The Interactive Patient: A Tool for Teaching Discriminating Data Collection in Therapeutic Problem Solving

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ABSTRACT. Teaching and evaluating the process of discriminating data collection as part of the skill of therapeutic problem solving is a difficult and complex task. The Interactive Patient is a Web-based, natural language, multimedia computer-based patient simulation that was developed to provide the user the opportunity to formulate and apply data collection strategies to a clinical case presentation. Similar to the actual practitioner-patient encounter, the simulation does not limit the user to preprogrammed choices in the process of data collection. The software assigns a relative value to both the content and the order of data selection, providing the user with feedback about the effectiveness of the data collection process.

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BACKGROUND

Over the past 20 years, schools of pharmacy have increased the emphasis on clinical decision making in professional education programs. Teaching students to identify pharmaceutical care problems, collect appropriate data, accurately assess problems, and develop and provide appropriate individual or population-based therapeutic interventions has become the model for training students to become more accomplished health care providers (1). A number of educational techniques have been incorporated into professional curricula to enhance the ability of students to develop and improve their problem-solving skills in therapeutic decision making. Among these techniques are case-based approaches to lectures, small-group problem-solving sessions, a variety of experiential learning rotations, and preceptor-student patient audit sessions. Despite the increased use of case-based learning as a tool to enhancing training in clinical problem solving, greater emphasis may be placed on the content required to formulate an appropriate therapeutic solution than on the problem-solving process necessary to apply the prerequisite knowledge to the clinical situation presented.

DISCRIMINATING DATA COLLECTION

An important step in the process of clinical decision making in therapeutic problem solving is the identification of discriminating data. Discriminating data may be defined as data which are both relevant and necessary to the appropriate assessment of a therapeutic problem and to the subsequent development of a reasonable plan. Depending on the pharmacy practice environment, data available to pharmacy practitioners may be relatively limited, such as in the typical community pharmacy practice setting, or may be enriched as in the acute or chronic care institutional setting. Irrespective of the practice setting, an accomplished health care practitioner addressing a therapeutic problem functions most effectively when aware of the requisite subjective and objective data essential to formulate an appropriate assessment and therapeutic plan.

Early in the experience of learning therapeutic problem-solving strategies, students are likely to seek data that may in some way be related to the problem being addressed but may be irrelevant to the ultimate choice of therapeutic modality. The value of information ascribed to collected data is highly dependent on prior beliefs and the state of the information/data collected. For example, a history of edema in a patient with shortness of breath appears to be valuable and important data to collect. However, if the examiner has already established a history of heart failure, the value of edema data in the process of further data collection associated with the task of problem definition drastically diminishes. Students must learn to understand how the expected value of information from data being sought is altered by the established value of previously known data and to adjust their approach to anamnesis accordingly. Teaching students the process of discriminating data collection may be incorporated into both disease module based therapeutics courses and experiential learning clerkships.

At an early stage of academic experience in a pharmacy curriculum, a student, faced with the decision of appropriate antihypertensive therapy, may identify the patient's gender and age, choose to ask a patient about family history of hypertension, or ask about the duration of the patient's hypertension. Although such data may be relevant to the question of risk assessment associated with the development of hypertension or to the risk of developing hypertensive complications, it contributes nothing to the therapeutic decision related to the choice of antihypertensive agent in a patient with known hypertension. In similar fashion, the process of determining the appropriate route of administration of a diuretic agent in a patient with heart failure depends much more on the student's ability to identify data related to the *severity* of the patient's heart failure rather than on the duration or the etiology of the heart failure. Data related to the patient's shortness of breath and pulmonary congestion on physical examination become much more discriminating in that decision than does the patient's weight or amount of ankle edema.

Using data to alter the prior belief of the probability of a specific diagnosis is only beneficial if the probability itself is linked to a therapeutic utility function. That is, not only is there little value in collecting data related to a problem that will not be acted on, but it may be costly by using provider time and financial resources or by adding potentially harmful diagnostic or therapeutic procedures. The skill of collecting data that is discriminating to the specific question being addressed (e.g., the most appropriate antihypertensive agent) plays a significant role in the ultimate ability of the student to become efficient in the process of therapeutic problem solving. Using traditional therapeutic problem solving assessment techniques such as multiple choice or short answer assessment exercises, however, does not easily allow the measurement of a student's ability to collect discriminating data during the problem-solving process. Computers, and especially simulated experiences, have been identified as effective tools for stimulating interest and increasing learning (2). A variety of computer-based patient case presentations have been developed which allow students the opportunity to apply clinical decision-making skills in simulated patient presentations (3-6). Experienced clinicians organize existing knowledge into simplified models so new knowledge can be easily understood as an example of an earlier problem. Students have fewer models to recall and therefore have to search extensively for solutions to the problems (7).

