

Teaching of Medical Informatics in UME-21 Medical Schools: Best Practices and Useful Resources

Craig L. Gjerde, PhD; Catherine F. Pipas, MD; Margaret Russell, MS

Objectives: *Information-based decision making is important to modern medical practice. This report identifies learning objectives, teaching innovations, and student outcomes for teaching medical informatics (MI) in medical schools that participated in the Undergraduate Medical Education for the 21st Century (UME-21) curriculum project. **Methods:** Project reports by the UME-21 schools were analyzed, and curricular content was classified in terms of the five categories for MI literacy adapted from the Medical School Objectives Project. Student self-assessments of adequacy of exposure to MI were reviewed. **Results:** Teaching methods included demonstrations, lectures, small-group tutorials, hands-on labs, and task-based assignments. The curriculum was taught during the first 3 years of medical school with medical librarians participating. Content examples in the five categories of medical literacy were: "Role of the Lifelong Learner" (accessing, evaluating, and using information and databases), "Role of Clinician" (obtaining patient information, using decision support), "Role of Educator/Learner/Communicator" (accessing information for patient education, student-teacher communication, studying Web-based cases, making presentations, accessing on-line course information), "Role of Researcher/Evaluator" (documenting patient encounters), and "Role of Manager" (using drug formularies and clinical guidelines). Seniors exposed to the UME-21 curriculum reported higher levels of exposure to MI than did untrained seniors 2 years earlier; however, seniors at non-UME-21 schools reported equally high levels. **Conclusions:** UME-21 schools developed creative materials for teaching students to use computers for learning, communication, and searching for information. Outcome measures suggest that MI has become an important curriculum topic in most medical schools.*

(Fam Med 2004;36(January suppl):S68-S73.)

Skills in medical informatics (MI) are important to modern medical practice. Shortliffe and Perreault define MI as "the rapidly developing scientific field that deals with biomedical information, data, and knowledge—their storage, retrieval, and optimal use for problem solving and decision making . . ."¹ They explain that "the emergence of medical informatics . . . is due in large part to advances in computing and communications technology, to an increasing awareness that the knowledge base of medicine is essentially unmanageable by traditional paper-based methods, and to a growing conviction that the process of informed decision making is as important to modern biomedicine as is the collection of facts on which clinical decisions or research plans are made."¹ Friedman, on the other hand, gives a slightly broader definition of MI, stating "Informatics is the science underlying the acquisition, maintenance, retrieval, and application of biomedical

knowledge and information to improve patient care, education, research, and administration."²

For many health care providers, the most visible component of MI is called evidence-based medicine (EBM), "the process of systematically finding, appraising, and using contemporaneous research findings as the basis for clinical decisions."³ MI is one of nine objectives in the Council on Graduate Medical Education report that was the philosophical foundation for the Undergraduate Medical Education for the 21st Century (UME-21) curriculum project.⁴ UME-21 leaders designated informatics and EBM as key skills to prepare physicians to practice in the changing health care environment.⁵ Likewise, the educational premise of the Association of American Medical Colleges (AAMC) in its Medical School Objectives Project (MSOP) was that "medical students should be able, at the time of graduation, to utilize biomedical information for: formulating problems; arriving at strategies for solutions; collecting, critiquing, and analyzing information; taking action based on findings; and communicating and documenting these processes and the results."⁶

From the Department of Family Medicine, University of Wisconsin (Dr Gjerde); and the Department of Community and Family Medicine, Dartmouth Medical School (Dr Pipas and Ms Russell)

This report identifies the common learning objectives and teaching methods used in teaching MI and EBM in 10 medical schools that participated in the federally funded UME-21 curriculum project and presents some innovative teaching ideas used at these partner schools.

Methods

Data were abstracted from written reports provided by project directors from each of the UME-21 schools to the project Executive Committee and verified by local UME-21 site leaders. Data were analyzed to identify the teaching objectives, content, teaching methods, and curricular innovations in the participating programs. The curricular content (Table 1) was categorized and reported in terms of the five MI categories adapted from the MSOP project.⁷ Categorization was made by the first author and reviewed by the other authors. Disagreements were resolved through discussion of the MSOP categories and the focus of the curriculum at the particular schools reporting.

