A Vertical Curriculum to Teach
The Knowledge, Skills, and Attitudes of Medical Informatics

Julie McGowan, Ph.D., William Raszka, M.D., Jeanene Light, M.L.S.,
Diane Magrane, M.D., Donna O'Malley, M.L.S., Tania Bertsch, M.D.
Vermont Initiative for Rural Health Informatics and Telemedicine
University of Vermont College of Medicine, Burlington, Vermont

It is becoming increasingly apparent that medical schools must begin teaching the knowledge, skills and attitudes of information literacy and applied medical informatics as core competencies in undergraduate medical education. The University of Vermont College of Medicine recognized that these core competencies were lacking in its curriculum, and in 1992 it implemented a four year, integrated program to give students the information habits essential to twenty-first century practice. The first graduates of the program are now in residencies and feedback has enabled the College to refine the program to better meet the informatics education needs of the next generation of physicians. The result of these efforts is the Vertical Curriculum in Information Literacy and Applied Medical Informatics; its process of development, the product of the process, and its outcomes are discussed.

INTRODUCTION

In 1991, the University of Vermont (UVM) College of Medicine began evaluating its curriculum to determine whether it would meet the needs of graduates in the next century. Among other changes in the health care environment, computer technology and the field of medical informatics were becoming fully entrenched. However, at UVM there was little education or training in computer applications in the curriculum beyond computer assisted instructional programs and the required Medline class.

Several reports from the medical education community were providing impetus to create an instructional program in medical informatics.[1-2] Accreditation groups strongly suggested that medical informatics education be added to the curriculum. Another strong voice for such a program came from a small but very vocal group of students who formed a computer user interest group and called themselves "The CyberDocs." This group and a number of other forces came

together to develop what was to become a dynamic, four-year, integrated curriculum in information literacy and applied medical informatics.

BACKGROUND AND SIGNIFICANCE

In the draft report[3] of the Medical School Objectives Project Medical Informatics Panel, medical informatics is defined as "the rapidly developing scientific field that deals with resources, devices and formalized methods for optimizing the storage, retrieval and management of biomedical information for problem solving and decision making." The word, "computers," however, is not part of the definition. Information management, long before the advent of computers, has been recognized as an integral part of medical education. Even Osler[4] and Cushing[5] saw the value of such instruction.

The first two of five recommendations made in a 1986 monograph entitled, *Medical Education in the Information Age: Proceedings on the Symposium on Medical Informatics,*[6] state that "Medical informatics should become an integral part of the medical curriculum. The teaching of medical informatics should include opportunities for specific instruction in its fundamentals as well as adequate examples of its application throughout the medical curriculum," and "There should be an identifiable locus of activity in medical informatics in academic medical centers to foster research, integrate instruction, and encourage appropriate use for patient care." This report underscored an earlier report of the Association of American Medical Colleges that served as the foundation for the National Library of Medicine's IAIMS (Integrated Academic Information Management System) program.[7]

Although there were a number of published mandates, most medical informatics education in the United States until the 1990's took the form of bibliographic instruction, integrated into

problem-based learning (PBL) curricula or as stand-alone classes, and computer assisted instruction used as an adjunct to the curriculum. While departments of medical informatics began to be created in American medical colleges, these departments had little to do with teaching medical students as part of the undergraduate medical school curriculum.[8] In addition, a tension between informaticians and medical librarians began to grow, with both involved in information management and yet each lacking recognition of complete ownership of the discipline within their respective academic medical centers.[9]

In Canada and Europe, informatics education in undergraduate medical school curricula has received stronger support. For example, Dalhousie University[10] and the University of Limburg[11] integrated informatics education into their PBL curricula. In Germany, 24 of 27 medical schools have departments of medical informatics and the respective faculty are all involved in teaching the subject to undergraduate medical students.[12] Charles University in Prague[13] is the nucleus for the EuroMISE (European Education in Medical Informatics, Statistics and Epidemiology) Project, with the medical informatics core housed at Erasmus University in Rotterdam.[14] Most of the European programs are based on a block approach which introduces informatics concepts at the point of greatest relevance, leading to deeper levels of learning. Also, while few of these programs are required, their importance is validated by required examinations.

