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Interactive multimedia patient simulations in dental and continuing dental education

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Any dentist knows that a dental student's fondest hope is to learn what he or she needs to know to practice dentistry. A few have the insight that this wish is unrealistic if "what I need to know" equals "everything I need to know I must learn in school." A more realistic wish for a competent novice graduate might be to learn a core of basic knowledge in various dental-related domains sufficient to allow transfer of what is learned to new situations. Practicing dentistry is only initiated in dental school. Practice presents an infinite number and variety of problems to solve. Similar problems are different in many ways, and there are striking similarities in different problems. It is a major goal of dental schools to prepare students for a flexible adaptation to new problems and settings. This transfer application of knowledge from one setting to another is a hallmark of success in learning and is essential for success in professions such as dentistry.

Educators always have had tools available to aid the process of turning information into knowledge. No one would dispute that books, paper, pencils, libraries, teachers, and a plethora of other items are the tools of knowledge making. Lectures, independent study, large groups, small groups, experiential learning, and other teaching strategies keep adding to the growing pile of choices. The computer is one of the more versatile educational technologies. It is so versatile and impressive that it tempts us to reach out to grasp it in a desperate attempt to find a solution to the chaos of strategies. This impulse is misdirected. We must look more critically at what we want to accomplish strategically in each educational venue and choose the best

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tool or tools to help us reach our goal. We can welcome the large and growing array of strategic choices.

This article neither attempts to justify the computer as a valuable educational tool nor defends the value of some educational strategies the computer makes possible. These cases are made elsewhere [1–5]. This article examines the act of learning and transfer in context as it applies to dental education and describes the fundamental use and application of computerized multimedia patient simulations to aid in this learning strategy. The article also draws on recently published standards and shows how simulated patients can aid schools of dentistry in meeting these standards.

In four years, the goal of dental education is to teach students a new vocabulary, basic biopsychosocial sciences, complex procedures, ethics, and professional and business management. The school also must prepare them to assume responsibility for managing patients' oral health needs in a context of whole-body health and prevention of disease. New graduates enter a massive for-profit health care system that has little concern for either the patient or the practitioner and great concern for the "bottom line." There is an overload of what current educators call "initial learning" [1] (eg, the preclinical and biopsychosocial sciences) and little opportunity for "transfer" [1] to the context of practice, treatment of clinical patients, in preparation for independent practice.

Transfer is defined as "…the ability to extend what has been learned in one context to new contexts [1]." Teaching this essential skill to dental students presents at least two problems: (1) Initial learning (new vocabulary, biopsychosocial basic sciences, and complex procedures) is taught in a crowded curriculum in which the focus of learning is largely on the ability to repeat previously taught facts or procedures. (2) The context into which this initial, fact-focused learning must be transferred is the human patient in varying stages of health and disease. The human patient has little regard for facts, absolutes, and rules of thumb and is a wellspring of unpredictable ambiguity. The skills needed to deal with patients are problem-solving skills that are not based on fact.

Dental education is faced with a transfer problem. The continuum from basic science to applied science, from normal to abnormal, from molecular to broad human application, and from theoretical to real patients living the theories begs for a bridge between contexts. If the patient is the final destination, a strategic educational transfer tool that has a foot in both contexts—preclinical didactic and clinical application—makes sense. Interactive patient simulations can address this problem. Previous computer-based patient simulation models stretched the limits of technology at the time [4]. These technologies used cumbersome hardware, and interactivity was limited because of software constraints. Authoring was difficult. Software currently available has made it possible to author realistic, effective interactive multimedia patient simulations. These interactive tools provide a realistic context for practice, aid in developing sound information gathering

skills, and reinforce concepts from initial learning. Interactive cases simulate the clinical patient but allow students to practice, make mistakes, learn from feedback, and develop problem-solving and decision-making skills.

