Evaluation of Computer Case Simulations for Teaching Clinical Pathology to Second-year Medical Students*

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ABSTRACT

A computer-assisted learning program for teaching clinical pathology to second year medical students has been developed and evaluated. These programs are designed to be used as supplements to formal lectures, laboratory exercises, and small group discussions. Students are given case histories and asked to select differential diagnoses, order and interpret laboratory and diagnostic tests, and make final diagnostic conclusions. In some cases, laboratory monitoring of treatment, e.g., drug therapy, is emphasized. The performance of the student is objectively evaluated during each stage. In addition, the amount spent for each workup is recorded with penalties given for excess or inappropriate test ordering. Separate evaluations are performed to assess the effectiveness of these programs as an alternative teaching format to (1) formal lectures and reading assignments, and (2) faculty-directed small group discussions. It is concluded that the computer-assisted learning method is equivalent to lectures and group discussions and is a format that is well accepted by students.

Introduction

Teaching medical students in laboratory medicine has traditionally focused on formal lectures and laboratory exercises. While these will continue to be a part of medical school education, the Association of American Medical Colleges has advocated changes in the curriculum whereby active problem-solving exercises should be stressed over the passive transmission of facts and information. This is particularly important for clinical pathology because many medical students are poorly prepared to apply efficient and cost-effective logic to the ordering of laboratory tests. Lectures given during the second year on this subject are not effective because of

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the large volume of information presented and the sense by students that the material is not immediately relevant to their basic science education. As a result, test ordering strategy often follows local customs passed on by senior students and interns.

One mechanism to teaching problem solving skills is to organize small group discussions and present cases that require further evaluation by laboratory testing. This actively engages students to seek out additional information and deal with each situation independently. Although this format has been shown to be successful elsewhere, there is reluctance by many pathology departments to adopt this format because it requires considerably more faculty time and effort. In resolving this conflict, computer-assisted learning (CAL) exercises using the case presentation format was developed. These CAL programs can produce a rapid response to individual requests, allow for independent self-paced, and interactive study with objective evaluations, and require no faculty supervision.

**Materials and Methods**

**Computer Hardware and Software**

Learning programs were written and compiled in Quick BASIC (Microsoft Inc.) using IBM-compatible personal computers and a disk operating system (MS-DOS version 2.0 or higher). An authoring program has been written for the development and input of new cases and data. The programs can be operated from a hard disc, or single 5¼” or 3½” disks.

**Learning Program Format**

A log-on procedure is used when the program is started. This program produces a statistics file which keeps a record of who has used the program, how well the user performed, and how much time was spent on the system. The statistics file also permits a student to interrupt the program and resume work at later time.

The learning portion of the program begins with a narrative of a clinical case history that is presented on the screen, and can be redisplayed at any time during the exercise. After reading the history, the student selects a differential diagnosis from a list of 20 to 50 entries related to the case. Students must then refine their diagnosis by ordering laboratory tests from a generic on-line laboratory manual containing over 500 chemistry, hematology, microbiology, and immunology tests that are typically available in a large hospital. In addition, a list of special diagnostic procedures is available (e.g., chest x-ray, EKG, CT scans, etc.). Students are given two opportunities to order and review laboratory tests. Ideally, the first tests should be selected to define better the site or nature of the illness with followup tests and special diagnostic procedures being ordered based on the results of the first set.

When the second group of results is received and reviewed, the student must make final diagnosis selections based on the history and the information gathered. The student can select any diagnosis from his original differential, or select a new final diagnosis. At the conclusion of the case, a final summary is printed discussing the major points of the case. The appropriateness of each selection made by the student is assessed. In addition, each program contains special graphics and flow charts that can be viewed or printed to illustrate key points of a particular case (e.g., the immunofluorescence staining pattern for antinuclear antibodies in case #4, or the indications for fine needle liver biopsy for case #1, session II). To
guide further reading, multiple choice study questions with detailed answers are available on-line.

Grading is based on the selections made for each section. All diagnoses and laboratory tests are assigned points. A range of positive points are awarded for the selection of appropriate lab tests and correct diagnoses. A zero or neutral score is given for tests that are not contributory but not harmful or expensive, or for diagnoses that are not completely correct but cannot be ruled out. A range of negative points are given for tests that are unnecessary, expensive and/or harmful, and for diagnoses that should have been ruled out. The cost of each test is also hypothetically charged to the participant. Although the price for any individual tests is not revealed, a total budget for the case is allotted and revealed at the end each exercise. Penalties are assessed when the student exceeds this budget. In this way, cost-containment is indirectly stressed without putting the major focus on diagnostic efficiency. The accuracy of final diagnosis is normally the most important criteria for case studies. However, these programs were designed for teaching clinical pathology, and thus equal weight has been given to the manner and efficiency of how the final diagnoses are achieved.