Lack of progress in introducing medical informatics education into the undergraduate medical curricula in United States' medical colleges is attributed to a number of factors. These include lack of technology, or resources to purchase it, lack of curricular time for "non-essential" instruction, lack of faculty time or interest in teaching the discipline, and lack of commitment on the part of medical school administrations.[8-9]

METHODS

The administration of the University of Vermont College of Medicine, through its Instructional Improvement Committee, made a commitment to introduce medical informatics education into the curriculum, beginning in 1992. While the College did not have a department of medical informatics, it did have a long history of involvement with medical informatics programs, including Dr. Larry Weed's work with automating patient care information in his PROMIS Lab in the 1970's and the Interact Telemedicine Project in the late 1960's. In addition, the College's medical library had recently been reorganized with the recruitment of several library faculty with Ph.D.'s or educational backgrounds in applied medical informatics and information literacy.

The process began with giving up curricular time in bibliographic instruction, one week of small group tutorials in the Family Practice clerkship, in return for several required modules focusing on curricular correlations during the basic sciences. These included a computer literacy class during matriculation which taught e-mail applications, an introduction to computer assisted instructional packages, and an exercise using the National Boards Computer-Based Testing, Case Simulation programs. The latter exercise served to excite the entering students about medicine, using computers as a tool.

Another early module was the requirement to have students append a Medline search to their required autopsy reports as part of the Pathology course. Medline courses were offered for those who felt they needed them; however, the courses were not required. Because the Medline search was evaluated, students frequently returned for a "refresher" course and resubmitted the exercise. This module also served to demonstrate what had been suspected in the lack of information literacy or applied medical informatics teaching in the curriculum. Pathology faculty felt that they did not have the time to teach something new, but with library informatics faculty willing to monitor the exercise, and with the approval of the administration, they had no problem expanding the autopsy report project.

Basic Principles
With a growing interest on the part of both the students and the administration in the new information literacy and applied medical informatics curricular programs, a "Vertical Curriculum" [E.G., a formal course integrated throughout the four years] was proposed. The goal of the program was to instill the knowledge, skills, and attitudes of information management in undergraduate medical students. It was designed to help the students develop the information habits which would assist in the

effective identification of information needs, the acquisition of pertinent information from appropriate sources, and the quality filtering of information for applicability to the specific medical problem and validity of the information presented.

While computer assisted instruction (CAI) was considered to be a desirable component of the medical school curriculum in general, it was not considered to be a part of the Vertical Curriculum. A primary distinction was made between the effective use of CAI and the skills of Applied Medical Informatics, with the former supporting the educational process and the latter building a foundation for clinical practice following graduation.

The following five principles were adopted:

1) Concepts, and supporting knowledge and skills, need to be introduced at a point in the undergraduate medical curriculum which will insure maximum relevance with both the educational process as well as the competency objectives defined for future practice.

2) Information management instruction needs to be fully integrated into pre-clinical and clinical courses and not presented as a "stand-alone" module within any course, no matter how relevant the context of the presentation.

3) Core information competencies need to be reinforced throughout the four year undergraduate program and in the residencies where appropriate.

4) Information faculty need to be part of the "teaching team," and accorded appropriate faculty status within the educational environment of the institution, specific College of Medicine department, and relevant course.

5) Assessment of the information management competencies needs to be frequent and handled as a routine part of the student evaluation of any course.

The principals stated above provided the framework for the development of the curriculum and provided guidelines for faculty in the design of their course modules. By 1994, the Vertical Curriculum in Information Literacy and Applied Medical Informatics spanned all four years of undergraduate medical education at the University of Vermont.

Resolution of Commitment Issues

While there was a general commitment on the part of the medical school administration to foster medical informatics education, and the Instructional Improvement Committee had endorsed the program, implementation was not guaranteed. Agreeing that such instruction is essential is one thing; agreeing to integrate it into any specific course, especially during the three-semester long basic science program at UVM, is another.