Cases are time-honored tools for teaching and learning in dental schools [4,6–8]. The first successful interactive case simulation program was the "DDxTx" program developed at University of Iowa by Finkelstein et al [4]. This system introduced the concept that student "doctors" could ask the computer-based, simulated patient a question and receive an answer. Students were required to make decisions and commit to a diagnosis and a treatment plan. The system used two computers and videodisk technology, and the authoring of cases was accomplished through using a word processor. This system is used extensively at the University of Iowa's College of Dentistry. Another patient simulation program resulted from the efforts of Dental Interactive Simulation Corporation [2]. Dental Interactive Simulation Corporation is a commercial venture that grew out of an attempt by regional dental licensing boards to foster the idea of using simulations instead of live patients to test students. Using highly technical interactive sequences and aimed at the practicing dentist, this program attempts to simulate all aspects of dental practice from patient registration to instrumentation, serial appointments, and record keeping. Nothing is available about the possibility of authoring with this system.

The idea is that when a student is presented with and must work through a patient problem in the form of a case, he or she learns problem solving within the context of practice. We know that adults learn effectively when they must solve problems that are in the context of what they will be doing upon completion of their education [9]. Cases provide effective vehicles for adult learners.

CASE STUDIES for Dentistry (CSD; MACROMEDIA, San Francisco, CA) is an example of an authoring system for interactive multimedia computer-based patient simulations that would be capable of filling this transfer role for dental students. CSD is an Authorware template designed so that any discipline in dentistry can build multimedia interactive case simulations that teach problem solving and critical thinking (information gathering, data analysis, decision making, action, and evaluation). The user is the "doctor" and the computer serves the dual role of patient and mentor. This program was developed by Virginia Commonwealth University School of Dentistry and is currently in use in the Virginia Commonwealth University curriculum. This authoring system is available to interested parties through newMentor, a software company in San Francisco. With the CSD authoring template, faculty who have no technical knowledge or programming skills can enter clinical content (eg, information, scenarios, images) in a friendly, familiar format to build fully functional cases in various disciplines (eg, oral pathology, oral medicine, endodontics). Difficulty depends on content and level of decision making.

In each CSD case, the student obtains the chief complaint and medical/dental history, performs a physical examination, looks at old records

(radiographs, images, charts), orders new radiographs, formulates a differential diagnosis, performs diagnostic tests to refine the differential diagnosis further, makes a final diagnosis and a treatment plan. Figs. 1–3 are representative screens from a CSD case.

In the chief complaint section, the student discovers why the patient came to the dentist and can ask questions that the patient answers. All questions generate constructive feedback to the student. The patient already has filled in the medical/dental history form, and the student can ask up to six questions of the patient on any item in the medical history. The student can look up medications mentioned in the history by clicking a drug reference icon beside the medication. Physical examinations include head and neck, intraoral, percussion, electric pulp test, and hot and cold examinations. All examinations can be performed on every patient and are followed up by multiple-choice questions. The student is free to order radiographs on any teeth or portion of the patient's jaws (eg, periapical [PAs], bitewing radiographs [BWX], panoramic) in the radiographs section. When the films are displayed, the student must answer questions about the radiographicfindings.

In the old records section, the student can view old radiographs, photographs, or charts that are available on that patient. The differential diagnosis

