DOCUMENT RESUME

ED 046 229 EM 008 648

TITLE Proceedings: Conference on the Use of Computers in Medical Education.

INSTITUTION Oklahoma Univ., Oklahoma City. Medical Center.

SPONS AGENCY Public Health Service (DHEW), Arlington, Va. Bureau of Health Manpower.

PUB DATE 68

NOTE 105p.: Reprint from Proceedings of Conference, Oklahoma City, Oklahoma, April 3, 4, and 5, 1968

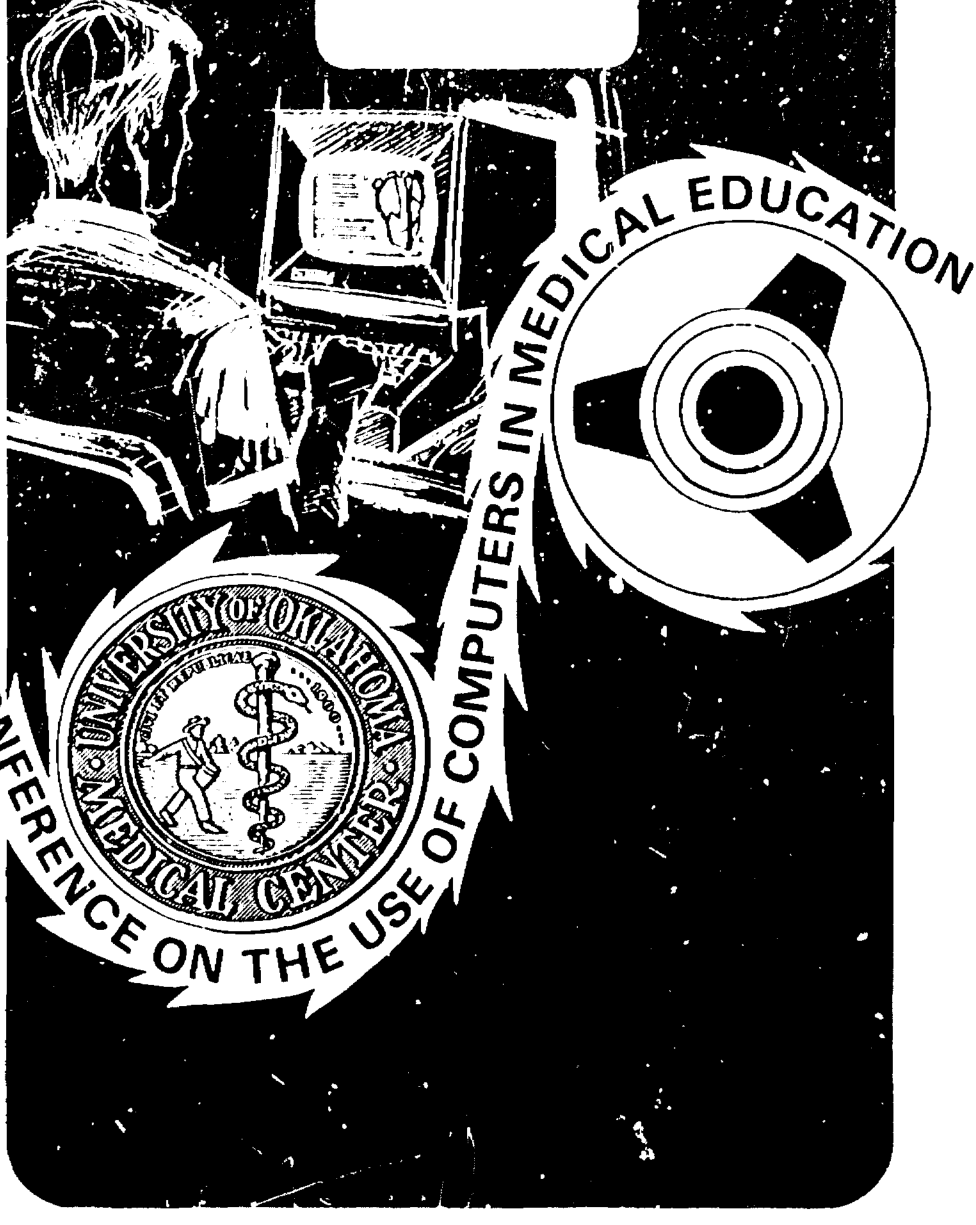
EDRS PRICE EDRS Price MF-$0.65 HC-$6.58

DESCRIPTORS Automation, Computer Assisted Instruction, Computer Graphics, *Computer Oriented Programs, Computers, *Conference Reports, Conferences, Costs, Faculty, Goal Orientation, Higher Education, *Medical Education, Medical Libraries, Medicine, Models, Professional Continuing Education, Social Change, Symposia, Technology, Undergraduate Study

IDENTIFIERS EDUCOM, EDUNET, Interuniversity Communications Council, MEDLARS, National Library of Medicine, Sim One, University of Oklahoma Medical Center

ABSTRACT

At a conference concerned with the role of computers in medical education, papers were given on the use of computers in continuing medical education, in clinical medical education, and in undergraduate medical education. Other subjects discussed were: medical technology and social change, criterion models of medical practice, faculty selection, EDUCOM (University Communications Council), automation in the medical library, MEDLARS, funding and costs, evaluation of computer use, and proper goals for medical education. It was resolved that the conference be held on an annual basis. (MF)



APRIL 3, 4, & 5, 1968 OKLAHOMA CITY, OKLA.

PROCEEDINGS

Conference

on the Use of Computers in Medical Education

Co-Sponsored by

U. S. Department of Health, Education and Welfare

Public Health Service

Bureau of Health Manpower

and

The School of Medicine

University of Oklahoma Medical Center

April 3, 4, and 5, 1968

University of Oklahoma Medical Center

Oklahoma City, Oklahoma

TABLE OF CONTENTS

FOREWORD

JAMES L. DENNIS, M.D.*
University of Oklahoma Medical Center

Distinguished guests and colleagues, welcome to Oklahoma, to Oklahoma City and to the University of Oklahoma Medical Center campus.

Someone has described planning as the projection of a wedding between the ideal and the practical. This is not easily accomplished in our complex society, but one of the catalytic agents that can make such a wedding possible is computer science. Current pressures upon medical education are twofold. From one side, there is the explosion of knowledge and from the other side, the pressures from society to fill the gaps in the health care system and to maintain the ongoing quality of the physicians we graduate to prevent obsolescence. Computer science offers perhaps the most attractive possibility for bringing order out of chaos.

When faced with the problem of relating medical education to societal needs, one must be very concerned about the protection of academic excellence and its future enhancement. The pressures to become involved in the delivery of mass health services to relieve the shortages and deficits that exist in the nation are tremendous. Many people now turn to the medical centers to solve their problems and we cannot ignore our responsibilities. The situation is similar to that of the chicken and the pig who were worried about their kind master who was having a very hard time. They wondered what they could do to help. The chicken said, "We can feed him," and the pig asked, "Feed him what"? The chicken responded, "We can feed him ham and eggs" to which the pig reacted immediately, "For you that's only a commitment, but for me that's total involvement." Certainly, anytime a medical educational institution takes on the responsibility of an undefined mass health service program, this means total involvement and with the same results that the pig anticipated. Therefore, we must have a protected core of academic excellence, as is found in the research and educational programs. Here is the fountainhead for new knowledge and new developments. The development of a health center concept whose activities get programming closer to the public, provides communication from the research bench and the academic desk by way of programs that permit an immediate transmission of new knowledge and new technology to the public.

We thought that the health service problems on the one hand and the health science challenges on the other were more than a single medical institution in a state such as Oklahoma could meet, without forming an alliance with others in our community who have responsibilities for the health sciences. We went to outstanding citizens of this state and discussed the possibility of developing what we now call the Health Sciences Foundation. This foundation. was formed not

*Vice President for Medical Center Affairs and Dean, School of Medicine to run the proposed Oklahoma Health Center but to aid and assist institutions who were willing to build in geographic proximity to the University as a core and to commit themselves to assisting the University in its mission of health manpower production and the pursuit of knowledge. The planning is well along and buildings are under construction. The Health Center will have interfaces with institutions at city, county, state, and Federal health agency levels and with both private and public agencies and institutions. Many central services and facilities will be shared by all of these institutions. This means that funds for capital investments that we receive at the Medical Center can go into laboratories, classrooms and beds rather than into steam, refrigeration and laundries. The Oklahoma Health Center is coordinated by an operations committee comprised of the heads of each of the institutions that will locate here. This committee determines feasibility and recommends policy and procedures to our individual governing boards. These are presented to the Foundation for implementation. All of these activities are tied together by a rather ambitious computer program and, of course, the concept of reaching out into the state is very much dependent upon computer technology and computer-based communication.

This conference, to explore the role of computers in medical education, is a very timely one because of the current examination into curricula, programs and facilities for health manpower. Much should be learned from this opportunity for knowledgeable people to interact, and the discussion could have a significant impact on the future of medical education.

PROGRAM

WEDNESDAY, APRIL 3, 1968

Chairman – Edward N. Brandt, Jr., M.D., Ph.D., *Conference Director*

WELCOME – James L. Dennis, M.D., *Vice President for Medical Center Affairs, University of Oklahoma Medical Center*

MEDICAL TECHNOLOGY AND SOCIAL CHANGE
J. Herbert Hollomon, Ph.D., *President-Designate*
University of Oklahoma

CONFERENCE OBJECTIVES
Joseph M. White, M.D., *Dean of Medical Faculty*
University of Oklahoma School of Medicine

EXCELLENCE – BUY OR BEGET?
Frank W. McKee, M.D., *Director of the Division of Physician Manpower, U. S. Public Health Service*

EVALUATION OF THE USE OF COMPUTERS IN MEDICAL EDUCATION
Stephen Abrahamson, Ph.D., *Director, Division of Research in Medical Education, University of Southern California, School of Medicine*

Panel Discussion by Faculty Members of the University of Oklahoma Medical Center Involved in Computer-Aided Instruction and Demonstration of the CAI System

Chairman: William G. Harless
Panel: Thomas N. Lynn, M.D., *Preventive Medicine and Public Health*
Arthur W. Nunnery, M.D., *Pediatrics*
Eugene D. Jacobson, M.D., *Physiology*
Robert C. Duncan, Ph.D., *Biostatistics and Epidemiology*
James [illegible] Cutter, M.D., *Anesthesiology*

THURSDAY, APRIL 4, 1968

Chairman: Joseph M. White, M.D.

EDUCOM – A Progress Report
James G. Miller, M.D., Ph.D., *Principal Scientist, EDUCOM, and Academic Vice-President, Cleveland State University*

PRESENTATION OF CONFERENCE PANEL SUBJECTS
Computers in Undergraduate Medical Education
Hilliard Jason, M.D., Ed.D.
Computers in Clinical Medical Education
Donald A. B. Lindberg, M.D.
Computers in Continuing Medical Education
George E. Miller, M.D.
Computers in Medical Libraries
Martin M. Cummings, M.D.

CONCURRENT PANEL DISCUSSIONS

Computers in Undergraduate Medical Education

Chairman: Hilliard Jason, M.D., Ed. D.

Panel: Stephen Abrahamson, Ph.D.
Alan Kaplan, M.D.
Theodore Peterson, Ph.D.
Lee S. Shulman, Ph.D.

Computers in Clinical Medical Education

Chairman: Donald A. B. Lindberg, M.D.

Panel: Robert Greenes, M.D.
Mitchell Schorow
John A. Starkweather, Ph.D.
James Sweeney, Ph.D.

Computers in Continuing Medical Education

Chairman: George E. Miller, M.D.

Panel: William T. Blessum, M.D.
Edward N. Brandt, Jr., M.D., Ph.D.
Gerald Escovitz, M.D.
Alexander Schmidt, M.D.

Computers in Medical Libraries

Chairman: Martin M. Cummings, M.D.

Panel: Robert Divett
Leonard M. Eddy
Irwin Pizer

FRIDAY, APRIL 5, 1968

Chairman: Norman E. Tucker

SUMMARY AND REPORTS ON PANEL DISCUSSIONS

Computers in Undergraduate Education
Hilliard Jason, M.D., Ed.D.
Computers in Clinical Medical Education
Donald A. B. Lindberg, M.D.
Computers in Continuing Medical Education
George E. Miller, M.D.
Computers in Medical Libraries
Martin M. Cummings, M.D.

RESOLUTIONS AND RECOMMENDATIONS

PARTICIPANTS

STEPHEN ABRAHAMSON, Ph.D., *Director, Division of Research in Medical Education, School of Medicine, University of Southern California, Los Angeles, California*

WILLIAM T. BLESSUM, M.D., *Medical Computer Facility, California College of Medicine, University of California at Irvine, Los Angeles, California*

EDWARD N. BRANDT, JR., M.D., Ph.D., *Director, Computer Facility, University of Oklahoma Medical Center, Oklahoma City, Oklahoma*

MARTIN M. CUMMINGS, M.D., *Director, National Library of Medicine, U. S. Public Health Service, Department of Health, Education and Welfare, Bethesda, Maryland*

JAMES A. CUTTER, M.D., *Head, Department of Anesthesiology, University of Oklahoma Medical Center, Oklahoma City, Oklahoma*

JAMES L. DENNIS, M.D., *Vice-President for Medical Center Affairs, Dean of School of Medicine, University of Oklahoma Medical Center, Oklahoma City, Oklahoma*

ROBERT T. DIVETT, *Librarian, School of Medicine, University of New Mexico, Albuquerque, New Mexico*

ROBERT C. DUNCAN, Ph.D., *Department of Biostatistics and Epidemiology, School of Health, University of Oklahoma Medical Center, Oklahoma City, Oklahoma*

LEONARD M. EDDY, *Librarian, University of Oklahoma Medical Center, Oklahoma City, Oklahoma*

GERALD ESCOVITZ, M.D., *Acting Chief, Continuing Education Branch, Division of Physician Manpower, Bureau of Health Manpower, U. S. Public Health Service, Department of Health, Education and Welfare, Washington, D. C.*

ROBERT A. GREENES, M.D., *Laboratory of Computer Science, Massachusetts General Hospital, Boston, Massachusetts*

WILLIAM G. HARLESS, *Assistant Director for Education, Computer Facility, University of Oklahoma Medical Center, Oklahoma City, Oklahoma*

J. HERBERT HOLLOMON, Ph.D., *President-Designate, University of Oklahoma, Norman, Oklahoma*

EUGENE D. JACOBSON, M.D., *Chairman, Department of Physiology, University of Oklahoma Medical Center, Oklahoma City, Oklahoma*

HILLIARD JASON, M.D., Ed.D., *Director, Office of Medical Education Research and Development, College of Human Medicine, Michigan State University, East Lansing, Michigan*

ALAN KAPLAN, M.D., *Acting Assistant Chief, Physician Education Branch, Division of Physician Manpower, Bureau of Health Manpower, U. S. Public Health Service, Department of Health, Education and Welfare, Washington, D. C.*

DONALD A. B. LINDBERG, M.D., *Director, Medical Center Computer Program, University of Missouri, Columbia, Missouri.*

THOMAS N. LYNN, M.D., *Vice Chairman, Preventive Medicine and Public Health, University of Oklahoma Medical Center, Oklahoma City, Oklahoma.*

FRANK W. McKEE, M.D., *Director, Division of Physician Manpower, Bureau of Health Manpower, U. S. Public Health Service, Department of Health, Education and Welfare, Washington, D. C.*

GEORGE E. MILLER, M.D., *Director, Office of Research in Medical Education, College of Medicine, University of Illinois, Chicago, Illinois*

JAMES G. MILLER, M.D., Ph.D., *Principal Scientist, EDUCOM, and Academic Vice-President, Cleveland State University, Cleveland, Ohio*

ARTHUR W. NUNNERY, M.D., *Department of Pediatrics, University of Oklahoma Medical Center, Oklahoma City, Oklahoma*

THEODORE PETERSON, Ph.D., *Computer-Aided Instruction Laboratory, Harvard University, Cambridge, Massachusetts*

IRWIN PIZER, *Librarian, Upstate Medical Center, State University of New York, Syracuse, New York*

ALEXANDER SCHMIDT, M.D., *Chief, Continuing Education and Training Branch, Division of Regional Medical Programs, National Institutes of Health, Department of Health, Education and Welfare, Bethesda, Maryland*

MITCHELL SCHOROW, *Chief, Instructional Systems Section, College of Medicine, University of Illinois, Chicago, Illinois*

LEE S. SHULMAN, Ph.D., *Associate Professor of Education Psychology and Medical Education, College of Human Medicine, Michigan State University, East Lansing, Michigan*

JOHN A. STARKWEATHER, Ph.D., *Coordinator of Information Systems, University of California San Francisco Medical Center, San Francisco, California*

JAMES SWEENEY, Ph.D., *Director, Computer Laboratories, University of Oklahoma, Norman, Oklahoma*

NORMAN E. TUCKER, *Education Consultant, Continuing Education Branch, Division of Physician Manpower, U. S. Public Health Service, Department of Health Education and Welfare, Washington, D. C.*

JOSEPH M. WHITE, M.D., *Dean of the Medical Faculty, University of Oklahoma School of Medicine, Oklahoma City, Oklahoma*

STEWART WOLF, M.D., *Regents Professor of Medicine, University of Oklahoma Medical Center, Oklahoma City, Oklahoma*

MEDICAL TECHNOLOGY AND SOCIAL CHANGE

J. HERBERT HOLLOMON, PH.D.*

Good morning, ladies and gentlemen. Welcome to the conference on computer and medical technology.

I speak to you on a subject on which I am not an expert. So I would like to make the subject somewhat more general at first. I wish to discuss the general relationship between technology and social change. We face a time in history in which many people believe that technology and its consequences have become so harmful to the society that this harm overrides the possible good that technology brings. People – young people particularly, perhaps more perceptive, more caring, more affluent than any young people of any society – have begun to ask questions: "How is it that you allow technology to pollute the atmosphere, when you build factories? How is it that the people who utilize technology allow the streams to be polluted so that our water supplies are undrinkable?" "How is it that a society can allow a system to operate that allows 50,000 people to be killed in highly technical devices called automobiles, and 2 or 3 or 4 million, whatever the appropriate number, wounded?" "How can a society not consider deeply the problems that are created with the introduction of agricultural technology which so improves the lot of the farmer and the efficiency of the agricultural process that it displaces the marginal worker and forces him into the city and leaves him there to sulk and to become discouraged and become disconnected with the very society which that technology is supposed to serve?" "How can a society be so inhumane as to bring new medical technology to a country to decrease the birth rate, increase the life expectancy and decrease the death rate and allow those people to starve?" The young person continues to ask, "What is the value of a system that does not consider slow starvation as deadly and as devastating as a sudden death?" "What," says the young fellow, "is the problem with a society that does not seem to be able to control the nature of the weaponry that technology brings – whether that weaponry is nuclear bombs or chemical and biological warfare?" That's one side of the question.

And the other side of the question is that the devices of technology, the engineering achievements of man over thousands of years, thousands of centuries in his evolution, have made it possible for man to survive at all. It seems almost abundantly clear that without weapons, man could not have survived and developed in an evolutionary way the deep culture and the nature of the society. The weapon became a tool, and the tool made it possible to remove much of the burden, at least of the affluent society, from man's back. It extended his arms; it plowed his fields; it helped in the treatment of disease. Technology has been the means by which it has become possible for man to use his creative talents to do something more than be a slave to the driving necessity of having food and shelter and clothing and protection.

Technology has two sides. It has on the one side the immediate and direct benefits that it brings in the treatment, the caring, the feeding, the housing, and the transportation of people. And it has another side, and that is its potential

*President-Designate, The University of Oklahoma, Norman, Oklahoma

harmful effects on the society in general. This dichotomy, this difference in viewpoint, causes the deepest possible division in those people who are of good heart as to what is the proper use of technology for the benefit of society, and who is to decide? It strikes me strange, that in engineering, in medicine, and science, the people who are concerned with the application of technology to the useful pursuits of man, are not at the same time deeply concerned with the ethical, moral, political and legal questions which that very technology produces in its introduction. Let me ask you a few questions: Who shall decide when and under what conditions artificial devices will be used to extend man's life? Shall we leave it to doctors, as presently trained, doctors who are highly capable and highly skilled technical people, but who are largely not knowledgeable of the law, of the society, of religion, faith, values and ethics? Having had to spend so much time becoming the doctor that he is, is it possible for him to decide the deepest kind of value judgments alone, such as who shall benefit from the technology which is just around the corner? Is it proper, for example, for a decision to be made as to which of two patients gets an artificial kidney because one of them happens to have more life insurance than the other and therefore his family can be better cared for? I wonder.

The technology which man has developed has made it possible for the social change in every modern society. Technology and its development led to the industrial revolution. Technology and its development led to the development of the modern city. Technology and its development made it possible for only 6% of the people in the United States to feed all the rest of us. Technology made it possible to handle information in such large quantities that no man can possibly compete with it as far as the storage, retrieval and codification of that information. Technology will, in fact, in the future make it possible for man to change the genetic character of men themselves. The technology that created the drugs so wonderful in the treatment of disease, is yet the very beginning of a technology which will so infuse education and medicine that we can speak of the present time, not as an industrial revolution, but as an information revolution. We are at the stage in the society where the extension of man's arm by machines and tools is now nearly complete, but the extension of man's mind and perception in the seeing, evaluating, handling, storing, and projecting information has only begun. And if you think today's sophisticated computers which are able to program themselves are sophisticated, if you think that information censoring devices that can be used remotely are sophisticated, I will remind you that they are yet but the very simple and nascent beginning of what will be, for we have now discovered, like the discovery of steam power and the mechanics of converting heat to energy, that it is possible to manipulate, control and calculate the handling of information. And we have discovered simultaneously that it is possible to do that on a very small scale, on a scale that does not yet reach the scale of the neural networks of the brain, but on a scale which in a decade may be so. We will be able as well to produce the kind of connections in a computer, that will make it possible for one to say truly that a machine thinks, rather than just solves problems.