Computer-based patient simulations have several advantages in clinical training compared to the use of actual patients. Simulations provide users with the opportunity to acquire skills in patient evaluation and management, provide the flexibility of learning at the convenience of the user, and provide immediate feedback on performance–all while eliminating risk to real patients. The complexity of the clinical simulation can be altered to meet the educational background and level of training of the user. Moreover, depending on the design of the simulation, the problem-solving process of the user can be evaluated in addition to the outcomes assigned by the user (8). Simulations have been validated in multiple health care related educational fields (9-11). Most simulations use checklists of data that a student is expected to collect or to avoid because of cost (risk to the patient, financial, time, etc.).

THE INTERACTIVE PATIENT II

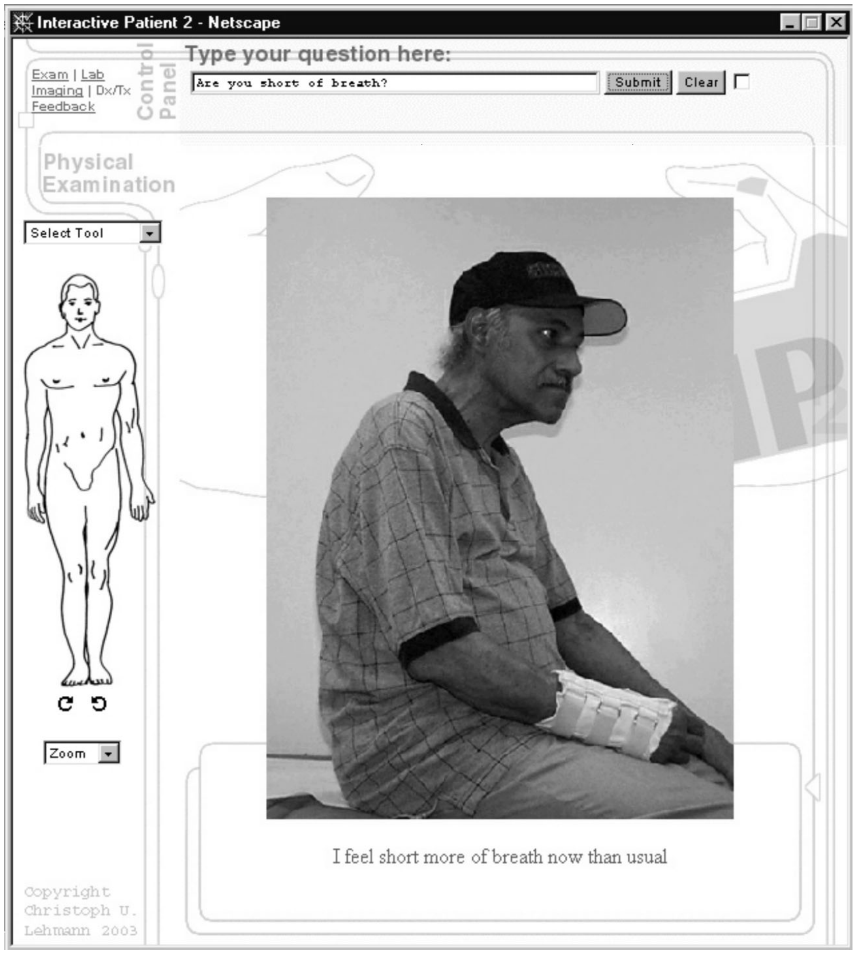
The Interactive Patient II (http://162.129.72.40/ip2) is a Web-based, natural language patient simulation that was developed as a model for evaluating the diagnostic and problem-solving skills of medical students and physicians (12). The software consists of relational databases that allow the user to collect subjective and objective data using an interface simulating a live patient encounter with a high degree of verisimilitude. The terminology databases contain a large number of canonical terms and phrases. Canonical phrases are synonyms for a word or a group of words that a user might use in a question. Canonical terms in a question are combined and compared to canonical phrases that are linked in a unique fashion to clinical findings. The natural language processing allows the user to "ask" the patient any question by typing in the question just as if it were being asked of a live patient: Do you have pains in your chest? How many blocks can you walk before you get short of breath? The software technology has been described previously and recognizes "short of breath" as synonymous with "difficulty breathing," "short-winded," etc. (13). The responses delivered to the user are dependent on a programmed prioritization of the number of terms used in the question: Do you have pain? Do you have chest pain? Do you have chest pain when you walk? Have you ever had chest pain in the past?

