Successful Teaching of Pediatric Fluid Management Using Computer Methods

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Objectives: To identify and measure differences in knowledge of pediatric fluid management procedures between students taught by computer tutorial and others taught by lecture or seminar.

Design: Cohort analytic study.

Setting: Two community-based medical school pediatric teaching services.

Participants: Eighty-nine third-year medical students with no prior pediatric fluid management experience.

Interventions: Forty-eight students at one community campus completed a microcomputer-based tutorial program that replaced all teaching sessions in pediatric fluid management. Forty-one students from a similar community campus were taught identical content by a pediatric critical care specialist using a seminar, reading material, and handouts.

Main Outcome Measures: Scores on 2 free-answer problems on treatment of a dehydrated child, which were graded by a single evaluator blinded to the teaching method used, and scores on a 20-item multiple-choice examination.

Results: The computer instruction group achieved significantly higher test scores than the seminar group for both the multiple-choice examination (81.1% vs 62.2%; \( P<.001 \)) and the free-answer test (85.4% vs 61.0%; \( P<.001 \)).

Conclusions: The computer tutorial in fluid therapy has been an effective means of meeting the defined objectives of the pediatric clerkship. Compared with traditional methods, students taught using the computer achieved significantly higher scores on tests of both factual knowledge and practical problem solving.


Fluid and Electrolyte Disorders

FLUID AND electrolyte disorders are common in children, and their effect on child health is great. Dehydration can quickly cause morbidity and mortality.¹ The Council on Medical Student Education in Pediatrics defines the area of fluids and electrolytes as a vital component of general pediatric clerkship teaching.² Understanding this topic is a major challenge for third-year medical students. Many students lack confidence in their physical examination skills, and their ability to assess dehydration is rudimentary. Basic math skills among their supervising house officers are often suspect,³ and these residents are often unfamiliar with fluid management.

Traditional methods to teach fluid and electrolyte management in pediatrics include lectures, assigned readings, independent problem sets, and case-based instruction. The teaching is often brief and depends greatly on the patient mix seen on the inpatient hospital ward. Each clinician and teacher may have an individual method of calculating fluid therapy and writing orders, and this variability in methods is often confusing to students.⁴ A more straightforward way to develop skills in this area would be to teach a single method of solving fluid management problems. By offering many opportunities for practice with such a standard method, we could build student confidence and improve knowledge of these difficult concepts.

Computer-assisted instruction has become common in many medical schools. Use of computers as adjuncts to teaching varies widely, including methods such as extensive and detailed multimedia textbooks,⁵ short interactive units that focus on specific topics,⁶ videodiscs and other media,⁷ nonbranching tutorials that are used in lieu of required reading and lectures,⁸ and many others. Computer instruction can provide repeated practice, immediate feed-
PARTICIPANTS, MATERIALS, AND METHODS

DEVELOPMENT OF THE FLUID TUTORIAL

The PFM tutorial was created to outline a systematic method of solving PFM problems, using a fluid calculation grid designed by one of us (M.J.P.) as the structure on which the instructional program was designed (Figure 1). Several educational techniques were used, including repetition and scaffolding. Each grid square was taught as a separate module and built on information learned in preceding modules, focusing the instruction on basic concepts rather than isolated facts. During the course of each module, students were frequently asked questions using interactive “pop quizzes” and were drilled regarding important concepts. Longer quizzes were used at the end of each module to ensure thorough understanding of the preceding material before advancing. This feedback provided students a way to measure their own performance and review materials based on their self-assessment. Students using the tutorial could enter any section of the grid at any time, which allowed students to set their own learning objectives within the framework of the structured lesson. The principles learned in the tutorial were immediately applicable to their work on the pediatric ward and could be put into practice quickly. The computer module was therefore consistent with many principles of adult learning theory.10

One author of the computer tutorial (M.J.P.) was a general pediatrician with 11 years of clinical and 9 years of medical education experience as pediatric clerkship director for third-year students. The other author (S.R.M.) was a certified physician assistant with 15 years’ experience in both clinical family medicine and medical education as an instructor of third-year medical students, who was pursuing a masters’ degree in education during the construction of the tutorial. This author’s computer programming skills were obtained through self-instruction, tutorials, and attendance at various computer education conferences. Both authors were engaged in full-time clinical and teaching practices in widely separate locations during the planning, writing, and pilot-testing of the tutorial. These competing responsibilities, as well as the necessity of exchange of data and revisions via the mail, extended the development time to approximately 6 months. Rather than being the result of continued consultations among a consortium of educators, computer programmers, and clinical specialists, this tutorial was a product of 2 active generalist clinician-educators who continued their practice and teaching roles while working on the program during their uncommitted time.