All of these things raise the deepest kinds of questions — questions, first, as to how these techniques are to be used and to what end, and how they shall affect the very people who use them, and what resistence will the practitioners of the old arts put up, for it is also true that technology, by being the mother of social change in many regards, is also resisted deeply and often effectively by the very people who have to put the technology to use. I was reminded one day of a conversation with President John Kennedy and one of his economics advisors. We were trying to persuade him and the President that everything that was being done except the final evaluation of the state of the economy by the economists could be done better by computer, and that we were not using computers to model the economy, but rather we were using some sort of subjective ad hoc judgment. I'll never forget the day we tried to persuade them that technology would make wiser judgment possible by economists if they would but use it to model the economy. The Economist said to me, "Herb, but then what would I do?" And you know, that's sort of an odd reaction – a reaction, however, that is completely understandable, for all of us depend for our security on the things we've learned when young, and we depend for our jobs on the techniques and tools of a decade or two ago.

Technology, specifically in medicine, will lead clearly to all sorts of artificial devices and implants. And here the question comes, just as in the case of drugs, under which conditions shall they be used, what tests shall be required and what judgment shall be made? These questions will be applied, even more specifically to computers, and I don't think the computer is nearly as important as the whole process of handling information. It is the whole system. It is the conversion, the calculating, the scoring, the retrieving, the displaying, and the orderly logical sequence of the process. All too often, computers are used simply to replace manual operations. The computer provides, however, a technique and a possibility of doing things with information that man can't do himself at all. And that's why it is so important for us to consider how computers and information systems will in fact affect diagnostic and clinical aid, work on organizational or administrative problems, and most importantly, aid educational tools. But they will not work if they are a mere substitute for what humans are now doing, and they will not work unless the computer and the information system is deeply tied to the very people who have to use the information once it is produced. Information systems in medicine will make it possible to aid large numbers of people with relatively fewer professionally trained medical people. That doesn't mean we won't need more trained medical people, but the relative number should be smaller.

One of the things that is so important in this country is that we have committed ourselves to two deep responsibilities about people. One is, that they shall have the opportunity to have all the education that their ability and motivation allows them, independently of their wealth, sex, and color. This ideal is very costly. The second ideal is that no man should be without adequate medical services because of his position, his race, his color. If we are to do these two things at a price we can pay, our only hope is to use technology in its most beneficial way.

OBJECTIVES OF CONFERENCE

JOSEPH M. WHITE, M.D.*

Mr. Chairman, Ladies, and Gentlemen:

I wish to add my welcome to that of Dr. Dennis and Dr. Hollomon. I sincerely hope that you will enjoy your visit with us and that you will find the conference both interesting and stimulating. Our increasing capabilities to discover new uses for the modern computer plus the enormous efforts now being expended in almost all our medical schools in modification and revision of the medical curriculum make this conference a timely one.

The use of computers as an educational tool is both direct and indirect. Indirect applications include the support of the administrative and research activities of a Medical School and, more recently, the processing of patient care information. Direct applications to medical education are now beginning to appear. These include information retrieval and the use of the computer as an instructional tool. It is this latter role that we will be concerned with in detail during this conference. However, we must keep the other educational applications in mind and fully explore the potential for them.

In any instructional system, three general problem areas must be considered. These have been described as the technical, semantic and effectiveness problems. The technical problem is concerned with the hardware and equipment capabilities required to implement the system. The semantic problem has to do with the relationship between the meaning intended by the instructor and the interpretation made by the student. That is, design of a system which will accurately convey the instructor's thoughts to the student. Finally, the *effectiveness* of an instructional system is concerned with those changes induced in the student by the instructional experience. Each of these should be carefully explored before introduction of any new system.

Before discussing the specific objectives of this conference, it would be well to mention some of the thoughts of others regarding the role of computers in an educational setting. Three major roles have been defined:

1. to serve as a resource to the student for study;
2. to assist the instructor in his own study and preparation and in provision of timely summaries of student progress individually and as a group; and
3. to provide assistance to the learning researcher. Some experience has been gained in each of these areas, especially in the undergraduate college curricula.

The following general questions must be explored if the objectives of this conference are to be realized—

1. What is now being done with computers in Medical Education?
2. What are the realistic potentials of computers in Medical Education?
3. What type of work must be done to realize that potential and how should this proceed?

**Dean, Medical Faculty, University of Oklahoma Medical Center*

These general objectives invoke a number of more specific considerations including:

What are the technical problems that must be overcome? What constitutes an effective system?

Perhaps more importantly, what requirements are placed on the faculty and students to enable them to make effective use of the computer based system? How can training programs be developed to permit them to meet those requirements?

Will students and physicians accept the direct use of computers as a part of their educational process? More specifically, will they utilize the potential of the computer by sitting at a terminal and interacting with an instructional program? How do we get them to take advantage of it?

How can the total effectiveness of this means of instruction be evaluated and, obviously, it must!

How should such a computer based instructional system fit into a modern curriculum? Should it serve primarily as a learning resource for the student or can it in fact be a basic part of his primary instruction? Should such a system be independent or should it be a part of a larger information system?

Although it is not possible at this time to provide the specific answers to all of these questions, we are hopeful that this conference can generate ideas and directions to follow if we are to find the answers.

The conference has been structured so that each of you will be able to participate actively in the discussion and as educators your ideas are needed. We feel that the more or less informal nature of this conference will permit an environment leading to full opportunity for you to express your own opinions and ideas. If this conference is to be a success it will mean that all sides of the issue have been explored. We are hopeful that this will be done.

Thank you very much.

STATEMENT OF THE SURGEON GENERAL*

WILLIAM H. STEWART, M.D.

Medical education is challenged today as never before in its history. The needs and aspirations for medical care expressed by the American people demand rapid quantitative growth. Our professional commitment requires that this growth must not be accomplished at the expense of quality. The explosive development of medical science and technology, by raising the potential for excellence ever higher, makes the production of such excellence increasingly complex and difficult.

For these reasons it is vitally important that medical education draw upon the best in educational technology. We simply cannot meet the new challenge with the old familiar methods. Yet, at the same time, it is equally imperative that we be selective in adopting and adapting new methodology. We cannot afford to accept new methods just because they are new, or abandon old ones because they are old. We need to measure such means against our fundamental purposes and choose accordingly.

Therefore, this conference is not merely timely; it is of the highest urgency. In wishing you a most productive and successful meeting, I am wishing more than that: that this conference may represent a significant stride toward more productive and successful medical education in the years ahead.

*Transmitted to Conference on the Use of Computers in Medical Education by Frank W. McKee, M.D., at opening plenary session.

EXCELLENCE - BUY OR BEGET?

FRANK W. McKEE, M.D.*

It is always a pleasure and privilege to participate in meetings dedicated to the study and improvement of medical education, and the exploration of better and more efficient ways of coping with this fundamental responsibility. I am particularly honored to be invited to speak before you begin your work in pursuit of the "Objectives of the Conference" that have just been laid before you, because this offers me the opportunity to share with you some broader perspectives of medical education into which these immediate objectives and your activities in support of them may fit. I should point out the rather obvious fact that my position on the program should convey to you that I am not in any sense an expert in the use of computers as an educational tool, or will I present any new experimental or other data about the subject of the conference; otherwise I would be included with the quality cast you have assembled for that purpose. Therefore, I happily accept my role as a layer of foundations, and will watch with interest the emerging structure of new contributions to the medical education process which you erect from man-made tools and systems.

As many of you know, I am privileged to head the Division of Physician Manpower in the Bureau of Health Manpower. This Division is the focal point for medical education in the Public Health Service. Within the responsibilities of our assignment are those related to the major support of educational programs, both in medical school curricula and in continuing education activities, in the construction of new schools for all the health professions, additions and renovations to existing schools, and in support of hospital and patient care facilities which are intimately concerned with the educational process. The newly programmed Basic and Special Improvement Grants, which are the Federal government's first clearly defined funds for support of educational operations, are within our review mechanisms. Through research grants and contracts, support is offered for a variety of investigations of new approaches to educational format, with the pious hope of a dividend of accomplishing some progress in the education of both medical students and practicing physicians while the experiments go on. All of these efforts are components of the overall mission of the Bureau of Health Manpower which is directed towards a quantitative and qualitative improvement in all the health professions in the provision of medical care for all the American people. In a nutshell, we are interested in increasing the number of qualified individuals who will responsibly take care of the sick, and act effectively in disease prevention and control, notwithstanding the other important considerations for develop-

*Director, Division of Physician Manpower, Bureau of Health Manpower PHS, DHEW ment of new knowledge and the ongoing study of disease processes.

Having outlined, then, the specific objective of increased numbers of qualified manpower, and having described the interests of my particular Division in the physician portion of this goal, and the various ways in which the production of physician manpower is supported, it is appropriate to offer some observations about the educative process itself and its dominant and pervasive role in the achievement of these national objectives. The following comments are not based on second hand or hearsay information, for, in dealing with all of the colleges of medicine and osteopathy, and having the privilege of assisting our national legislators and others in replying to a wide spectrum of inquiry and criticism of present medical care systems in the United States, one develops a reasonably accurate, continuing, and rather acute familiarity with what a variety of our citizens think is wrong or lacking. In our ability and agility to respond to such inquiries, a number of problems are further identified and possible solutions are generated.

The concerns of the public, as presented in correspondence, and in other inquiry, fall into two categories. The first is that there are not enough physicians doing the right things in the right places. Rural areas, and inner cities seem to be the most easily identified deserts of health care, but other geographic areas and even our utopia of modern living, the suburb, has its problems. The fourth branch of the Division of Physician Manpower, to which I have not heretofore alluded, Physician Utilization and Supply, is concerned with solutions to the problems of physician distribution, through encouragement of studies of more effective practice patterns, investigations of why major gaps in health personnel exist, and the means that might be best used to correct these unfortunate, and occasionally desperate, situations.

The second major concern of the public relates to the inability of large numbers of apparently eminently qualified young men and women to gain admission to medical school. Letters on this subject are directed to a number of government officials with pleas for intercession on behalf of this or that individual, a practice which is consistently regarded as meddling in the affairs of a school or schools. But, be that as it may, when there is public clamor, there will be action, and it is our hope that the expansion of established schools and the construction of new schools will provide increased educational opportunity for every qualified applicant in the United States.

These two citations are foci of public attention and represent a surfacing of deeper and more complicated concerns about medical education which are in the purview of all of us who are involved both in providing it and supporting it. These latter problems are many, with a large overlay of human nature in them, which often, surprisingly, is more serious than financial problems. Of late, a number of cliches to identify elements of these problems have crept into the language of medical educators, and while some of these are tiresome and irksome and subject to interpretation by the one using the term or phrase, they do bespeak both complacency and, paradoxically, a certain insecurity and "whistling in the dark to keep up courage" sort of attitude. Since I hardly have time today to run through a glossary of terms used by medical and other educators to describe the ideals, the goals, the problems, and the underlying financial needs, yea, even demands, for their achievement or solution, I will mention only one – "EXCELLENCE."

Excellence is about as complete a word to define educational aims as one could wish, and has as synonyms — superiority, preeminence, worth, value, goodness, purity, and greatness. Its essential meaning is merit and virtue, and could well join with motherhood, peace, the American flag, and the reduction of taxes as a standard under which we could all join. Excellence appears with an element of glibness in medical school publications, particularly those directed towards alumni and granting agencies, and I quote one such:

"In the face of pressures for change, it is especially important that we keep our primary goals and responsibilities clearly before us.

"The first of these is excellence in education. This arises from the capabilities of the staff, the quality of the student body, and the continuous upgrading of our educational program. It arises, too, from the commitment of the staff to recognizing the individual qualities of each student and building upon them. Although we will not invariably be successful, we strive for an environment in which understanding and enjoyment of education are shared by students and staff alike. As pressures rise for the education of more physicians, we must examine our educational goals, explore innovations, and establish our programs on the basis of the best evidence available."

This is what I would call a complete statement, and while an expression of but one school, it could well serve all, and be a preamble to whatever might follow as definitions of accomplishment or requests from any and every source for support for faculty, students, and facilities. It is hard to fault as an expression of goals and implies all of the definitions and synonyms of excellence in its stated quest. But while it can escape criticism as an ideal, it most certainly, to those who know about processes of implementation, lays itself bare to searching question, and the "feet of clay" on the quicksand of its major premise. In pursuit of excellence, medical education has assumed a flavor of Madison Avenue and the supermarket, with "capabilities of the faculty" prominently mentioned as a pillar in generating "excellence in education."

Perhaps these "capabilities" should be scrutinized more closely to determine what they are, what they should be, and whether they are actually directed at the purposes of medical education and its ultimate goal of helping solve the problems of a real world of people, disease, and untimely death.

Some years ago, before the enormous investment of the Federal Government in support of medical research, medical schools followed integrated programs embodying teaching, research, and patient care with minimum categorization, because of the recognition of the importance of all these elements in physician education. In recent times, however, this categorization has been carefully identified, the components have been legislatively isolated, and the integrity of the school as a common center for medical education has been greatly changed. This situation has led, in turn, to considerable change in the faculty, those who constitute it, and what the ideas of both the school and the faculty member are about correlated responsibility. Recruitment of faculty is now a highly competitive exercise for trained individuals in short supply and is characterized by high interest and investigation of almost everything about the candidate that has to do with prestige, funds, and personal contribution, in varying meanings of the term. Strange and unwarranted assumptions about teaching qualifications, character as a man, and as a model for students, are often made, and may be covered by a statement such as, "He's a nice guy, and the students seem to like him." The candidate himself is usually more captivated by the personal advantage of the situation, and concerns himself with his space, his arena of control, be it medical specialty or research, his teaching "load," not "opportunity," and what colleagues he will find worthy to help continue the rise of his star. From this sort of activity, then, comes one aspect of faculty capability, which is hardly conducive to a program of medical education directing young men and women to preparation for assuming major responsibilities in the care of sick people.

A second factor in faculty capability is the actual involvement of patient care. At one time, all medical schools had numbers of competent full-time serious clinicians, who not only taught medicine, but personally practiced it. They were backed up by a substantial part-time or volunteer faculty who were actually engaged in private medical practice, and brought to the students and house officers a true flavor of day-to-day practice to complement other lessons of greater breadth or depth. With the growing ability, and incidentally, real need to attract funds through the mechanism of research and its considerable support, more and more full-time faculty were added to the medical schools. Concomitantly, burdens of increasingly demanding practice greatly diminished the time available to the private practitioner to participate in regular teaching schedules. But whatever the factors responsible, this change in personnel has done a grave disservice to many students who have a conscientious desire to become accomplished practitioners outside a university or medical school setting, and has effected a considerable diminution in "capability of the faculty" in its broader sense. Some expanded use of affiliated hospitals has compensated to a degree for this change, and perhaps explains the popularity of these programs, a popularity that often mystifies the full-time faculty member in his university hospital office.

A third factor in determining "capability of the faculty" is whether there is any general understanding of the reasons for the existence of a particular medical school, and what its major internal role might be, as well as its responsibility in the local, state, or national complex. Such understanding should involve the President and the Board of Trustees as well as the Dean and the faculty. In some instances, where a single school exists in a given state, this responsibility should be quite clear, but I have been amazed in a recent visit to one such state to find the wide differences of opinion of the state legislators and the medical school administration as to the fundamental purposes of the medical school. However, if the true goals of the school are defined, and generally agreed upon, and if there is the intention to produce qualified graduates, who will contribute to the real world of dealing with illness and its prevention and control, and who will be educated to develop high standards of responsibility and human concern, then the "capability of the faculty" is more easily attested, and the achievement of excellence is a real possibility. How strange it seems, in this day of heart transplants, Nobel and other prestige prizes, and enormous individual project grants, that excellence can be pursued as a goal within itself. It actually can be more closely approximated by accepting a clear and obvious responsibility, meeting it, and finding satisfaction in a job well done.

Excellence, true excellence, was once developed and nurtured as a home-grown product and expressed itself in a dedication and loyalty to the institution and understanding of its purposes which was truly representative of "capability of the faculty." The teamwork was the result of years of associations with established trust and mutual interest. The final product — graduated physicians — reflected a stability, responsibility, and concern which was *true* excellence. The World Series will always be a better display of baseball than the All-Star games, and the school that begets its own excellence will always have more to offer its students and the people for whom it is responsible, than purchased "excellence."

From this inherent capability, then, comes the greater wisdom for designing a dynamic, competent, and inspiring education program, which might *really* be accepted by the faculty responsible for it. The "quality of the student body" cannot fail to be enhanced, with perhaps some resolution of problems of admission and the alarming attrition of admitted students, and some true student enthusiasm for "the continuous (ly) upgraded educational program." Concern for direct patient care, coupled with good educational techniques, will ameliorate public anxiety about physician supply and availability. Such concern will also have a salutary effect on the wasteful and distressing problem of increasing student attrition.

A profession as essentially human as medicine must have a firm base in the character of its primary seat of production — the medical school, for it is from this focus that the true quality of professional excellence emanates.

On behalf of this ideal, it is the policy of this Bureau and Division to support institutions and strengthen them through their chosen administrative channels, so that the determination of the essential educational need is neither dissipated nor eroded by less important considerations. It is equally important for the Association of American Medical Colleges, acting through its individual constituents, to review the whole spectrum of faculty acquisition and to encourage principles and procedures more consonant with the needs and purposes of the system.

The role of this conference is to discuss among knowledgeable people an exciting adjunct to the processes of medical education, which can offer real assistance in solving problems of increasing information and demands for accelerated production. I look forward to some interesting revelations and accomplishments, but the keystone of this keynote address is that the success or failure of our system of medical education, in its multitude of individually tailored and variously directed programs, depends on the character and the quality of its leaders and proponents. The refinement of procedure, the innovation of method, the desire for excellence as expressed through graduates dedicated to medical care in all its facets, will always rely for their success upon the human beings who choose to accept responsibility for the achievement of the goals of the profession, not the particular whim of a certain school or individual. The goals of the profession were defined long ago by Hippocrates, Jesus of Nazareth, Maimonides, and have been earnestly supported through the ages by considerable numbers of men of dedication and principle. Perhaps we should all devote more attention to this fundamental matter, and I would urge your personal consideration.

EVALUATION OF THE USE OF COMPUTERS IN MEDICAL EDUCATION

STEPHEN ABRAHAMSON, Ph.D.*

The use of emerging computer technology in education is, of course, quite recent. And, as is the case of the application of educational innovation to medical education, the introduction of computers as an aid to medical education comes significantly later. Thus, when one asks questions concerning *evaluation* of the use of computers, answers cannot really be found in data at this time. At least, data in substantial and/or significant amounts do not exist. Thus, this paper cannot assume the familiar form of a review of research or of a synthesis of published (or unpublished) reports. Rather, at this stage of development of the application of computer technology to medical education, one can only look forward to the design of studies and collection of data.

Consequently, exercising familiar license, the author is changing the topic. The modification truly reflects the chronological sequence of events in educational innovation, incidentally, and attempts to warn – through some discussion – of the days ahead. What factors must be considered as evaluation is planned and experiments are conducted? What data are needed to help us make informed judgments? What kind of research design will provide an adequate test of the use of computers in medical education?

Despite the fact that millions of words of glittering prose (and possibly some of poetry) have been written on the topic of evaluation, some review is essential at the outset so that later discussion will not become snagged in the thistlepatch of conflicting definitions. All too often, mutual understanding in this area cannot be achieved because of differences in just plain definitions.

Avoiding the use of technical jargon and an extended presentation of a formal definition (evaluation is a continuous process, based upon criteria cooperatively developed, and concerned with the status of and changes in students' behavior) one must still acknowledge the steps in evaluation. No matter how many times it has been said before, no matter how many different authors have written these things, evaluation still consists of these component parts.

(1) *Evaluation still begins with the definition of objectives.* This statement has been made so often and by so many people that listeners (and readers) weary of hearing (and reading) this dictum. But it is nonetheless true; it is nonetheless important; it is nonetheless – unfortunately – disregarded. It often seems that because we have "talked about objectives" for so long that we have somehow – through some catharsis – rid ourselves of the need to define objectives. Such is far from truth. With regard to any educational program or exercise the questions must be raised (and answered): What should the students

*Director, Division of Research in Medical Education, School of Medicine, University of Southern California, Los Angeles, California

know at the end of this educational experience? What should they know how to do? How else should they be changed?

(2) *Evaluation still demands criteria by which to judge students' achievements of those objectives.* While these are sometimes embodied in a good statement of objectives, more frequently they are omitted. How much new information should students have acquired? How proficient should they have become in the execution of specific skills? These questions should be answered, incidentally, *before* the attempt to measure achievement and not afterward by scrutinizing scores of other records and assigning some "logical" (statistical or otherwise) cutoff point or points.

(3) *Evaluation still requires measurement of the achievement of each of the objectives.* And educational measurement is best accomplished uni-dimensionally. That is, acquisition of information is most appropriately and reliably measured by application of some achievement-test technique — pencil-and-paper, perhaps. The measurement of achievement of skills necessitates some observation of the students in performance of those skills — either directly or through the aid of electronics in the form of video-tape. But measurement, in whatever form, provides the information concerning student progress needed for the fourth step.

(4) *Evaluation still includes implementation in the form of action* involving the student, the program, the objectives — or even the profession. One must study the results of measurement in the light of stated objectives, and according to the criteria make decisions — and take action. Here is the judgmental phase of evaluation. But it should not stop short of the accompanying action to revise the program, review the objectives, certify the students, or initiate new studies of students, program, or profession.

Concerns in evaluation of the use of computers in medical education are perhaps best expressed in these four questions.

