Medical informatics deals with the organization and management of information in support of patient care, education, research, and administration. It draws from disciplines such as cognitive and educational psychology, decision theory, information science, and computer science. As the Medical Informatics Association of American Medical Colleges stated:

"Medical informatics is a developing body of knowledge and set of techniques concerning the organization and management of information in support of medical research, education, and patient care. Medical informatics combines medical science with several technologies and disciplines in the information and computer sciences and provides methodologies by which these can contribute to better use of medical knowledge and ultimately to better medical care."

Medical informatics focuses on information and how it is identified, stored, and used rather than the equipment that makes this process possible (though the tools, of course, are a necessary component). The end objectives of medical informatics are data retrieval, information processing, interpretation, formulation, and the appropriate use of computing and communication technologies necessary to apply that knowledge in the clinical decision-making process at the time and place that a decision needs to be made.

This article will first outline a rationale for medical informatics education. This will be followed by a brief discussion of the activities under way within the Michigan State University College of Osteopathic Medicine (MSUCOM) in support of medical informatics curriculum development offered as one framework for implementation. We finish with a brief discussion providing summary comments and an overview of future issues.

Rationale

Medical informatics is important and necessary because of the vast amounts of increasing data and information physicians must draw upon, appraise, and use to help diagnose, treat, and manage patient problems. It is impossible and unrealistic to expect medical students and physicians to remember the myriad facts pertinent to any one patient’s problems. Much of the information found in medical textbooks is outdated by the time it is published. As Weed pointed out a quarter of a century ago, in transferring knowledge from the scientific literature to deploying that knowledge in delivering healthcare, a “voltage drop” occurs. That is, there is a dilution of the “knowledge of what should be done in a clinical situation to what actually is done for the average patient on the average clinical encounter.”

The medical decision-making process is only as good as the information that is taken into account. We must help students identify the best available information, make certain they have access to it when it is needed, and help develop the cognitive skills necessary to use it effectively and efficiently. We must provide them the necessary skills to discern if the information they retrieve is valid, generalizable, and applicable to a particular patient. Clinicians need to have access to tools and the cognitive and behavioral skills necessary to help them manage this information. Although care is called for to not let technology distort the meaning of thought itself, computers are one obvious method to help provide students such skills. As the National Library of Medicine states:

"The role of information technology includes the teaching of content, but even more important, concerns the method of education. Students should be given fewer answers and more tools—tools for self-teaching and for synthesizing, framing, and revising knowledge. They should have the opportunity to practice, from the earliest days of professional education, skills of seeking out information, testing hypotheses, and solving problems. The underlying objective in the use of information technology in health sciences education is not so much the transfer of current information, but more importantly, providing an environment that encourages the student to take increasing responsibility to become an independent learner, with emphasis upon understanding and application of knowledge."

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W eed has argued that medical education should focus on “the process (the approach) for dealing with any problem, not on memorizing the details about specific diseases and procedures in medicine.” The challenge is to develop improved educational experiences to help our students become more efficient at identifying clinical questions, locating and synthesizing information, and applying it (as knowledge) to patient care. To achieve this, additional work needs to be done to (1) improve the critical appraisal skills of our students; (2) to locate, prepare, and coalesce learning and clinically relevant resources for “any time, any place, any pace” access, and (3) to continue to expand access to robust, high-speed networks and a variety of interoperable computing and communications tools.

Tremendous progress has been made along a number of fronts in the arena of computing and communications technologies over the past decade. Progress has also been made in efforts to integrate medical informatics into medical education and practice. Despite these developments, the hoped-for future of ubiquitous point-of-service access to high-speed networks and the ready availability of numerous electronic datasets (including the electronic medical record) to help in patient management and care have yet to arrive. Concerning the medical school environment, pedagogy in general remains stuck in a long-outmoded model. This model is based on a (generally) segregated “two-plus-two” curriculum (2 years of basic science education and 2 years of clinical training) and a premise that lecture and memorization (supplemented with variable patient exposure and hands-on training in clinical medicine) will instill a relevant, usable knowledge base and set of skills usable, when needed, in the application of patient care.

The practice of medicine and the science behind it are constantly changing. We have seen a number of technologic advances in medicine in recent years. Examples include genetic genotyping, balloon angioplasty, magnetic resonance imaging, and artificial heart transplants. The medical profession has embraced and widely adopted the use of all kinds of technologic aids to enhance their diagnostic and treatment abilities. The computer is seen as a similar technologic aid, one that has the capacity to expand a physician’s capacity with its ability to more efficiently store, recall, summate, and disseminate medical knowledge.

