Interactive simulated patient—an advanced tool for student-activated learning in medicine and healthcare

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Abstract

An advanced learning system for interactive simulation of patient cases (ISP) is described. The system was designed to meet specific pedagogical needs where student activation and problem orientation were two of the key issues. The system includes features such as video based illness history-taking function using free text input, highly interactive physiological examination procedures, extensive laboratory tests and detailed user feedback. The system was constructed mainly in Authorware Professional, starting more than 10 years ago, and it is now available in refined versions in different languages. Twelve pedagogical and three technical features were initially defined for the project. All of these aims were fulfilled. The ISP system has been successfully used in education, and in international collaboration, including three applicability field tests. The system is also a powerful research tool for studying for instance medical decision-making.

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1. Introduction

The clinical encounter between the patient and the professional is crucial in all healthcare areas. Typically, students train for this encounter by meeting real patients in the university hospitals. However, for a number of reasons, it has become more and more complicated to accomplish this in recent years. It is an increasing problem in most developed countries that university clinics lack “good educational cases”. This is because most “normal” patient cases are now handled outside the university clinics. Another important reason is the shortened clinical periods for the students.
at each department; new subject areas pressure the curriculum. A third reason is that ethical considerations make some patients unsuitable for students. Other factors including patients’ willingness further limit the number of real cases available (Eagles, Calder, Nicoll, & Sclore, 2001; Finkelstein, Johnson, & Lilly, 1991; Garret & Callear, 2001; Gordon, Wilkerson, Williamson Shaffer, & Armstrong, 2001; Hooper, O’Connor, & Cheesmar, 1998).

This means that students on most programmes in the health care sector (including but not limited to medicine, dentistry, physiotherapy and nursing) are meeting fewer and fewer real patients. When they meet these patients other factors, including economy and experience, limit the potential for the positive learning outcomes normally associated with real patient encounters. These and other problems have led to the search for new case-based learning methods like standardized patients (real human actors), which are used at many universities in the world. However human actors are associated with high costs for training, delivery and management (Hubal, Kizakevich, Guinn, Merino, & West, 2000). Additionally, a human actor is not optimal when the educational goal also covers different laboratory tests, X-rays or physical exams linked to pathological heart sounds etc (Hubal et al., 2000). Moreover, a full diagnostic procedure cannot be tested with standardized patients.

This has led to experiments with computer-based case presentations, or computer simulation of cases (CSC) as it often is called. Over the years several systems have been developed, such as simulations for medical lectures (Harless, Zier, Smith, Dube, Duncan, & Ayers, 1992), web-based case presentations (Hayes & Lehman 1996), and systems for postoperative nursing care planning (Hjelm-Karlsson & Stenbeck, 1997). However, many of them have limitations concerning realism, interactivity or applicability (Bergin & Fors, 1992; Vick & Birdwell-Miller, 1998). Recently, a simulation system using “avatars”, a 3-dimensional representation of a person, has been published, where the use of completely virtual (animated) methods for the training of patient history taking is suggested (Hubal et al., 2000). However, this technique has not been tested in real student courses.

With the introduction of multimedia the authoring tools have also been made user-friendlier, allowing both easier and faster development of highly interactive simulation systems. Because of this, and inspired by the early collaboration with Dr. William Harless around the CASE-system (Bergin, Helmers, Sten, Wester, & Widman, 1981; Harless, Drennon, Marxer, Root, & Miller, 1971), we started to develop a new series of advanced simulation tools at Karolinska Institutet (KI) in 1990, called Interactive Simulated Patient, ISP (Fors & Bergin, 1996; Bergin, 2000). This system was constructed in such a way that it is possible to simulate virtually any part of the interaction between the simulated patient case and the users, including an interactive dialogue with the “patient”, a physical examination and laboratory tests.

The ISP project initially focused on creating a specific pedagogical setting with advanced and up-to-date technology. The system is not designed to replace any real patient encounters. One aim is to allow students to manage a clinical encounter with complete test resources as realistically as possible, in ways that are not possible with real patients. The pedagogical base and the system design have served as a model and base for other systems in the department such as systems for education in dermatology, in kidney diseases and even for petroleum geology. One recent example is the project ISP-VL, an instance of international cooperation between the Stanford School of Medicine in the United States, on one side and KI and Uppsala University in Sweden on the other. In that project the ISP-system was translated to English, refined and modified to suit specific demands. Specific results from that project will be published separately.
The aim of this paper is to present the pedagogical intentions, the system design, the technological achievements and finally some field tests performed by students.