EVALUATION PROTOCOL

The computer-assisted learning programs were evaluated using second-year medical school student classes at the University of Texas Medical School at Houston in the 1987–88 and 1988–89 academic years. During the first year of the study, CAL programs were evaluated as to their potential use as supplements to traditional lectures and reading materials. A group of 34 paid volunteer students was selected from the second year class and divided into equivalent groups by ranking students according to their current numeric grades in the pathology course and then alternating the students for selection into each group. In this way, the average score for each group was not significantly different \( p > 0.01 \) from each other at the time of the evaluation. Retrospective tabulation of final course grades also showed that both groups were identical.

Group I was given a reading assignment on a general chapter describing anemia; group II was given a CAL program specifically focusing on macrocytic anemia. In preparing the differential diagnosis for this case, it was expected that group II students would also learn about other causes of anemia such as iron deficiency, hemolytic, anemia of chronic disease, etc. After one week, both groups were given a questionnaire, and an identical multiple choice quiz covering the reading material. In this phase of the study, it was important to know if the students in group II would do as well as those in group I even when the testing material was not specified. The mean of test scores were evaluated using the \( t \) test. In addition, different CAL cases were made available to all students on an optional basis, and their subjective evaluations were obtained. About 45 percent of the class of 190 participated. A total of 22 students from the group responded to a questionnaire given at the end of the course.

During the second year of the study, CAL programs were evaluated as a possible replacement to lectures and faculty-directed discussion groups. Many of the formal lectures previously included in clinical pathology were eliminated and replaced with discussion groups and CAL programs which were given over a three-week period. For example, the lectures on liver and pancreatic enzymes and the review of viral hepatitis were replaced by the first case (table I). For case #1, half the class was instructed to participate in small group discussions,
TABLE I
Description of Computer Assisted Learning Cases and the Average Amount of Time Spent on Each Session During Year Number Two of the Evaluation*

<table>
<thead>
<tr>
<th>Case Number</th>
<th>Description</th>
<th>Average Time Spent in Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>session I</td>
<td>Acute non-A non B hepatitis</td>
<td>35</td>
</tr>
<tr>
<td>session II</td>
<td>Chronic active hepatitis</td>
<td>24</td>
</tr>
<tr>
<td>session III</td>
<td>Alcoholic Liver cirrhosis</td>
<td>31</td>
</tr>
<tr>
<td>Number 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>session I</td>
<td>Bacterial endocarditis</td>
<td>42</td>
</tr>
<tr>
<td>session II</td>
<td>Complications with glomerulonephritis</td>
<td>23</td>
</tr>
<tr>
<td>session III</td>
<td>Therapeutic selections and monitoring</td>
<td>12</td>
</tr>
<tr>
<td>Number 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1 session)</td>
<td>Vitamin B12 anemia</td>
<td>43</td>
</tr>
<tr>
<td>Number 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1 session)</td>
<td>Acute seleroderma</td>
<td>31</td>
</tr>
</tbody>
</table>

*Students in small groups were allotted 50 minutes per case.

and the other half was given CAL programs covering the same material. For case #2, the groups were reversed; students in the computer group were instructed to perform the exercise through group discussions, and vice versa. For cases #3 and #4, students had an option as to how they could perform the exercise. A single multiple choice exam was given to all students with specific questions on the case materials presented, and general questions on clinical pathology. Statistical evaluations were computed on the mean of these results. In order to assess learning efficiency, logs were kept on the actual amount of time students spent in class or on the computer terminal.

Results

The average score of the multiple choice quiz for the two groups who participated during year #1 of the study, and the amount of time spent on the exercise are shown in figure 1. No significant difference was observed ($p > 0.1$) between the mean of these two groups for either parameter. When students were polled concerning their preference towards the learning format, 29 of 34 students (86 percent) selected the computer-assisted learning approach as shown in figure 2. When these students were asked how computer-assisted learning should be used, a combination of responses were obtained. Some felt they could replace laboratory sessions and small discussion groups exercises, and some felt lectures could be eliminated or reduced.

Of the students who performed the CAL programs on an optional basis during year #1 of the evaluation, 86 percent (19 of 22) of those who responded thought that the exercises were good preparation for case study discussions. When asked how they thought computer-assisted learning should be used in the curriculum, 43 percent (nine of 21) thought it should be used as a replacement for small group discussions, while the remainder thought a combination of small group discussions and computer simulations should be used in the pathology course.