Compared to other clinical problem-solving scenarios that contain a limited number of programmer predesigned questions from which the student must choose, the natural language design of the Interactive Patient II gives the user the opportunity to ask whatever questions are deemed appropriate and in the order deemed appropriate (Figure 1). Instead of being prompted, users have to develop their own line of questioning based on data already gathered. This design directly mimics the real patient-provider interaction during which the choice of questions is unlimited. The natural language design of the Interactive Patient provides a real-life scenario in which the user can phrase questions as if the patient were being addressed directly (14). There are currently more than 6,000 findings in the Interactive Patient II database. Because each finding can be triggered in at least 5 to 10 separate ways, we estimate that the Interactive Patient II "understands" approximately 50,000 questions.

Currently, the Interactive Patient II stores all of the user interactions with the simulation in the order in which they occurred. Using a Bayesian Belief Network of differential diagnoses and finding nodes, we are developing a technique that uses posterior probabilities of differential diagnoses and utility functions (it is more beneficial to treat sepsis than a cold) to determine the expected value of information of any remaining clinical finding. The student's interaction with the case at any given point will be compared to the best possible choices based on the computed expected values of information. Using this technique, we will not only be able to assign a numeric value to the student's performance, but will also be able to demonstrate to the student why a specific finding (or set of findings) would have resulted in a better information yield at a particular point of the interaction, based on the information instantiated (data collected).

In addition to the ability of the Interactive Patient II simulation to allow the user to phrase questions in a manner similar to a real patient-cli-

FIGURE 1



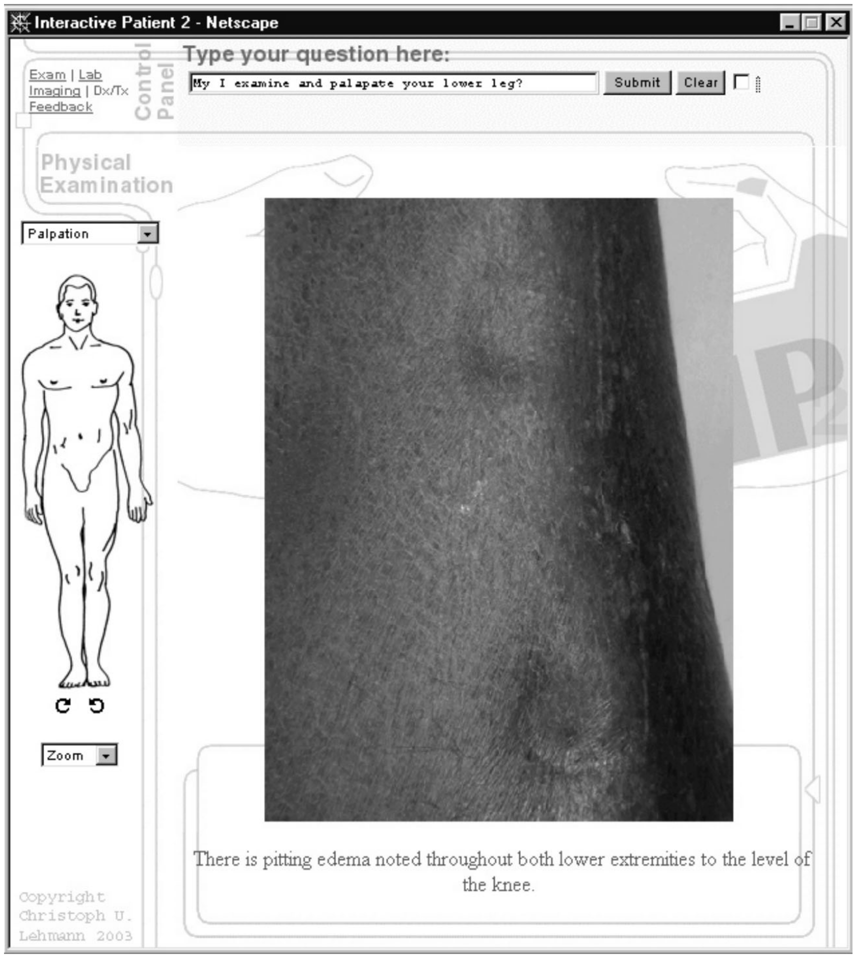
nician interaction, the simulation places a relative value on the order in which questions are asked. Because questions already asked instantiate data (the student already knows that the patient had recent chest pain), prior beliefs are changed (it is now more likely that the patient has coronary artery disease), and as a result, the expected value of information for questions related to family history of coronary artery disease has drastically diminished. In addition, the expected value of information for the next question is always affected by the utility of treatment of the differential diagnoses. In a simulated hypertensive patient follow-up visit, the value of a question related to the symptom of recent chest pain or shortness of breath would be ranked higher than questions related to the patient's family history of hypertension or a patient's remote chest pain history. Likewise, user questions related to shortness of breath in a patient with heart failure could be valued to a higher degree than questions related to dietary sodium indiscretion.