Medical informatics at MSUCOM
MSUCOM’s current efforts at expanding medical informatics education builds on groundwork laid over the past decade. The college’s strategy has resulted in the establishment and enhancement of infrastructure, staffing patterns, and a variety of curricular and administrative uses of computing and communications technologies. These historical activities have resulted in variable—though substantive—enhancements of our curriculum involving technology. Our current medical informatics initiative (http://www.com.msu.edu/medinfo/initiativehome.html) represents a broad-based, multifaceted, structured, and coordinated effort to create a culture at MSUCOM that supports the appropriate incorporation and use of medical informatics throughout our educational continuum. Components of the initiative are outlined below.

Creating a culture of change supportive of medical informatics
A key assumption underlying MSUCOM’s medical informatics initiative is that there must be a central, identifiable unit within the college responsible for spearheading the effort. This is necessary to provide direction, leadership, and expertise and to help coordinate activities, foster communication, and increase “economies of scale.” Spheres of responsibility of the Office of Medical Informatics (OMI; http://www.com.msu.edu/medinfo/) include faculty, staff, and student support for network and microcomputer functions; information systems and Web functions; media services; classroom planning and support; curriculum development, implementation, and evaluation as they relate to the use of informatics; and a variety of liaison functions with numerous constituents within the college, at the university, and within the profession (http://kobiljak.msu.edu/index.html and http://www.com.msu.edu/OMI). Since its creation in April 2001, OMI has initiated the following steps and drawn on a number of existing activities, outlined below, to help promulgate informatics development.

1. Creating a task force—This task force (http://www.com.msu.edu/medinfo/initiative/taskforce.html), which meets monthly, comprises faculty, educational and evaluation specialists, and OMI staff. Its functions include the following:
   - Define curricular components (including goals and measurable objectives) associated with competency attainment;
   - Determine what skills students will be required to have at entry into medical school;
   - Develop a survey to assess faculty needs relative to technology use and faculty development;
   - Identify existing curricular components supportive of the attainment of informatics-related skills;
   - Identify existing resources;
   - Meet with faculty, departments, and appropriate committees to help review existing computer use and informatics components in the curriculum;
   - Support the development, implementation, and evaluation of appropriate new curricular activities supportive of medical informatics training congruent with existing course and curricular goals and objectives;
   - Survey course coordinators to determine what informatics skills are important in their courses; and
   - Develop methods of evaluation.

2. Creating an advisory committee—A college-wide medical informatics advisory committee (http://www.com.msu.edu/medinfo/initiative/advcomm.html), with representatives from all college departments and OMI staff, has been formed. This committee’s purpose is to provide a broad-based forum for discussion and planning around the medical informatics initiative. Its current charge includes the following:
   - Facilitate college-wide communication around informatics;
   - Aid in the showcasing of technologic and teaching innovations;
• Help to identify faculty and curriculum development needs;
• Provide input into college- and university-wide technology planning and requests for university funds; and
• Help with faculty survey administration.
3. Other proactive and contributing efforts—A host of other activities—some long-standing and some relatively new—support the college’s medical informatics initiative in that they serve to help inform us of college needs and embed computer use in the daily work of our faculty, students, and staff. Among these are the following:
• Meet regularly with departments to discuss the progress of the medical informatics initiative, showcase specific projects and new technologies, and assess needs as they relate to desired training;
• Carry out strategic planning activities aimed at gathering information about “customer” needs and helping OMI set priorities;
• Mount course protocols on the Web (www.com.msu.edu/aa);
• Implement Web-based course and faculty evaluation for all courses (http://kobiljak.msu.edu/Evaluation/UnitII.html and http://kobiljak.msu.edu/Evaluation/UnitIII.html);
• Increase use of computer-assisted learning tools, Web-based course materials, and course management using Blackboard’s CourseInfo (supported by M SU; http://kobiljak.msu.edu);
• Internet-based modules and resources related to critical appraisal, clinical decision making, and informatics (http://www.lib.msu.edu/behm/medinfo/index2.html; http://www.msu.edu/course/ost/602/med_info/med-info-main.html; and http://www.msu.edu/course/ost/602/med_info/med-info-main.html); and
• Promote use of handheld computers in the curriculum (http://www.com.msu.edu/medinfo/initiative/handheldcomputing.html);
• Provide ongoing support for the student Kobiljak Computer Center and expansion of connectivity for students;
• Digitize media for use in the curriculum;
• Develop anatomic three-dimensional visualization curricular resources (http://hal.bim.msu.edu/);
• Use of class-specific electronic mailing lists (by year and course) to communicate with students;
• Provide ongoing development and expansion of college Web pages (http://www.com.msu.edu and http://www.com.msu.edu/ss/index.html);
• Expand connectivity to community-based training sites;
• Adopt a Web-based, M SU-sponsored attendance system for staff;
• Develop extensive information systems in support of core college functions (http://www.com.msu.edu/isa/infosys/);
• Use of computer-based access to unit- and department-level budgetary information;
• Develop an extensive set of Web resources to foster communication and program administration among our geographically distributed statewide campus system (SCS; www.com.msu.edu/scs);
• Upgrade our college network (now at 100 Mbps);
• Obtain funding for faculty computers;
• Expand and enhance use of video-conferencing; and
• Develop “technology classrooms” (providing an array of computing and multimedia capabilities).

