RÅDET FÖR HÖGRE UTBILDNING
COUNCIL FOR THE RENEWAL OF HIGHER EDUCATION

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Computer Based Simulation in Pediatric Emergency Care

Abstract

Objectives

To give the student a better understanding of emergency paediatrics (or of other medical specialities) by means of computer simulation of clinical cases.

To develop a tool for examining students in medical disciplines (e.g., paediatrics) using computer simulation during Objective Structured Clinical Examinations (OSCEs). See Bouhuijs and co-workers (Medical Teacher, 9, 183-191).

The Problem

Although both theoretical and practical skills are important aspects of medical training, it is rarely possible to train independent decision making, as a more experienced doctor is always formally responsible. Moreover, it is seldom possible to train the management of the severely ill as not only are such patients scarce but naturally they are even more in need of an experienced physician.

Nonetheless, all doctors must have certain procedures and treatment alternatives at their fingertips, despite the practical difficulty of training them to manage these situations in practice. One way is by using dolls or volunteers during emergency or accident training programs, though this is a cumbersome procedure. Thus, there is no readily available and simple teaching tool that can be used to provide this kind of training.

The Solution

The solution is to develop a program package divided into two parts. The Emergency Writer is the first part being developed in which the teacher designs the cases that will be presented to the student. The cases created with this powerful tool are linked together to lessons. They will be constructed in collaboration with other paediatric departments in Sweden. The second part will be the Emergency Paediatrics, which will present the cases to the student. The Emergency Paediatrics is under preparation and the Emergency Writer is completed.

The medical students may choose English or Swedish as language for their training. It will be possible to choose a new lesson or to restart an old one. In examination mode the software only gives limited feedback and forces the student to complete a given lesson. The student has access to a log of all events during a lesson and a summary statistics.

The Emergency Writer has been demonstrated during the Medcal conference in Malmö in April 1996.

Computer-Based Patient Simulation - A New Way of Teaching and Examining in Emergency Medicine

Introduction

We have already developed a Patient Simulator for use with a Macintosh computer, a version that has been used as a teaching aid in our emergency paediatrics course since 1989. The program was demonstrated for the Council for the Renewal of Undergraduate Education during a meeting in February 1994. We have now developed a software compatible with IBM PC by the support of the Council. The software consists of Emergency Writer, where the teacher can create and modify lessons containing an arbitrary number of cases. The student uses instead Emergency Paediatrics for training. The two pieces of software uses the same database concurrently. The knowledge database is currently being set up by the Departments of Paediatrics in Malmö and is planned to contain 15 diseases to cover basic paediatric training. In addition, we will be collaborating with the other Universities in Sweden teaching paediatrics.

The Project Leaders

Carl-Erik Flodmark is Assistant Professor and Tomas Sveger is Associate Professor of the Department of Paediatrics in Malmö. Mikael Ericsson is a program engineer.

Objectives of the Project

To give the student a better understanding of emergency paediatrics (or in the future of other medical specialities) by means of computer simulation of clinical cases.

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Nonetheless, all doctors must have certain procedures and treatment alternatives at their fingertips, despite the practical difficulty of training them to manage these situations in practice. One way is by using dolls or volunteers during emergency or accident training programs, though this is a cumbersome procedure. Thus, there is no readily available and simple teaching tool that can be used to provide this kind of training.

The training of aeroplane pilots involves similar difficulties. Certain manual skills must be reflexive, e.g., dealing with a fire without previous experience of this situation as it rarely occurs. Thus, during the training of a pilot, computer simulation is a crucial adjunct to the consolidation of essential manual skills.

In a similar manner the professional skills of a doctor, for instance in dealing with cardiac arrest, have to be consolidated. Opportunities for the practical training of medical students in dealing with such situations are of course very rare.

Likewise, it is difficult to examine students in emergency medicine owing to the relative rareness of the cases and the need of an experienced doctor in the immediate care of the patient. Moreover, in paediatrics it is difficult to persuade the patient to volunteer for numerous serial examinations such as are needed during OSCEs to obtain uniformity of the procedure.

Finally, using computer simulation it is much easier to assess a student's progress.

Hypothesis

Using computer simulation in emergency medicine, the student's development of intuitive and conceptual understanding will be better than is possible with traditional teaching methods in this field.

In addition, the examination of students may also be less susceptible to bias than is the case in traditional teaching.

A sound development principle

The patient simulator is different from those described in reports elicited by our literature search (see below), which usually comprise a limited number of cases where the diagnostic and treatment alternatives increase exponentially.