Nationally, students in all participating programs used a common evaluation instrument called the Clearwater Survey to describe their attitudes toward MI and to re-

port their participation in informatics and EBM activities. In addition, graduating seniors at the UME-21 schools and all other medical schools responded to the AAMC graduation questionnaire (GQ) about the adequacy of their educational programs.⁸ Some Clearwater Survey and GQ items referenced teaching and learning about MI; these are reported in Table 2. There was no centralized examination in the UME-21 program to assess cognitive learning outcomes; similarly, each program internally evaluated its own specific learning goals and teaching programs. Table 3 lists the learning objectives and teaching innovations used at each school.

Results

The common learning objectives identified in the study, listed in Table 1, are reported in terms of the five MSOP categories for MI literacy: role of the lifelong learner, role of clinician, role of educator/learner/communicator, role of researcher/evaluator, and role of health care system manager.⁷ Several activities related to the students' role as educator/learner/communicator, since programs made extensive use of computer-based programs for teaching, learning, and communication. Computer literacy skills needed for clinical care

Table 1

Medical Literacy Content in UME-21 Programs (Grouped by Medical School Objectives Project Categories)

1. Role of the lifelong learner
 - Accessing, evaluating, and using information resources for life-long learning (eg, medical literature, bibliographic databases such as MEDLINE, PubMed, evidence-based medicine databases, Internet resources, textbooks)
 - Maintaining and enhancing computing skills
 2. Role of clinician
 - Obtaining information about the patient (accessing medical records, ethics for use of records)
 - Using decision support (drug interactions, evidence-based medicine applications, personal digital assistant (PDA) applications for dosage and risks)
 - Formulating search strategies for finding information (In category 2, as "searching for information about a patient." Also in 4)
 - Making decisions for individuals and groups by the use of prevention guidelines, health quality indicators, community and national health data, drug formularies, clinical guidelines, cost data, and evidence-based medicine applications (data on the Internet or PDA programs). (In category 2 as "making decisions about a patient." Also in 5)
 3. Role of educator/learner/communicator
 - Accessing and using computer-based information for patient education
 - Communicating among students, program staff, and preceptors via e-mail and listserves
 - Studying Web-based clinical cases
 - Making presentations using PowerPoint
 - Receiving feedback on MEDLINE and PubMed searching skills
 - Audiotaping patient encounters for review of communications skills with faculty
 - Accessing course-related information and resources—the syllabus, teaching resources, course orientation, and evaluation forms—available to students and preceptors
 4. Role of researcher/evaluator
 - Documenting patient encounters and quality of teaching (eg, using PDAs to log events)
 - Researching student learning experiences through analysis of student-kept logs
 - Formulating search strategies for finding information (In category 4 as "researching search strategies". Also in 2)
 5. Role of [health care system] manager
 - Making decisions for individuals and groups by the use of prevention guidelines, health quality indicators, community and national health data, drug formularies, clinical guidelines, cost data, and evidence-based medicine applications (data on the Internet or PDA programs). (In category 5 as "health care protocols" for systems-based care. Also in 2)
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included access to patient records, searching medical databases, and using decision support. Managerial skills included using the Internet to access government health data and health care plan guidelines. The role of lifelong learning was evidenced by students obtaining and reviewing databases and medical literature. The role of research/evaluator received less emphasis; it consisted primarily of logging patient encounters.

Teaching Methods

The most commonly used teaching methods in the UME-21 schools were demonstrations, lectures, small-group tutorials, hands-on labs, and task-based assignments. Internet-based instruction was used for many of the assignments and medical applications. Medical librarians commonly participated in teaching computerized literature search strategies to first-year students; some provided individualized feedback about students' search skills.

MI in UME-21 was usually taught during the first 3 years of medical school. Before the start of third-year clinical rotations, there was often a refresher on the use of EBM and MEDLINE databases. In conjunction with off-campus rotations, there was often an orientation to dial-in communications with a laptop computer sent with students going to clinical sites that had poor computer resources. One school provided a PDA to each student and trained students to log their clinical learning encounters and to use other clinical applications.

Teaching Approaches

Table 3 lists some of the innovative teaching approaches used by UME-21 instructors. The most notable of these include: The Clinical Practice Guideline Worksheet was a student exercise for researching and using evidence-based clinical guidelines from Internet sites, and the Patient Education Issues Worksheets was an exercise for training students to identify, access, and use patient education material. The Community Assessment Exercise was an exercise to train students to perform a community health assessment using information accessed from the Internet. Documentation (PDA-based) of patient encounters and student learning involved a program for documenting patient information, type of learning, and teaching; a sheet for coding common primary care problems; and timely edu-

cational and administrative reports prepared from these data. Finally, students had options for learning about electronic technology and medical information uses in clinical practices.