Increasing emphasis is being placed on patient assessment skills in pharmacy curricula, in part related to the increasing opportunities for pharmacists to practice in the ambulatory care setting (15). The Interactive Patient II, a multimedia simulation, provides the user with the opportunity to collect physical examination data in a manner that closely simulates the clinician-patient encounter. By selecting "exam" the user is presented with various techniques via pull-down menus (inspection, percussion, auscultation, etc.). The specific body site to which the technique is applied is identified by selection of the appropriate anatomical site with the computer curser on a model body image map that can be rotated or magnified, and the actual results of the examination technique (heart sounds, lung sounds, photograph of the ankles, etc.) are provided (Figure 2). Using this technique, heart, lung, and abdominal examination, for example, can be accomplished.

Alternatively, the natural language interface can be used to access parts of the physical examination. For example, the question "May I examine your abdomen?" will result in the appropriate clinical finding. The original Interactive Patient was designed for use by medical students and physicians; therefore, interpretation of physical examination data was left to the analysis of the user. Because the Interactive Patient II is being designed for use by pharmacy students and pharmacists as well as physicians, an "interpretation" is available to assist with physical examination findings if the user chooses to use such an option. For example, if the pharmacy student user chooses to auscultate the patient's lungs but is unsure of the sounds being produced, activating the interpretation will display the results in written format (e.g., moist crackles). Finally, laboratory (e.g., blood and urine chemistries) and imaging (e.g., x-rays, ultrasound results) data for the patient are available through a series of pull-down menus created "on-the-fly" from the laboratory or radiology items available in the database. Alternatively, the user may also use the natural language interface to access the same information.

Ultimately, the Interactive Patient II simulation will allow the user to develop an assessment and therapeutic plan for the problem presented

FIGURE 2



by the simulated patient. Upon implementation, the individual user's assessment and therapeutic plan can be compared to results generated by experts in the field and to the results of other users at similar or different levels of professional training. Because the Interactive Patient II simulation is a Web-based multimedia patient scenario, comparison of an individual student's or group of students' data collection and problem-solving process can be compared to individuals or groups of selected students or professionals with access to the World Wide Web.

DISCUSSION

Teaching pharmacy students therapeutic problem-solving skills is a complex, time-consuming task that is undertaken longitudinally through both didactic and experiential teaching in most pharmacy curricula. Many health professional curricula contain disease module based courses in therapeutics that both present the relevant clinical data and provide students with opportunities to use the data presented in clinical problem-solving scenarios. In subsequent experiential courses, students are expected to apply the material they have previously learned to actual patient encounters. The expectation that students have not only learned the factual information related to disease management but also possess the skills required to extract relevant and discriminating data from both patients and medical records in an efficient manner may be overestimated given typical assessment tools used to measure such skills. A traditional method of evaluating the ability of students to efficiently collect discriminating data and apply that data to therapeutic interventions typically falls upon clinical preceptors who observe students in actual patient encounters. In early clinical experiential training, preceptors, especially in the ambulatory care setting, may express frustration with the extended length of time students take to obtain subjective and objective data during patient encounters. In addition to the naivety of students in that environment, some of the delay may be associated with the inexperience of the student in "leading" the history taking, and additional delay may be the result of extraneous data collection due to the student's lack of recognition of the critical data required in the encounter. Ultimately, students may learn to become more efficient data collectors through evaluation and critique offered by preceptors or by direct observation of preceptor technique. It would certainly be advantageous for students to have an opportunity to increase their level of skill in discriminating data collection prior to their exposure to real patients in the clinical setting.