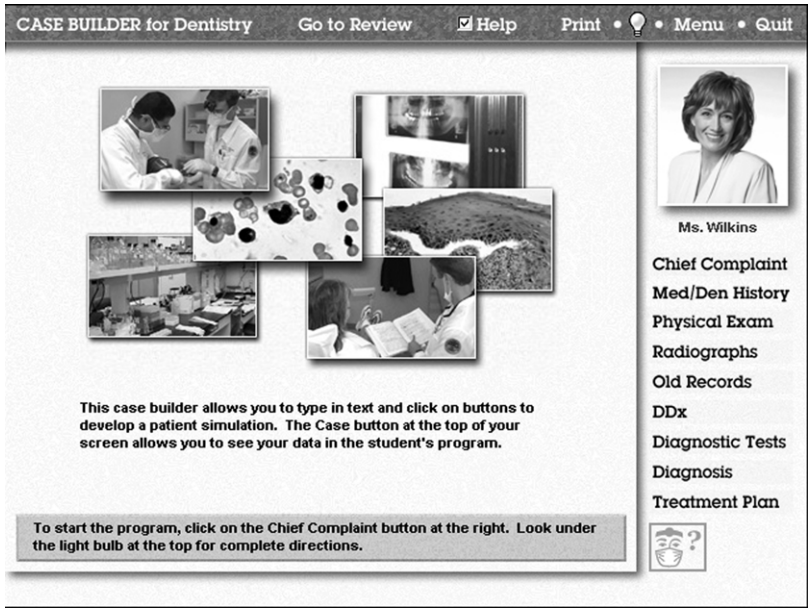

Fig. 1. Opening screen of a case studies case in the case builder module. This is the point at which the author begins to build a case. Note the elements of the case in the right margin under the patient photo. (© 1998–2001. All rights reserved, Virginia Commonwealth University. Patient photo copyright free from the CD, ''Everyday People,'' Signature Series #16. Photodisc, Inc, 2013 4th Avenue, Seattle, WA 98121, USA).

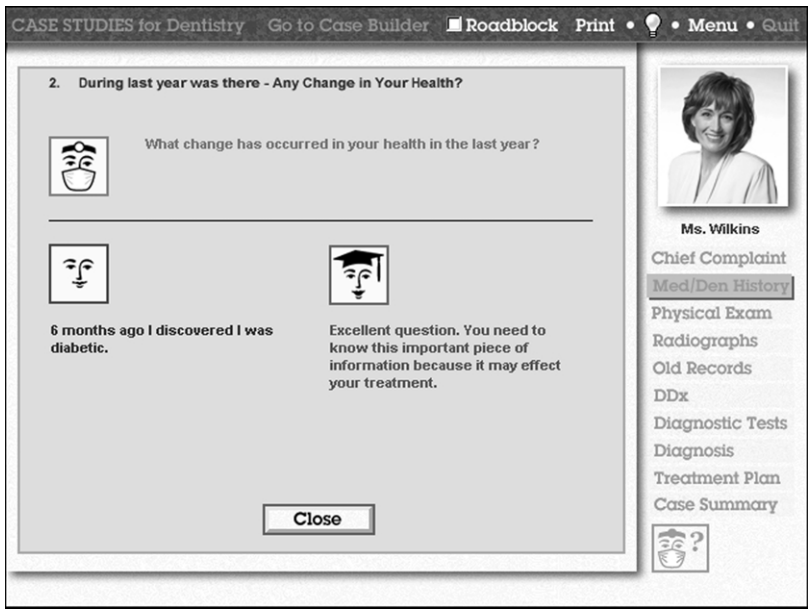

Fig. 2. Doctor question screen from a case study. The author supplies the question and the patient provides the answer and the feedback. (© 1998–2001. All rights reserved, Virginia Commonwealth University. Patient photo copyright free from the CD, "Everyday People," Signature Series #16. Photodisc, Inc, 2013 4th Avenue, Seattle, WA 98121, USA).

section presents a list of possible diagnoses from which the student selects the diseases that he or she wishes to include in the differential diagnosis. Diagnostic tests (biopsy, exfoliative cytology, hematology, blood chemistries, and culture and sensitivity) are available to help differentiate between diseases on the differential diagnosis list. The student receives the results and is asked multiple-choice questions about the significance or implications of the test. After obtaining the results of the diagnostic tests, the student types the diagnosis in the space provided.

Finally, the student proposes a treatment plan that can include any or all of the following: prescription, periodontics, surgery, endodontics, restorative, referral, follow-up, or no treatment. The student must choose all appropriate actions in the treatment plan before being allowed to finish. The program constructs a case summary during each case session. This text file records sequentially every choice and decision the student makes while working through the case. This case map is a valuable tool for keeping track of progress, and it can serve as the basis for discussion during any conference with an instructor. The summary is available for the student to view (but not alter) while they work. At the finish of the case, the summary is printed along with the student name, case title, date, starting time, and total session time.