Evaluation

Graduating medical students from UME-21 partner schools reported high levels of involvement with many of the MI skills tracked in the study. For most items, this indicator increased from 1999 (with seniors untrained in the UME-21 curriculum) to 2001 (most seniors trained for 2 years of UME-21). In the 2001 survey, a high percentage of graduates from the UME-21 schools judged that they were adequately exposed to medical information database searching (94%), regularly used the Internet to obtain information for care of their patients (97%), used practice guidelines established by national or managed care organizations (93%), and used a computer-based clinical record system (90%). In contrast, however, the GQ data show that

Medical Informatics Item	1999 UME-21 Seniors (Untrained)	2001 UME-21 Seniors (Trained)	2001 All Schools Seniors
Conduct sophisticated searches of medical information databases*	94%	94%	93%
Use the Internet to get patient care information	91%	97%	—
Use practice guidelines in patient care	88%	93%	—
Use a computer-based clinical record system*	78%	90%	88%
Protect confidentiality of patient information in computers*	68%	84%	85%
Access clinical information from an EBM database (eg, Cochrane)	37%	64%	—
<i>Evidence-based medicine, in general*</i>	<i>All Medical Schools 1999</i>	<i>All Medical Schools 2001</i>	
	78%	86%	

* Data were from the Association of American Medical Colleges graduate questionnaire; all other items are from Clearwater Survey.

— No data available from non-UME-21 schools

Table 3

Medical Informatics Learning Objectives and Teaching Innovations by School

<i>School</i>	<i>Learning Objectives</i>	<i>Teaching Innovations</i>
Dartmouth Medical School	<ul style="list-style-type: none"> • Use of handheld computer-based encounter documentation system (PDAs) • Access MEDLINE using OVID • Web-based curriculum for off-campus students 	<ul style="list-style-type: none"> • Expansion of documentation system from family medicine to internal medicine and pediatrics • Expansion of documentation system to MIs to begin documentation of 4-year “clinical portfolio” • Documentation system has helped clerkship directors revise curriculum to complement preceptor experiences
University of California, San Francisco	<ul style="list-style-type: none"> • Determine clinical and patient services available in managed care 	<ul style="list-style-type: none"> • Utilize quality information • A third-year longitudinal clerkship experience designed in collaboration with a managed care organization, a city and county community health network, and Kaiser • A listserv is used where students choose one of nine content areas and report back
University of Massachusetts	<ul style="list-style-type: none"> • Describe various electronic technologies that support patient care, medical education, and health care communications • Effectively use computer-based technology and software applications • Apply knowledge and skills of medical informatics in presentations 	<ul style="list-style-type: none"> • Fourth-year “mini-selective” in medical informatics • Student presentations using technologies
University of Miami	<ul style="list-style-type: none"> • Effectively search the MEDLINE database • Effectively use the Internet and informatics technology to find and use information • Use PowerPoint to prepare a presentation 	<ul style="list-style-type: none"> • Medical librarians participate in teaching and evaluation of search strategies. • Sophisticated search strategies are expected of students; individual feedback is provided. • Required task-based assignments
University of Nebraska	<ul style="list-style-type: none"> • Locate and evaluate information for patient care in electronic environment—library’s on-line catalog, journals, bibliographic databases, and drug information. • Perform searches 	<ul style="list-style-type: none"> • Use of several skills (particularly EBM principles, informatics on a computer, and individual patient) to complete a population-based study • A library orientation session • A library workshop for a community medicine project • A refresher workshop on EBM sources for third-year students • A Web-based course for off-campus students.
University of New Mexico	<ul style="list-style-type: none"> • Use the Web and library resources to obtain up-to-date information on patient care issues. 	<ul style="list-style-type: none"> • Librarian-taught tutorial on searching and resources.
University of Pennsylvania	<ul style="list-style-type: none"> • Access Internet resources • Utilize EBM in self-directed learning and patient management • Describe the patient/family as information consumers • Access school’s intranet from community sites. • Use health policy Web sites • Give PowerPoint presentation • Obtain and assess validity of patient management data 	<ul style="list-style-type: none"> • Use of EBM in preclinical and clinical curriculum. • Students make small-group presentations (requires MEDLINE search and critical analysis). • Required health policy project (data gathering, synthesis, presentation, and written report.)
University of Pittsburgh	<ul style="list-style-type: none"> • Use skills in self-directed learning with a variety of medical information systems • Describe informatics applications that impact community-based ambulatory care • Access, retrieve, manage, and utilize information resources • On-line full-text articles and electronic text citations 	<ul style="list-style-type: none"> • Fourth-year EBM elective • Course Web site with on-line curriculum, learning objectives, set of references • Orientation session teaches how to structure clear, focused clinical questions about a patient’s care • Supply on-line communication tools and learning resources to students training in community sites

