Architecture for a graduate level educational program in the area of computer systems in medicine

by LAURENS V. ACKERMAN

Rush Medical School
Chicago, Illinois

and

DANIEL K. HARRIS

American Medical Association
Chicago, Illinois

INTRODUCTION

A professional discipline, in its embryonic stages of development yields practitioners who, through interest and/or circumstance, avail themselves of fragmented knowledge from other disciplines, synthesize intellectual common denominators, and apply these common denominators consistently to a multiplicity of problem situations. Eventually, the embryonic discipline will generate additional knowledge from within, which is generally considered to be a necessary precursor to formal acknowledgment by society that a new discipline has in fact emerged.

The practitioners of a new discipline will, at first, be convenient instruments for use in sporadically occurring situations requiring the application of their specialized knowledge. Over time, however, sporadic needs may become commonplace—more so than the practitioners trained to satisfy them. It is at this juncture—the transition of a profession from a convenience to a necessity that the mettle of the profession to produce qualified practitioners is tested.

The evolution of computer expertise in the medical environment has tended to emerge according to the pattern suggested in the above scenario. The computer science and systems professionals serving the medical community represent a diversity of backgrounds, both educational as well as experiential. Due in part to this diversity, fundamental, qualitative norms of performance for medical computing professionals have not surfaced. Indeed, the sources of computer expertise to serve the medical community are difficult to identify because of the lack of educational patterns as well as educational institutions offering programs in medical computer science.

PROGRAM OBJECTIVES

The purpose of the educational program described is to provide a structured, coherent, educational framework of sufficient breadth to permit the development of professional expertise in one or more of the following health system areas.

(a) Clinical systems development
(b) Medical administrative systems development
(c) Medical computer science

As the central theme of the program is to train professionals in the many and increasing facets of medical computing, several corollary interests surface naturally. These additional interests include:

(a) Establish the basis for continued research and development of medical computing systems.
(b) Develop a reservoir of expertise sufficient to meet the medical computing needs of the ambulatory care environment in addition to those of the medical center environment.
(c) Provide a basis for the development of continuing education programs for physicians and laymen with interests in medical computing.
(d) Provide a dynamic model for medical schools and other educational institutions to consider as a starting point in the development of similar programs.
(e) Develop professionals capable of communicating at the medical, computational and administrative levels in the development and administration of health systems.

HISTORICAL CONSIDERATIONS

The architectural components of the program offered for consideration have been influenced by the educational dynamics present in the commercial and biomedical engineering computer environments over the last twenty years. Analysis of these two apparently dissimilar environments reveals several commonalities which have combined
to cause the current pattern in medical computing education and development.

First, both the medical and business environments have tended to obtain computer expertise from apparently logical sources. In commerce, the accounting function served as the source of manpower and in medicine, biomedical engineering was selected (implicitly) to develop needed expertise. This "selection process" has resulted in a traditional de-emphasis of computer and associated disciplines as legitimate activities in their own right. Until recently, the computer or management science profession did not exist in the commercial environment. In the medical sector, the computer profession continues to be represented as an extension of the biomedical engineering function. As the use of the computer is increasingly extended in non-bioengineering areas, this orientation, at least in some quarters, is beginning to change.

Secondly, computer education has had an on-the-job orientation at a period in time when the technological emphasis has been in developing new, more sophisticated computer hardware systems. The result has been that applications oriented programmers and systems analysts have tended to proliferate the same systems and applications under changing and more complex hardware configurations. It is not surprising therefore, to be confronted with a widening gap between hardware capability and the capability of the programmer and analyst to utilize it effectively.

Third, because the orientation in both medical and commercial computing has been device and application oriented, the emphasis on the man/machine interface has been decidedly oriented toward the machine. Analysis of the influence on behavioral mechanics of the environments in which computers operate has not been an integrated component of the educational experience of computer professionals. The trauma normally experienced when a "hospital information system" is implemented in what is generally acknowledged as a complex, interrelated human organization is not surprising. The experience in this regard suggests that instruction in the behavioral and organization dynamics of human organizations is at least as important to system success as instruction in computer programming and systems analysis.