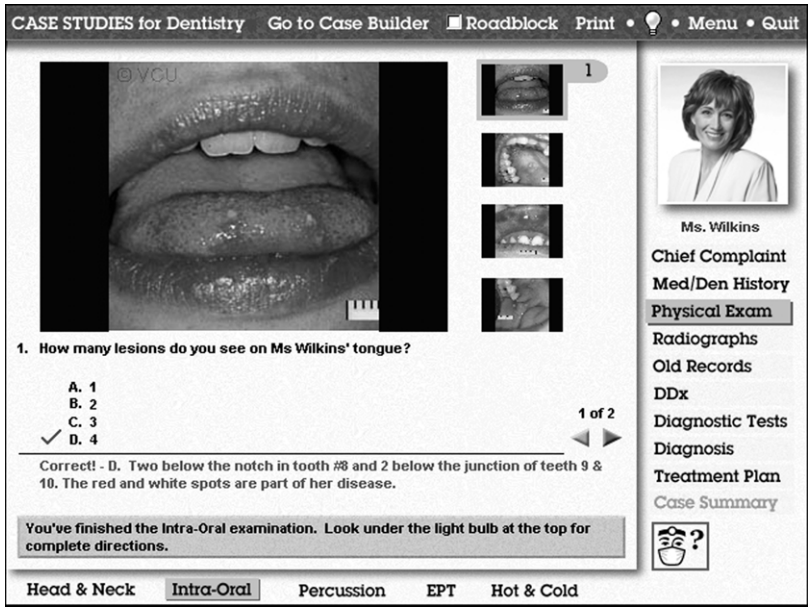

Fig. 3. The intraoral examination screen from a case study. The author asks the student up to two multiple-choice questions about each image. Note other physical examinations that are available on the bottom of the image. (© 1998–2001. All rights reserved, Virginia Commonwealth University. Patient photo copyright free from the CD, "Everyday People," Signature Series #16. Photodisc, Inc, 2013 4th Avenue, Seattle, WA 98121, USA).

With CSD, students collect information, evaluate that information, propose alternate theories based on that information, and make independent decisions. Such a tool requires knowledge transfer from initial learning to application. CSD patient simulations exhibit the following information:

- Interactivity: Students can ask the patient questions and the patient answers. They can order diagnostic tests and receive results and reports on familiar forms. The student makes decisions, performs physical evaluations, asks follow-up questions, orders treatments and medications, and refers and follows the patient.
- Random access: As in life, all actions, and information gathering can be initiated and reviewed randomly.
- Anytime/anywhere utilization: The CD-ROM/PC format allows students to work with the cases at their own speed in a comfortable environment of their choice.
- Decision making: Virtually every step in CSD involves making a decision. No information is "given" to the student. As in a live clinical situation, the student must decide what information is needed and how to gather it (eg, questions, laboaratory tests, radiographs). Whether to initiate an action, ask a question, or differentiate between several

alternatives, students are free to make or not make the choice, act, ask, or do nothing within the case environment. Once a decision or choice is made, the consequences of that choice are revealed to the student through "feedback."

- Feedback: Rich feedback is a valuable teaching tool for authors and students. At every step, whether the student is asking a question, making a decision, or ordering a test, the "mentoring" function of a CSD case is at work in the feedback. Case authors design their own feedback according to the needs of their target students.
- No testing/no penalties: CSD are teaching/learning tools, not tests. No patients die. Faculty authors are in full control of the content and tone of the questions and feedback. Student users do not accumulate points or race against a clock. The student always reaches the correct diagnosis. The pathways may vary, but they always get to the end. The objective is to get to the correct diagnosis and treatment as efficiently and directly as possible.

Complete authoring control allows the builder to place emphasis where he or she wishes. This control is an important factor when custom building cases for specific educational objectives. For example, one can create a patient with a specific disease combination that teaches a student to sort out the differences between the two diseases at the interface. Case simulations can teach content and process, but like any other teaching tool, cases cannot be the only vehicle for teaching anything.