In table I are described the cases that were presented during year #2 of the study and the average amount of computer time spent completing each case.

![Figure 1](image-url)
In the group discussion format, 50 minutes were allotted for each case. The objective results of the evaluation during this phase is shown in Table II. The number of students participating in each group was not identical to that of the experimental design because no student could be deprived of his/her right to select the learning format preferred. Indeed, many students participated in both formats, while some performed neither. The results showed no differences ($p > 0.1$) in the means of test scores from students who performed the exercise on computer vs. oral discussion groups for the sum of test scores or for any individual case. Although there is a slight decrease in overall student performance between those students who did both the computer and oral discussion group exercise vs. those who did neither exercise, the difference is not significant ($p > 0.1$).

Student preferences were also evaluated during this trial. While specific students were assigned to cases #1 and #2, students had an option as to how they could perform cases #3 and #4. Our results showed that of the 132 students who chose one format over another, 114 (86 percent) selected the computer-assisted learning format. In addition, 58 of 68 students (85 percent) who responded to a questionnaire thought that an equal or greater number of cases should be presented in future pathology courses, indicating their acceptance of this format. This was particularly encouraging sign to us, as 61 of these 68 students responded as being infrequent personal computer users (<5 times per month). Two-thirds of these students also felt that these exercises should be given over the entire course instead of during a single block.

**Discussion**

The concept of computer-assisted learning is not new to medical education.

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**TABLE II**

Objective Evaluation of Computer Assisted Learning Versus Group Discussion Exercises Based on Examination Performance During Year Number Two of the Evaluation

<table>
<thead>
<tr>
<th>Case Number</th>
<th>Computer Assisted Learning Only</th>
<th>Group Discussion Only</th>
<th>Both</th>
<th>Neither</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$n^*$</td>
<td>Score</td>
<td>$n^*$</td>
<td>Score</td>
</tr>
<tr>
<td>1 (7 questions)</td>
<td>77</td>
<td>5.87</td>
<td>62</td>
<td>5.77</td>
</tr>
<tr>
<td>2 (5 questions)</td>
<td>99</td>
<td>3.49</td>
<td>40</td>
<td>3.52</td>
</tr>
<tr>
<td>3 (4 questions)</td>
<td>114</td>
<td>3.22</td>
<td>19</td>
<td>3.37</td>
</tr>
<tr>
<td>4 (3 questions)</td>
<td>114</td>
<td>1.55</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Totals, four cases</td>
<td>-----</td>
<td>14.13</td>
<td>14.16</td>
<td>14.40</td>
</tr>
</tbody>
</table>

*$n^*$Number of students in each category.
Prior to the current widespread dissemination of low cost home or personal computers, use of these teaching aids was limited to workstations within learning resource centers. The CAL programs, however, are now being used directly in the classroom, laboratory, office, and home. The advantages of computers for medical education include quick access to large volumes of information, individual interaction between the student and author, and the ability to simulate real-life situations by the modification of clinical outcome to decisions made by the student.

The CAL programs have been written for a variety of undergraduate, postgraduate, and continuing medical education needs. One of the earliest programs was written by Schneiderman and Muller, who in 1970 showed that computer-based exercises were feasible for test ordering strategy. More recently, learning programs, specifically in pathology, have included lessons in hematology, computer-directed laboratory exercises in microbiology, case simulations for clinical diagnosis, and programs for which computers direct the viewing of anatomic pathology materials on slides and microfiche. Marion et al have reviewed the effectiveness of some of these new learning approaches and generally conclude that students are taught equally well by CAL as with traditional learning lectures. Our evaluations were designed to determine how effective CAL programs were in directing education, in addition to how well this format was received by students and how much faculty and administrative time was needed to implement CAL. It was found that our students learned equally well using CAL as they did with lectures, reading assignments, and small group discussions, with the majority of students finding these exercises more enjoyable than the traditional approaches. Moreover, it was found that the amount of student and faculty time needed to perform and administer these exercises, respectively, was less than what was needed for small group discussions.

It is our conclusion that computer-based learning is an excellent means of introducing the problem-solving format to second-year students, provided that students have access to computers either at home or at learning resource centers within the school. Many lectures have been eliminated and the number and size of small group discussions reduced to a figure more commensurate with the number of faculty who are willing and are available for teaching. For the next school year, it is planned to use a mixture of lectures, faculty-directed oral discussion groups, and CAL programs, preceded by classroom examples of how clinical cases should be evaluated by laboratory testing. A representative sample case is available through the authors.

Acknowledgments

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References