Finally, and perhaps most significantly, physicians, computer programmers and analysts, and administrators have tended to insulate themselves within their respective roles. Communication among functional entities is hampered partially due to terminology differences and partially due to role isolation. Systems development tends therefore to be unilateral in thrust and execution. The hospital information system is in actuality, an administrative information system. Clinical laboratory systems tend to be driven by individual computers without multiplexing capability for information exchange.

PROGRAM ARCHITECTURE

The program offered for consideration is graduate in nature. It assumes a general knowledge of fundamental data processing concepts and requires a knowledge of computer programming. Basic characteristics of the program are as follows:

1. The program offers a Masters or a Doctoral degree.
2. Program duration will vary from two years to four years, depending upon the candidate's academic and experiential backgrounds, as well as the type of degree sought.
3. The program would be open to, and encourage the participation of, both physician and non-physician candidates.

The program will offer a core series of courses in each of six major areas. These areas include:

1. Computer Science
2. Medicine
3. Mathematics
4. Administration
5. Systems Architecture
6. Computer Systems In Medicine

A key element of the program is the integration of each basic area with all others. Thus, the physician will have the fundamental knowledge necessary for effective communication with the administrator and computer scientist. The non-physician will be given essential medical knowledge necessary to communicate with the physician. Candidates in each area of interest, through the core
courses, will be sensitized to the needs and terminology idiosyncratic in the other areas.

Course offerings are structured to: (a) provide insight into fundamental concepts, (b) establish the framework for development of design techniques and (c) provide an opportunity for the candidate to apply concepts and design techniques in a live environment.

Administrative component

The core courses in the administrative component of the program are intended to provide the candidate with detailed insights into the structure and operating components of the administrative sector of the health care delivery system. Core courses dealing with finance, economics and management activities as they relate to development of the health administration information base are presented. In addition to traditional administrative material, students will also be presented material concerning organization theory and analysis as well as the behavioral dynamics of group interaction in structured and unstructured environments. Thus, in addition to possessing the ability to define and design administratively related medical systems, students will be expected to have a clear understanding of the environment which these systems are intended to influence.

Systems component

Courses offered in the systems component of the program are intended to provide the student with:

(a) A fundamental appreciation of the concepts of systems theory and organization.
(b) An insight into the inter and intra structural mechanics of systems.
(c) An appreciation of systems techniques available for the development of clinical and administrative EDP information systems.
(d) Insights into the man/machine interface vis-a-vis medical EDP systems.

Students completing the courses in the systems component will be expected to be capable of applying systems development techniques consistently in a multiplicity of medical design environments as well as integrating discrete components of the medical environment into coordinated development activities.

Computers & medicine (administrative) component

This graduate program component provides the student an opportunity to intensively study medical administrative systems in various health care settings under varying conditions. Stress will be placed upon administrative medical systems whether in operation or in the process of being developed. Students will be given the opportunity to interact with systems designers and users. As system design requires optimization of available resources in the context of a given environment, students will be provided opportunities to design and program EDP systems stressing design options and quality assurance mechanisms both in a machine and man/machine context.

Medical component

Cognizant of the extreme complexity of medicine, the program does not emphasize the use of computers in systems analysis of medicine. Rather, the student is provided a concept of the system that he is analyzing. Although the system and computer person have many techniques which are theoretically capable of analyzing a system, the reality of systems analysis requires a delicate intertwining of theory and practice to produce an operational and practical system. Both the computer scientist and systems scientist, plus the administrator, must have a knowledge of the system in which they are functioning and in this instance, that system is medicine. An objective of this educational pattern is to provide an understanding of some of the problems encountered by physicians and other paramedical personnel, and solve these problems in terms of methodologies taught in the program. To this end, the student will be provided a basic medical physiology sequence in what might be called disease states, taken from a system perspective (as that is the orientation of the students) approaching a point where the student will attend grand rounds and understand the problems presented there. This represents a radical departure for most administrators and computer systems personnel who either feel caught up by the overwhelming difficulty of the medical sciences or feel more secure inside of their traditional roles. The medical component of the program, therefore, represents a unique opportunity for non-physicians to empathize and communicate effectively in the medical systems design environment.