1. Does the use of computers facilitate learning?
2. If so, does it do so at the expense of other objectives?
3. What is the cost of the use of computers to facilitate learning?
4. Does the use of computers result in less faculty and/or student input of time and/or effort?

Essentially three areas of study are involved: (1) effectiveness, (2) cost, and (3) efficiency. The first two questions above deal with effectiveness, while the third and fourth refer to cost and efficiency, respectively. All of these become major concerns in *any* educational venture — but particularly in the situation involving the introduction of innovation. There is no quarrel with the contention that conventional and standard and traditional methods in education should be studied critically. For all too long education has enjoyed the luxury of assumption of achievement rather than having to test its processes critically. It has been said that physicians have such an enviable record of achievement in application of their professional performance perhaps because half their patients would get better anyway. It is undoubtedly true also, in that vein, that teachers (and traditional education) can boast of having achieved instructional goals because students would learn anyway!! Thus, all education *should* be subject to careful study. But the real burden is upon the innovator, as we all know. The introduction of change in teaching methods must be accompanied by careful study. Especially as we operate in areas involving increased costs —or potentially increased costs — is it incumbent upon us to document our success, or lack thereof. There is one comforting thought, incidentally. The more we attempt to study impact of educational innovation, the more we manage to learn about conventional educational processes. The more we apply ourselves to tasks of educational measurement with regard to studying outcomes of newer methods, the more refined our measurement techniques become — and these can then be applied in *any* educational milieu. The message really is to avoid any sense of paranoia, to avoid a posture of "why me?" when asked to justify — in educational outcome terms — the use of computers in medical education.

Effectiveness — Does the use of computers facilitate learning? If so, does it do so at the expense of achievement of other educational objectives? The study of effectiveness cannot even begin, let alone proceed, without a clear statement of objectives. One cannot determine whether learning has been facilitated without the answer to a prior question: learning of what? At the same time, one must keep in mind that there are usually many objectives being sought — although perhaps not all in that specific application of instructional media. Nevertheless, they must be considered. For instance, if a technique is employed to facilitate the acquisition of information, it is important to know, of course, whether it did so. It is equally important, however, to discover whether the use of that technique *also* (accidentally, inadvertently, incidentally) negatively influenced student attitudes toward learning, toward continued study, or even toward particular aspects of patient care. It is possible for one learning experience to promote achievement of one set of objectives while significantly deterring achievement of another. Studies of effectiveness should try to include some measurement of achievement of other objectives, hopefully representative of all of the educational objectives of the total educational effort. In a sense, rival hypotheses must be stated and tested.

In studying effectiveness, investigators must also avoid the error of testing for educational gain only at the completion of the instructional process. How long do students retain the new information? Over how long a period of time can students still perform the skills they learned? Data collected in other studies suggest rather strongly that retention may be related to certain other variables: utility, motivation, experience. Studies of retention of information and skills gained through the use of computers in medical education, thus, will help in the understanding of this aspect of education.

Cost — It seems a shame to have to spend time on the question of cost. Here, again, is a question not really raised with regard to many other modes of instruction. Unfortunately, the burden of proof is on the innovator. And the initial cost of equipment plus the expense of operation and maintenance are not insignificant. In addition, there is the area of preparation of "software" — the subject matter preparation, the programs themselves. The cost in dollars and cents must be studied and included in evaluation.

But that's not all the cost that must be studied. In addition, the input of faculty time and effort in monitoring, in evaluating student progress, in just learning how to prepare programs and use the computer hardware must be considered. Finally, revision and modification costs must also be calculated. Such costs in conventional education are minimal and frankly not considered. Where the technology demands efforts beyond the normal range, a systematic examination is in order.

Efficiency — Does the use of computers affect faculty time and effort necessary to achieve the educational goals? By the same token, what is the effect on student input of time and effort? Essentially, a ratio of "output" to "input" is involved and should be studied. The study of output must include such factors as number of students educated, how much they learned, how long they retain what they learned, how well they apply what they learned, how much they are stimulated to study more, and the like. The study of input includes such factors as how much time the instructors invested, how much time the students devoted to the learning process, how many faculty members were involved, how long it took the students to reach required performance levels, and the like. It is possible that an "efficiency ratio" or an "efficiency index" must be developed and applied. Without it, statistical design must be employed to allow this area to be explored intelligently, for it is the area in which many claims have been made — and will continue to be made.

Another interesting area of concern must be exposed and explored before this discussion moves on to suggested study design. This is the area of concern for patient safety and comfort. One persistent educational problem has always been how to have beginning students learn skills, the performance of which poses a threat to the safety and/or comfort of the human object, the patient. At the University of Southern California, this concern led to the development of a computer - controlled anthropometric manikin — a patient simulator, which has come to be known as "Sim One." The original purpose was to provide a simulated patient on which beginning anesthesiology residents might learn the skills of endotracheal intubation prior to their having to perform the intubation of real, live patients. At least, the motivation to begin this interesting work lay in this area of concern. The stated purpose of the project was to test the feasibility of simulating a living patient, capable of responding in a lifelike manner to things done to it. In addition, effectiveness of its use in training anesthesiology residents is being studied.

Sim One is quite life-like in appearance, having a skin-colored, skin-textured plastic covering in the form of a real human being. Sim One has the configuration of a live person from the waist up and is in the posture of lying on an operating table, left arm extended and ready for intravenous injection, right arm fitted with blood pressure cuff, and chest wall adorned with a stethoscope taped over the approximate location of the heart. Sim One breathes; has a heart beat, temporal and carotid pulse, blood pressure; opens and closes his mouth; blinks his eyes; responds to four intravenously administered drugs and two gases administered by mask-and-bag or by tube. The important thing to note here is that Sim One has been used in the training of residents and effectiveness tests reflect a great potential contribution to human safety and comfort through having beginning students make their early errors and gain their proficiency and confidence on a computer-controlled "teaching aid" rather than on a real patient.

The test of effectiveness involved five pairs of residents. These were assigned at random in such a way that five residents were allowed to use Sim One and five were not. The measure of proficiency was a simple one. Hospital anesthesia records were examined by the anesthesiology staff and a judgment was made about each: Would you trust this resident alone in the operating room on the basis of performance like this? Needless to say, names and dates were concealed from the rater. One criterion selected was the achievement of four consecutive "plus" ratings; that is, the rater *would* trust the resident in the operating room alone on the basis of what he reviewed in that chart. While the final analysis of data is not available at this moment, preliminary review indicates that it takes the non-simulator-trained residents twice the number of trials in the operating room to reach that criterion level of performance when compared to the simulator-trained residents. Such a difference obviously represents a substantial difference in risk to patients!!

It should be noted, incidentally, that Sim One represents a remarkably imaginative application of computer technology to problems of medical education. Here is simulation at its most sophisticated; a realistic body with life-like responses under computer logic. The dollar-cost of development has been high and the cost area in evaluation is indeed not on the positive side of the judgmental ledger. Effectiveness and efficiency will be borne out by data but the combination of cost and effectiveness might be found formidably negative in implication. However, the *human cost* factor — patient safety — must also find its way into the total cost-effectiveness equation. Thus, there are now *four* areas for study: effectiveness, cost, efficiency, and *human safety*.

How should evaluation be conducted? The best single, simple answer is a formal, carefully controlled, experimental study. Not only will evaluative data be forthcoming, but comparisons with conventional educational methods will be possible. In this approach, one must attempt to control for all variables except one: the use of computer. Then with valid and reliable measurement of achievement level taken before and after the conduct of the educational experience, the investigators can document whether the use of computers did in fact "facilitate learning." And it must be pointed out that this kind of study is most likely to catch the attention of and convince the skeptics — *if* the use of computers does make a difference. Since the men who teach in medical schools are themselves scientists, they constantly seek data in support of ideas. Education is no exception for them in this regard. Furthermore, the areas of educational achievement studied should reflect the value structure of medical school faculty members. In other words, if achievement in basic science areas is important, measurement of achievement in this area should be included — always remembering, of course, that this is true only to the extent that such achievement is part of the objectives.

Unfortunately, this approach is the most difficult to achieve in evaluation. Individual differences among students pose the first problem; faculty differences, the second. No two schools are really alike enough to allow for one to be used as a "control" for another. Introducing change of any kind also manages to change the total educational setting so that speculation can be raised concerning whether measured change in achievement is really only a reflection of the act of change itself: the so-called "halo" or "Mayo" effect. And, experiments within one school, conducted with time as the control variable, often stimulate other kinds of change within the school — even to the extent of drawing a different applicant-pool of students.

As if these difficulties were not enough, another — less clear — problem needs mentioning. Each instructional mode may in fact have different goals which can best be served. Thus, to attempt a comparison in achievement when different teaching methods are used might start with a major bias if the achievement of the same educational objectives is attempted using methods truly adaptable to quite divergent goals. But at this stage, such a consideration may be less important. It is presently in the best interest of medical education and of the use of computers that experimental design be accomplished wherever humanly possible.

Where experimental design is not feasible, however, there is still the need for good, thorough evaluation. Has the educational experience really brought about the changes in students that were desired? (Were the objectives realized?) How much faculty time and effort were required? (How much did it cost?) Such an approach required "only" the definition of objectives, the statement of criteria, the selection or construction of measurement devices, the performance of measurement, and the interpretation of data collected. (Note the setting off of the word, "only"!) If this process is achieved properly, the investigators will at least know whether objectives have been realized even if they cannot tell whether the process represents something "better" than another approach.

The role of the innovator is not an easy one. Not only is he the guy with the "ideas." Not only must he then find ways of accomplishing his ideas. Not only does he become the activist in introducing the innovation. Not only must he seek and obtain support for his idea. He must also test the idea and be prepared to defend – with data – in the face of all the difficulties in obtaining such data, his innovation. The role of the true innovator is a demanding one. He must be imaginative and flexible in order not to become "locked in" to one approach in the application of his *genre* of innovation. Computer use is a case-in-point. Storage and retrieval of information is but one of the many potential applications, yet for many this has become the end-all. He must promote the search for evaluative data – despite the fact that there are no such data available concerning conventional modes of teaching. He must serve as "public relations" man for the entire area of innovation – not as high-pressure salesman, incidentally, but as thoughtful, data-laden investigator, raising questions and providing data rather than exhorting, promoting, and promising Utopia through panacea. Here, then, is the essential contribution of evaluation of the use of computers in medical education.

EDUCOM—A PROGRESS REPORT

JAMES G. MILLER, M.D., Ph.D.*

EDUCOM, the Interuniversity Communications Council, is a prototype endeavor, a research-oriented attempt to bring about educational innovation. Let me begin by illustrating, in a somewhat lighthearted and irrelevant fashion, the problems of innovation and the need to move slowly and cautiously when initiating new programs.

A pretest had been carried out on the effects of diet on the aging process. The experimental animals were porpoises. The porpoise is considered by many to be nearly as intelligent as man. They have large brains and are, in a sense, aquatic, humanoid basketcases. The porpoises were given a number of different feeding regimes. A diet of newly hatched sea gulls was found to slow down, almost to halt, the aging process. It appeared that what amounted to immortality might be a possibility.

The pretests were so striking that the research group received a large NIH program-project grant. Large, concrete porpoise pens were built on the seashore for containing the experimental animals. Up in the hills, an aviary for hatching sea gulls was built. A truck was dispatched daily to pick up the young fledglings and to take them down to the pens to feed to the porpoises.

One day as the truck passed the City Zoo on its regular run, an old, distinguished, sedate lion suddenly and inexplicably bounded out of his cage and into the path of the truck. The truck could not help but run over him. The police soon arrived and arrested the truck driver for "transporting young gulls across staid lions for immortal porpoises." If this irrelevant and irreverent fable does not illustrate the dangers of innovation, nothing can.

EDUCOM was founded about three years ago by a number of medical deans and chancellors, specifically, those at Duke, Virginia, State University of New York, Rochester, Pittsburgh, Michigan, Illinois, and California. It was founded to facilitate and accelerate the use of the new information processing technologies, where desirable, throughout the health sciences, educational, research and service activities of colleges and universities.

It soon became apparent that EDUCOM's functions should not be restricted to the health fields but should be extended to all academic disciplines. While some of EDUCOM's present members of the Board and officers are physicians, the majority are not. The organization has expanded rather rapidly although very little effort has been made to give it publicity. An article in *Science* appearing in October, 1966, is the only published article describing the total EDUCOM program. There have, however, been a number of publications relating to various specific projects.

At the moment, there are 89 universities on our membership roll. They include about 250 campuses. EDUCOM is open to all colleges and uni-

*Principal Scientist, EDUCOM, and Academic Vice President, The Cleveland State University.

versities of Canada, the United States, and Mexico and will be pleased to accept your institution into membership if it is not a member.

Several universities in England, France, Czechoslovakia, Sweden, Holland, and Australia have indicated an interest in carrying out similar activities and in cooperating with American universities. We intend to consider potential international applications as soon as some of our initial North American projects have given rise to services which will be of real help to participating institutions. International cooperation across oceans will be facilitated by educational satellites which may be in orbit four or five years from now.

Dr. Jordan Baruch has recently become our new President. A member of the MIT staff, he was formerly the head of the MEDINET program of General Electric. With the transfer of our national headquarters to Cambridge, Massachusetts, we have developed a redefinition of our function. In the words of our new president, a major EDUCOM function is "to facilitate the extraorganizational communication of the universities." The reason that the emphasis is on extraorganizational communication is because EDUCOM does not, except indirectly, intend to participate in activities which can be carried on as well by an individual professor or an individual university. We are interested, rather, in helping institutions of higher education to share their resources and carry out joint programs which can be more efficiently handled, improve quality, and/or cut costs. We are concerned with relationships not only among universities but between them and other parts of our society. We shall be concerned with such extraorganizational activities as the regional medical programs, for example, which involve not only universities and medical schools, but also private hospitals and private practitioners.

PANELS ON RESOURCE DEVELOPMENT

EDUCOM is presently involved in reorganizing its technical and research programs, forming a new series of national interuniversity panels. In the past we have operated through interuniversity task forces. The first task force was responsible for the programs in networking. The chairman of this task force has been Dr. George W. Brown, who was the founder of the Western Data Processing Center at UCLA and who has recently become Dean of the College of Administration at the University of California at Irvine.

The original task forces were "bootstrap" o p e r a t i o n s. Volunteer workers from the participant universities gave their time, prepared programs and proposals, and carried out research activities. EDUCOM has now attained some financial stability, however, having received several foundation grants, industrial grants, grants or contracts from the federal government, as well as institutional dues. It will soon be feasible for each of the panels to have full-time one or more professional staff workers, either in the central office in Cambridge or in the Bethesda office, where some of the government supported research activities are now going on.

The network task force will be reorganized into the panel on interconnected computers, which will be concerned with the organizational and structural interconnection of computers, the hierarchical organization of data within them, and human access to their capabilities.

A second panel on resource development will be the panel on video and films, concerned with the use of video recordings, films, live production, closed circuit TV, and other such tools for augmenting the educational process.

Third, the panel on micrographic development will be concerned with the utilization of such techniques as photochromic reproduction in storing masses of document information, the interphase between such systems and the computer, and the use of such micrographic images.

The Work of a Panel

A new panel goes through a stage of group dynamics and a stage of self-definition of their mission. It may identify areas of appropriate activity for EDUCOM and it can suggest specific projects for EDUCOM or some subset of its members. Such a panel will be different from a study section of the National Institutes of Health, for example, in that its major role is to initiate programs rather than to respond passively to programs suggested by individual professors or by universities. But it certainly can receive such suggestions. In a few cases such suggestions have eventuated in programs that have been supported or sponsored by EDUCOM.

EDUCOM panels can communicate among themselves to establish joint activities, since there will be intersections of interests among the panels. And they can maintain temporal continuity. The life span of a group or organization may be far longer than any individual human life span. This means that continuity of programming is feasible even if individuals rotate in and out of various panels.

Panels in the Applications and Utilization Area

The first of these is the panel on extended education, concerned with the continuing education of the professional, with the resumed education of those whose education has been interrupted, and with the reeducation of those dissatisfied with their careers. The panel on extended education is a reformulation of the task force on continuing education, chaired by Dr. George E. Miller, Director of the Office of Research in Medical Education at the University of Illinois College of Medicine.

The second panel in the applications and utilization area is the panel on libraries and data banks. The panel is concerned with the utilization of stored information in the educational process, with the instructional implications of the fact that large bodies of data can be made rapidly accessible, and with the development of the library function broadly defined. The work in library communications was formerly in the EDUCOM task force on networks. It has become clear to us that, while there have been and will continue to be important overlaps between networking activity and library functions, they should be dealt with by separate panels because they are fundamentally independent fields.

The third EDUCOM panel on applications and utilization is the panel on external affairs, concerned with legislative matters, public policy, and social issues involved in educational information processing. Its predecessor was the EDUCOM task force on legal and related matters. It is co-chaired by Professor Benjamin Kaplan of the Harvard Law School and Professor Arthur Miller of the University of Michigan Law School. The new panel will include attorneys, specialists in libraries, television, and computers, and educators. EDUCOM has taken an active role in a number of matters directly related to utilization of the new technologies in education, of whose importance many university faculties and administrations are unaware. For example, Congress is presently working on new copyright legislation, the first to appear before Congress in about 60 years. The draft of the bill passed by the House precluded the possibility of operating legally such an interuniversity computer, library or television network as EDUCOM envisions. EDUCOM universities and officers sent statements or appeared at the Senate Committee hearings. These matters were also discussed with representatives of publishers and other industries. EDUCOM has had some role in slowing action on the copyright legislation, which was written before the importance and implications of computers and networks became clear. The legislation can now be rewritten to permit adjustments for new technological developments as they occur.

EDUCOM is also concerned with antitrust and negligence laws in the operation of interuniversity and intrauniversity networks. A nonlegal but very important area concerns the ethical use of confidential information. This is particularly important to physicians in terms of patient records.

EDUCOM'S Plans for Networks

Although EDUCOM is concerned with all applications of technologies in education, it has devoted particular attention to the sharing of resources through the development of networks, planning to develop and operate a prototype interuniversity network. Networks are nothing new. Natural networks have been in operation as long as there have been colleges and universities with one-way or two-way communication between two or more students and faculty members. A conference is one form of operation of a natural network.

A different kind of network is a physical network like the telephone network or the mails. A thorough analysis of communication among and within universities requires a comparative evaluation of traditional and new networks. Because a network employs a new technology obviously does not mean, of course, that it is better.

At the same time that EDUCOM is involved in planning electronic networks, it is also developing an organizational network. Each of our member universities has an institutional representative who communicates with his campus and represents his university with a vote on the EDUCOM Council. The Council elects the Board of Trustees and the Board of Trustees selects the permanent officers and full-time staff. If we place a prototype network into operation, it must have its own organizational structure as well.

EDUNET

The most intensive planning activity related to networks in EDUCOM was accomplished at the University of Colorado at Boulder in July, 1966. The conference was funded by a grant from the National Library of Medicine, the National Institutes of Health, the National Science Foundation, and the Office of Education. About 185 people attended, representing each of the 42 universities then members of EDUCOM, the major long line and hardware companies, publishers, approximately 15 government agencies, and a number of foundations. The conference produced a book called EDUNET, a report of the conference including opinions of the participants and a set of recommendations.

The conference almost unanimously agreed that there were real needs in colleges and universities for an interuniversity network.

It was unanimously agreed that many different types of networks are technically feasible. An analysis was made of different possible configurations of networks, and their possible costs were estimated. The book also outlines an organizational structure which would be able to operate such a network. The last chapter is an informal proposal to a number of government agencies who might contribute to the funding of such a prototype.

The basic concept of EDUNET is to encompass a number of activities already underway in a limited fashion. Some of these are limited geographically, regional networks. EDUNET is conceived as a national or conceivably, ultimately, an international network. Some networks are limited to a single medium, e. g., a network for programmed instruction, a television network, or a network for teletype transmission of bibliographical information. EDUNET is devised on the assumption that all media must be employed, each when most appropriate educationally. From the technical point of view, it is possible to operate multiple media on the same bandwidth, switching from one to another as required. EDUNET is also intended to involve all disciplines within the university. Some of EDUCOM's projects are for one field, such as our plans for networks in bioagriculture and biomedicine. Such endeavors are useful ways to begin, but limitation to a few disciplines is educationally unsound. Other fields would feel neglected if only physicists, chemists, engineers, and physicians had access to the new forms of information processing. EDUNET is also devoted to achieving as soon as possible on-demand access by the user to information, on-demand access, not only to documents but to television programs, computerized programmed instruction, and all other media.

We propose to join a number of colleges and universities in an experiment lasting three years or more — but for a definitely limited period. This experiment would be designed to indicate what is feasible and what is not, what is worth doing and what is not, what is too costly and what is reasonable in terms of dollars and human effort. The network would be operated with one staff and evaluated with another, to be sure that the operators do not bias the evaluation of the benefits the system provides to the users.

We propose to establish an EDUNET laboratory with a single director supervising a staff at three or four locations. One location would be at the Research Triangle in North Carolina, one in Ann Arbor, Michigan, and one on one of the southern campuses of the University of California. A fourth location might be at an Ivy League university. The EDUNET branch laboratories would be interconnected with four switching stations, possibly at San Francisco, Denver, Chicago, and Boston. The entire interconnection would constitute the kernel network.

The first year we would spend approximately a million dollars recruiting a staff and deciding on such questions as the organizational structure for EDUNET, its operating policies, issues of compatibility for hardware and software, the selection of hardware for the branch laboratories, what materials would be put on the network, the selection of long-line services, and how costs would be accounted for and charged to users. In the second year, budgeted at approximately three million dollars, narrow-band interconnection of the points on the kernel network would be established and one after another service would be put on it. By "narrow-band" we mean a bandwidth equal to approximately 12 parallel telephone channels.