Patient simulations in curriculum

Cases can become part of a curriculum infrastructure in several ways:

1. Making basic science clinically relevant
2. Preparing for clinical problem solving
3. Teaching new clinical content
4. Making hard-to-find patients available
5. Providing opportunities for practice and remediation
6. Creating standardized patients
7. Teaching self-evaluation

Making basic science clinically relevant

Dental accreditation standards teem with "must" statements that can be addressed in whole or in part by introducing case simulations. Interactive, multimedia cases can become part of the curriculum infrastructure. Basic science curriculum is customarily taught in separate courses (eg, biochemistry, anatomy) throughout the first 2 years of dental school. The versatility of simulation authoring allows cases to be constructed toward specific

ends. Faculty can build simulated patients whose realistic problems confront students with the immediate clinical relevance of basic science content. The feedback mechanism of these cases allows faculty to introduce new concepts within the patient context, reinforce prior knowledge, and refer students to further study in texts and literature resources that are of immediate relevancy. This early confrontation with clinical problems in a simulated patient piques student interest and allows them to assume the role of a doctor.

Preparation for clinical problem solving

Interactive simulated patient experiences early in the curriculum introduce the principles and process of clinical problem solving. In addition to basic science relevance to clinical practice, students learn information gathering, hypothesis testing, decision making, diagnosis, treatment, and evaluation. Case authoring versatility allows faculty to build specific problem-solving skills into cases and give feedback that supports the use of such skills. Several cases can be used to teach specific skills incrementally. By the time of the first encounter with live clinic patients, students already have had practice in asking questions, interpreting answers, and making decisions.

Teaching new clinical content

Specific content information is often more powerfully presented in the context of a patient problem, especially one that requires analysis. We all have had such an experience. Using interactive patient simulations to reveal new subject matter in the context of a patient encounter and enriching the experience with feedback is a useful teaching tool. Students can interact with a simulated patient who has a specific disease or condition or who needs a specific therapy. This context-based interaction teaches students from their own and the patient's point of view. An added benefit for faculty is authoring a case in which they must consider the doctor's and the patient's viewpoint. This dual perspective stimulates faculty to think through content carefully from more than one perspective. Faculty experience a surge in understanding their content, which can only lead to more confident teaching.

Making hard-to-find patients available

During the clinical years, dental students learn that most patients have normal medical, social, and family histories. Students have limited or no experience in devising therapy plans for so-called "medically and psychosocially compromised" patients. Students must be prepared to deal effectively with patients who present with major medical issues. Patient simulations can

be useful in that they can be authored specifically to give students experience dealing with diseases, conditions, and psychosocial situations that are considered important, although underrepresented in the general clinic patient population. This sound educational principle of repeated examples in different contexts underwrites knowledge transfer between contexts.

Practice and remediation

Interactive multimedia patient simulations can be used to provide preclinical skills in information gathering or provide remediation for students who need additional practice in specific skills for dealing with patients. For example, reviewing a medical history with a patient is an acquired skill. One must learn and practice the science and art of obtaining a history. Many students know they should be asking questions of the patient regarding the chief complaint or the positive elements of a medical history, for example. In these cases the student must practice not only asking questions and dealing with the various patient responses but also deciding what specific questions to ask in any given circumstance. Mentoring through careful question construction and feedback gently eases the student into the notion that patients do not come with "given" information, only the information that we can tease out of them through questioning and other investigative means. Cases can be constructed to include only chief complaint and medical history. Cases can be made to illustrate the subtleties surrounding what questions to ask and how to obtain and interpret answers and relate the information to the patient's problem. The feedback feature makes this type of case development particularly powerful.

Creating standardized patients for measuring competency

Because of the control the author has in building a case, he or she can standardize content among several cases so as to construct a valid instrument to measure outcome or competency. Many of the competency skills that are virtually impossible to measure on live patients because of the infinite variability and vulnerability among humans can be measured using carefully authored interactive multimedia patient simulations. This feature provides an excellent means of evaluating curriculum and creating valid, directed remediation.

Standardization of clinical patients is becoming increasingly important as licensure and specialty boards withdraw from requiring candidates to perform procedures on living patients. Because authoring cases with a program such as CSD is much easier and more versatile, it makes standardized interactive patient simulations more attractive in assessing competency.

All of these features lead to making interactive multimedia patient simulations excellent tools for continued competency evaluation and continuing education. The features of case standardization and targeted content and

feedback are particularly useful in this area. More and more, licensed dentists are being held accountable for hours of continuing education for recertification in a specialty and for licensure. Interactive, multimedia patient simulation authoring systems such as CSD figure strongly in solving these problems. As more simulated patients are introduced into the curriculum, graduates become accustomed to interactive cases as a vehicle for education. They demand case simulations as part of the array of offerings in continuing education. Simulated patients will become part of the future continuing education scene.