Computer science component

Prior to entrance into the program, the student must demonstrate competence in a computer language as well as a basic understanding of fundamental computer technology concepts. Because of the balance between administration, systems, and medicine, with the computer as a unifying element, the student should gain knowledge of a business and a scientific language, probably COBOL and FORTRAN (with PL1, the extent depending on his interest). Additionally, there should be a comparative knowledge of other languages to permit the student to ascertain which language should be used in a particular application. Also, an important aspect of the student's education will be medical data base design, as this will be the basic building block for systems, computer and medical applications. Finally, it is desirable that the student have knowledge (at the assembly language level) of one multiuser, time share system so as to have an idea of the
technical components in a large multiuser system employed in a hospital.

Computers & medicine (clinical) component

Inherent in the medical and administrative courses will be the various respective computer applications. However, in-depth courses in computers in clinical medicine are provided to aid the student in the development of design capability. The core section of this program is not intended to completely acquaint the student with the computer in clinical medicine, but it is thought very important to orient the student to some of the problems he is likely to encounter as well as possible alternate solutions. A course in clinical computer systems in medicine will specifically examine the computer as used in clinical activity. In pursuing this area the student will be required to develop a minimum level of competence in mathematics including matrix theory, statistics, and probability, in addition to demonstrating knowledge of current techniques in artificial intelligence and pattern recognition. Pertinent mathematical techniques addressing classification, clustering, automatic diagnosis, and decision techniques will be stressed along with current methods available to model medical knowledge. In addition to the theoretical level the student will also examine systems in use in university and nonuniversity hospitals and ambulatory settings in addition to examining various commercially available medical computer systems.

PROGRAM DESIGN

Because of the interdisciplinary nature of this program there is room for both M.D. and non-M.D. candidates to matriculate into a variety of operational, research and teaching roles. The program is designed for a multitude of people with different backgrounds and interests, offering a basic series of core courses enabling them to communicate at multidisciplinary levels and then follow various specialization tracks that emanate from the core. The M.D. candidates would not be required to take the physiology and disease system courses, but it is understood that the M.D.’s probably would require some remedial work thus equalizing the M.D.-non-M.D. course load. The tracks are then divided into three thrusts which would include administrative, clinical systems, and computer science. To provide students an experience in administrative and clinical live environments, internships are required of both types of students in both areas. Additionally there would be an activity called “Computer rounds,” intended to attract other members of the hospital to provide a purposeful discussion. Inherent in this program is the concept that this is mainly an operational activity with provisions for students to gain a theoretical appreciation of concepts at work in the operational environment. The degree structure is organized to provide an “operational” and “theoretical” candidate with a similar core background. After approximately two years, the student would be given the choice of continuing his studies for a Ph.D. or elect to stop at a Masters and become active in the operational environment. The function of the Ph.D. is to educate a person to perform research in operational areas; whereas the Masters is established for an individual anxious to initiate activity in the health care environment without having to pursue the extended research of a Ph.D. activity.

SUMMARY

As was indicated earlier, the purpose of the educational program offered for consideration is to provide for a structured, coherent, educational framework of sufficient breadth to permit the development of professional expertise to influence advancement in the areas of clinical systems, medical administrative systems, and medical computer science. The root concept supporting the program structure is the emphasis of cross communication and training in the functional components of the health care delivery system. The computer, to be sure, does not represent an end point in itself. However, as the use of the computer proliferates in the health care community, the computer serves as a catalyst to draw heretofore isolated areas of the health care system into integrated focus, both conceptually and operationally.

There are several alternative methods available to train the expertise necessary to fill a growing technological need in the medical community. Traditional “on-the-job” training programs, such as those often employed in the commercial environment offer apparently fast solutions to the imbalance between supply and demand of medically oriented computer professionals. However, for reasons discussed earlier, these programs tend to lack consistency and depth, over the long term.

The program architecture offered for consideration is intended to serve as a basic model for graduate programs in computer systems in medicine. As is the case with any model, it has built into it the type of flexibility necessary to accommodate a changing, dynamic environment. However, in so stressing the need for flexibility, it also recognizes the need for unanimity among health care functions traditionally isolated in operation. The coalescing point is the development of a rational, well integrated system. With the delivery of health care as the principal focus...not administration, nor computation, nor theoretical medicine functioning as independent activities, but rather these important activities functioning in concert, as a whole.