Whenever any service became operative, any EDUCOM university that wanted to use it could do so. It would have to pay the long-line charges to the nearest point on the kernel network. The university could use the service any way it wished to on its own campus. If it had a remote terminal system or computer system which was incompatible with EDUNET, it would have to make the transformations required — either through a black box or by programming. Conversely, if they wanted to contribute a service prepared on their campus to other universities through EDUNET, they would have to put the information into EDUCOMpatible format so that it could be carried on the network.

In the third year, we would expand the bandwidth to permit two-way color television. The cost would be about six million dollars. We may be underestimating costs. That depends on how complex our services become, unanticipated operational problems, and inflation. We are attempting, however, to keep the costs as low as we possibly can so that there is a reasonable chance to raise the necessary funds. The universities will contribute their appropriate share of the funds required. The government will not be asked to provide the total amount. The universities will pay for their own terminals, for the long-line charges to interconnect with the kernel network, and for some services.

Many of the services we put on the network will be prepared by governmental or nonprofit private organizations. We have made tentative arrangements with quite a number of such organizations to use their services. Such inputs will of course be much less expensive to us than if we had to prepare them. A considerable amount of machine-readable information is available now to go on such a network if arrangements can be made.

The Office of Science and Technology has taken cognizance of our proposal, has assigned responsibility for it to the Department of Health, Education, and Welfare, and under HEW to Dr. Louis Bright, Associate Commissioner for Research in the Office of Education. On various occasions he has called together interested agencies to discuss the EDUNET proposal.

It seems probable that EDUCOM may be requested to extend the plans for another less ambitious network. We have proposed EIN, the Educational Information Network, to include certain aspects of EDUNET.

We have had a discussion about EDUNET with a member of the White House staff. On November 7, 1967, the President announced his support for the development of "networks for knowledge". In the President's message on education to the 1968 Congress, he recommended the Networks for Knowledge Act of 1968, which is Title 9 of the Education Bill of 1968, H. R. 15067. This proposes networks almost identical in principle to that outlined in the book "EDUNET." Hearings on this bill were held several weeks ago by the Special Sub-committee on Education of the House of Representatives and the bill is now being reviewed in the Senate.

I have mentioned EIN, the Educational Information Network. EDUCOM is striving for the ultimate development of an embracing program like that of EDUNET. At the same time it is important, however, to carry on networking activities relevant to the missions of various funding agencies. We have a contract with the National Library of Medicine to plan a National Biomedical Communications Center which may involve networking in that field. We have a contract with the National Library of Agriculture to develop a plan, in association with the EDUCOM landgrant universities, for information transmission in bioagriculture. We have an agreement with the Dental Health Center of the United States, when funding is available, to work in the area of a dental health information system. We have a grant under consideration by the Office of Education jointly with the National Science Foundation for the development of EIN, a network limited to one of the media, i.e., computers. Work on the Educational Information Network is expected soon to begin according to the following planned chronology:

Phase I

1. Engage a limited group (up to 20) universities in agreement permitting remote accessing of their computer facilities. (More than 20 universities have already volunteered to cooperate.)

2. Establish standard documentation format for a description of computational facilities available and produce a directory of such computational facilities for participants.

3. Establish technical representatives at each participating location to act as liaison and sources of information about operations.

4. Set up a record-keeping system to identify usage patterns for charges and further planning.

5. Establish an on-line directory to supplement the initial printed directory.

Phase II

6. Establish a means for data transmission among centers consistent with their individual format constraints.

7. Develop a system of automatic referencing between and among computers at participating facilities, and

8. Generate and document data bases for expanded nets.

We believe that many man-years are being spent in different EDUCOM universities in writing programs for local computers which are already or computers in other universities. This is true of programs of many sorts — for programmed instruction, for data banks, and for computational use of computers, among others. To diminish the great costs of such duplication, EIN may enable a user on one campus to dial into a computer on another campus which already has the program he desires, so permitting him to benefit from the work already done elsewhere.

I have been able to mention only some of our present programs, and those only briefly. We expect that there will be applications for such programs to the health fields, to patient-record systems and to medical education, research, and service. It is vital that all scientists and professional people be able to gain rapid access to relevant information and that our institutions be able to share resources. Networks can help in this. They can enable our universities to become a society of universities, to establish in our nation universities without walls that permeate many activities of our country. They can give us democracy of access to information. Not only in Boston, New York, Chicago, and San Francisco will users be able to obtain specialized information in depth, as is now true, but a new college or university wherever it is, a small institution in the Rocky Mountains or a financially weak Negro college in Alabama can have as good or better access to information as Harvard does. Networks can aid in improving the general quality of instruction, research, and professional services throughout the nation.

Discussion Periods ...

Question: Has EDUCOM developed relationships with industry?

Dr. Miller: We have received no-strings-attached grants for EDUCOM activities from the General Learning Corporation from IBM, and in smaller amounts, from other corporations. We also have received a grant from RCA to support a conference. We have six members-at-large on the Board of EDUCOM and three of those members are from industry. Each of them is an individual who is distinguished in education, for example, Francis Keppel, who is well known as an educator and is also Chairman and President of General Learning Corporation; and Carrol I. Newsom, Vice President for Education of RCA, former President of New York University. We have also at present a representative from IBM and one from General Electric. At various EDUCOM conferences representatives of the publishing, long-line, hardware, and broadcasting industries, have participated. While EDUCOM is planning a prototype experimental network, it is not at all sure that in the long run it is the responsibility of the universities to run such networks. After we are clearer how network services can help universities, some industry or industries may wish to provide the services on a reasonable profit-making basis. That would be quite acceptable to EDUCOM.

Question: Has EDUCOM devoted attention to problems of compatibility among local and regional networks?

Dr. Miller: We may expand the EIN study to determine the technical characteristics of all the regional educational networks, for computers, libraries, television, and so on, in an effort to ascertain to what extent they are compatible. Millions of dollars of local, state, and federal funds are going into regional networks of various sorts. So far as I know, no one regional network planning group is taking informed notice of the technical characteristics of another in order to be compatible. EDUCOM may attempt first of all to learn the characteristics of present networks. Then, when we have developed, in the light of these facts, suggestions about what might be appropriate standards, we will propose them through proper technical channels. We are conscious of the fact that if you establish compatibility regulations too soon you may restrict proper development. On the other hand, sometimes decisions must be made or chaotic waste occurs. I personally believe we are near the time when we must make such decisions. We have talked to the Bureau of Standards about such matters, as well as to other agencies involved in setting standards. While some standards — for television, for example — are now well established, in other areas there are none at all. We would obviously follow Library of Congress or Library of Medicine standards or others set by responsible bodies whenever they exist. In areas where standards have not been formulated, some group must make the decision. Large hardware and software investments are being made by universities in the current year. If these products obtained are so incompatible that Wisconsin cannot take advantage of developments at Cornell or Cleveland State cannot benefit from work at California, there will be a great loss to all of us. There is danger of a debacle like the color television hassle between CBS and NBC some years ago or the battle among the makers of different sizes of long-play records or tape cartridges. A solution must be found soon and EDUCOM is aware of the problem.

COMPUTERS IN UNDERGRADUATE MEDICAL EDUCATION

HILLIARD JASON, M.D., ED.D.*

Undergraduate medical education in this country is in a state of re-examination and revision in proportions without precedent. "Efficiency" and "effectiveness" have become watchwords of curriculum committees. Patterns and techniques of instruction which had been hallowed by decades of use are being modified and even jettisoned, and the search is on for new instructional modalities which hold the promise of getting more done in less time.

The growing sense of need for better educational methods has been paralleled by an increasing availability of potential solutions. Within the past decade we have come to understand the process of instruction more precisely and technological aids to the process have appeared in increasing profusion. Programmed instruction, teaching machines, automatic cartridge movie projectors, simplified audio recorders and television are all part of the growing technology of education. Because of its far greater flexibility, potency and cost, the computer represents the culmination of this trend.

To understand the promise and the problems computers might bring to medical education, we must understand something of: (1) the process of introducing a major innovation into an educational system, (2) the current educational requirements in medicine, and (3) the particular characteristics of the computer which may or may not fit into these educational requirements.

Innovation in Education

An innovative device of the scope of the computer can be a mixed blessing. We have recently begun to enter a new era in medical education: one in which a half century of educational conservatism is giving way to a receptivity for, indeed a hunger for, new and promising approaches. As much as many of us rejoice at this venturesome spirit, we must be wary of its potential pitfalls. Most worrisome of all is the capacity of new *devices* to be mistaken for new *ideas*. The act of accommodating old instruction to new packages, such as television or the computer, can prove to be worse than mere maintenance of the *status quo*. The glossy new packaging tends to deceive both the student and the teacher into believing that something new, and therefore better, is happening. In actual fact, what often happens is that considerable energy and money are invested in creating a situation that is even harder to change than was the conventional instruction it is mimicking.

We have repeatedly seen, for example, the poorly delivered stultifying lecture become even more so on the TV monitor. With sadness I must report that the equivalent has begun to occur with the computer, in some people's hands. One can now find examples of electronic

*Director, Office of Medical Education Research and Development, College of Human Medicine, Michigan State University, East Lansing, Michigan

reincarnations of the pompous, arrogant professor whose instructional strategy is the demand of compliance rather than the promotion of independent skills in the student. The computer generated reprimand of "Nonsense! You should know better!" fails to help the student learn what he did wrong or where to go next. Simply put: bad instruction isn't made good by inclusion in a new medium. The essence of these miscarriages of modern methods is that they are attempts to provide solutions, without awareness of the nature of the existing problems: they are accommodations of conventional instruction to available technology, when continuing modification of the instruction itself and adaptations of the technology are needed. For educational innovation to be meaningful, it must derive from a sound understanding of educational requirements, so that available technology can be properly modified and exploited, and thereby provide worthy solutions.

Requirements of Medical Education

A. What We Learn

I will turn now to some requirements of an effective medical education: first, in terms of what it is that students must learn.

The most frequent and most desperate plea one hears today in medicine is that we must find ways for dealing with the inundation with which we are allegedly faced, as a consequence of the "information explosion." Statistics are repeatedly cited on the multiplying number of journals and journal articles as evidence of this trend. There are two sides to this problem which deserve our attention. They are neatly highlighted by the following quotation:

"Those who have occasion to enter into the depths of what is oddly, if generously, called the literature of a scientific subject, alone know the difficulty of emerging with an unsoured disposition. The multitudinous facts presented by each corner of Nature form, in large part, the scientific man's burden today, and restrict him more and more, to a narrower and narrower specialism. But that is not the whole of his burden. Much that he is forced to read consists of records of defective experiments, confused statements of results, wearisome descriptions of detail, and unnecessarily protracted discussions of unnecessary hypotheses. The publication of such matter is a serious injury to the man of science."

These timely remarks are taken from John Langley's presidential address to the Physiology Section of the Royal Society, in 1899 (1). It seems that the information explosion, and its accompanying "garbage explosion," began some time prior to the present decade.

Most of us would willingly concede that much of the seeming explosion of knowledge is in truth, a dilution with trivia and irrelevancies. There has been, however, an undeniable and very considerable expansion of our understanding of life processes. I challenge, however, the usual implications that are derived from this expansion. Rather than complicating the process of learning, I contend that the growth of knowledge has actually simplified the process. I will turn to some other quotes to help make the point.

"I know that I am shockingly ignorant. I could take exams in college but could not pass any of them. Worse than that: I treasure my ignorance; I feel snug in it. It does not cloud my naivete, my simplicity of mind."

This is not the statement of a San Francisco "flower child," it is the observation of one of our most distinguished scientists, the Nobel laureate, Albert Szent-Gyorgyi (2). It was said in a context that should become clear from the following additional quotes:

"It is widely spread opinion that memorizing will not hurt, that knowledge does no harm. I am afraid it may. Dead knowledge dulls the spirit; fills the stomach without nourishing the body."

He points out that we have books and libraries "to keep the knowledge in while we use our heads for something better." And it is our instructional challenge to help students learn to use their heads for "something better" than simply storing information. A major point of this paper, to which I will shortly return, is that the computer can help us do better jobs of both storing information and teaching students to use their minds for "something better." First, let me linger one moment longer with Szent-Gyorgyi, to emphasize a notion that will help clarify the point.

"Science tends to generalize, and generalization means simplification. My own science, biology, is today not only very much richer than it was in my student days, but is simpler, too. Then it was horribly complex, being fragmented into a great number of isolated principles. Today these are all fused into one single complex, with the atomic model in its center. Cosmology, quantum mechanics, DNA and genetics, are all, more or less, parts of one and the same story – a most wondrous simplification. And generalizations are also more satisfying to the mind than details. We, in our teaching, should place more emphasis on generalizations than on details."

Put in other words, the expansion of knowledge has left us with a lighter, rather than a heavier, burden. We are far better equipped than ever before to help our students come rapidly to grips with the central, organizing issues of our disciplines. We can provide the conceptual base which permits the skills of the *manipulation* of knowledge, the skills of acquiring, validating and using knowledge, rather than the mere *possession* of knowledge, to become the mark of the educated man in medicine. It is the acts of evaluating and generating knowledge, more than retaining it, that seem proper goals for our instructional programs. And it is in this transformation of goals, not in the adoption of new devices, that the heart of educational innovation lies.

B. How We Learn

Let us turn from *what* students should learn to *how* they learn. Among the many conditions of effective learning, two requirements are paramount: First, the student must practice, *during* learning, the very things he is to be able to do as a *result* of learning. That is, if he is to be able to distinguish abnormal from normal heart sounds, he must practice that very act. If he is to be able to solve clinical problems, he must practice the various steps, the components, of problem solving. Second, the student must have frequent and reliable information on the appropriateness of the progress he is making: he must have "feedback." To illustrate: if he is to learn to swing a golf club, he must not only get to see where the ball goes as a result of his efforts; he will make his most efficient progress if he can see a movie or videotape of his actual swing and he is helped to see the crucial components of the total skill, such as the position of his head, the line of his shoulders, his stance, and so on. Similarly, if the student is to learn to solve medical problems, he needs to know the correctness of his solutions, but he also needs to know his competence at managing the crucial components of the process; such as problem sensing, problem formulation, information search and resolution. These skills have been identified and elaborated by Shulman (3).

While the earning of intellectual skills, such as problem solving, is far more complex than the learning of mechanical skills such as golfing, we have been considerably less effective than golf instructors in providing the exquisitely important ingredient of meaningful feedback.

To recapitulate, I suggest that among the central challenges of current medical education are: (1) developing techniques for helping students learn to effectively manipulate knowledge, (2) enabling them repeatedly to practice these manipulations, and (3) providing frequent and reliable feedback on their success at the overall process, and at its components. Computers have a unique set of characteristics which, if properly exploited, can fulfill these requirements with remarkable effectiveness.

Characteristics of Computers

The specific characteristics of modern computers and the ways in which they function, have been well described in a recent publication by Caffrey (4), intended primarily for technically uninformed readers. The general characteristics with which I will here deal are those matters which provide the computer with its special potential as well as its limitations, as an educational device.

Among the computer's greatest strengths are the SPEED with which it can search its memory, undertake a calculation or solve a logical problem, the PATIENCE with which it will systematically repeat questions or otherwise deal with refractory students, the nearly unlimited capacity of its MEMORY for storing all manner of information, the IMPARTIALITY with which it will deal with different students and changing characteristics within the same student, the consistent LOGIC with which it handles sequential information or intricate problems, and its ADAPTABILITY to wide variations in the manner of presentation of the same problem through the availability of virtually unlimited capacity for branching to alternate possibilities. In the process of performing all these functions, it can keep complete records of the entire proceedings. As we will see shortly, this is a singularly important function for educational purposes.

Among the more serious of the computer's limitations in performing the kinds of educational challenges it tends to be given are its FLEXIBILITY being limited as it is in its responses to the finite repertoire which its program necessarily provides, its essential lack of ORIGINALITY, in comparision to the human teacher with which it is so often compared, its FALLIBILITY in terms of the electromechanical breakdowns to which current computers remain prone, and its essential lack of PERSONALITY, or patently synthetic programmed personality, which remains a somewhat jarring characteristic to many students who are otherwise caught up in the humanoid characteristics of the interaction.

The process of adapting the computer to the instructional requirements in medicine must include the extraction of maximum advantage from its strengths and careful accommodation to its limitations.

Computers in Undergraduate Medical Education

Before discussing the computer as an instrument of direct instruction, I will briefly mention some of the ways it can increase the efficiency and capabilities of administrative functions which support the overall educational system. Although they are not seen as part of the purposes of the present paper, they are mentioned for completeness. The processes of student record keeping, class and patient scheduling, educational budget management and the development of a reference memory on a variety of relevant subjects are all parts of the computer's potential contribution to education. They have been discussed by

Caffrey (4). The exceedingly important functions of library maintenance and management have been described by Brandt (5) and will be elaborated upon in this conference by Dr. Martin Cummings.

The remainder of this paper will be devoted to those educational applications in which the student receives instruction through direct contact with the computer, using a remote terminal. This consists of a typewriter-like apparatus which permits both the student and the computer to ask and answer questions in a fairly free exchange. There may be, in addition, a television-like tube for the display of printed information or diagrams, as well as computer controlled slide projectors, movie projectors, and audio recorders, for providing the student with sensory inputs of various types. I will briefly examine the four major types of educational uses within this setting.

A. Information and Concepts

Conventional medical education is so information oriented that it is no surprise to find that a fair proportion of early computer based instructional programs have been primarily information oriented. A fairly typical illustration of the strategy employed is represented by the model adapted from Spolsky (6) in Figure 1. This model, it will be noticed, takes advantage of the adaptability, logic and patience of the computer to systematically check, and if necessary correct, the progress of the student in acquiring a body of information. It should be clear that the computer is fully capable of drilling students in the acquisition of information. Information acquired in this way, however, will generally not last long. Information of the complexity required in medicine, paradoxically, is acquired best when it is *not* the primary center of attention, but is part of applications that are meaningful to the student. As discussed earlier in the paper, information that is not alive and vivid for the student is best left to books or some other repository.

B. Intellectual Skills

Essential in its relevance to the graduate physician, and hence to the student physician, are the skills of identifying and solving problems, generating and testing hypotheses, and formulating judgments. The characteristics of the computer make it possible to present the student with repetitive instances of these procedures for practice and mastery. It is here, it seems to me, that the computer holds its greatest potential in undergraduate medical education. Return to Figure 1 and imagine, if you will, a problem oriented, rather than an information oriented, program. The errors that the students here make are *process* rather than *content* errors, and the remedial assistance they are given deals with the components of the intellectual skills being learned, rather than with facts being acquired. For example, they might be alerted when they draw an unwarranted inference or arrive at a judgment with insufficient evidence. And, most important of all, the computer's capacity to retain a total record of all transactions in which it engages, enables the student to be provided with the cognitive equivalent of a video-tape of his thought processes. In fact, the computer print-out of the problem-solving process in which the student has engaged is far more flexible than a video tape. It is more like a map which can be scanned in its entirety and compared to other maps, for critical evaluation. Much like the golfer who makes startling progress through being confronted with his own swing, the medical student learning intellectual skills, when provided with the feedback of the print-out, can make unprecedented strides in areas previously barely

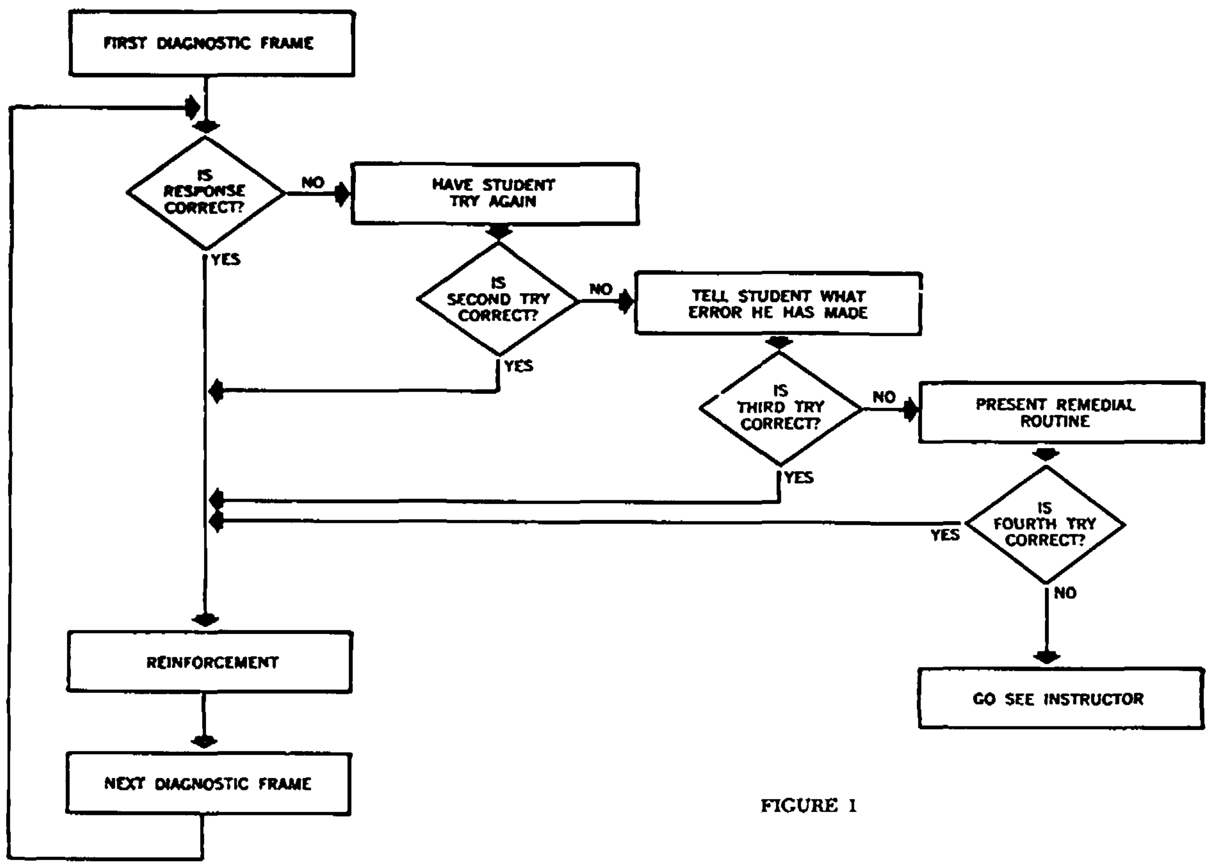

FIRST DIAGNOSTIC FRAME
IS RESPONSE CORRECT?
NO
HAVE STUDENT TRY AGAIN
YES
IS SECOND TRY CORRECT?
NO
TELL STUDENT WHAT ERROR HE HAS MADE
YES
IS THIRD TRY CORRECT?
NO
PRESENT REMEDIAL ROUTINE
YES
IS FOURTH TRY CORRECT?
YES
NO
GO SEE INSTRUCTOR
REINFORCEMENT
NEXT DIAGNOSTIC FRAME

FIGURE 1

touched by conventional medical education.