By contrast, our approach is based on the use of a virtually unlimited number of possible case presentations, where the clinical picture and such factors as the patient's weight and age are variable without entailing exponential increase in the diagnostic and treatment alternatives, and thus avoiding the necessity of a massive data base in constructing the program. The number of cases will be limited initially, but as the teacher will be able to add data from his own cases it is possible to expand the database through collaboration between teachers.

The cases are illustrated by pictures in colour or, if appropriate, presented as short-videotaped sequences.
The student communicates interactively with the program and is furnished with feedback regarding his performance as appropriate.

The student's interaction with the program is divided into tutorial sessions, culminating in an examination session where his/her knowledge and performance are evaluated by the student and the teacher using the detailed log created by the software.

The examination of students

As contact with the patient is a focus during OSCEs, hitherto computerised case simulations have been avoided. However, this focus is not possible when it is question of training a student in the examination of critically ill patients, as they are often unconscious and/or in immediate need of life-support procedures. Thus, contact with the patient is not a factor of primary interest.

Using a computerised tool for examination it may be easier to create an objective examination situation. To this end, the computer simulation must be a valid picture of reality and the individual student has to understand the differences between reality and simulation, and the limitations imposed by the simplification of reality. The students test this during the development of the knowledge database.

The technical solution - a summary

The program has been developed using Microsoft Visual Basic software in a manner facilitating its modification to render it compatible with other (present or future) operating systems.
As the source code of the program is 100 % self-developed, payment of royalties is avoided, thus promoting the spread of the patient simulator and its use by all medical faculties. Moreover, as the instructor can supplement the database with his own cases, it is possible to use the program in other countries. Furthermore, the drug database uses the ATC system for classification, a WHO standard.

The patient simulator makes full use of the Microsoft Windows facilities and graphics options. The user communicates with the patient simulator with mouse, clicking on variant items in the user interface such as radio buttons, check boxes, and scroll bars. The user interface should be as intuitively as possible. For this reason cartoons with balloons as a frame for radio buttons,

check boxes, and scroll bars. The setting is an emergency unit comprising different cubicles with a patient in each. The teacher can decide the appropriate number of cubicles for each lesson. The user chooses which patients to treat and in which order. The patient simulations are presented in parallel, and in real time with respect to the medical events, actions of the user, the user's level of competence The patients are displayed on the screen in high resolution graphics, enabling the pictures to be used as part of the medical evaluation, if appropriate. Also a series of standardised pictures different by age and sex and appearance (cyanotic, icteric etc.) is provided when detailed medical information from the picture is not necessary. The pictures change with every medical event or user action, and can be complemented with sound or speech as required. All the data base information such as diagnosis, drugs and medical equipment are stored in a relational database. The data is organised in tables and structured with a key index to facilitate rapid searches for information and the avoidance of redundant data. The patients and their diagnoses are selected by the computer at random, but are presented in accordance with specific logical rules. This makes it possible to obtain a large number of patients with a wide variety of diseases.

The organisation of the database and the search rules govern the course of the disease. It is possible to create chains of events for progress of a disease but also for improvement. The different chains may be linked.

The user may choose different levels according to the user's level of competence. The differences are not only the speed of the software but also the delay in the feedback to the user. Upon completion of the session the teacher evaluates all events both from medical and ethical points of view using the detailed log.

The significance of the project
Ference Marton has shown the importance of computer simulation in the education of engineers ("Computer Simulation As A Tool For Developing Intuitive And Conceptual Understanding" no. 1991:03 "Datapedagogiska notiser 12 från Göteborgs universitet" (ISSN 0282-2156)). Our program should be of importance in introducing this technique in the field of emergency medicine.

Moreover, the use of computer simulations in OSCEs constitutes a new alternative for the instructor responsible for constructing appropriate test situations.

Similar Projects

No other projects that combine simulation of an endless number of presentations in an OSCE are taken up in Medline (the computerised medical data base available on line). The following reports of related projects have been published:

- Tanner TB and Gitlow S (Proc Annu Symp Comput Appl Med Care 1991 pp. 894-6) describe software, run with the Windows 3.0 graphical user interface (GUI), simulating typical cardiac emergencies. It has not been used for examination, however.
- Schwid HA and ODonnell D (Anaesthesiology 1992 pp. 495-501) describe a software simulating emergency situations and their outcome, and used in testing registrars in anaesthesiology, faculty anaesthesiologists and anaesthesiologists in private practice. Even anaesthesiologists with years of experience made serious errors. This could be explained by lack of congruence between the computer simulation and reality. The program was not used in undergraduate education, however.
- Harless WG and co-workers (Acad Med 1990 pp. 327-33), using an interactive videodisk patient simulation model, showed that the students tested became personally committed to the care and management of the simulated patient. The program formed part of the final examination but required very advanced ("high-tech") equipment. Only two case simulations were produced. The user interface was the focus of the study.