2. Initial construction phase

2.1. Intentions

The construction of the ISP system began in 1990 and a number of features were determined to be important for fulfilling the educational goals of the Karolinska Institutet. The most important of these pedagogical criteria were:

1. The system should stimulate student-activated learning methods.
2. The system should stimulate collaborative learning.
3. The system should support problem-based learning (PBL).
4. The system should make the simulation of the clinical encounter as realistic as possible, with as few restrictions in user freedom as possible.
5. The system should enable the presentation of cases concerning most illnesses and disorders.
6. The cases should be usable for students of medicine, dentistry and nursing as well as other areas.
7. The simulation should contain a free patient history function using natural language.
8. Most examination and laboratory techniques clinically available should be incorporated into the system, including a full physical examination capability and most lab tests and imaging techniques available in a major hospital.
9. The result of laboratory examinations should be accompanied by the cost for the examination.
10. The system should also give the user detailed feedback at the end of the sessions.
11. It should be able to track a students’ use of the system in detail, enabling a teacher to follow a user’s problem-solving strategy.
12. The system should be compatible with use for examination purposes.

There were also several technological requirements that should be fulfilled including:

1. The system should run on both Windows and Macintosh computers.
2. The system should be modular so that new features and new patient cases can easily be added.
3. Accessible development tools should be used so that even teachers with minimal programming knowledge could work with some modules on their own.

This list of pedagogical and technological features was then used as an important foundation when starting the system development (Bergin, 2000).

2.2. Design phase

The project started with an extensive literature search, exploration of the market and discussions with professional multimedia developers to try to find suitable development tools and strategies for implementation.
Regarding authoring systems of choice, there were several available in the early 1990s including, HyperCard, SuperCard, Authorware Professional, Macromedia Director, Icon Author and IBM's LinkWay and AVC (Audio Visual Connection). Also pure programming languages were considered as possible candidates. However, taking into account the earlier technical criteria 1–3, together with some of the pedagogical criteria, there were very few to choose from, in fact none of the earlier systems fulfilled all these criteria. The system that seemed to be most promising and also had a number of other positive characteristics was Authorware Professional. At that time this was a new system used to create an initial prototype for testing both the ideas behind the ISP system and the tool itself. This icon-based system is today available in version 6 and supports all three major platforms, Windows, Mac and the Web.

To develop the ISP system, a number of different specialists were contracted, and a project group consisting of more than 20 people was formed, including multimedia experts, video and audio technicians, photographers, illustrators, animators, programmers, designers and most important, pedagogical and medical experts. A very important group of students was also formed with the main responsibility for testing and continuously evaluating the system. The student group has changed over the years, but has mostly been comprised between two and five students at different clinical levels at KI. During the field tests in the United States, a number of students were also recruited locally at Stanford University. All of the development work was performed in-house at Karolinska Institutet’s department of Medical Informatics and Educational Development, which had most of all necessary personnel, except the medical domain experts. The experts/teachers furnished the project with suggestions of cases, clinical images and all other necessary data, including lab values and X-ray images.

A detailed manuscript including patient history questions and answers, laboratory data and physiological examination data was created for one pilot case. This manuscript then served as a template for the other cases. Every patient case is constructed from a combination of real and fictive patient-history questions, clinical photos and video clips of professional models and actors acting as patients, X-ray images of real but anonymous patients and a number of other sources. No real patient photos or videos are used. The models are contracted to allow all photographs and videos to be used for medical educational purposes, including the Web.

Most of this work was rather straightforward, although time consuming. For example, to get all the 500–600 necessary X-ray and other images of a “normal” and not pathological condition was harder than anticipated. After searching the complete imaging archive of one of the major hospitals at Karolinska Institutet, most of the necessary images have been found. All images were analogue when given to us, and then digitized at a major commercial photographic laboratory, using PhotoCD Pro as storage format. In the ISP system, all images are compressed in to 24-bit JPEG format.

The percussion and auscultation sounds needed were obtained from two healthy persons in the development team, the sounds were recorded in analogue format and then digitized, filtered and stored as WAV or AIFF files.