C. Technical Skills

The flexibility of the computer, combined with a multimedia terminal, permits the student to be presented with wide varieties of EKG tracings to be interpreted, slides to be read, or heart sounds to be deciphered, to mention only a few of the possibilities of instruction in technical skills where student responses can be immediately judged and repeated practice provided. An even more sophisticated possibility is the creation of complex simulation situations, such as "Sim I," developed by Drs. Stephen Abrahamson and J. D. Denson for the training of anesthesiologists.

D. Evaluation

The capacity of computers to keep a complete record on all its transactions with students permits an unusually comprehensive and elaborate evaluation, both of student performance and instructional effectiveness. The singularly attractive possibility which emerges is that of *computer-monitored* instruction. In a way we have never been capable of doing in the past, student progress can be assessed from day to day, rather than term to term, and instructional adjustments made, literally, as needed. The extent to which this can elevate our efficiency can, at present, barely be imagined. In addition, the memory and adaptability of the computer permits the development of a store of great ranges of evaluation materials, which students can use at any time to assess their own progress along many dimensions of any discipline. Still further, formal accreditation-type evaluations can be undertaken more flexibly and more reliably with the computer. An imaginative new computer-based technique for evaluating students of large differences in ability, in a manner that exposes them to a unique set of questions which are maximally adapted to their level of performance, has been described by Chauncey (7).

CONCLUSIONS

The computer, without question, provides the potential for an enormous technological leap forward in education. Its long range promise and consequences can barely be glimpsed, if recognized at all. Many of the steps, however, which must now be taken to help us profit most from this potential, can readily be seen.

Most important is the need for us to identify, as explicitly as possible, the real purposes of medical school instruction. We must then define, as precisely as we are able, the characteristics and components of the competencies our students are to acquire. These must be formulated in terms that duplicate or parallel the circumstances in which they will actually be applied following graduation, so the practice we provide our students in school will be maximally relevant and real. Provision must also be made for effective feedback to the students on their success in acquiring these compentencies.

A burning question in the minds of many is: if we succeed in properly exploiting the potential of the computer, will the live teacher be displaced? In an observation that is equally relevant to computers, B. F. Skinner has said that, "Any teacher who can be replaced by a teaching machine, deserves to be." The point is this: the computer can, indeed, do certain things better than the live teacher. It was more than a half century ago that Thorndike observed, "a human being should not be wasted in doing what forty sheets of paper or two phonograph records can do. Just because personal teaching is precious, and can do what apparatus cannot, it should be saved for its peculiar work." (8) The challenge before us is not how to suppress computers so as to permit teachers to go on doing those things they no longer need to do. The challenge is, rather, to exploit computers to their maximum and, at the same time, work to redefine the human teacher's role so that we may take full advantage of his potential, which no machine of the foreseeable future will possibly duplicate.

No innovation of this potential magnitude is without risk. Shall we wait until all the data are in and move forward so delicately and with such caution that all false starts and errors will be avoided, or should we acknowledge the enormous promise now available to us and forthrightly and vigorously take some chances? Let me answer the question by analogy. Everyone seems to remember that Babe Ruth held the all-time home run record for many years. Very few people seem to remember that for almost as many years he held the all-time strikeout record. It seems to me that in all areas of human endeavor, the achievement of greatness comes only from taking calculated risks. Let us take some risks, because the promise of computers seems without precedent in the history of education, and, intelligently used, should provide us with the instructional equivalent of a series-winning grand-slam home run.

REFERENCES

1. Fletcher, W. M., *J. Physiol.* (London), 61:1-27, 1926.
2. Szent-Gyorgyi, Albert, "Teaching and the Expanding Knowledge," *Science*, 146:1278-9, Dec. 4, 1964.
3. Shulman, Lee S., "The Study of Individual Inquiry Behavior," Presented at the Amer. Psychol. Assn., Washington, D. C., September 2, 1967.
4. Caffrey, J. and Mosmann, C. J., *Computers on Campus*, Washington, American Council on Education, 1967.
5. Brandt, E. N., Jr., "Electronic Computers in Medical Education of the Future," in *Clinical Anesthesia*, 1:125-36, 1966.
6. Spolsky, B., "Some Problems of Computer Based Instruction," *Behavioral Science*, 11:487-96, 1966.
7. Chauncy, Henry, "Some New Approaches in Testing," *J. of Med. Ed.*, 41:No. 7, Part 2:25-32, July, 1966.
8. Thorndike, E. L., *Education, A First Book*, New York: The MacMillan Company, 1912, p. 167.

ADDITIONAL BIBLIOGRAPHY

1. Bowden, D. H., Computer Aided Instruction in Pathology. *Canadian Medical Association Journal*, 97:739-42, 1967.
2. Brown, M. C. Electronics and Medical Education. *Journal of Medical Education*, 38:270-81, 1963.
3. Dryer, B. V. Thinking Men and Thinking Machines in Medicine. *Journal of Medical Education*, 38:82-92, 1963.
4. Entwisle, G. *et al.* The Use of the Digital Computer as a Teaching Machine. *Journal of Medical Education*, 48:803-12, 1963.
5. Feurzeig, W., *et al.* Computer-Aided Teaching in Medical Diagnosis. *Journal of Medical Education*, 39:746-54, 1964.
6. Fonkalsrud, E. W., *et al.* Computer Assisted Instruction in Undergraduate Surgical Education. *Surgery*, 62:141-7, 1967.
7. Harless, W. G. The Development of a Computer Assisted Instruction Program in a Medical Center Environment. *Journal of Medical Education*, 42:139-45, 1967.
8. Kirsch, A. D. A Medical Training Game Using a Computer as a Teaching Aid. *Methods of Information in Medicine*, 2: 138-143, 1963.
9. Long, J. M. *et al.* Experience Teaching Computer Programming to Medical Students. *Journal of Medical Education*, 40: 657-60, 1965.
10. Overstone, J. A. Computer Assisted Instruction in Undergraduate and Post Graduate Medicine. *Medical Journal of Australia*, 2:487-91, 1966.
11. Swets, J. A. *et al.* Computer Aided Teaching. *Science*, 150:572-6, 1965.
12. Suppes, P. The Uses of Computers in Education. *Scientific American*, 215:207-220, September, 1966.

SUMMARY

COMPUTERS IN UNDERGRADUATE MEDICAL EDUCATION*

Panel: Hilliard Jason, M.D., Ed.D., Chairman, Stephen Abrahamson, Ph.D., Alan Kaplan, M.D., Theodore Peterson, Ph.D., Lee S. Shulman, Ph.D.

It is not possible to give credit in a summary like this to everyone's favorite idea. As a matter of fact, it is difficult to include the most salient points of a three-hour discussion. However, this paper will attempt to give at least an overview of the major ideas discussed.

Our approach was first to take a look at the present state of the use of computers in undergraduate medical education. Dr. Theodore Peterson reported as to the work underway at Harvard University, some generalities based on their work and their summary of the work of others. Dr. Lee Shulman helped us look into the future to some new ways computers might be used in achieving some objectives, particularly in the area of developing the processes of medical inquiry. Dr. Stephen Abrahamson helped us stay reality-oriented with his very apt and effective reminders of the approaches that are necessary to evaluate properly what we are doing as we do it, and Dr. Alan Kaplan of the Bureau of Health Manpower provided perspective as to the hopes, wishes and plans of the federal government in the area of support of computers in medical education. In order to bring some coherence to a rather free-flowing and not always systematic discussion, eight general conclusions derived from the discussions will be presented. In addition, Dr. Shulman's comments will be presented as an appendix to this summary.

The *first conclusion* which can be stated with some acronymity, is that computers in undergraduate medical education are not yet in what might be called an implementation phase. Any school that does not now have a computer should not feel that they are somehow missing out on an important contribution to their education program. In fact, this leads to the *second general conclusion*, which is, that the primary justification for having a computer would be for a few innovative and even unique studies of its utility and effectiveness in medical education.

The *third conclusion* which ties into the first two, is that the issue of cost in the use of computers is a complex but a seemingly important one, and there seemed to emerge two different positions regarding cost in the ways computers might be used in undergraduate medical education. When computers are used to do something that is already being done, then cost was an exceedingly important consideration. The ratio of cost to effectiveness was one of the central issues in determining whether what we now do can possibly be done differently or better with a computer. But there was a second position and that is of the possibilities that computers bring that may enable us to do things we aren't doing at all now and may enable us to realize instructional objectives that are not available now. In areas like this,

*Presented by Hilliard Jason, M.D., Ed.D., Chairman, at the closing plenary session of the conference.

cost becomes a far less important consideration. That is, if we can use the computer and our studies of it to help us produce a physician of higher quality than we have produced before, then cost is no longer an issue. Our dedication has been that if we can produce something really worth producing, cost becomes a secondary issue.

A *fourth general conclusion* is that the technology of the computer seems to be considerably ahead of our readiness to take full advantage of it. The most central and most pressing need that was repeatedly identified was the urgency with which we need a far better delineation of our objectives in undergraduate medical education. These are not the broad, philosophic, abstract program objectives of trying to produce good physicians; these are the hard-to-define but exquisitely important instructional objectives that commmunicate what are indeed the specific competencies that a graduate will have, if we are to regard him as a worthy graduate of our school. These have never been defined, and as has been said before, if you're not sure where you're going you might end up somewhere else. The need for precision in defining objectives does not require government support, it does not require hardware; it does require the conscientious dedication of medical educators to the task of working together and coming to grips with what it is a physician is going to be able to do. Not only what he is going to be able to know, but what he is going to be able to do, if we have confidence in him and in the quality of our instruction. The important point is, that whether we go about doing that explicitly or not, we have done it. Without defining objectives explicitly, we have defined all sorts of objectives implicitly, just by doing what we do when we assign a particular class to a particular topic. That is a definition of objective. By failing to be explicit in objectives, we run a terrible risk of which we were reminded several times on the panel. That is, the risk of achieving some objectives at the expense of more important ones; that by helping students work in a particular area we might be failing to help them learn how to work in another area. For example, if we have students do a very significant portion of their independent learning on a computer, are we perhaps running the risk of failing to help them with the important skills of learning how to learn without a computer? There are more important questions than that, and these relate to our current examination system. We communicate to students most effectively what our objectives are by the exams we design. Another way of communicating effectively our objectives is by investing a great deal of effort into what we put inside a computer. If we convey a lot of ephemeral details and very short-lived information because that's what is easiest to put into a computer or easiest to examine on paper and pencil tests, then we are communicating to them fundamentally that learning is not a very relevant activity, and that the act of participating in medical education is a game which you play in order to get a degree. Then you end up with one of the great tragedies of medical education in America; the production of generations of physicians who are committed to the notion that learning is something they will spend the rest of their career avoiding. If we don't design our programs, our total educational programs, and our computers in a way that helps physicians develop the skills and dedication to continue to modify themselves the rest of their lives, anything else we do is of no importance.

The *fifth general conclusion* that ties in very closely with the last, is that intuition just isn't enough in educational planning or computer usage in medical education. Intuition has led to a program of medical education in this country that can safely be described as rigid in the extreme. Despite the evidence of the remarkable diversity among medical students, we have somehow intuitively fashioned the program that tries to pretend that everybody learns in the same way, at the same speed, and is interested in the same things. All of this flies in the face of everything we know about people. So that if we are going to use computers intelligently, we need to put aside intuition because it has failed us, and we have to start assembling data. We have to build into our computer usage a very generous allocation of funds, time, and effort; to start a process of evaluation of what we are doing; and to develop a research base that will guide us in the future. A specific suggestion finding favor was the idea of encouraging and developing regional efforts at research in medical education and various parts of medical education – categorical sub-parts of the total picture.

The *sixth general conclusion* would be that it is inexcusable to undertake a project today in the use of computers in undergraduate medical education without a major investment in evaluation of the process.

The *seventh major conclusion* was that the promise of computers for undergraduate medical education is enormous, indeed. It brings more than just its own utility; it is having the heuristic effect of forcing us to clarify our educational objectives more precisely than we ever have before, of promoting a re-thinking of our purposes and a re-thinking of our methods that is long overdue. More significant still, besides being capable of direct instruction and being capable of direct evaluation of students, the computer is capable of storing its own processes as they are conducted and becomes a remarkably effective tool in evaluating its own functions with our direction and with our design.

The *eighth and final major conclusion* is finding the proper balance between the live teacher and the technology represented by the computer, which is the greatest challenge that we face. Our challenge is not only to use the computer intelligently, but to re-define imaginatively the role of the live teacher because so much of his time and effort in undergraduate medical education is now devoted to things we already know can be done better by technology. If we are going to provide a quality medical education, if we are going to undertake the remarkable complex transformation of a college student into a professional position, we have to provide him with effective models of what it is we want him to become. What we need is the creation of live teachers who will embody, will not just espouse but will embody those things we have decided we want our students to become. This a machine can never do and this is where the proper role of the live teacher begins to be defined and this is where much work remains to be done.

INQUIRY, COMPUTERS AND MEDICAL EDUCATION*

LEE S. SHULMAN, PH.D‡

I speak to you as someone engaged in the study of the manner in which people learn, organize what has been learned and employ that organized body of knowledge in the service of solving problems. I call this process *inquiry*, after John Dewey. An examination of inquiry can provide educators concerned with the teaching of future physicians a source of monitoring, evaluation and modeling that will serve them exactly as we have claimed the computer can serve the student. We say that it is important for the student to receive appropriate feedback so that he has a constant perception of how closely he is approximating some ideal model of how a physician operates. If we as educators are going to presume to program the computer to provide that kind of service for the student, we need very clear ideas in our own minds of what are the criterion models of medical practice, medical diagnosis, interviewing, history taking and physical examination. These are the models which the computer must employ. We ought to specify these models before we design any program. I do not know that we have accomplished this, as yet.

Types of Models

How do we generate this kind of model? One approach, which we might call *the experience model*, is to make careful observations of men and women who are identified by the community of medical practitioners and scholars as being *criterial physicians*. These individuals represent in their behavior the finest kind of medical practice we can identify. We then attempt to abstract from a careful analysis of what they do under various conditions, and finally employ that abstraction as the model we put into our computer so that it, in turn, can now react and give feedback to the medical student who is learning. This is the sort of thing that is done in the heuristic programming of a computer to play chess or prove mathematical theorems. We do not have in the medical literature extensive studies of the actual behavior of fine diagnosticians in sufficient detail to lead us to a model such as this one. This kind of research will be necessary in order to make medical instruction significantly more effective.

The second approach is to develop *logical models*. We ask ourselves, not how do good practitioners practice or good diagnosticians diagnose, but rather what appears logically to be the model for inquiry, be it medical inquiry or any other kind of inquiry. The illustrative model I shall now describe, in simplified form, is derived from Dewey's philosophy of inquiry. It has directed my research efforts over the last six years.

A Model of Inquiry

We begin with the stage of *problem sensing*. Most real inquiry does not begin the way we represent it in schools.

**Presented as appendix to summary of panel discussion on Use of Computers in Undergraduate Medical Education.*

‡Associate Professor of Educational Psychology and Medical Education, College of Human Medicine, Michigan State University.

There, we present students with problems to solve which have already been very carefully formulated. Rather, much of inquiry in a natural setting begins with the problem solver or inquirer being placed in a situation that is terribly ambiguous and undefined – where the edges are blurred and the distinctions are not clearly made. His first task is to sense where the problems lie and to distinguish what is problematic from what is not. We all recognize that two individuals can encounter essentially the same situation, which one of them will see as problematic while the other will merely nod and go on. Problem sensing is a very subtle kind of process. We do painfully little to train people in problem sensitivity. It may be, however, differences in the ability to sense problems that distinguishes the medical thoroughbreds from the horses that pull the milk wagons.

Once a problem has been sensed, it must be put into words or categories. That is, it must be formulated. John Dewey observed that a problem well formulated is half solved. The manner in which we formulate any sensed problem delimits the kind of resolution that we are capable of generating. A problem formulation determines the kinds of information we are going to seek out in our search, the kinds of hypotheses we will entertain or reject, and the kind of solution that we will admit as possible. *Problem formulation* is the second stage or aspect of inquiry.

The third is *search*. Search can be both external and internal. We not only conduct search by asking questions of patients, performing a physical examination, calling for certain kinds of laboratory tests and generally gathering information from the outside. There is also internal search. We have enormous storehouses of information between our ears and, potentially, in our computers. The question is how much of this information do we seek, and which of it do we seek? The interaction of the internal and external information-gathering constitutes this total process of searching. The search is defined as the sequence of operations, questions, movements, frustrations, revisions of tactics, and the like, that the individual undertakes in order to transform the problem-as-formulated into a personally-felt resolution.

Problem resolution occurs when we decide that we are finished and the problem which initially keyed off the inquiry is solved. In the studies we have conducted of inquiry in teachers, we find enormous variability among individuals in what they will accept as a resolution of a problem. This is closely related to their formulation, but it is also related to individual differences in personality, values, intelligence and training. Unfortunately, differences attributable to training are usually accidental, because rarely do we have a clear model in mind when we engage in instruction.

It is very important to note at this point that the model of inquiry described above does not require a rigid sequential ordering of steps wherein all inquiries can be subdivided into four simple stages representing each of the four above-named processes. The natural process of inquiry has these four parts as somewhat independent components. Any particular inquiry will look very much like a computer program with its many loops and digressions. The steps of inquiry act as the basic operations in the program. Thus, it would not be unlikely for a given subject to sense that a particular problem exists, proceed to formulate it in a particular way, initiate search activity in order to gather data concerning the problem, realize as a result of the initial search that his problem formulation is misbegotten, return and reformulate the problem, while doing so sense an additional problem or two, thus reformulate once again, and so on.

Medical Inquiry

What happens when you take this kind of model and attempt to apply it in the context of the medical situation? The diagram of Figure 1 suggests that the input of a specific case interacts with the organized body of knowledge possessed by the physician, his long and short-term expectancies of what he will encounter and the general strategies or heuristics he has learned, to generate as output the medical diagnosis, treatment and evaluations. The full complexity of medical inquiry is surely not represented in this diagram. The relations between this model of medical inquiry and the general inquiry model are only suggested here. A far more detailed analysis must await much additional effort.

I think it is fair to say that the acquisition of organized bodies of knowledge has been the major focus of discussions in this conference, with the assumption that the computer is useful in making more efficient and effective the manner in which these bodies of knowledge are acquired and organized. Not yet answered satisfactorily is: How do alternative ways of organizing a body of knowledge have different consequences for directing the process of inquiry? This is the name of the game in medicine, as it is in teaching and in other complex problem solving tasks. We teach the organized bodies of knowledge, not to create little living libraries of our subject, but rather to make these bodies of knowledge maximally retrievable and useful in the service of inquiry. Is Socratic teaching, whether live or by computer, the most effective way of accomplishing this? Is drill to the point of overlearning the most effective way? The most general question for the different aspects of the inquiry process we are trying to teach in medicine is: Which approaches to learning are most likely to assist us in achieving our multiple goals?

The computer must be introduced into the flow of medical instruction as part of a systematic strategy of educational development. First a map of objectives must be drawn in very specific and operational terms. These will include organized bodies of knowledge, certain kinds of expectancies on the part of the physician, and strategies of inquiry. All these affect the conduct of medical inquiry. The future impact of the computer on the practice of medicine is likely to be reflected in a shift of instructional emphasis away from the organized bodies of knowledge to the strategies of knowledge-retrieval and inquiry. Next, the materials representing possible paths to the terminal objectives must be developed. Third, the materials and objectives must then dictate the combination of software and hardware most appropriate to guiding our students in traversing the map. Fourth, the total instructional system so designed must be implemented under carefully monitored conditions. Finally, the results of that implementation must be evaluated in terms of the original map of objectives. This evaluation could lead to changed instructional tactics, modifications in the map, or both. If we too quickly try to move into the implementation stages without prior, or at least simultaneous, effort in the planning and design stages, we are likely to generate more chaos than progress.