Table 3
(Continued)

<i>School</i>	<i>Learning Objectives</i>	<i>Teaching Innovations</i>
University of Wisconsin	<ul style="list-style-type: none"> • Perform electronic and Internet-based retrieval of information • Utilize handheld computers (PDAs) • Use practice guidelines 	<ul style="list-style-type: none"> • Feedback on literature search • Required literature search • Session on "Medical Uses of Palm Pilots" • Preceptors' link to school Web page • Audiotaped review of patient encounters • Preceptors have optional activities linked to six UME- 21 content areas.
Wayne State University	<ul style="list-style-type: none"> • Create electronic database of patient-oriented questions and answers • Access patient education materials and resources • Access Internet resources • Perform a community health assessment 	<ul style="list-style-type: none"> • PDAs given to continuity clinic students to log clinical learning exercises and patient encounters. • Expand log project to OB-GYN clerkship and possibly school wide. • Use WHO Web page to compare health status of industrialized countries. • List two interventions that would increase the US disability-adjusted life expectancy rank in the world. • 15 clinical learning exercises based on UME-21 objectives

class of 2001 seniors from all US medical schools reported similarly high levels of exposure to database searching (93%) and using a computer-based clinical record system (88%). US seniors rated the time devoted to their general EBM skills as 78% adequate (or excessive) in 1999; this rating was 86% in 2001.

Discussion

To introduce these medical trainees to MI literacy, UME-21 schools commonly chose to focus on several factors. These included the educator/learner/communicator role of computer-based communication and Web-based learning and on the lifelong learner role of searching for and using information in bibliographic and other EBM databases. The managerial role skills (eg, practice guidelines, drug formularies) and clinical role skills (eg, drug interactions, PDA decision-support applications) introduced some students to topics that were less commonly practiced by the preceptors who provided them with clinical supervision.

Research roles received little emphasis in these UME-21 curricula. This seems to be an appropriate balance of emphasis for medical students, most of whom will need to achieve informatics literacy focused on clinical care.

Teaching of these MI literacy objectives (with the exception of basic MEDLINE searching) required development of new curricular materials appropriate for medical students; earlier teaching had been faculty development targeted at early-adopter faculty. Some programs were compelled to identify new teachers from their managed care partner organizations who could

teach these topics. Many of those teachers were unaccustomed to teaching this content to medical students.

While informatics teaching was generally seen as important content area in the training of medical students, it required a faculty commitment to add more topics to a full curriculum, role modeling by clinical faculty and preceptors who teach the students, and technical and financial resources. For example, the PDA project for tracking patient encounters required PDA and network software development, student training, computer maintenance, preceptor development, data gathering and analysis, preparation of student reports, distribution of reports to teachers and students, and timely use of information to guide the students and the program. As noted, informatics teaching presented challenges. On the other hand, investment in MI teaching opens up a wealth of new opportunities for education, research, and patient care. It increases access to essential clinical information, enhances communication, addresses the MSOP literacy requirements and new residency competencies,⁹ and complements further use of distance learning. It also prepares students to work in modern health care environments—a central UME-21 goal.

Overall, UME-21 schools designed creative ways to introduce MI topics to their students. Our data showed increases in the levels of educational experiences reported by seniors at UME-21 medical schools over the 2-year study period. Similar responses, however, were identified for all US seniors, according to the GQ data. Training in MI was becoming a component of medical student education at all schools.¹⁰⁻¹² Nonetheless, the

curricular materials and the lessons learned at UME-21 schools may be useful to others engaged in teaching MI.

Corresponding Author: Address correspondence to Dr Gjerde, University of Wisconsin, Department of Family Medicine, Room 2030 Medical Sciences Center, 1300 University Avenue, Madison, WI 53706-1532. 608-263-4713. Fax: 608-263-4928. Clgjerde@facstaff.wisc.edu.

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