Teaching self-evaluation

One of the most important skills a dentist must learn is that of self-evaluation. Dentists in practice must monitor themselves to see if their treatments meet accepted standards of care. For example, the dentist must learn how to tell if all the caries are removed, if the degree of gingival inflammation is reduced, or if the white lesion is one on which a biopsy should be performed. This skill is fostered by a gradual weaning of the student away from looking to the instructor to give the nod, the smile, or the "go ahead." Interactive multimedia patient simulations that are constructed to encourage the student to take responsibility in criticizing his or her own work are useful in developing independent judgment. Using a patient simulation, such as one constructed with the CSD system, a student is presented with choices at every step. Depending on the subject of the case, students can be faced with judgments as to which question to ask, how to interpret answers, how to interpret physical, laboratory or radiographic findings, and what treatment steps to initiate. The student makes the judgment, and the faculty author encourages or critiques that judgment through the feedback. The live patient is the ultimate test, of course, but students who have been exposed to interactive multimedia patient simulations are better prepared to exhibit judgment in clinic and are more assertive in their care decisions.

Interactive multimedia case simulations can aid directly in reforming dental education and in meeting new accreditation standards. Custom-built case simulations afford a versatile, customizable, convenient, and cost-effective tool for fostering relevancy, standardization, practice, competency, remediation, and broad experience.

Interactive multimedia patient simulations provide tools for educators and administrators who are involved with curriculum development in schools of dentistry. It is possible to see how simulated patients can play a leading role in addressing the 1995 Institute of Medicine Report, "Dental Education at the Crossroads" [10], and the 1998 "Accreditation Standards for Dental Education Programs" [11]. In the following discussion, specific recommendations from these two documents are quoted, and examples are given as to how interactive simulations can be substantially effective in addressing these specific recommendations.

Simulations and the Institute of Medicine report

In the Institute of Medicine report, recommendations 4–6, 18, 19, and 22 can be addressed specifically by introducing interactive patient simulations into the curriculum. Recommendation 4 is presented as an example of how interactive, multimedia, computer-based simulations can be useful in implementation of the Institute of Medicine recommendations.

Recommendation 4

To stimulate progress toward curriculum goals long endorsed in dental education, the committee recommends that dental schools set explicit targets, procedures, and time tables for modernizing courses, eliminating marginally useful and redundant course content, and reducing excessive course loads. The process should include steps to

- design an integrated basic and clinical science curriculum that provides clinically relevant education in the basic sciences and scientifically based education in clinical care. * Interactive multimedia patient simulations can be authored to present computer-based patients whose realistic problems challenge students with the immediate clinical relevance of basic science content.
- incorporate in all educational activities a focus on outcomes and an emphasis on the relevance of scientific knowledge and thinking to clinical choices. * Many of the competency skills that are virtually impossible to measure on live patients because of the infinite variability among humans could be measured using carefully authored patient simulations.
- shift more curriculum hours from lectures to guided seminars and other active learning strategies that develop critical thinking and problem-solving skills. * Every CSD case is an active learning experience. Students make choices and decide what to do when and how to do it. During every case session a ''case summary'' is generated that maps the steps a student takes in progressing through a case. This self-assessment tool can be used for post-case review and critique in faculty-student conferences (critical thinking).

Students who enter dental schools are highly computer literate and are attracted to dental programs that make full use of educational technology tools in their curricula.

Simulations and accreditation standards

Interactive multimedia patient simulations address many of the ''Accreditation Standards for Dental Education'' published by the Commission on Dental Accreditation of the American Dental Association effective January 1998.

According to this document, "must" is defined as indicating "an imperative need or a duty; an essential or indispensable item; mandatory." Schools can address many standards set by the Commission on Dental Accreditation by using interactive patient simulations in the curriculum. Specifically, examples from Standards 1 and 2 are used to demonstrate how this would work.