Research in Medical Education

I shall conclude with an urgent plea I make not only to medical educators but to educators of all kinds. For too long we have allowed complex and expensive educational operations to be piloted by the seats of our pants. We decide what we do on the basis of our reactions to what was done to us. This can work in

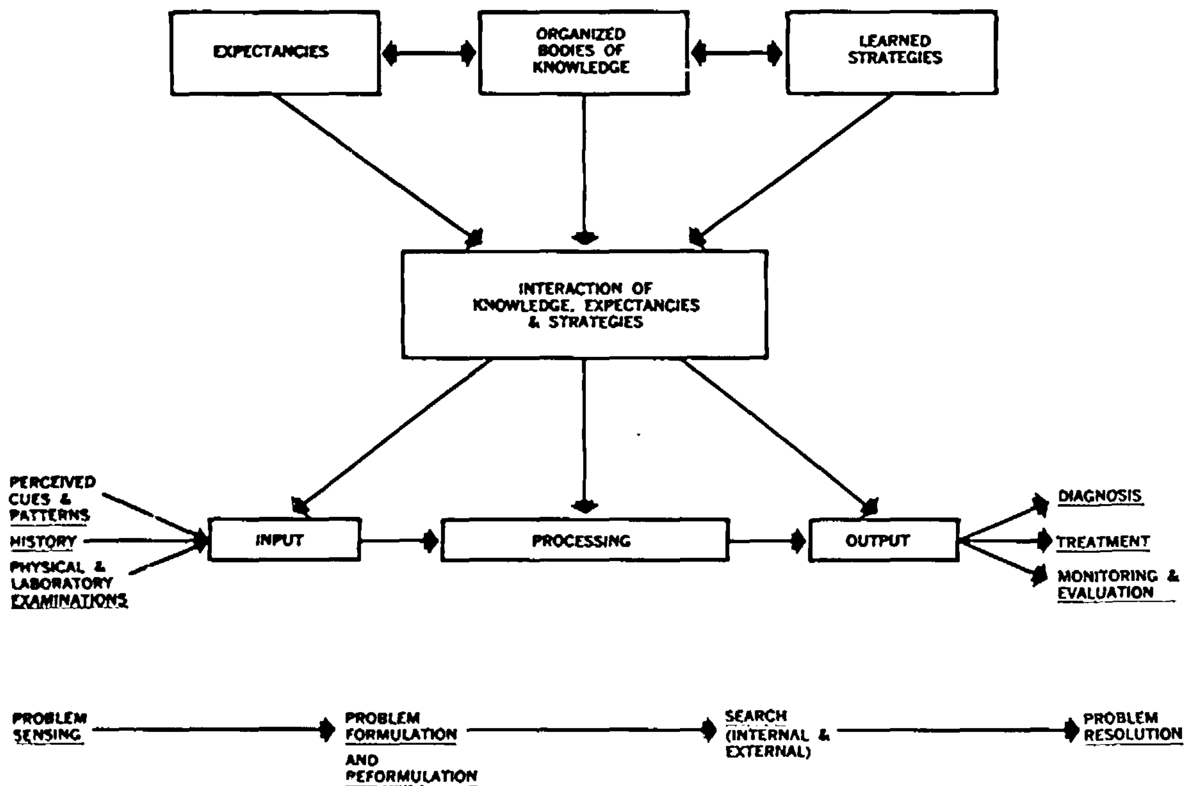


FIGURE 1. A Model for Medical Inquiry

two ways. We can either repeat our own experiences or react against them and do the opposite. Both are equally untenable.

We must get beyond this level of doing things just because we intuitively feel this is the best way to do it. We must attempt to study carefully the processes in which we are engaged. I am not suggesting that people in medical education run to the studies of B. F. Skinner and try to extract his findings and apply them directly to medical education. That will not succeed, because medical education is not the same as teaching pigeons to play ping pong or even 6-year-olds to count. Rather, we need to create a discipline of the psychology of medical education that will bear a relationship to the general psychology of education and learning – a relationship that is parallel to the relation medicine as a discipline bears to the basic sciences. Clinical medicine is an intermediate discipline between the basic sciences and direct medical application. The applied discipline of the psychology of medical education must have analogous characteristics. It does not now exist except as a set of intuitively-derived dogmatic statements. How can the creation of this field be accelerated?

The scope of systematic research which is needed in medical education is great. In order to achieve that scope as quickly as possible, we must implement broad programs of research in medical teaching and learning, making best possible use of the small number of currently active personnel in that field.

A strategy I would recommend for your consideration is the following: Let us establish a series of *Medical Education Research Laboratories* around the country. They could be organized on either a regional basis, or through joining together units which share interests but may be in different parts of the country. Each laboratory would be dedicated to a specific research mission in medical education and would draw upon the resources, facilities and research populations of all its cooperating units – universities and hospitals. Such missions might include the specification and definition of objectives for medical education, the development of evaluation models and evaluation instruments in medical education, the uses of technology including the computer, the study of the medical inquiry process and studies of the acquisition and use of organized bodies of medical knowledge.

The *Medical Education Research Laboratories* must also assume a training function in order to produce the research and development personnel needed to disseminate, implement and evaluate the research-based approaches which emerge from the laboratories. This medical education research effort cannot be left to individual medical schools, but must be coordinated systematically on a nationwide basis.

Ivan Pavlov is said to have told his students, "Ideas and theories are like the wings of birds – they allow man to climb and soar to the heavens. But facts are like the atmosphere against which those wings must beat, and without which the soaring bird will surely plummet back to earth." We are at a moment in the history of medical education when we must buttress our myriadic ideas and theories about the best forms of medical education with painstakingly collected facts. In this effort the computer will be an indispensible tool. Without this research effort, the computer in medical education could become our newest enemy.

COMPUTERS IN CLINICAL MEDICAL EDUCATION

DONALD A. B. LINDBERG, M.D.*

There are a number of sources from which one learns clinical medicine. Computer systems have potential roles to play in providing access for the student or physician to information. We will examine examples of such systems.

The student or physician learns about medicine from four major sources. These are: common sense and lay beliefs; by examining the facts of patient care; by exposure to purely didactic information; and from the personal guidance and precepts of his teachers.

Facts of Patient Care

One learns medicine from the opportunity to personally care for patients or to see care given. This is a valuable, but limited experience. One cannot see examples of each and every disease, treatment, outcome, and evaluation of such processes. Consequently one learns by drawing upon the experience of a whole institution. A computer system can provide valuable assistance merely by serving to retrieve patient records, to search the hospital files for records, and by permitting comparisons to be made between different groups of patients or different treatments or management schemes. (1) (2)

In such cases the real learning is done by the student reading and studying the usual written hospital record. The computer has merely guided him to the correct record.

Inquiries into the records of laboratory determinations can also be a source of learning. Systems have been provided so that the inquirer can see the frequency distribution of results of a determination during past hospital experience, and so place his patient's results in a perspective of the institutional experience (3). The system provides the ability to retrieve any item of laboratory studies for any patient, or alternatively to retrieve and display categories of results (such as, those patients with cholesterols greater than 300 mg%) or by compounding categories (such as by also requiring that the patients be of a particular race, or sex, or that the results have occurred during a certain time period). It is also possible to require in such an inquiry that the results of a second or of a third determination also meet certain specifications. The net result of such compounded inquiries is merely the display of data or the listing of patient identification numbers — nothing creative or innovative. Yet such a facility permits the student or physician to ask questions of the mass of potential "teaching data" which might otherwise be difficult to use via manual record room systems.

An additional benefit of the facility

*Director, Medical Center Computer Program, University of Missouri Medical Center

to retrieve the results of laboratory determinations is provision to the laboratory director of added quality control capability. He can, for example, specify very closely the format of reports, the requirements for release of a report (i. e. tolerable "limits" and special rules), the permissible precision for reporting, the extent to which quality control sera for a given batch run may vary from the most precise estimate, the extent to which aqueous standards may vary from their expected curvilinear relationship. The laboratory director can take into account the relationships between the results of multiple simultaneous determinations in formatting his "limits" systems (4). A simple example of this kind of rule is the requirement that hemoglobin concentration and hematocrit bear a sensible relationship to one another when both estimates are available for the same blood sample. Computer systems for examination of laboratory determinations can permit the laboratorian to ask such questions before erroneous reports creep into the patient care system. When reports deviate from the "limits" systems, the resident physician has an opportunity to re-examine the situation and approve or disapprove the report. Such constant re-examination of premises and performance, as well as the creation of new limits and rules serves an educational and training function for the house officer and the laboratory director as well. At the very least, such systems direct ones attention to the exceptional clinical case, ideally the case requiring professional intervention and judgement.

Didactic Information

The published medical and scientific literature is indexed by the National Library of Medicine, publishers of the Index Medicus. This citation data base itself can be searched by the NLM computer system, and hopefully this system will be replicated at many other medical centers (5).

There is now the potential to store considerable quantities of information on microfiche systems, which in turn can be indexed by computers (6). At present one cannot (practically speaking) transmit the images of microfilmed text pages over long distances. Perhaps image transmission (e. g. "Picture Phone") will in the future make a reality of the dream of browsing through the library via the computer.

An experimental program at Missouri (called Consider) attempts to allow the student or physician to scan across a broad spectrum of medical knowledge. The data base employed is a magnetic tape version of the AMA Current Medical Terminology (CMT), kindly provided by Dr. Burgess Gordon. Our programs permit the inquirer to type onto a computer terminal a statement of the signs, symptoms, or other findings from a patient. The system then searches the formatted statements of CMT and displays for the doctor a list of the names of diseases in which the findings occur in the combinations specified, and hence which must be considered. Medical students have found the program challenging and often educational. It is amazing how long a differential diagnosis one can encounter and how often the teacher has forgotten much of what is contained in Dr. Gordon's slim volume.

Recorded audio medical lectures have been developed at the University of Wisconsin (7). Under such a system, the user can telephone to the message center, request a particular lecture, and get the benefit of a careful presentation without leaving his office. The original audio tapes have been loaned by Wisconsin to various Regional Medical Programs and other educational groups. At Missouri the Wisconsin tapes are utilized through an automatic answering apparatus so that the operation is totally unattended. The critical ingredient in such a system clearly is the necessary high quality of the lecture material. Computers enter the picture only on the technical side. Switching many incoming calls between hundreds (or potentially thousands) of recorded lectures will be a computer job. Similarly, providing systems so that the medical user may learn of the existence of an appropriate recorded lecture may well be a future computer job.

Research and Analysis

Computers have of course been utilized for the statistical and/or mathematical analysis of research data for many years (8). Recently computer systems have made it possible to assist in learning clinical medicine by re-examining certain medical techniques. For example, use of Slack's automated patient history taking system (9) permits the doctor for the first time to repeat the process of obtaining a patient history. The same can be said of the interpretation of electrocardiograms by computer systems (10). One probably cannot relearn a fact or concept in quite the same way (with or without a computer). Even so the advent of "Computer Aided Instruction" systems should permit a far more careful study of learning processes in those who learn through computer terminals than has ever been possible in the past.

It is beyond the scope of this paper to review the numerous excellent ventures into true "computer diagnosis". I refer to the work of Lusted and Ledley, Warner, Lodwick, Reichertz, and Moore and others. In all cases a computer system is requiring certain observations or measurements from the physicians before attempting to calculate a diagnostic likelihood. The effect on the user is to demand greater precision and consistency than usual. Often the program guides him by asking "the next logical question". For example before the Lodwick and Reichertz program will yield up an opinion concerning the likelihood of bone tumor, it requires the resident or fellow to make seventy observations and/or measurements on the roentgenograms or patient. Even after the diagnostic programs have evolved to the minimum number of true discriminating factors, it seems likely they will still be able to ask for observations and measurements which will help the beginner learn medicine and the practitioner remember it.

There are innumerable examples of computer terminals and apparatuses designed to give the researcher a new way to visualize his data. Multi-dimensional plotting and display, symbolic representation of data, conversational mode of statistical analysis – all offer real potential for insightful analysis of medical data from groups of patients. It remains for us to learn to use modern display devices so as to "give a new dimension" to the data for the individual patient at the time of his illness.

REFERENCES

(1) *Lindberg, D.A.B.: Electronic Retrieval of Clinical Data. Journal of Medical Education* Vol. 40 No. 8, (*August*) 1967, pp. 753-759.

(2) *Buck, C. R., Jr., Reese, G. R., and Lindberg, D. A. B.: A General Technique for Computer Processing of Coded Patient Diagnoses. Missouri Medicine*, 63: 276-279; *Passim.*, (*Apr.*) 1966.

(3) *Lindberg, D. A. B.: The Computer and Medical Care. Springfield, Charles C. Thomas Publisher*, 1968.

(4) *Lindberg, D. A. B.: Collection, Evaluation, and Transmission of Hospital Laboratory Data. Methods of Information in Medicine, Vol.* 6, *No.* 3 (*July* 1967), *pp.* 97-107.

(5) *Austin, C. J.: "The Medlars Project at the National Library of Medicine." Library Resources and Technical Services, Vol.* 9, *No.* 1 (*Winter*, 1965), *pp.* 94-99.

(6) *Photographic and Computer Systems in Biomedical Information Handling, L. C. Kingsland, American Documentation Institute*, 26th *Annual Meeting, Chicago, Ill., October* 1963.

(7) *Meyer, Thomas C., Department of Postgraduate Medical Education, The University of Wisconsin. Personal communication to the author.*

(8) *Stacy, R. W., and Waxman, B., (Ed): Computers in Biomedical Research. Vol.* 1. *New York, Academic Press*, 1965.

(9) *Slack, W. V., Hicks, G. P., Reed, C. E., and Van Cura, L. J.: A Computer-based Medical History System. New England Journal of Medicine*, 273: 194-198, (*Jan.* 27) 1966.

(10) *Caceres, C. A.: Electrocardiographic Analysis by a Computer System. A.M.A. Archives of Internal Medicine*, 3: 196-202,(*Feb.*) 1963.

SUMMARY

COMPUTERS IN CLINICAL MEDICAL EDUCATION*

Panel: Donald A. B. Lindberg, M.D., Chairman, Robert Greenes, M.D., Mitchell Schorow, John A. Starkweather, Ph.D., James Sweeney, Ph.D.

Dr. Robert Greenes described the present computer system at the Massachusetts General Hospital which utilizes a conversational mode for the collection of information for the patient medical record. This system uses a branching response approach to keyboard entries on the part of the medical user. Both teletype terminals and cathode ray tube terminals are employed. The latter include a special device produced at the Massachusetts General Hospital that consists of a number of fine parallel wires crossing the face of the cathode ray tube screen. When the medical user touches one of the wires to indicate his choice of a response displayed on the computer terminal, his body acts as capacitance to activate a circuit whereby the computer senses his choice.

Dr. Greenes stressed both the need for relatively carefully formated entries in the patient record and the need for the medical user to enter free form responses on the computer terminal. In some cases the standardized or formated responses are "fixed field" although this is not always necessary. Processing of the totally free form entry is possible because the conversational mode has already contributed a considerable structure to the data.

This system is being utilized in an experimental mode on a regular basis for three patient record data collection compilations. These are the automated patient history, the conversational mode system whereby the M. D. can answer the results of his physical examination of the patient, and a system through which the radiologist is able to enter his impressions following interpretation of roentgenograms.

Dr. Greenes, Dr. G. Octo Barnett, and their associates want to extend the experimental system in order to investigate new applications and new areas in the hospital setting. Dr. Greenes stressed that one of the advantages of this type of system, especially in the example of the radiology system, is the ability the system gives medical users to monitor the thoroughness with which x-rays are examined. This can play a definite role in the educational process of residents and young physicians studying radiology.

Dr. Greenes did not see any *major* problem in the existing hardware or computer soft ware. The major problem at the moment is the extreme amount of time involved for the radiologist to produce a dictionary, branching code, instructions and the thesaurus capability required by such a data collection system. It is possible that a radiologist could spend the better part of a full year in designing a system to handle only a portion (perhaps as small as fifteen per cent) of the total dictionary and associated systems required for the field of diagnostic radiology. Consequently, the

**Presented by Donald A. B. Lindberg M. D., Panel Chairman, at the closing plenary session of the conference.*

limiting factor in this clinical data collection system is the amount of time possible for clinical physicians to contribute to building new portions of the system.

Dr. James Sweeney described the history of the Tulane information processing system as well as the present more advanced version known as GIPSY. He stressed the general problem of estimating the true information content of data collected through computer systems. Dr. Sweeney's system deals only with information which can be represented by alphanumeric characters, and only information as it is perceived by the human "sensor." The major objective for individuals designing computer systems is not so much that the system need be a total and perfect reflection of the real data, but that it not lose any information which has been perceived by the human observer. The system then becomes a repository for the observations of the human being, and should provide him capability to inquire into this repository. In order for the systems to be at all manageable and realistic in a medical setting, Dr. Sweeney felt it essential to strip off from the total information of the hospital all that is not likely to have essential worth in patient treatment and medical teaching. Dr. Sweeney disdained the two extreme views: the view that all clinical information is exceedingly unreliable and "noisy" and the view that leads some people to wish to collect all information connected with patient care. Dr. Sweeney characterized the latter approach as the "pack rat principle" and pointed out that one should have a fairly good idea of the use to which information will be put before committing oneself to a computer data collection system.

Dr. Sweeney stressed that the medical record has very many functions. It is not, in his opinion, well organized at present for purposes of scientific inquiry. He also raised the question whether medical people become well trained in the normal course of their education for conducting scientific inquiries into information systems like the present paper medical record. Even with computer repositories of medical information, Dr. Sweeney felt that some new approaches and possibly some formal education of medical personnel might create a more useful total system.

At present, Dr. Sweeney is supervising the reprogramming of his general information processing system to comply with the needs of I.B.M. 360 computing hardware. He expects to be done within a year and expects the system to be generally usable by other investigators, both medical and general scientific. Dr. Sweeney's advance planning includes a scheme to provide on-line inquiry to investigators into their research data files, using computer terminals. His mode for collection will remain for the moment the paper form utilizing certain "self encoding" principles developed over the years by him and his group.

Dr. Sweeney acknowledged the existence of a problem in the existing manufacturer-supported programming languages. On the other hand, he saw the major problems to be still in the area of definition by medical personnel of the uses to which information will be put, careful systems design, and the possibility for innovative uses of computers to be developed in the future. He noted that the inquiry capability he plans to develop has the possibility to give a new dimension to the interphase between the human and the computer data base. He had developed interactive inquiry capability into his system using second generation hardware. Under these conditions, the response time in the system was three to four minutes. He feels that his new system can reduce this to three to four seconds, and that response times in the range of one second will probably be required in order to obtain optimal interaction between a research investigator and his data base.

Mitchell Schorow described the work that Dr. George Miller and he are doing in primarily addressing themselves to the problem of educating medical personnel for clinical problem solving. The systems with which they are working permit them to create within the computer system the patient history data base utilizing a single actual patient history, a combination of actual patient histories, and where necessary, artificial constructs. The computer system permits the student to "treat" the patient by permitting him to ask the system for information about the patient and his responses utilizing virtually free form natural language. For example, the system presents to the student the information that he has a "patient who is a forty-nine year old white male with low back pain of two years duration, of increasing severity for the past six months." The student is then given the opportunity to make diagnostic investigations and treatment of the computer "patient." The responses of the system are designed to contribute to the student's gaining clinical acumen and good judgment.

Mr. Schorow and Dr. Miller are utilizing I.B.M. 1500 computer hardware and writing in Coursewriter II language. At present, they believe that their system is capable of giving totally appropriate responses to the student's free form questions in about seventy per cent of the cases. This is in contrast to their belief that a minimum of ninety per cent appropriate responses are necessary in the long run for the system to be a complete success. In fact, their system is still in an experimental stage, although operating in a gratifying manner.

Another major obstacle for these investigators to overcome is the amount of author time required in order to create a good student teaching program. At present, about forty hours of author time are required in order to produce one to two hours of student teaching material. Members of the panel were quick to note that even the forty hours represents a very considerable improvement over the amount of author time which was required by other computer-aided instruction systems. In many cases in the past, one hundred to two hundred hours on the part of the author have been needed in other systems to create one hour of student teaching material.

Response time of the present Schorow system averages from four to five seconds, with a maximum response time of thirteen seconds. Mr. Schorow felt that any response in excess of eight seconds in such a system was totally unsatisfactory, since the delay left the student intolerably impatient. His feeling is that within the next two years, the response times of their system will have been reduced to acceptable levels.

Mr. Schorow stressed the need to have built-in objective evaluation criteria in the development of all such systems. He did not feel that his own system is sufficiently far advanced at present to report the complete evaluation at this time. His anecdotal experience with the system encouraged him to believe that the system was quite acceptable, in fact, exciting to medical student users. About one and one quarter hours are required for each student to complete a single clinical medical problem.

The problems presented to Mr. Schorow in creating a system capable of accepting totally free entries on the part of the student were described as serious ones. In order to accomplish this, the authors have utilized prepositional and propositional calculus, and other advanced theoretical information handling technics within the programming system. He seemed to feel that these technics will ultimately prove adequate to the problem.

Dr. John A. Starkweather described his professional obligations at the University of California. These include the duty to improve education for both the medical student and medical professional community as well as nursing students and personnel, and other medical and paramedical groups within the entire medical center complex. In order to accomplish the task, he described the division of his central computing staff into groups concerned with education, research, and patient care, and operating as separate units. All three of these groups as well as the scientific users, utilize a single computer facility, in the form of an I.B.M. 360/50. As a consequence, Dr. Starkweather utilizes OS/360, operating in multiple fixed partitions, including tele-processing partitions as well as batch-processing partitions. A second smaller computer (360/20) is included as part of the system. The interphase between the two systems being "HASP" input/output spooling routine.

Dr. Starkweather stressed that it was possible to serve this diversity of computer users with existing technics. On the other hand, he emphasized his feeling that ideal and optimal application of a computer in medicine, especially computer-aided instruction systems, definitely requires new programming languages. These languages must interphase between the medical educator and the various rigorous and complex requirements of OS/360 and its Job Control Language. One such attempt involving Dr. Starkweather's new programming language system PILOT was described. PILOT is itself written in PLI programming language. The intent of this system is to aid in teaching problem solving to students and in teaching the method of inquiry into patient problems to medical personnel. The ultimate aid of the PILOT system is to permit the medical educator to create his teaching routines with a minimal amount of programming knowledge, and to permit him to do some file handling through remote computer terminals when the system is finally completed. Dr. Starkweather stressed his belief that the present tools for inquiring into computer systems, for teaching of problem solving. and for simulation as a means of computer-aided instruction are still extremely primitive.