Curricular context and efforts supportive of informatics development
Medical education is a career-long process extending from medical school into residency and continuing through all years of medical practice. We are interested in instilling the skills necessary to ensure our students become strong critical thinkers and efficient managers of information. Our current medical education system assumed its educational form at the turn of the century with the recommendations of Flexner’s report. Flexner was concerned with what he believed was a discrepancy between what was then current medical science and the process of medical education. Despite enormous time and effort being placed into the process of medical education to correct for this discrepancy, current clinical medicine continues to fall well short of scientific standards. The increased curricular focus on evidence-based medicine (EBM) has attempted to bridge this gap. The practice of EBM requires the integration of individual clinical expertise with the best available external clinical evidence from systematic research. Technology and computers will play integral roles as we initiate coordinated curricular efforts to enhance student education to facilitate the incorporation of EBM and best practices into our curriculum and behaviors of our students.

As “horizontal” users of information technology, physicians need “broad functionality across a wide variety of systems and resources” to effectively integrate informatics into their practices. For this reason, a variety of computing and communications applications should be implemented throughout and integrated within the curriculum to ensure students learn “about, through, and with” computers to help build skills related to computer literacy, communications, information management, computer-aided learning, critical appraisal and decision making, and patient management. Koschmann argues this will foster “termless learning,” which involves the abilities of assessing the adequacy of one’s knowledge, efficiently redressing identified deficiencies, and directing ongoing learning in a rapidly changing world. Learning about computers entails basic familiarity with their functioning. Learning through computers involves the use of computer-assisted instructional tools to help students learn medically related content. Learning with computers involves daily use of computers to support students’ curricular activities.

To address these realities and meet these goals, the OMI is beginning to implement a strategic plan for developing medical informatics curricular goals and objectives, the identification of implementation strategies, and the establishment of outcomes-based evaluation. We intend to develop and integrate pedagogical activities that support medical informatics training within existing courses and believe an integrated approach is...
The use of technology in medical education has become more widespread, and the need to develop informatics skills is increasingly being recognized. This approach will help facilitate faculty development. Skills, where appropriate, are now being taught in one course, moving the student through basic and advanced computer-based applications. Implementation includes the steps briefly outlined below.

1. Defining and inventorying informatics competencies—Drawing from resources such as Crandall and colleagues,20 Staggers and colleagues,21 and the AAM C’s22 recommendations for informatics training to support physicians’ roles as lifelong learners, clinicians, educators/communicators, researchers, and managers, the Medical Informatics Task Force constructed a defined set of eighteen measurable informatics-related skills that we are tracking across our curriculum (http://www.com.msu.edu/medinfo/initiative/competencies.html). This will help us first to identify where informatics-related components exist. It will also help us address questions relative to where and when in the curriculum these skills should be taught, who should be involved in the instruction, which pedagogical approaches are best, and the appropriate evaluative strategies to employ to facilitate objective, outcomes-based assessment of student attainment of informatics-related skills. We want informatics to expand and reinforce professional skills, and we assume technology’s role may encompass augmentation, enhancement, or replacement of traditional teaching strategies. The task force uses a curriculum inventory methodology to measure outcomes-based attainment of skills. As mentioned previously, this will be a focus of the task force. One example of our efforts in this area is our recently completed premedical competency assessment of basic computer skills among our new students during orientation in August 2001 (http://kobiljak.msu.edu/T Training/O rientation/index.html). Drawing from suggestions outlined by the AAM C,21 we measured students’ performance in the areas of file management (local and remote), e-mail (basic and advanced), word processing, and use of the Web. We are hopeful this methodology—among others—will prove fruitful in developing meaningful evaluation strategies to objectively document successful attainment of our goals.