The tutorial was developed using Preceptor, a proprietary HyperCard-based high-level educational development environment written with HyperTalk. This application significantly truncated development time by allowing us to create learning modules as larger curriculum sections instead of creating individual screen cards one by one. The entire skeletal structure, including text fields, interactive buttons, content cards, and larger section-related programming code, was created automatically by Preceptor in minutes. Entering text into fields and content cards and designing the screen graphics became the most time-consuming part of the project.

NECESSARY COMPUTER RESOURCES

The PFM tutorial requires an Apple Macintosh 68030-based computer or better with at least 8 megabytes of RAM, 3 megabytes of free hard disk space, and Macintosh Operating System 7.1 or better. Because this is a stand-alone application, neither HyperCard nor HyperCard Player are required.

STUDY PARTICIPANTS

In each admitting class at the University of Illinois, 120 students begin instruction in basic sciences at the Urbana campus. At the end of the first year, approximately 50 students from this entering cohort enroll at each of the sites in Rockford and Peoria, the second and fourth largest cities in the state, respectively. Each city serves as the hub for medical care for its adjacent geographic region. These

RESULTS

On the multiple-choice examination, there was a highly significant difference in student scores, favoring the computer instruction group (81.1% vs 62.2%; $P<.001$)

COMMENT

Compared with similar students taught by traditional methods, students taught using computer methods had better performance, both on tests of factual knowledge of PFM and actual practical problem solving. This supports our hypothesis that a computer-based tutorial in PFM allows medical students to master these skills effectively. Our decision to use the computer as the sole formal means of teaching this topic was supported. The change in teaching technique did not place students at risk but rather seemed to give them an advantage, since this group obtained significantly higher test scores.

We did not administer pretests to the students in this cohort to determine their prior knowledge of PFM. Because none of the students had been previously enrolled
community-based campuses rely heavily on volunteer faculty. All students have similar second-year preclinical courses and pass the US Medical Licensing Examination Step 1 before advancing to clinical work. All clinical students have an 8-week pediatrics clerkship in the third year with the same course objectives, and use the National Board of Medical Examiners pediatric subject examination for grading and assessment. In both community sites students spend 4 weeks on a general pediatric ward, attend newborn nursery and ambulatory clinic sessions, and have exposure to pediatric subspecialists. No students in this cohort had any classroom or clinical exposure to pediatric fluid and electrolyte management techniques prior to the start of their pediatric clerkships.

All students receive instruction from house officers in addition to pediatric faculty: first-year family practice residents in Rockford and both pediatric and combined internal medicine and pediatric residents in all years of training in Peoria. The presence of upper-level pediatric residents gives the Peoria students an added source of reference that is not available in Rockford.

STUDY DESIGN

We gave the Rockford (computer instruction group) students 24-hour access to a personal computer (Macintosh, Apple Computer) and required them to finish the PFM tutorial by the end of the clerkship. Students arranged their own schedules to make independent use of the computer, completing as much of the program as they chose at any one session. The average time needed to complete the entire instructional unit was 4 hours.

Peoria (seminar group) students were taught by a pediatric critical care specialist who gave a 90-minute seminar. During the study period only 1 instructor gave this seminar. An extensive handout was provided before the session and references were provided for student use. These resources remained consistent throughout the study. The topics covered in the seminar and handouts were identical to the material taught in the computer program. During the lecture, the students were shown a single method to solve PFM problems, but the limited time in the classroom session prevented practice or drill. Students were encouraged to do this on their own and several practice cases were distributed. No efforts were made to evaluate whether students completed these practice cases. This teaching session was similar to the method used on the computer instruction group campus before the institution of the computerized tutorial.