Standard 1: institutional effectiveness

1–3: The dental school must demonstrate the effectiveness of its programs and units using a formal and ongoing outcome assessment process to include measures of student achievement.

- Many outcomes are stated in terms of a specific skill students must demonstrate in some interaction with patients. It is possible to construct interactive multimedia patient simulations to require specific knowledge and skill levels so when students are able to complete the case successfully, they can be said to have demonstrated a certain outcome and are ready to progress to the next level. Control and flexibility built into a system such as CSD case builder facilitate standardization for this purpose.

Standard 2: educational program

Curriculum management

2–7: The dental school must define the competencies needed for graduation, which must be focused on educational outcomes.

- Competencies are skills that students must master to fulfill the educational outcomes defined by the curriculum. Interactive patient simulations can be standardized to help students master skills such as interviewing, describing, and interpreting clinical and radiographic signs, making evidence-based decisions, and ordering appropriate laboratory tests, to name a few. An outcome, such as "review and interpret a patient's medical history" also can be measured via the use of interactive multimedia patient simulations. Students can be assigned to work through several patients with medical histories that represent varying degrees of difficulty and complexity. After completing the series, students are better equipped to obtain histories on live patients.

These examples indicate how dental education can be served by making use of the power in computer-based, interactive multimedia patient simulations. These tools are currently readily available for dental educators to use in curriculum development. Case authoring is as easy as typing information into designated text boxes. Cases can make many aspects of the curriculum exciting, interesting, and clinically relevant for dental students. Faculty also can benefit from the authoring experience. There is no doubt that the thought processes that go into case authoring cause faculty to

examine their teaching. Specifically, case authoring causes one to ask, "Why am I using this information?" "What do I expect the student to take away from this case?" "How can I structure this case to address this point specifically?" Faculty members who author cases probe their own educational philosophy and methodology deeply, and the experience will lead to richer pedagogy.

Education is a fluid process that involves all the inconsistencies, ambiguities, unpredicatabilities, and variations attributable to human behavior. Human education is difficult and must be open and accommodating. Every dental education program must offer as many opportunities as possible for students to learn. Educational opportunities should encourage self-motivation, curiosity, imagination, and independence. Exploration, hypothesis testing, use of resources, and trust of instinct must be emphasized. Such a system must make the widest array of tools available to its educators. Educators, for their part, must articulate clearly their intentions and directions and be informed about the latest tools. With the availability of friendly, simplified authoring, computer-based interactive multimedia patient simulations have joined the array of tools educators can use to help students turn their information into knowledge.

References

[1] Bransford JD, Brown AL, Cocking RR. How people learn: brain, mind, experience, and school. Washington, DC: National Academy Press; 2000. p. 206–30.
[2] Johnson LA, Wohlgemuth B, Cameron CA, et al. Dental Interactive Simulations Corporation (DISC): simulations for education, continuing education, and assessment. J Dent Educ 1998;62:919–28.
[3] Johnson LA, Cunningham MA, Finkelstein MW, et al. Geriatric patient simulations for dental hygiene. J Dent Educ 1997;61:667–77.
[4] Finkelstein MW, Johnson LA, Lillie GE. Interactive videodisc patient simulations of oral diseases. J Dent Educ 1987;52:217–20.
[5] Willis DO, Smith JR, Golden P. A computerized business simulation for dental practice management. J Dent Educ 1997;61:821–8.
[6] Alessi SM. Fidelity in the design of instructional simulations. J Computer-based Instruct 1988;2:40–7.
[7] Blunter MC. A role for clinical case simulation in basic medical science education. Psychologist 1985;5:397–403.
[8] McGuire CH. Simulation techniques in the teaching and testing of problem-solving skills. J Res Sci Teach 1976;2:89–100.
[9] Newble DI, Entwistle NJ. Learning styles and approaches: implications for medical education. Med Educ 1986;20:162–75.
[10] Field MJ. Dental education at the crossroads: challenges and change. Washington, DC: National Academy Press; 1995.
[11] Commission on Dental Accreditation, American Dental Association. Accreditation standards for dental education programs. Chicago: Copyright Commission on Dental Accreditation; 1998.