Even so, computer systems have the potential for giving appropriate responses to relatively free inquiries on the part of students. Dr. Starkweather felt that at this very moment, the basic approach of branching conversational mode structured inquiry presented by Dr. Robert Greenes from the Massachusetts General Hospital system probably is closer to being an operational reality than the free form entry systems. In essence, he believed that the matrix of questions and responses used at Massachusetts General Hospital is presently totally realistic, but that the system he himself is striving to create for handling free form inquiries offers a greater potential in the long run, and that this potential can ultimately be achieved.

Dr. Starkweather stressed two additional conclusions: one, that the facility of a large computer to store vast amounts of information, whether patient care information or didactic information, will in fact make a major contribution to medical teaching; two, the extreme importance in the long run of the computer's ability to provide the knowledge of many medical authorities to help one single student.

Dr. Starkweather presented in some

detail an application of his programming system in which a student can learn to conduct a psychiatric interview. A characteristic of this system is the ease with which the novice computer user can answer the system and begin his learning experience. Dr. Starkweather stressed the fact that although the system is obviously a simulation experience, the individuals using it seem to enter very seriously into the simulation. For example, individual users seem to be compelled to quickly answer some sort of response to the computer terminal questions, even though they would prefer to think over the answer and even though the question may be an awkward one. In this respect, they seem to forget that the computer terminal itself is so utterly patient.

At present, Dr. Starkweather's major programming system is operating well within the medical center and has good language handling capability, although it has some temporary limitations on the number of terminal units it can serve. The language is designed to aid the user by offering conversational mode assistance to him while his programming efforts are being conducted. The system is based on a former similar system with which Dr. Starkweather had had experience, namely Computest on the I.B.M. 1620.

The major problems Dr. Starkweather described involve very serious limitations in present manufacturer-supported programming language. He plans to correct this problem by extending his own compiler/interpreter programming system. He, the other members of the panel, and numerous members of the audience were in agreement concerning this issue: they all stressed their desire for federal government and manufacturer support for the development of new languages for medicine and specifically for medical education. Dr. Starkweather suggested four specifications for any such new language.

1. The language should offer ease of entry to the computer novice. In connection with this, he stressed the extremely poor quality and total unreadability of existing manufacturer produced programming manuals.

2. The language should offer ease of editing; that is, facility with which the author can make minor alterations in his text and instructions.

3. The language should offer ease of translation from similar or more primitive programming languages. This is extremely important so that instructional material can be exchanged between medical users in different institutions.

4. The new language should offer the ability to print for the user his source level instructions utilizing more than one level of readability. This would mean that the individual relatively unfamiliar with the program or even other programming languages could request a "print out of the program" in a relatively conversational, even verbose, form. On the other hand, the experienced individual should be able to request a statement of the program in very much more terse, compact, and efficient style.

A number of members of the audience expressed their agreement with the requirements Dr. Starkweather laid out as well as the general inadequacy of present programming languages. One member suggested that with respect to medical education, we were at a point analogous to the days of scientific programming before the existence of FORTRAN and other appropriate scientific high level languages.

There was considerable discussion at different portions in the afternoon meeting from the audience concerning the recurrent theme: why are there not more existing completed courses in medicine available through computer-aided instruction. All participants seemed in agreement:

1. That there are no completed medical courses.
2. That even the most promising provisional courses at the present will have to undergo extensive medical testing and evaluation.
3. That an entire medical course, at least in the traditional medical school sense, is unquestionably far too large a unit with which to begin attempting computer-aided instruction. Many participants felt that a single one hour lecture might represent a realistic unit for the medical educator to approach with computer technics. Other participants, especially Dr. Greenes, preferred to approach a clinical problem rather than either a lecture or a course. The magnitude of the problem was hard to represent but he agreed that it might well be of the same order of magnitude as a single lecture.

There was considerable discussion aimed at explaining the present essentially primitive state of computer-aided instruction in medicine. Many explanations were offered. A popular one seemed to be the belief that the problems in medicine were essentially very much more complex than the problems presented in teaching undergraduate subjects of a seemingly more quantitative and more rote nature. Examples were offered: statistics, languages, grammar school spelling and arithmetic, and college physics. The latter example was challenged by one of the panel members who suggested that it had cost more than $200,000 to program one college physics course, and that the final result had not been totally acceptable to the teaching department involved. Consequently, one was left with the feeling that the participants generally agreed computer-aided instruction could be utilizied in areas where the teaching unit was sufficiently small, and the material to be covered was sufficiently well defined; but that in fact, neither of these conditions had yet been identified in a truly medical setting.

As an extension of the above, there was considerable discussion from both the audience and the panel concerning the question of new roles for computers in medical education. Virtually everyone was willing to concede that the use of computers to compile and give inquiry capability to the patient record keeping system probably provided a suitable asset in a medical education setting. There was, however, very little enthusiasm from the audience to pursue this problem during the meeting. There seemed to be willingness to believe that this endeavor was worthwhile, especially if the questions asked such a computer data base were aimed at an epidemiological or population level, and especially if epidemiologists were able to play a role in teaching students to ask such questions.

In a similar way, there was a great willingness on the part of the participants to accept the contention that overtly instructional, traditional computer-aided instruction technics could take their place in the long run as a valid portion of the medical education armamentorium. Even so, most people were willing to admit that accomplishments in this sphere were presently quite limited and the technics essentially still primitive. For this reason, there was a very general consensus that the profession should continue vigorously to seek new imaginative applications for computers in teaching. This might take the ultimate form of diagnostic games, computers as an aid in logic and reasoning, computer simulation of mental and/or physical processes or as yet totally undiscovered applications. In order to pursue this course of action, it was agreed that one should make every attempt to include objective evaluation criteria into such experiments. It was the belief of the section chairman, to which he garnered surprisingly little support, that the proper application of cost effectiveness criteria cannot be made to the experimental systems unless one carefully specifies the states of development through which such systems need to pass. In this sense, he was urging the application of staged development technics utilized in engineering; for example, creation of specifications and requirements, pilot model, prototype model, test model, production model, and final evaluation. In defense of this contention, it should be noted that there was only one engineer in this section meeting. He was an industrial engineer and concurred with the desirability of staging experiments.

A member of the audience asked the group for general recommendations for a university administrator in planning for computer terminal capability in the design of a new campus structure. The consensus was that:

1. The school should make provision for possible coaxial cable connections between the new building and the campus computer site (probably this would mean a tunnel).
2. With the new building, suitable telephone line conduit should be provided to each office and laboratory.
3. False or "deaf" ceilings should be used.
4. Air conditioning should be provided.
5. No cables or electrical connections should be buried in concrete, nor should "channels" in concrete be used.

These were general recommendations. The group agreed that provision might be made for a small peripheral computer in the new building if a large number (more than eight or twelve) computer terminals were planned. A small computer would also probably be needed within the building if complex physiological simulations were planned (such as the automated anesthesia dummy described by Dr. Abrahamson).

Inquiry was made of the group for a published estimate of national, state, or regional manpower needs with respect to medical computer personnel. Primarily the question here was the need for development of medically oriented computer systems and operators, computer programmers, and information scientists. All those asked felt most such persons were in critically short supply but could neither document this need nor identify institutions at which such persons are being trained.

In summary, the participants were enthusiastic about the potential of contributions of computers to medical education. They seemed to feel generally that this field is presently in its infancy; that it should be explored in an openly experimental framework. A major limitation to progress in the field at present is the exhorbitant amount of author/clinician time required for the creation of even experimental systems. The participants seemed to feel that this problem was best attacked by the creation of new computer programming languages, pre-languages and/or systems, of a sort to support conversational mode interaction between the relatively inexperienced user of computers and the necessarily large and complex computing systems which will be required.

COMPUTERS IN CONTINUING MEDICAL EDUCATION

GEORGE E. MILLER, M.D.*

I will begin with a disclaimer. My knowledge of computers is best described as rudimentary, and if I speak with any semblance of confidence about bits and core, of CRT and 360-50, it is because my associates have programmed me with some care to respond appropriately to natural language input. Having made such a confession I must also acknowledge that my justification for accepting an invitation to appear on this program is based upon a conclusion that the key word in context of the conference title is not computers but education, a field in which I feel somewhat more comfortable.

For in fact, the computer is neither more nor less than a tool, neither laudable nor objectionable except in terms of the task it is to perform. And when that task is continuing education then the problem is formidable, for debates about the perplexing and frustrating issues in this field grow ever more shrill. Of only one thing do we seem certain: the pressure is mounting for the universities and others to *do* something, preferably something new and hopefully with new tools as well. Among the new tools to which we are turning, the computer is nearing the crest of a wave of enthusiasm that was only recently vacated by programmed instruction. Discussion of computer assisted instruction is becoming a babel in the land, and talk of networks and compatibilities and software can be heard almost everywhere. But in the language of communication theorists the educator must ask whether all this sound represents a message — or merely noise.

I am personally inclined toward the view that there is not only an important but a critical message to be heard, but one cannot deny that the noisemakers are also plentiful among us. These are the ones who seem to be saying that this dazzling new medium *is* the message — and like the medical educators before them who made the same claims about films and television and programmed instruction they divert us from the central question of educational purpose to be served by such exciting tools.

This cautionary comment must have a familiar ring, but it is now touched with a note of urgency. For the widespread restlessness about improving means of bringing an ever growing body of medical information more rapidly to practitioners is accompanied by a mounting faith that the incredible information storage and retrieval capacity of the computer can accomplish this allegedly critical task. While it would be foolhardy to deny the accelerating pace of knowledge growth, it is at least defensible to raise the question of whether the problem of continuing education is lessened or magnified when a practitioner seeking information gets a MEDLARS printout of eighty citations on the topic

**Director of Research in Medical Education, University of Illinois College of Medicine*

about which he has inquired. The technical achievement of such a production is staggering, but the educational impact may leave more than a little to be desired.

The educational issue then is not computer capacity and versatility, but rather what kind of information shall be stored, in what manner it should be processed and retrieved, in order to serve what educational objectives. In my own troubled search for an answer to this question I have come, on April 4, 1968, to a point of identifying four functions to which the computer seems both ready and able to make a contribution to continuing medical education. I share them with you not in any confidence that they will survive your scrutiny, but in the hope that they may serve as organizers for our discussions this afternoon.

The first, to which I have already referred in passing and which will be more fully developed by Dr. Cummings, is the *library function*. I find it difficult to believe, as some seem to imply, that the library of the future will be a collection of discs and tapes and punch cards from which words will flow as a steady electronic stream in response to the command of a discriminating client. But the evidence is persuasive that there are more efficient means of searching for an informational bit than poring through a card catalogue or the Index Medicus. The computerized search function, with retrieval of selected abstracts or rapid reproduction of full texts will surely be an important contribution to the physician who has a specific question for which a specific and documented answer is available. Aside from the technical problem this poses, there is an educational problem of retrieval, of matching level of inquiry with level of response, and not overwhelming the inquirer with more information about penguins than he cares to have. I suspect that this library function will be of greater significance in the continuing education of academicians (who seem to have a high level of tolerance for irrelevant information) than for practitioners — but that is a matter of speculation.

The fact remains, however, that this function will be useful in fulfillment of only one objective of continuing education, and one which at least some of us believe to be of secondary rather than primary importance: that of providing information. It does not guide learning, but responds to practitioner-generated inquiry which can as easily be a major effort to find small things as essential study of critical matters. Such random activity must sometimes be best described by Dorothy Parker's phrase, "There is less here than meets the eye."

Secondly the computer can serve a *consultative function*. It has been said by some, although without benefit of any discernible evidence, that the best continuing medical education occurs when a consultant and practitioner work together in solving a perplexing clinical problem. To the extent that this is true, the role of the consultant-teacher would appear to be primarily that of bringing a special body of information, or a particular skill in applying both familiar and new knowledge, to the problem at hand. It is such a function that seems to be served by some of the imaginative computer applications that have already been introduced into clinical practice in some parts of the country. For example, the computer analysis of electro-cardiograms which not only frees a physician-interpreter from routine tasks but also focuses his attention upon elements of the tracing that require special consideration; the clinical diagnostic system which guides a practitioner's inquiry and from a vast memory core can suggest diagnostic probabilities, as well as possibilities that have escaped his attention; the rapid calculation of radiotherapeutic dosage which incorporates consideration of many variables that might otherwise have been neglected or omitted; the continuous monitoring and synthesis of physiologic data from patients in coronary care units, patients whose course may be modified by early recognition of impending complications; the rapid analysis and weighting of historical items in screening examinations, with probability projections that allow a practitioner to focus his attention upon the most significant matters in his encounter with an individual patient. All of these may provide substantial and significant assistance to a physician in the fulfillment of his professional role, and thus contribute to solution of the critical manpower shortage which besets us. But the question that must occupy our attention here is whether these things, or indeed whether more conventional consultative exchanges, are educational in the sense that they extend the learner's ability to deal more efficiently or more effectively with comparable problems he encounters in the future, or in another setting. It is surely possible that they may do so, and I am prepared to accept this as a potential, if not a demonstrably achieved outcome. But at the same time it seems important to note that a crutch may lead to dependence as well as to independence. Nor does the use of a more efficient kind of crutch necessarily influence the nature of the outcome. There would probably be no dispute with the view that electronic measurement of the hemoglobin level is more precise than the Tahlquist method, but there might be considerable question whether the introduction of accuracy has led practitioners to more rational practices in the treatment of anemia.

If the consultation function is to be useful as an educational instrument it must probably be accompanied by some systematic review of what has been learned, not merely what diagnostic or therapeutic goals have been achieved.

Third is the *tutorial function*, perhaps the most familiar of the species included under the genus computer assisted instruction. It is this form that many visionary directors of continuing education programs have in mind as they picture a computer network for a city, a region, a state, or in the case of EDUCOM, a nation. Such a mode lends itself to discrete course packaging, and to systematic consideration of highly important clinical content and concepts. With the complex branching capabilities which even a simple computer offers, the instruction may proceed not only at an individual learner's pace, but may bypass informational bits with which he is already familiar. Unlike the book, which also offers these advantages over classroom instruction, the tutorial form of computer instruction forces active participation in the learning process and some assurance that the necessary content has been mastered to a predetermined level before proceeding to the next stage. And the recitation, which most such programs require, has the advantage of being personal and private so that the revelation of ignorance carries no social threat, unless the learner personalizes the computer-tutor and tries to beat the transistors in much the same fashion that students have for so many years tried to beat the living teacher.

Recognizing these several advantages, which reflect the incorporation into educational technology of substantiated theoretical concepts of learning, there are still many who cry out in despair that such mechanical and dispassionate instruction might displace the warm and personal interaction between live teacher and live student. I suspect that most such complaints come from teachers picturing what they think they do with students rather than from any accurate depiction of what occurs in lectures, conferences, even seminars, in hundreds of continuing education programs all over the nation. Is listening with one hundred others to an expert talk (with the opportunity to ask questions at the end of the hour – if there is time left) really personal instruction, while engaging in active individual analysis, interpretation and discussion of information with a carefully programmed computer really impersonal? And for those who insist that such an exchange is mere training, not real teaching, I would note the comment by B. F. Skinner in a recent *Science* paper that when we know what we are doing it is called training, and when we don't it is called teaching.

Despite the advantages of planned coverage, carefully specified learning objectives, active learner participation and immediate feedback, the tutorial mode of computer assisted instruction is still focused upon information which has been selected and processed by a teacher, and whose acquisition is assumed to be accompanied by transfer into professional practice. It is this assumption that must be most seriously questioned, for practitioners have long known, for example, that bacteriologic identification of an organism should precede institution of antibiotic therapy or, at the very least, confirm the choice after the fact, but even casual inspection of the reality reveals the frequency with which this logical pattern is ignored. Such discrepancy between knowing and doing is the most disquieting problem of all for thoughtful leaders in continuing education.

It is for this reason that I am particularly attracted to the fourth educational function the computer may play – the *simulation function*. In order to avoid any potential argument let it be openly acknowledged at once that simulation is not reality. But at the same time let the claim be underscored that for some instruction it may be more useful than reality. For in simulation it is possible to extract a critical and planned segment of an often complex and unpredictable world; to control the evolution or sequence of important variables; to provide learners with opportunity for independent action without doing harm to either subject or object; and through this dynamic mechanism to provide immediate feedback of consequences of an intervention, not merely information about what might transpire. It is an instructional form that focuses upon use rather than mere possession of knowledge.

There are already exciting developments in computer simulation, ranging from relatively simple to dismayingly complex. Spivack's arrhythmia trainer, one of the simpler applications, creates a situation in which sudden changes in electrocardiographic pattern displayed on an oscilloscope demand prompt and proper application of electrical stimuli to a synthetic torso in order to reverse, for example, ventricular fibrillation or to initiate appropriate pacing of a potentially disastrous heart block. A more complex mode is Sim I, Stephen Abrahamsons' life-size dummy whose respiratory activity, pulse rate, blood pressure, skin color and pupillary size, among other things, are under computer control and respond to drug administration as well as to other interventions used by the anesthesiologist in managing patients at surgery. Using this model, a trainee can be faced with a variety of situations he will shortly encounter in the operating room, and allowed to deal with them repeatedly, without risk to real patients, and with immediate feedback about the effect of his judgments and his actions.

Another program is John Starkweather's simulation of the clinical interview in which a student may play either the role of physician or of patient, while the computer carries out the other part of the dialogue.

The method with which I am most familiar, however, is that under development in our own unit under the direction of Mitchell Schorow. This has grown out of the printed patient management problem, the erasure examination which has become one of the more familiar simulation methods in current medical education. Here the learner is provided with the bare bones of a problem — usually little more than the patient's presenting complaints. Selection of general problem-solving strategies and specific management tactics must then be independently generated using natural language input, and with responses provided through typed output, visual display (such as x-ray, electrocardiogram, biopsy specimen), or sound (such as heart sounds, lung sounds, and segments of spoken historical information that provide non-verbal as well as verbal cues). Management interventions are followed by alteration in clinical course, such that a learner may deal successfully with a problem, inadvertently induce complications with which he must then deal, or lose the patient to another physician — or to the pathologist. But Lazarus-like, this patient can rise from the dead, and if necessary suffer the same fate again and again.

While such an encounter is demonstrably exciting, we must certainly avoid the comfortable trap of equating excitement with learning. They may be associated, but it is not necessarily so. The carefully created simulation, however, does provide an unusual opportunity to determine the means by which a learner attacks a problem, the types of evidence he accumulates before taking action, the relative weight he assigns to evidence of different kinds, the extent to which effects of early interventions influence his subsequent actions, and his manner of dealing with deviations from anticipated outcomes. If the sampling of this behavior is sufficiently large it may even allow some generalization about his characteristic pattern of performance which, when cast against the judgments of a criterion group, can focus attention sharply upon the strengths and weaknesses of his knowledge and his methods of utilizing knowledge. In short, it provides diagnostic data which may then be used to prescribe educational therapy specifically selected to correct his performance deficits — therapy that may be in the form of books, journal articles, courses or tutoring.

It is such a posture that has been assumed by the EDUCOM Task Force on Continuing Education — that educational therapy abounds, but diagnosis of need is in very short supply. With the Educational Testing Service and research groups in medicine, engineering and education a proposal has been developed to study use of the computer, among other methods, for the purpose of developing such educational diagnosis, and not merely the shotgun therapy which seems to characterize so much of continuing education. It is the hope of this study that a library of simulations designed to provide the basis for diagnosis will not only direct attention to individual and group needs but will also heighten the awareness that learning begins with recognizing a question, not having an answer, with the process of seeking and not alone with some product that others have found.

Such a shift in educational strategy will not be easy to achieve, for teachers have long managed to divert a variety of instructional methods to their own needs. There is no reason to believe that a computer will accomplish a magical transformation of teacher-centered instruction to student-centered learning. But it does create an opportunity for individualization of learning that one can hope will be grasped and exploited to the full.

The developmental stage of any new method is certainly not the time to raise questions about cost, yet it is an issue that must ultimately be faced both realistically and quantitatively. The current enchantment with computers will not last forever, and when the enormous bills for programmers and analysts, long lines and equipment begin to seem burdensome, we had better be prepared to defend with something more solid than enthusiasm our view that computer-aided learning for practicing professionals is not only effective but competitive. As the investment in hardware and software goes steadily upward, I would plead for the diversion of some significant segment of that investment, in every developmental program, to systematic study of use (once the bloom of novelty has faded), of cost (once the developmental price has been paid), but most importantly of effectiveness. And it is here that we will require a measure of humility that has not always characterized the physicians who conceive programs of continuing education, or the media masters who have nourished and supported them. Our greatest need is a spirit of inquiry — not about *computers* (in continuing education), but about *continuing education* (with computers).

And on that shrill note I shall retire to the wings.

SUMMARY

COMPUTERS IN CONTINUING MEDICAL EDUCATION*

Panel: George E. Miller, M.D., Chairman, William T. Blessum, M.D., Edward N. Brandt, Jr., M.D., Ph.D., Gerald Escovitz, M.D., Alexander Schmidt, M.D.

The panel and audience were charged by its chairman with development of discussion and recommendations which could guide those interested in working with computers in Continuing Medical Education and those who may have responsibility for funding such work. Members of the audience introduced themselves and their major interests and questions. It was found that although the audience consisted of a diversity of backgrounds and interests, their questions were very similar. The audience was actively involved in the discussion and this report includes their contributions as well as those of the panelists.