Realizing that the program needed to teach the knowledge and skills necessary to support medical decision making, most of the early efforts focused on the clinical clerkships. By the third year of the program, informatics faculty team taught in every core clerkship except surgery. However, after matriculation with its computer literacy module, the only exposure to any form of information literacy or informatics education prior to the clerkships came in the form of the autopsy reports.

Around the same time period, the entire curriculum of the College was in the process of change, with more emphasis on primary care earlier in the program, and this offered unexpected opportunities for curricular integration. An interdisciplinary program, the Vermont Generalist Curriculum, was created to enhance early generalist competencies during the first year of medical school. One of the foci was on experience in an office setting, and two classes of information access have become a required, and graded, part of the experience. This program not only teaches medical students to use available tools for information problems, but also involves off-site preceptors in the experience.

The knowledge and skills taught during this part of the Vertical Curriculum are reinforced and amplified during the core clerkships. The program builds on previous skills of information literacy with an introduction to evidenced-based medicine and critical analysis of the literature. It builds on simple use of e-mail with a requirement for off-site information acquisition in support of patient care during a rural preceptorship experience and transmission of assignments back to the informatics faculty member at the academic medical center. It builds on simple training in the use of the patient care information system to collect laboratory and medication data on patients with an exercise in

the use of clinical decision support software to assist in making diagnostic or management decisions.

Although the Vertical Curriculum uses a required, fully-integrated approach to teach information literacy and applied medical informatics, there is one additional element that insures its value as a fundamental program in the undergraduate medical school curriculum. This is reflected in the means of evaluation of the various modules. Most medical students tend to place a higher educational value on the knowledge and skills on which they will be examined. To insure that information literacy and applied medical informatics are not relegated to a tangential area of knowledge, course objectives of the various informatics components are evaluated as part of the standard evaluation process in all of the core clerkships and virtually all of the other required courses.

Recognition of Faculty

Because most of the informatics faculty are drawn from medical library faculty, post-doctoral fellows with an interest in medical informatics, public health and epidemiology professionals, and nursing and allied health faculty, there is frequently an issue of credibility, especially in the area of assigning grades, among the medical students. This issue has been solved by giving these faculty joint or clinical appointments in the respective departments in which they team teach.

Technology Support

One of the major issues identified as inhibiting medical informatics education, beyond administrative commitment, time in the curriculum, and faculty time, is the lack of available technology. While Vermont does not have a large endowment and ranks at the bottom for state support of higher education, it does have a grassroots determination to make good ideas succeed by leveraging resources and innovation. The computer resources in the College computer labs to support the Vertical Curriculum are minimally adequate. However, information resources are networked throughout the academic medical center campus and available whenever information questions arise.

Five years ago, the College of Medicine through a number of health community partnerships, unveiled VTMEDNET, the state-wide comprehensive health information network.[15] In addition to providing health information to health care providers in the state, it serves as a distance learning backbone, connecting rural preceptorship sites through an electronic umbilical cord back to the academic medical center.[16] Several small grants have enabled the purchase of notebook computers which support distance medical informatics modules.

RESULTS

An outline of the Vertical Curriculum as it is now organized is found at the **URL:**
    sageunix.uvm.edu/dana/vertcurr/outline.htm
The curriculum, of necessity, is dynamic and changes routinely to meet the changing information and health care environments. For instance, in 1997, the clinical core in pediatrics taught advanced Medline searching and quality filtering of journal citations followed by critical analysis of the literature. It now teaches quality filtering and critical analysis of web-based information.

As mentioned, evaluation is a key component to the Vertical Curriculum. In addition to evaluating medical students on their mastery of content objectives, several small research projects have been conducted to evaluate the impact of various components of the curriculum. One of these was a pilot study done on students in the Obstetrics and Gynecology core clerkship in which the experimental group of students had informatics instruction intervention and the control group did not. They were then surveyed as to their source of information for questions and whether or not they found the answer. The experimental group found the right answer 20% more frequently than the control group and used the literature rather than asking colleagues.