To develop the most difficult part, the patient history function, a manuscript consisting of around two hundred common questions and their corresponding answer was constructed for each case. Usually this was created from the imagination of the project leader, who is also a physician. The process was supported by dialogue with a specialist in the field. The manuscript was then used to record all answers from an actor on videotape, which is digitized and stored in Apple QuickTime format.
2.3. Initial refinement

The group of students mentioned earlier was used to test and refine the history function for all cases. The detailed log files and oral comments from the students were used as feedback for further development. Then a new version was created, which was used for new tests and refinements until a satisfactory functionality was reached. The design and development of the other parts, including physical examination and laboratory tests, were performed using conventional multimedia programming techniques. This was always done in collaboration with teachers, clinicians and the student group, who furnished the project with constant feedback and constructive critique.

All cases were based on a “normal” case with normal lab tests and physical examination findings, allowing the developing team to only change a limited number of data that were specific for individual cases.

2.4. Technical achievements

The system developed contains these main features:

- A free-text driven, patient-history function in natural language with all patient responses to the user questions made by digital video clips.
- A detailed physical examination including inspection, auscultation, palpation, neurology, percussion, reflexes and more, interactively applicable on all parts of the body.
- A complete set of laboratory tests, including more than a thousand chem. lab tests, pathology lab tests, microbiology, MR, CT and X-ray images and endoscopic procedures.
- The laboratory results are presented with costs for the examinations, with a running total for the whole procedure.
- A user-adjustable notes function including all results from the patient history, physical examination and lab tests as well as an individualized user-notebook function.
- An interactive diagnosis proposal function.
- A detailed feedback function.
- An information central with literature references, ISP-VL chat site and an integrated Medline search engine.
- A complete and detailed log of individual user interactions.

All functions are freely chosen by the user and are available at any time, except the detailed feedback, which is displayed only when the user has proposed a diagnosis.

The layout of the patient-history function is displayed in Fig. 1. The user enters the question in free text using the keyboard. After pressing the Enter-key, the corresponding video clip is displayed for the user. The system uses a large set of video clips (more than 200 per case), which corresponds to nearly a thousand different question possibilities. Limited misspellings are tolerated. Using combination of clips and a “semi-intelligent” data base function, the simulated patient can “react” to repeated questions, on sexual harassment and other unwanted questions by showing frustration, by becoming angry and even by leaving the physician’s office. To some extent the simulated patient can also interact “spontaneously” with the user, especially if the user does not ask any questions for a long time.
An integrated help function is also available, based on the US medical “Bates guide” (Bickley & Hoekelman, 1999) assisting less experienced students in the choice of questions from a menu system.

The physical examination is steered by the user selecting first what type of examination is wanted (inspection, palpation, auscultation, temperature, pulse/blood pressure or reflexes), then selecting which body part to apply the exam on. The examination technique or body part can be changed at any time. In Fig. 2 is a typical examination procedure showed.

Laboratory tests are chosen by the user from a lab menu, displayed in Fig. 3. Ten groups of laboratory tests are available, covering more than a thousand different tests and including Chemical, Pharmacological, X-ray and other imaging labs, Microbiology, Immunology and Endoscopy tests and more.

When the user is ready to submit a proposal of a diagnosis, the proposal is entered in free text in the interactive diagnosis proposal function. If correct, or within acceptable limits, a short description of the actual case is given, with medical background and discussion of differential diagnostic procedures. If any of a number of predetermined incorrect proposals is given, short feedback is given upon that particular diagnosis, followed by an option to continue with the case. To promote reflection, the users are also asked to motivate their preliminary diagnosis.

The user can at any time call for feedback in the Feedback module. However, to avoid revealing the actual case’s correct diagnose before the user has entered a proposal, the feedback is very limited before that event has occurred. Additional feedback is also given on unnecessary or potentially harmful investigations that are carried out and also on the cost of lab tests ordered, see Fig. 4.
The case simulations available today are concentrated in five areas, representing central issues within medical education and areas where important discussions on varying diagnoses could be held. The areas are Internal medicine, Surgery, Dentistry, Ear, nose and throat (ENT) diseases and Infectious diseases. All together, more than 20 different cases are available today in Swedish and English. Translation of the system into French and Spanish has begun.

3. Initial field tests

3.1. Method

The ISP system has been applied in a number of different course settings in a number of universities in Sweden and in the USA. Most of these settings used different versions of the system for initial prototyping and refinement. The system has also been applied as a support tool in a number of routine courses at two Swedish and one American university.