Saliterman SS (Mayo Clin Proc 1990 pp. 968-78) has used a computerised simulator for critical care training, coupled to a replica of the human torso. The software was not evaluated as an examination tool.

- MacKinnon GE (Am J Hops Pharm 1992 pp. 2740-45) has used computerised simulation of five patients for hospital pharmacists with good results.
- Finally, Mulligan R (J Dent Educ pp. 16-24) compared computerised training with conventional training of dentists. The computer training manifested a tendency towards better results.

Our patient simulator for use with Macintosh hardware has been evaluated by the first 59 students to test it. They indicated their assessments on visual analogue scales from 1 to 10, where 1 denoted complete disagreement with the items and 10 complete agreement. The results, given as means ± standard deviations were as follows:

The software has given me valuable medical knowledge 6,7±2,0 SD
The software is easy to use 9,0±1,8 SD
This type of education should be expanded 8,6±1,9 SD
The function of the former Patient Simulator
The program is constructed with 4th Dimension software for Macintosh hardware. It contains an unlimited number of case presentations of different paediatric diseases.
Five patients of different age, weight and sex are randomly presented at the beginning of each session.

The patient's condition deteriorates when the treatment is inappropriate or if a specified period of time has elapsed without appropriate action by the user. Findings during physical examination of the patient are reflected in changes, and this is illustrated with a new picture (as necessary). The patient may be admitted to hospital or sent home when cured or improved. After this a new patient will

enter the room.
The effectiveness of the student is indicated by the number of cases given appropriate treatment in a given period of time.
The student may choose different degrees of difficulty.

Methods

General

The project is divided into eight major parts (A, B, C, D, E, F, G and H).
A to C are further divided into the following items:

- The model to structure the knowledge base
- The creation of the relational data base
- The storage of the knowledge system (i.e., the relational data base combined with the rules governing its use)
- The Emergency Writer
- The photographic pictures
- The Emergency Paediatrics
- The core that processes all events
- Evaluation of the student's performance

Each item on the list is explained below:

The model used to structure the knowledge

As generally applicable as possible a model of how to structure the medical knowledge is created and tested using our present version.

The creation of the relational database

The different ways of constructing the data base have been considered carefully. Different aspects such as minimum average search time, effective use of storage space, etc. have been taken into consideration. The amount of information the database can store is dependent on computer capacity, i.e., free storage-space on the hard disk. The database containing 15 cases would approximately take 10-20 Mb hard disk space.

The storage of the knowledge system

The storage of data is based on the structural model mentioned above. The information is divided into tables with the normal relational data base rules. As the first priority is the search speed, the index keys are of prime importance. The inclusion of redundant data is minimised.

The Emergency Writer

The entry of new patients is as simple and logical as possible. This has been achieved by means of a sophisticated user interface permitting selection from values pre-set either by the software or by the teacher. The instructor can use information already stored to create similar cases by advanced copy and paste functions.

The photographic pictures

High-resolution colour graphics is used for the presentation of the patients. The adoption of a device-independent technique facilitates the use of all kinds of equipment such as video and sound recordings besides photographic pictures. Moreover the appropriate graphics mode will be taken into consideration. The

pictures will be compressed provided decompressing them does not restrict speed.

The Emergency Paediatrics
The user interface is easy to understand. To achieve this, the interactions is based on the concepts of cartoons. This means the balloons indicate who is talking and who's action is performed. Within the balloons radio buttons, check boxes, and scroll bars are used. The students opinions has been taken into account and will be used continuously.

The core that processes all events
The core has been tested for functional capacity and reliability. This testing will continue to get a version that is as reliable as possible. Forestalling the effects of user errors has been an important aspect.

Evaluation of the student's performance
First, knowledge of therapeutic and diagnostic procedures and their appropriate application but also the use of drugs is tested. Secondly, during the test situation the student is supervised by the examiner who may also check the student's reasoning for therapeutic choices. The student's knowledge in emergency paediatrics will be assessed in relation to the extent of his/her practice with the program.
It will be possible for the student to receive an evaluation of all events, which can either be printed out on paper or saved in the database. There are two types of evaluations. During the treatment of the patients an overall log will be presented for the student on screen. After the sessions have been closed a more detailed log can be printed out for discussion with the teacher. It is also possible to save the session and continue later. Each student can save his own lessons. The teacher can clear the records when necessary.

