students in the multimedia group found their
exercises to be less repetitive than students in the text-based group. Repetition on the one hand may be a cause of nuisance; on the other hand, it may contribute to a better understanding of the problem-solving process. In view of the latter effect, such courseware has also been referred to as "drill and practice" exercises. It has frequently been discussed how much repetition is required for students to acquire sufficient knowledge and skills to adequately and independently resolve dental problems, and about as many times, it has been concluded that this is mainly determined by the individual characteristics of a student. Courseware in general and multimedia simulation programs in particular permit a student to acquire problem-solving skills in an individualised and self-paced manner. Students using multimedia programmes may decide to use as much repetition as they like, thereby only limited by the number of cases available. The fact that the students in the multimedia group found their learning material to be less repetitive hence indicates that they chose to repeat cases or parts of cases less than did their colleagues in the text-based group. In fact, they used a feature of the multimedia program to individually satisfy their needs. The fact that they required less repetition to achieve approximately the same level of problem solving skills than students from the text-based group, indicates that they acquired these skills significantly faster. This finding is confirmed by the considerably lesser amount of time reported by students in the multimedia group to be spent on learning the material.

During the past 10 years, there is a trend among students to buy personal computers, among other reasons, for study purposes (9). As the well-equipped multimedia computers are considerably more expensive than regular PC's, it was decided to use the low cost CD-i technology to develop PAINDE'NT. The hardware consists of a CD-i player, which is generally less expensive than a TV set, connected to a TV monitor. It was expected that this technology would be particularly appealing to students to run multimedia programs at home. However, regardless of the hardware used, the production of multimedia programs remains very expensive. The production costs of PAINDE'NT were in the range of a 1-year salary for an assistant professor. It is evident from this comparison, that the release of multimedia programs may never become cost-effective, unless they are produced and used by consortia of dental schools. The attractive features of multimedia programs may become more economically achievable when a large group of teachers agree on the content of the program and larger groups of dental students will buy these programs. Groups of dental schools should collaborate on the basis of joint effort, shared responsibility and investment, and perhaps most importantly, an a priori obligation to use the programs in their curricula. The same multimedia programs can possibly be used in postgraduate and continuing education (10). From a cost-benefit point of view dental education could benefit from a spread of multimedia courseware among the comparably large numbers of practising dentists. In view of this, dental schools and dental associations should sincerely consider collaborating in this perspective.

References


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