Furthermore, three special field tests of the system have been performed. These applicability tests were performed in the years 1999, 2000 and 2001, where the objectives were to assess the general opinions of the users (students) as well as to study a number of specific questions regarding both the system as such and the learning possibilities for ISP.
As the system is designed to give students control of the clinical encounter, it was very tempting also to give them control over some of the evaluations. Three student volunteers were given resources to perform evaluations including limited access to senior teachers and pedagogical experts. They were largely free to design the evaluations themselves. The results of their evaluations were published in internal reports at the department, but excerpts are given later. Their sub-

Fig. 3. The laboratory module. Above, the chemical lab tests are ordered from a list. Bottom, an example of the result of another lab, an X-Ray of the sinuses.

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jects (students) were mainly recruited through local advertisements at the hospitals. They received a small fee for their participation—a fee corresponding for example to two tickets to a cinema.

In test 1 (1999), students at one university hospital in Stockholm were asked to join as volunteers. The invitation to participate was made after a brief presentation of the aims of the ISP system, given after a lecture. The 17 students that accepted this invitation were all studying on the MD program at Karolinska Institutet. Thirteen were enrolled in semester five, three in semester seven and one in the ninth semester. The MD program at KI is 11 semesters long and clinical contacts start in the fifth semester. The group was comprised of six male and 11 female students with the median age of 24.

In test 2 (2000), 23 students from semester six, seven or eight of the MD program at the Karolinska Institutet participated. Thirteen were male and 10 female. Median age was 24.

In test 3 (2001), 30 students from the MD program at Lund University in the south of Sweden volunteered. Sixteen were studying on the tenth semester and 14 on the sixth. Thirteen were men and 17 female students. The program at Lund also totals 11 semesters with clinical contacts starting in semester five. Median age was not compiled here.

All three of these tests were conducted as 90–120 min sessions. The ISP system was first briefly demonstrated for the whole group, followed by the individual work with the ISP case “Britt”. The purpose of the field test and the general aim of the ISP system were presented to the students beforehand.

The students (who all were more or less used to working with both real patients and paper based patient cases) were instructed to try to “solve” the case as if it was a real patient, using all the possibilities of the system in any order and finally to suggest a suitable diagnosis of the case.
After finishing, all students were asked to fill in a paper-based questionnaire. In tests 2 and 3, the students were also interviewed by the test-leader. During these interviews, a number of structured questions were asked regarding opinions about the ISP system as a learning tool, with slight variation across the field tests, but there was also free data collection.

The questionnaires contained selected questions regarding prior computer knowledge, patient contacts, ideas about the ISP system interface (like ease-of-use) and finally also questions regarding the learning possibilities with ISP. The questionnaires contained 20–30 different questions where the students were told to answer by choosing any number of a seven-point scale (or in study 1, a 10-point scale). As the field tests were performed as individual elective projects, more or less driven by the individual test-leader students, the questions differed in the three studies. Nevertheless, some questions were common to all three studies. Furthermore it was also possible to add free text comments to most of the answers.

3.2. Results

During the three tests, 70 students participated (30 from Lund and 40 from KI). All of the participating students went through the whole ISP system and all of them also “solved” the case (as measured by submitting a correct diagnosis). As indicated in the questionnaires, the general opinion of the students was very positive to ISP. Many of the questions were directed towards the technical refinement of the system. The 10 questions of most pedagogical relevance are given in Table 1 (the questions are translated from Swedish).

When examining the free-text inputs from the students, a number of different individual comments were given, which mostly were positive.

Some examples of positive comments:

- The system feels very comprehensive—fun way to study—good level of difficulty.
- ISP gives a complete presentation of a case—information about what you should have done and what you really did—nice.
- Good with a detailed feedback—good to see the costs and to be able to auscultate the heart and lungs in several places.
- Good with prices on lab tests—positive that the ISP patient could be as irritated as real patients can be.
- Good to be able to ask any question—good to be able to order any lab test and perform any phys exam.
- ISP mimics the real situation at a local clinic—good exercise.
- Britt had a realistic illness—realistic and good way to train—active way to train.

Some examples of less positive comments:

- Britt could not answer all questions—she was got irritated a little too easily.
- The patient did not understand all follow-up questions.
- I miss the possibility of employing some surgical examination methods.
- I would like to be able to measure blood pressure when the patient was lying down.
- Hard to find some lab tests in the long list.
In conclusion, the questionnaires and the interviews revealed that most students were very positive to the ISP system and the way it presents cases. However, the patient-history interview should, if possible, be refined and a more clear lab list be prepared. Most of the students stated that they would like to have more cases like ISP in their future training.

There were no major differences between the three universities in these results.