The project phases:
A. Pilot study
All the components listed above were scrutinised and the technical solutions were evaluated.
B. System analysis
Analysis of the items listed above for the purpose of programming.
C. Programming
The programming of the software.
D. Software testing
The software was using the core of cases. Students and other users were invited to test the system.
E. Construction of the cases
A limited number of cases have been put into the data base to test all aspects of the program. After the program was rid of any major bugs or other problems, the medical knowledge in emergency paediatrics is currently being added to the data base, divided into different lessons.
F. Using the software in OSCEs
The program will be used in examining students after a sufficient number of

lessons have been constructed. The proper way of using the simulation tool will be established with the help of students' performance during examinations. This phase of the project has not yet started but is fully financed by the Department of Paediatrics in Malmö and nation-wide when appropriate.

G. Documentation

The project has been documented according to the items mentioned below under "Documentation" (i.e., the process, the result and the manuals). Yearly reports have been sent to the Council. The costs have followed the initial plan. However, the costs for the project itself had to be cut down due to that costs for participation in conferences was not included in the project plan. Later during the project the Council paid for the participation in conferences.

H. Evaluation

The software will be evaluated both according to the construction itself and the educational outcome. See below under "Evaluation".

TIME SCHEDULE

The time schedule could be followed regarding the production of the software. However, the savings for the Department of Paediatrics in Malmö made it necessary for the project leader to work part time with software development and part time with regular education and hospital care. This has lead to a delay in the development of the database and the use of the software in examination.

DOCUMENTATION

The process

The project has been documented with a project-planning tool. The time schedule was regularly checked according to plan, the costs being followed in the same way.

The future

The use of the software will be integrated in the curriculum and possibly in form of an examination in paediatrics. The OSCEs might be a regular part of the examination procedure at the departments responsible, at the University of Lund, University Hospital MAS, and after collaboration with all the other Universities teaching paediatrics it will go nation-wide. A conference will be held in Malmö during spring 98 where the software will be presented for the director of studies in paediatrics in Sweden.

The manuals
The software is documented by help file for use by students, and another help file is provided for the teacher's use in case construction.

EVALUATION

The students' opinions regarding the teaching at the department will be regularly evaluated by questionnaire, special items of which will concern the use of OSCEs constructed with the software. This will be done by the involved Departments of Paediatrics.

In addition an evaluation performed by the Council is suggested as follows.
A cost benefit analysis of how effective the construction of the software has proved, as compared with using regular computer programmers.
The introduction of this software to other instructors and their construction of cases could be monitored, thus enabling comparisons to be made between students' performance at different universities.

Summary

The aim of the present project is to develop and evaluate a networked interactive curriculum in periodontology for undergraduate students of Oral Health Sciences. Developments of computer technology and the hypertext mark up language (html) allow for an interactive presentation of text, images, sound and video. The scientific and clinical development is rapid and there is a strong need for continuous updating of educational material. The ease by which the material can be updated electronically makes the html technology an excellent instrument for institutions to provide undergraduate as well as postgraduate students with relevant learning material.

A workshop in Interactive Periodontology is organised as a start for the project. Educational sessions are designed using a combination of problem-based learning (PBL), teacher consultations and electronically mediated hypermedia documents. Hypermedia documents are developed in various areas. Text, images, voice and video sections are imbedded in the documents. The material will be accessible over Internet using the html technology, and links to relevant external material will be included. Students at the participating institutions are provided with Internet access and computer multimedia facilities.
Students are planned to be involved in the establishment of the documents and to work in the project. Email and interactive programmes will be used for communication between students and teachers. However great effort will also be taken to provide direct personal contact between the students and the teachers.

The project will be evaluated by determination of the knowledge and skills of the students participating as well as interviews of teachers and students. Statistical follow up of the use of the electronic documents will be undertaken. Forms for evaluation will be provided over Internet. Time used for writing and

testing the documents will be recorded and an estimation of costs involved performed. The evaluation of the project will be continuously reported at an Internet address.

The participants in the project are divided into a project team and a quality team with individuals from various countries. The development of interactive instruments for learning is expected to increase the learning effect of the studies. The availability and continuous updating of the electronically provided material will serve to reduce the gap between the knowledge fronts and the material traditionally used for teaching.