A second study is currently being done as part of a National Board of Medical Examiners' grant to develop a single station OSCE (Objective Structured Clinical Examination) to test the outcomes of applied medical informatics and information literacy education. The University of Vermont students comprise the experimental group of students in a two-site study, and initial results suggest that integrated informatics education does have an impact on the retention of knowledge and skills necessary to use informatics tools to solve clinical information problems.

A less objective measurement of the Vertical Curriculum has taken place for the last two years during the senior exit interviews. Prior to the implementation of the Vertical Curriculum, the College had received numerous complaints that it was doing little to prepare students for future practice in the area of computer instruction. Recently, however, students have been very supportive of their applied medical informatics education, and they especially echo these sentiments upon return from residency interviews to places which lack either the infrastructure or educational commitment.

CONCLUSIONS

The Draft Report of the Medical School Objectives Project Medical Informatics Panel suggested implementation strategies for implementing medical informatics education into an undergraduate medical school curriculum. The University of Vermont College of Medicine developed its Vertical Curriculum in Information Literacy and Applied Medical Informatics along virtually all of the same premises, with the possible exception of having informatics faculty team teach with discipline specific faculty for reasons of internal institutional politics.

Initial results show that the medical informatics educational objectives are being met. However, longitudinal research needs to be done to determine whether students retain the knowledge and skills of information management after graduation.

REFERENCES

1. Muller S. (Chair). Physicians for the Twenty-First Century: Report of the Project Panel on the General Professional Education of the Physician and College Preparation for Medicine. J Med Educ 1984; 59(11 pt 2).
2. Educating Medical Students: Assessing Change in Medical Education – The Road to Implementation (ACME – TRI Report). Acad Med 1993; 68(6 suppl).
3. Medical Informatics Advisory Panel, American Association of Medical Colleges Medical School Objectives Project. Draft Report. 1997.
4. Wylde, CF. Practical education of the medical student in library methods. Bull Med Libr Assoc 1927, 15:27-30.
5. Cushing H. The doctor and his books. Amer J Surg. 1928; 4:100-10.
6. Meyers JD. (Chair). Medical education in the information age: Proceedings of the Symposium on Medical Informatics, Association of American Medical Colleges, Washington, DC, 1986.
7. Matheson NW. Academic Information in the Academic Health Sciences Center. Roles for the Library in Information Management. J Med Educ 1982; 57:1-83.
8. Florance V, Braude RM, Frisse ME, Fuller S. Educating physicians to use the digital library. Acad Med 1995; 70:597-602.
9. Frisse ME, Braude RM, Florance V, Fuller S. Informatics and medical libraries: changing needs and changing roles. Acad Med 1995; 70:30-5.
10. Kaufman DM. Integrating medical informatics into an undergraduate curriculum. Medinfo 1995; 8(pt 2):1139-43.
11. Hasman A. Education and medical informatics – Five years of experience at the University of Limburg. Proceedings of the Fifteenth Annual Symposium on Computer Applications in Medical Care, 1991 Nov 17-20, Washington, DC: AMIA 1992:273-7.
12. Haux R, Dudeck J, Gaus W, Leven FJ, Kunath H, Michaelis J, Pretschner DP, Sonntag HG, Thurmayr R, Wolters E. Recommendations of the German Association for Medical Informatics, Biometry and Epidemiology for education and training in medical informatics. Meth Inform Med 1992; 31:60-70.
13. Zvarova J, Engelbrecht R, van Bemmel JH. Education and training in medical informatics, statistics and epidemiology in EuroMISE. Int J Med Inform 1997; 45:3-8.
14. van Bemmel JH, Sollet PCGM, Grashuis JL. Education in medical informatics in the Netherlands: A nationwide policy and the Erasmus curriculum. Meth Inform Med 1989; 28:227-33.
15. McGowan J, Evans J, Michl K. Networking a need: A cost-effective approach to statewide health information delivery. Nineteenth Annual Symposium on Computer Applications in Medical Care, Washington, DC: AMIA 1995:571-5.
16. McGowan JJ. A vertical curriculum in applied medical informatics in support of rural primary-care education. Acad Med 1994; 69:430-1.