2. Assessment of informatics skills attainment—To date, though technology use has been embedded in our curriculum in multiple ways, it has not been systematically evaluated. Course coordinators, in conjunction with academic programs staff, now routinely review technology use in the curriculum, and student perceptions of its efficacy in helping meet course objectives is increasingly being gathered. But we still need to develop systematic, required inclusion of informatics-related curricular components and methodologies to measure outcomes-based attainment of skills. As mentioned previously, this will be a focus of the task force. One example of our efforts in this area is our recently completed premedical competency assessment of basic computer skills among our new students during orientation in August 2001 (http://kobiljak.msu.edu/T Training/O rientation/index.html). Drawing from suggestions outlined by the AAM C,21 we measured students’ performance in the areas of file management (local and remote), e-mail (basic and advanced), word processing, and use of the Web. We are hopeful this methodology—among others—will prove fruitful in developing meaningful evaluation strategies to objectively document successful attainment of our goals.

3. Faculty development in support of medical informatics—Faculty development must be an integral part of our initiative. Our priorities for faculty development will be determined from data obtained from the faculty survey, the advisory committee, OMI’s strategic planning activities, ongoing meetings with departments, and by project-specific needs. They will include a variety of methodologies, including both large and small group colloquia, seminars and workshops, demonstrations, and one-on-one instruction. The Web will play a role in helping develop and deliver resources asynchronously at the time of need. We will draw from a variety of resources to help with this effort, including expertise among OMI staff, college faculty, the SCS Library of Medicine in 198623 (knowledge representation, knowledge and data acquisition, medical decision making, cognitive aspects of decision support, human-machine interface, information storage and retrieval, technology transfer and dissemination, and supporting technologies and enabling activities) are much the same as the future applications indicated by Fagan and Shortliffe22 (telemedicine, remote consultation, integrated health records, computer-based learning, remote computing for bioinformatics, patient and provider education, and disease management). What is different now are the increased bandwidth and computing power available to support successful implementation of informatics and the presence of the Web, providing access to information “any time, any place, any
pace” and some solutions to platform incompatibilities. Challenges remain. Technology use in the curriculum is still too often characterized by fragmented development of projects, no overall plan, lack of integration of software/hardware, and minimal sharing of resources or support personnel. Altering pedagogical styles and changing faculty teaching behaviors is not easily or quickly achieved. Goals remain dependent on still higher bandwidth with increased reliability and decreased latency, wider diffusion of electronic medical records, and financial models making applications cost-effective and practical. Planning and implementing informatics across MSUCOM’s distributed SCS, involving numerous hospitals, hundreds of clinical training sites, and over 1000 clinical faculty is not trivial.

Implementing medical informatics within the college is an evolving process. Our objectives are to train our medical students to be efficient users of information, to provide them an appreciation for how accessible information is to them, and to teach them the skills necessary to discern what information is appropriate, reliable, and relevant to patient care. We envision accomplishing this by embedding informatics experiences into existing preclinical courses and clinical clerkships to ensure that computers become a daily and expected part of their study and work routine. Learning the skills necessary to manage medical information has always been one of the greatest challenges in medical education, and medical informatics is a vehicle that can help us reach this goal. The medical student who learns these skills will have an advantage over those who do not. Our goal at MSUCOM is to help our students develop good information habits and become more comfortable and efficient managers of information.

As previously mentioned, we are in the process of implementing a process to support the incorporation of a variety of computing applications throughout and integrated within the curriculum to ensure our students learn “about, through, and with” computers. The march toward including medical informatics in our medical education systems continues. Progress has been made. The work entails efforts on many fronts involving continuing infrastructure enhancements and curriculum and faculty development support. It includes the technologies used to support the computing and communications infrastructure (“pipes and wires” and the computers and audiovisual peripherals connected to them) and the process or “social reengineering” required to effectively integrate appropriate informatics into medical education and (more fundamentally) clinical practice. More work remains to be done.

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References