4. Discussion

4.1. Technical aspects

As is pointed out earlier, the preferred method in medical education is mostly seen as using real patients for learning how to solve clinical medical problems (Dammers, Spencer, & Thomas, 2001). However, a number of studies indicate an increasingly limited access to real cases, and a number of patient simulation systems have been developed over the years to increase the access to patient cases for learning. This shortage follows from a declining number of appropriately complicated patient cases at the university hospitals, ethical considerations and limitations in time and money (Eagles et al., 2001; Finkelstein et al., 1991; Garret & Callear, 2001; Hjelm-Karlsson & Stenbeck, 1997; Hooper et al., 1998; Hubal et al., 2000; Rendas, Pinto, & Gamboa, 1999;
Sakowski, Rich, & Turner, 2001). Most of the case simulation systems available today are limited in user interaction and freedom of use and seldom allow a realistic interaction with the subject. This is especially true in the case of interactive illness history taking. They are often designed to teach a pattern in patient management with corrective actions from the program instead of supporting the problem solving process. Moreover, they rarely provide the user with most physical examination procedures and laboratory tests available in a hospital of today, limiting the applicability in a life-like student-activated learning setting (Bergin & Fors, 1992; Fors & Bergin, 1996; Hayes & Lehman, 1996; Hubal et al., 2000; Vick & Birdwell-Miller, 1998).

Even if some authors point out potential general problems with computer aided learning in medicine (Devitt & Palmer, 1999; Rogers, Regehr, Yeh, & Howdieshell, 1998), many positive papers have been published, which indicates that Computer Simulated Cases (CSC) might be of value (Fors & Bergin, 1996; Hayes & Lehman, 1996; Hubal et al., 2000; Iserson, 1999). Positive findings have also specifically been pointed out for systems aiming at training medical problem solving (Devitt & Palmer, 1998).

The development of the ISP system (and the whole ISP project) was based on a specific educational situation, with clear pedagogical ambitions, including problem-based learning. Without this and the predetermined educational and functional requirements, the outcome could very well have been less successful. This was for example very clear at an early stage when professional multimedia and learning-system developers were contacted to discuss system development and the piloting of the first prototype. It was more or less impossible for these companies to understand the complex nature of the medical area itself, and especially our objectives with strict focus on the medical problem-solving situation and on user freedom without limitations. This led to the decision to develop the system ourselves without outside contractors.

Thus, the ISP system has been developed in-house at Karolinska Institutet with the focus on a very flexible, free and highly interactive system, allowing most users to perform procedures and interactions available in a real patient case. Another clear aim was to try to simulate the complexity of the patient–doctor encounter as realistically as possible. As described in this article, the ISP system is more flexible and interactive than most systems available today, even if some parts still are limited in degree of realism. This limitation is for example more obvious when tactile interactions like palpation is performed, which in reality is felt as a mixture of sensations of skin temperature, humidity, texture and/or tenderness. In ISP, these findings are displayed as text only. Another limitation in ISP is the dialogue, which does have obvious limitations. All answers must be pre-recorded and the analysis of the free text input must be pre-programmed. Nevertheless, most students report ISP as being very realistic and—more important—very stimulating to work with.

Regarding the cost-effectiveness and possibility to develop cases applicable for many subject areas, the development procedure must be discussed. The initial version of ISP was resource intensive and took a number of years to develop, but since any new case is based on these available data, only minor features need to be adjusted for each new case. To create a new case, less than 5% of the program code needs to be modified.

Furthermore, early in the ISP project, teachers pointed out that it is crucial to be able to create new cases with ease. This led to a discussion of a number of new system-design ideas and additional tools. The ISP-VL project required fast and easy international collaboration, and this has resulted in the creation of a central Web-based case database where all data, including the patient
history video clips, answers, questions, laboratory data, X-ray images and physical exam results might be stored. Using this database it is rather simple to create new cases out of the extensive material available. Because of the possibility to create many cases over time, to distribute them on different hardware platforms and to apply them in different educational settings and course domains, it is indicated that the cost per student hour is acceptable. This must also be seen in the light of the very wide scope, freedom of interactions and the high realism of the system.

Discussion about the authoring tool used, Authorware Professional, is also crucial. There are a number of development tools available and even more were available at the time of the earliest version of ISP in 1991 (Stocking & Benjamin, 1995). Even if none of them seem to be optimal, Authorware with its intuitive and flexible interface seems to do the work better than any other system that exists today; it enables construction of modular and flexible programs that suit many platforms. Interestingly, Authorware is one of the few systems still on the market from the review we did in 1991 and from the review by Stocking and Benjamin (1995).