To measure differences in student knowledge between these 2 groups, a 20-item multiple-choice examination about fluid therapy was given. In the seminar group, this was accomplished using a 1-hour written test near the end of the clerkship. In the computer instruction group, the identical multiple-choice examination was included within the computer program. This group completed the test any time after the conclusion of the computer-based instruction. Once the examination was started, the computer would not allow students to exit the examination section until all the test items were answered, preventing attempts to do additional review and get a better score. Each student’s score from their first attempt at the test was used for analysis in this study, but students were allowed to repeat the test as many times as desired.

To measure students’ ability to apply their knowledge to an actual case, we gave 2 free-answer fluid therapy problems to all students at the end of the clerkship. These involved determination of fluid maintenance requirements and plans for rehydration. Both questions outlined clinical situations that a house officer might encounter when admitting a dehydrated child to the hospital. For this section, all student responses were graded by a single evaluator using a predetermined key and grading form. This evaluator was kept blinded as to the community site of the students.

Both examinations were reviewed for validity, correctness, and appropriateness by the respective chairman of pediatrics at each campus. At the seminar group campus, the chairman had been responsible for fluid and electrolyte teaching for many years and confirmed that the content of the examinations was consistent with the method taught in that site and that the answer key was correct. Results from each of these examinations were tabulated and data were compared using 2-tailed Student t tests.

The differences seen in this study may be due in part to the increase in time needed to complete all parts of the computer program. The amount of time the students spent studying fluids and electrolytes in the seminar group cannot be determined. If seminar students attended the scheduled session and did not complete any additional supplemental reading or practice, their computer instruction colleagues would spend more than twice the time studying PFM. If this occurred, differences in learning and test performance between the groups in the manner we found would be expected. Also, although in the seminar group campus lecture attendance is required and traditionally has been close to 90%, we cannot determine whether any particular individual student attended the seminar. Clearly computer instruction students would be favored if the seminar students did not attend the instructional session. The presence of these effects and their importance to the outcomes seen cannot be precisely quantified by our study.

Different student evaluation methods between the campuses may account for some of the observed differ-
ences in scores. It is possible that by insisting on completion of the computer program, faculty give added emphasis to PFM. While seminar group faculty also find this subject important, the teaching session is only one of many lectures and thus students at that site may not attach any added significance to the subject.

Differences between the groups on the multiple-choice examination may be due to the computer instruction students completing their test immediately after the conclusion of the instruction, rather than at the end of the clerkship as in the seminar group. However, since both groups completed the free-answer examination at the end of the term, this second independent examination would not have been similarly affected. Computer instruction students scored higher on both of the examinations and with differences that are of similar size, so this effect is probably small.

Students in the seminar group completed their multiple-choice examination under proctored conditions. In the computer instruction group, the multiple-choice examination was only accessible on a single computer housed in a small cubicle in close proximity to the departmental secretary to discourage cheating. However, these students were not directly proctored.

At the end of the clerkship, the computer instruction students had an essay examination testing their knowledge of 6 core topics in general pediatrics, while seminar students did not have this test. Computer instruction students are told that the essay examination will include a fluid problem, which probably draws greater attention to the topic. If the seminar group had a similar essay examination, it is possible that the difference between the sites would be less marked.

Alternatively, these findings may be due to our decision to teach a single method for solving fluid problems, with the computer serving as a means to provide students with practice in this method, rather than a result of the use of the computer itself. If a standard approach to fluid therapy calculations was taught using traditional methods, it might clarify this question.

If the content was subdivided into several focused sessions, with each part having assigned problems for practice and drill, similar to a mathematics class, a different outcome might be obtained. However, it is doubtful that this could be accomplished in the context of a third-year pediatrics clerkship. This idea could be tested using nonphysician teachers to give the lessons during the preclinical years. Such a trial might shed light on the question of whether the difference between the study groups is due to the use of the computer to deliver the instruction, or instead to the act of teaching a standard method of operation to the students.

The computer tutorial in fluid therapy has been an effective means of meeting the defined objectives of the pediatric clerkship. Compared with traditional methods, students taught using the computer achieved significantly higher scores on tests of both factual knowledge and practical problem solving.

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