The Interactive Patient is an educational tool that gives students the opportunity to learn the process of subjective and objective data collection in a controlled, but realistic, setting. Not only does the simulation provide a method of assessing the ability of the user to collect data that is discriminating in its relevance to therapeutic problems being presented, but it also allows for an assessment of the structure of the problem-solving process that the user has employed in the process of data collection. In the heart failure case that has been developed for initial testing, it would be appropriate for the user to ask about shortness of breath early in the process of data collection because the student with an appropriate didactic background should understand the higher value of data associated with symptoms of pulmonary congestion compared with symptoms associated with peripheral edema. Given the ability of the Interactive Patient simulation to "track" the process of data collection, the evaluator can also determine whether the appropriate subsequent questioning related to the degree of dyspnea (i.e., "How many blocks can you walk before getting short of breath?") was collected. In this fashion, the structure of the user's data collection can be analyzed. Through feedback provided by an analysis of the user's data collection and assessment process, the student can learn the structure of an efficient and effective data collection process that could later be employed in the actual patient encounter. The Interactive Patient provides pharmacy faculty with a unique tool that allows students' process in discriminating data collection to be evaluated and improved upon prior to its implementation in the clinical setting.

CONCLUSION

The Interactive Patient II is a web-based, natural language patient simulation that can be used as a tool to assist pharmacy students in the process of learning effective and efficient methods of data collection and assessment. As a result of the comprehensive subjective and objective database contained in the simulation, clinical therapeutic (and diagnostic) problems associated with most common acute and chronic disease states can be developed and tested. Analysis of an individual student's or a group of students' problem-solving processes can be evaluated and compared to others with access to the World Wide Web.

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REFERENCES

1. Hepler CD, Strand LM. Opportunities and responsibilities in pharmaceutical care. *Am J Hosp Pharm.* 1990; 47:533-43.

2. Bahr JP. Computer-aided instruction in perinatal education. *Am J Perinatol.* 1986; 3:147-50.

3. MacKinnon III GE, Pitterle ME, Boh LE, et al. Computer-based patient simulations: Hospital pharmacists' performance and opinions. *Am J Hosp Pharm.* 1992; 49:2740-5.

4. Abbey LM. Interactive multimedia patient simulations in dental and continuing dental education. *Dent Clin North Am.* 2002; 46:575-87.

5. Goolsby MJ. The role of computer-assisted simulation in nurse practitioner education. *J Am Acad Nurse Pract.* 2001;13:90-7.

6. Guagnano MT, Merlitti D, Manigrasso, et al. New medical licensing examination using computer-based case simulations and standardized patients. *Acad Med.* 2002; 77:87-90.

7. Stevens RH, McCoy M, Kwak AR. Solving the problem of how medical students solve problems. *MD Computing.* 1991; 8:13-20.

8. Downs SM, Marasigan F, Abraham V, et al. Scoring performance on computer-based patient simulations: Beyond value of information. *Proc AMIA Symp.* 1999; 520-4.

9. Devitt JH, Kurrek MM, Cohen MM, et al. The validity of performance assessments using simulations. *Anesthesiology.* 2001; 95:36-42.

10. Roffman DS, Tobias DE, Speedie SM. Validation of written simulations as measures of problem solving for pharmacy students. *Am J Pharm Educ.* 1980; 44: 16-24.

11. Engberg SJ, White JE, Belle S. Establishing criterion validity of a computer-based clinical simulation. *Proc Annu Symp Comput Appl Med Care.* 1991; 737-41.

12. Lehmann CU, Lehmann HP. The Interactive Patient: A multimedia case simulation on the Web. *CyberMed Catalyst J Alliance Med Internet Prof* [electronic journal]. URL: http://www.amip.org/catalyst/cc_lehman2_html. Accessed 2002 May 21.

13. Lehmann CU, Nguyen B, Kim GR, et al. Restricted natural language processing for case simulation tools. *Proc AMIA Symp.* 1999; 575-9.

14. Friedman C, Hripcsak G, Shablinsky I. An evaluation of natural language processing methodologies. *Proc AMIA Symp.* 1998; 855-9.

15. Longe RL. Teaching physical assessment to doctor of pharmacy students. *Am J Pharm Educ.* 1995; 59:151-5.