Systems that are designed with more limitations and less realism than ISP are cheaper and faster to develop but since their use is more limited and their scope most often directed towards a specific medical domain (Vick & Birdwell-Miller, 1998), we think that systems like ISP have a better chance to be accepted by teachers and students over time. The proven possibility to use cases at different universities with different curricula and in different countries, further strengthen us in this view. Over the years, the ISP system has been used in a large number of courses at many different universities in Sweden and elsewhere with good results as measured by student and teacher opinions (unpublished results and Bergin & Fors, 2002).

The complete log function, which is necessary for the continuous refinement of the cases, also makes the system a powerful tool for research, one example being in the field of medical decision-making. Physicians at different stages of their career (students, post graduate, specialists, etc.) could for example be compared in detail in solving a simulated case.

As is mentioned earlier, three specific technical features should be present in the system, and ISP incorporates all of them. The system can run on both Windows and Macintosh computers, and also on the Web. There is, however, no Macintosh version running at present. As described earlier, new features and new patients are easy to add. Finally, teachers should be able to do modifications themselves. This has only been possible with the addition of a flexible Web-based database, that has been up and running the last year.

4.2. Pedagogical aspects

In this paper, the three different student tests covering 70 students from two different universities showed that most students were positive to ISP and that about 80% of them rated ISP as realistic. The average score regarding their general thoughts on ISP as a learning tool corresponded to eight on a ten-point scale, indicating a very positive reception.

Moreover, as has been mentioned earlier, this project has served as a model for a number of other projects around case simulations at KI. A recent example is the ISP-VL project in which, among other things, a test was carried out with 75 students from Uppsala University and Karolinska Institutet (Sweden) and Stanford University (USA). The ISP way of presenting cases was compared with the normal paper-based case presentations they were used to. Many students reported that they could not make a good comparison since ISP was so much better and realistic.
(unpublished data and Bergin & Fors, 2002). Similar opinions were collected from teachers involved (Bergin & Fors, 2002).

Observations from these experiments are at present under study. It was obvious, however, that ISP is a powerful tool to support collaborative learning. Media clips demonstrating the high degree of interaction between the pairs of students in front of the computers are available (Bergin, 2000).

These findings indicate that ISP is a tool with a high degree of realism that is advantageous to use in clinical and/or preclinical learning situations.

Computer-based simulation systems are not as natural as a real patient and therefore some universities are using so called standardized patients (human actors) in their learning, which has been proven to yield good results. However, this is a very expensive and also somewhat limited method (e.g. no real lab tests, X-rays, etc. can be performed). The learning outcomes and possible usage of standardized patients as compared with different CSCs are interesting areas for future research in our group. It is important to find the educational niches for the different educational tools.

Furthermore, highly interactive simulation systems like ISP seem to activate students more than traditional methods. This is also subject to further research in the group, particularly to determine whether the degree of realism in the systems influences the learning outcome.

Twelve critical features were defined in the system-design phase. These features were listed earlier. It is the opinion of the authors that all these features are present in the existing system. Most of these features are self-evident. A few had to be proved with experiments. The field tests performed so far and preliminary results from tests in international collaboration supports these. A few comments follow on four of the features:

#3. It has been proved that the system supports problem-oriented education. From a pedagogical and technical point of view it is quite possible to use the system in a strict PBL-surrounding. This has not yet been tried, but will be in a near future.

#4. In the test results presented earlier, a clear majority of the students judged the system to be realistic. It is, however, evident that a computer simulation cannot compete with a real-patient encounter. A more suitable question is whether the system is as realistic as possible. This is dependent on available technology. Future developments will make the simulations even more realistic. It is also a question for ongoing research within the department.

#6. The system is usable in most fields of health-care education. So far it has only been tested in medical education.

#7. The history-taking function in natural language works acceptably well. There is, however, need for improvement. The interpretation of natural language is a tricky business and collaboration with a team of linguists has been established.

5. Conclusions

There is a need for advanced; yet simple-to-use, educational aids to support case based studies in the health-care sector. More than 10 years ago we started the development of a system for
computer-based simulations of the patient encounter, with the emphasis on learning to solve
general medical problems. After a continuous development and refinement stage and after several
field studies, this system has proven to fulfil very advanced educational and technical demands on
a simulation model to be used in medical education.

Even if these results are very promising, the research group will continue to study possibilities
for case-simulation tools like ISP. For example, the possibility of engaging the students emotion-
ally and the impact of this engagement on learning are two areas for further research.

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