The first major consideration was the relationship of computer based instructional systems to other computer based health care systems. Dr. William Blessum of the California College of Medicine pointed out that he had been active in attempting to stimulate interest in computer based systems by pilot applications for medical students. The computer group has been active for about nine months and there is interest in development of a system which utilizes computer-assisted instruction to the maximum extent possible. At the present time it is difficult to decide on which instructional system to use since a number of significant ones are available. Furthermore, there are a wide variety of terminals and philosophies of design for the operating system in which computer-assisted instruction takes place. It is a continuing problem to determine how best to take advantage of the various programs available because of the wide variety of hardware configurations. Dr. Blessum challenged those engaged in computer-assisted instruction to realize that it is in an embryonic state of development and must be approached in an investigative atmosphere. He emphasized the need to be as compatible as possible and yet to realize that there is a danger in being compatible too early since this may restrict innovative approaches. Therefore, he emphasized the need for generation of a master plan for all applications of computers in medicine so that library systems, medical information systems, computer-aided instruction, etc. will all be components of the same general system. The advantages and disadvantages of such an approach were discussed. Specifically, it was pointed out that building a computer based instructional system as a part of a total health information system could provide a means for stimulating physicians to accept the computer as an instructional tool and to use it. The principal problem to be faced by developers of computer-aided instruction is how to get this form of instruction to physicians. Should terminals be put in doctor's offices or can they take advantage of this through other means? It was felt that if computer-aided instruction were

*Presented in closing plenary session of the conference by Edward N. Brandt, Jr., M.D., Ph.D.

part of a total health information system, one could more readily justify providing terminals for physician's use since it would be possible to have at his disposal many functions, such as summaries of clinical data, diagnostic assistance, information retrieval, etc. that would be of value to him. Furthermore, this would provide a means for obtaining feedback from the physician so that he could help define and contribute to the objectives of his own continuing education for translation by educators and computer scientists. The question as to whether physicians would use terminals for any purpose was discussed. It was alleged that medical students do accept them and if a computer based health information system were able to play a consultative role and lead to improved patient care, physicians would make use of it. However, much discussion centered around the physicians acceptance of the computer especially as a part of his continuing education. In summary, there is virtually no information available as to physician acceptance and careful study is needed. A computer based health care system could provide high quality care of patients since it would have the advantage of having necessary data available and the results of group experiences to assist in judgments. However, in the development of such a system there is the need to separate judgments from facts and to provide for group rather than individual judgments.

Another advantage to introducing CAI by this means is that it would have the virtue of peer group pressure on the physician to take advantage of a very potent tool. However, physicians will make use of it only if the computer based system improves the quality of their activities and if the system is well designed and meets their needs. All of this discussion was based upon acceptance of the concept that the purpose of continuing medical education is to improve the quality of patient care. The group was also reminded that knowledge of what constitutes good care and use of such knowledge are not necessarily the same.

The disadvantages of building the CAI system as a part of a health information system were also discussed. In the first place, such a system may become a "crutch" for the physician and thereby defeat thinking and learning. Furthermore, if the system provides for punitive action or enforcement of particular ideas, this may in itself defeat its acceptance and lead to the development of poor attitudes towards its use. However, such a system permits continuing education to be indirect and thereby not require the physician to spend blocks of time in his education and this is desirable. Furthermore, the material presented will be relevant to the physician's activities and this has the greatest chance of inducing behavioral changes.

The discussion then turned to consideration of the objectives of a computer based continuing education program. Quality patient care was considered to be the most important objective of continuing medical education, but relatively little is known about what motivates physicians to obtain further education. Studies should be carefully and systematically designed to determine what the objectives of continuing education should be. A very important point was made that getting information to physicians was not as important as inducing them to make use of this information. The material presented should be relevant to his own goals and therefore it is necessary to determine what these goals are and to translate them into meaningful educational strategies. The evaluation of any instructional system must depend upon the realization of goals and therefore it is necessary to set objectives in advance.

Other questions that need careful and systematic study were also discussed. For example, does a computer based instructional system actually inhibit learning or perhaps better stated, under what conditions does such a system inhibit learning? If, for example, it were used by the physician as a decision making tool, it might influence the physician to not continue his education. Furthermore, its use as a policing device would lead to rejection rather than stimulation.

Is it better to introduce computer based instruction into medical schools and then continue with these students than to try to expose physicians who have developed study habits over years of training? The general problem of influencing medical students and physicians to change their habits of study is faced by educators interested in CAI since it will not be used if it does not prove to be a more efficient and successful method. CAI does have the virtue potentially of providing individually based instruction and thereby of being an effective self study tool. However, the realization of this depends upon access to medical information on a very side scale, hence, the apparent desirability of making it a part of a larger information system.

Discussion then turned to the role of computers in continuing medical education. The tutorial approach may not be indicated in continuing medical education due to the potential lack of relevance to the physician's concern. Again, it was emphasized that the immediate problem is not one of getting information to the physicians, but of stimulating behavioral changes based upon that information. The tutorial approach is most effective in the presentation of factual information to be learned and hence by its very nature is fairly rigid in design. Flexibility to permit the student to select the material or portion thereof that he is to learn is very desirable. More sophisticated diagnostic methods to assist him in this selection would be of benefit but at this time such methods have not been developed. Computer simulation of clinical situations that are revelant is one approach to get the physician involved and to make it important to his own practice. Such situations permit the physician to develop a solution with the assistance of the computer as a tutor. Experiments involving simulation of clinical situations are underway, hence, more information about this aspect will be forthcoming. Again, the consultative role of providing information and assistance in decision making by means of tie-up with a health information system was also pointed out. This provides the physician with access to empirical as well as theoretical information and experiences.

The consensus of the panel was that the goals of continuing medical education are to develop a set of attitudes towards: (a) use of records in the broad sense as a basis for judgments; and (b) appropriate medical care.

Therefore, it is recommended that there be developed carefully and systematically planned investigations into: (a) what should be the specific objectives of continuing medical education; (b) will instruction developed from a computer based health information system enhance or inhibit learning; (c) how will physicians use such systems; (d) will such systems lead to increased motivation for further education; (e) how does one develop compatibility of existing systems; and (f) what are the potential uses of computer-aided instruction in continuing medical education? It was stressed that work to develop a greater diversity of computer based instruction must continue and be evaluated before the role of the computer in continuing medical education can be defined. However, such development should not ignore, but should attempt to gather information to answer the above questions.

AUTOMATION IN MEDICAL LIBRARIES*

MARTIN M. CUMMINGS, M.D.† AND RALPH A. SIMMONS‡

In science, read, by preference, the newest work; in literature, the oldest.
Edward Bulwer-Lytton – *Hints on Mental Culture.*

THE CHALLENGE

An important purpose of medical education is the transfer of skills, knowledge, and information from a variety of sources through a variety of media to the student and practitioner. A most important resource in this process is the medical library. We have become increasingly conscious of the relative roles of other media so important in the communication processes, including the information transfer that takes place through personal discussions with colleagues, attendance at professional lectures, and the use of the newer audio and audio-visual materials including television. But the literature – the written word – remains as a principal vehicle through which scientific concepts, facts, ideas and observations are transferred.

The growth of the medical literature has almost doubled over the past decade, as has been true in practically all scientific fields. The literature itself abounds with articles discussing the exponential rate of growth of scientific periodicals and writings. The order of magnitude of this "explosion" has been frequently debated with estimates of scientific periodicals being published today ranging from 35,000 to over 100,000. It has been estimated that there are more than 18,000 serial publications in the biomedical field alone, with an equal number of medical books and monographs generated throughout the world annually. The growth rate has been described by Derek de Solla Price of Yale University. "The most remarkable conclusion obtained from the data . . . is that the number of journals has grown exponentially rather than linearly. Instead of there being just so many new periodicals per year, the number has doubled every so many years. The constant involved is actually about fifteen years for a doubling . . ." (1) Vannevar Bush wrote as early as July 1945 . . . "There is a growing mountain of research. But there is increased evidence that we are being bogged down today as specialization extends. The investigator is staggered by the findings and conclusions of thousands of other workers – conclusions which he cannot find time to grasp, much less remember, as they appear." (2)

Our society looks to the university as the instrument of primary responsibility for the creation of knowledge through research, its dissemination through teaching and its application through service. The centers for education in the health professions have been developed

*This paper was prepared by Dr. Cummings and Mr. Simmons as an extension of the subject, "Computers in Medical Libraries," presented by Dr. Cummings at the conference.
†Director, National Library of Medicine.
‡Head, Information and Computer Science Staff, Research and Development program, National Library of Medicine.

within this university framework to accomplish this task with respect to knowledge in health-related matters. Society originally looked to the libraries as instruments to preserve recorded knowledge at a time when the corpus was small and manageable. Today they have taken as an equally important function the organization and retrieval of needed information from the present enormous body of knowledge. Thus the library represents a central learning resource serving our universities.

Health science libraries are faced with an ever increasing challenge. This is not due solely to the rapid growth in the medical and related literature; the widening range of users and their accompanying diversity of requirements compound the problem. The list of users may include undergraduate students, graduate students, postdoctoral fellows, interns and residents, members of the teaching faculty in the basic sciences, clinical faculty members, practitioners in the health center or its environs, medical researchers, dentists, veterinarians, pharmacists, nurses, and other allied health personnel. It may also include other regional and hospital clients, health departments, welfare agencies, local industries, the county medical society, miscellaneous lay persons, attorneys and others. The basic homogeneity of the principal users of a medical library remains as an asset to the medical librarian in providing required services but as this list suggests, that advantage is no longer so pronounced. The importance of interdisciplinary application of knowledge and research will continue to require expanding services and capabilities of the medical library.

In addition to the quantitative changes of information and users facing the medical libraries, there have been important qualitative changes in medical education. Curricula have broadened in scope and depth. New subject areas have been incorporated as knowledge increases. Undergraduates are more involved in research. The student must absorb more of the total body of science and then be responsible for keeping up with new knowledge. It is no longer the medical undergraduate alone who must be educated, but the practicing physician. B. V. Dryer in the article "Lifetime Learning for Physicians" has stated that . . . "The gap between scientific knowledge and application grows wider each year because of at least four reasons: the rapid advances of research; the maldistribution of opportunities for continuing medical education; educational inadequacies even in those places where opportunities do exist; and patterns of educational organization and dissemination of knowledge which are not efficient in terms of the physicians students' needs." (3)

The opportunity to prepare students with the needed attitudes to meet the later demands of continuing education must not be lost. The things which young medical students learn in their formal educational courses set the direction of their future lives as physicians and scientists. Harvey Cushing, who on many occasions pointed out the importance of the medical library for support of medical education, research and practice, commented on the importance of teaching students the value of their library as follows: "To inoculate a doctor with the library-habit he must be caught young and here, as I see it, you have an excellent opportunity in being nearer to a growing centre of medical education. . . .

"If you are to infect the young with the reading habit, you must set the trap for them, so baited that they will walk into it unawares. Books must be made accessible. It is someone's business in every medical school to teach laboratory methods to the students but it is no one's particular business to teach them how to use medical literature. . . ." (4)

The subject of the need for continuing education should not be left without some reference to the place the hospital is assuming and the role of its library in this process. The hospital represents the location where the professional health personnel can bring scientific knowledge to bear on a problem. Within the last four decades, additional educational programs have been started within the hospital as it represents an unique environment where certain kinds of postgraduate education can take place. It is clear that the hospital must take increasing responsibility for education at all levels. When the hospital is thus viewed as a scholarly institution involved in research and education as well as patient care, the need for effective access to medical and related scientific knowledge is self-evident. The dilemma is that the requirement for the availability of the scholarly record is so broad that no single hospital library has the resources to properly respond.

The problems of scientific communication confronting medical librarians appear to approach the insurmountable; quantity of information rapidly growing, quality of education and research improving, information user groups expanding, interdisciplinary requirements enlarging, and education throughout a professional's career demanding support. It seems likely that the health sciences libraries will have to take on a new identity and function to meet this challenge.

Libraries are even now rapidly turning to the electronic technology to respond to society's demands. The use of advanced data processing equipment, including computers, coupled with the research and techniques developed and being extended in the emerging field of information sciences holds great promise for the solution of the biomedical communications dilemma. There is a warning, however, that must be sounded before exploring the applications and potentials of these new technologies. William Osler, on stressing the importance of organizing and extending smaller libraries in medical societies or hospitals for continuing education of physicians, wisely pointed out, "It is much simpler to buy books than to read them, and easier to read them than to absorb their contents." (5) In a similar view, it is much easier to introduce computers into libraries than it is to design systems for their productive and efficient use.

Historical Development of Library Automation

The mechanization of data processing, including both what is known as EAM (Electronic Accounting Machinery) and the newer computer equipment, has an intricate and somewhat elusive history. As early as 1780 Joseph Marie Jacquard invented a machine in which perforated cards controlled the pattern of hooks and needles for use in weaving; the English mathematician, Charles Babbage, conceived the idea of an automatic digital computer about 1835. He called his proposed machine an "analytical engine", but was unable to complete a working model before he died in 1871. (6) It is generally acknowledged that the first operational device using perforated cards for tabulation and statistical purposes was developed in the 1870's, and represents the real genesis of the present multi-million-dollar data processing industry.

The invention of the electrical tabulating machine using punched cards is generally attributed to Herman Hollerith, a statistician, who was working at that time for the United States Census Office. But from his own records, and those of others, it is clear that it was a physician who first suggested to Hollerith that an electrical machine utilizing punched cards should be developed for use in the 1880 census. This physician was Dr. John Shaw Billings, the principal figure in the history of the present-day National Library of Medicine, serving as its first director from 1865 to 1895, and unquestionably the preeminent figure in the entire field of medical librarianship.

Serving as a consultant to the Census Office, Billings suggested in 1880 "that the various statistical data of the living and the decedent might be recorded on a single card by punching small holes in it and that these cards might then be assorted and counted by mechanical means according to any selected groups of these perforations." (7) The electrical tabulating machine developed as a result of these suggestions was actually used in connection with the 1886 mortality records of the city of Baltimore, in the Surgeon General's Office for compiling and tabulating Army health statistics in 1889, and in the handling of data collected in the United States Census of 1890.

The extension of these earliest developments to library applications was non-existent until the middle of the 20th Century. It is true, however, that mechanical means for expediting library work have been considered for many years, although not in what would generally be considered the data processing area. The very first volume of the forerunner of the *Bulletin of the Medical Library Association*, the *Medical Library and Historical Journal*, dated 1903, contained an article on the use of the "typewriting machine" in cataloging. In addition, telephones have long been accepted as library machines, and, except for unusual items, hand bookbinding has given way to machine-bound books. It was not until the late 1940's, however, that a few libraries began using unit record equipment for their various business operations such as purchasing and payroll.

As computers became available, a few industrial and research libraries began limited information storage and retrieval work using these devices. Basically, these early systems closely resembled the processing done with the usual payroll and personnel records — formatted files, read serially. The development of the following generations of computer hardware and improved software techniques have led to extensive experimental work searching for effective applications to library operations. Probably the most significant advances in terms of the computer's application to information storage and retrieval have been the tremendous increase in computer storage and the capability for a series of users to query the central computer file simultaneously and from remote locations. These developments have opened a new era for the advancement of library services.

Despite these applications and significant developmental activities in the 1960's, library automation is still in its infancy. An exhaustive literature survey conducted by Donald Black and Earl Farley for the publication of the first volume of the *Annual Review of Information Science and Technology* (8) included very few articles covering aspects of library automation systems in operation or planned in any single library. The overwhelming preponderance of the literature consisted of why automation is the coming thing, why one should become familiar with what machines can do, and discussed various applications to one library function or another.

Automation of Library Activities

The word "system" as used in scientific management or related to the scientific method of problem solution designates an organization of interacting parts intended to accomplish a particular purpose. This rather all-encompassing definition can include a wide variety of activities not the least among which is the library. The library is certainly intended to accomplish a particular purpose, or more accurately a series of purposes, although these are all too often forgotten in the busy days of "doing things". Certainly the library can also be properly considered an organization of interacting parts.

System analysis is a method of handling complex problems — a method so simple and yet so powerful that it has been applied successfully to problems in engineering, business, and government. If a library is truly a system and system analysis has proved so valuable to other enterprises, this method of problem solution should be equally successful for library operations. An examination of a library from the systems analysis viewpoint is desirable before considering the mechanization of its activities.

Systems analysis demands the statement of both final objectives and of intermediate objectives. Otherwise there is no way in which design and performance can be measured and evaluated. Libraries may have many objectives or purposes. There have been a number of efforts to state these purposes in systems terms. It can be said, as V. W. Clapp has done, . . . "to provide access in bibliographic and physical terms to the records of human communication"; (9) or as stated by Becker and Hayes . . . "to obtain, preserve and make available the printed materials required for use by its patrons and in so doing to store recorded knowledge for future generations." (10) These expressions provide a background against which each element or part of the library system can be tested.

The purposes and objectives of medical libraries have been outlined in the opening paragraphs of this paper, particularly the role of the medical library in medical education. Health-related orientation makes medical libraries distinctive in that the user population is considerably more homogeneous than in a general library, and the emphasis that has been placed on the library's role in medical education requires an active rather than passive role so typical of most libraries. These distinctions require careful consideration by those engaged in analysis, design and management of medical libraries. In spite of these differences, it is equally true that many of the detailed functions required within any library are basically similar.

Operationally, all library systems employ four basic processes: the acquisition of publications, the creation of surrogates for the items, the storage of both, and the access to one or both upon request. In accomplishing this work, most library practice revolves around the records that are kept of the books, documents and periodicals that make up the main store of the library. The library, thus, is essentially a set of files. The basic set are the items themselves; a second set are those providing access to these items; and a third set are the necessary administrative type files. The creation and processing of these files and records presents an enormous data handling problem for the librarian. It is readily understandable that Dr. Billings, as a librarian, would be a leader in the development of mechanized data processing equipment, but equally puzzling that so little use was made of it through the years by the libraries of the world.

The first inventory of library automation activities was carried out in mid-1966 by Creative Research Services, Inc., for the Document Division of the Special Library Association and the Library Technology Program of the American Library Association. The report (11) tabulates the extent of mechanization and automation plans of 1130 institutions of 6150 which replied to the mail questionnaire.

The statistics resulting from this survey indicate that the typical mechanized library is a university or special library with a collection of over 50,000 books and more than 1,000 periodical titles. It has a staff of at least ten but no more than twenty members, evenly divided between professional and non-professional. It has its serial control function running on electrical accounting machinery (EAM) and its accounting function running on computers. The facilities of the library's host organization are used rather than the machine equipment owned or leased by the library itself. This typical library has plans to mechanize its circulation control and accession list functions in the next one to two years. (This description of the typical library was derived by Eugene B. Jackson from the statistics taken from the survey.) (12)

Although such a typical library is only a creation from statistics compiled through a survey and the data are now almost two years old, it does give some indication of present conditions. Perhaps more meaningful are the statistics shown in *Figure* 1 for the various library functions. The total 638 represents the number of libraries reporting some use being made of either electrical accounting machinery (EAM) or automatic data processing (ADP) equipment. As shown by the percentage figures, progress has been made toward automating conventional library operations.

First EAM and now a growing number of ADP systems have been adopted for the control of the library's management data in functions such as accounting and in the processing activities represented by acquisition, serials control, announcement lists and book catalog and catalog card production. In the areas more directly related to service to the users, the progress toward automation has been generally slower. This is the phase of operations involving the question of which documents in the library contain information on a specific subject. As Adkinson and Stearns have stated, (13) in the first phase (management data and processing activities) we have automated our inventory control over packages of information; in the second phase (the service to users), we are extending our efforts to automate into the process of determining which packages in the inventory contain answers to

Functions	% Using EAM Equip.	% Using ADP Equip.	% Planning for EAM/ADP Use
Accounting	20	26	21
Acquisition	12	9	45
Serials Control	21	22	48
Circulation Control	19	14	45
Catalog Card Production	11	7	29
Book Catalog Production	10	15	36
Accessions Lists	15	18	44
Retrospective Searches	12	24	45
Union Lists	12	13	25
Inter-Library Communications	10	2	17
Key-word-in-context Indexes	6	20	17
Current Awareness	5	12	24
Number of Libraries	638	638	912

Figure 1 Use and plans for use of EAM and/or ADP equipment in libraries and information centers.

Note: Selected statistics from *The Use of Data Processing Equipment by Libraries and Information Centers*: a survey prepared for Document Division, SLA and Library Technical Program, ALA under a grant by the Council on Library Resources; submitted by Creative Research Services, Inc.

particular questions. The function listed in *Figure* 1 as "retrospective searches" covers this latter activity and the percentages of 12 and 24 shown in the table are higher than one might expect. This is somewhat misleading when placed in the restricted context of libraries; but is explained by the reminder that the survey included the information systems of industry where some of the more significant progress has been made in the automation of retrieval operations. There are, of course, notable exceptions to this generalization, and in the medical field these exceptions exist largely because of the availability of the automated bibliographic citation file known as MEDLARS (Medical Literature Analysis and Retrieval System), established and maintained by the National Library of Medicine.

Medical Library Applications of Automation

The automation efforts at NLM were first directed toward support to the publication of *Index Medicus*. Beginning in 1964, the Library placed the bibliographic citations for the articles selected for entry into *Index Medicus* on a magnetic tape and used a computer to generate a printed output. Since August of that year, the printing has been accomplished with the use of the computer file and NLM's GRACE (Graphic Arts Composing Equipment). This same machine-readable file of citations now supports the most significant and far-reaching example of computer application to retrospective searching of medical literature.

The MEDLARS file now contains approximately 750,000 citations to articles from about 2400 selected medical journals. It can be entered through the selective use of the terms in a controlled vocabulary for the retrieval of the qualifying citations. It requires trained searchers to transpose a user's question into the proper search formulation, the punching of a deck of cards for entry into the computer, and then the serial searching by the computer of the file for the citations. This is a batch computer operation, i.e., searches are batched in groups of 30 to 40 and are entered together for a single pass against the total file, print-outs are made of the retrievals and the results forwarded to the requestor.

The principal operating techniques of MEDLARS for constructing and organizing machine-readable records, and for the searching and retrieving from these records, still require the human to assign words as labels to represent the contents of the documents. Then, upon searching, he must transpose a question into the same labels and express them in logical relationships in order to retrieve the item desired. The human intellect and ingenuity have been put to the test to provide effective schemes by which this matching of terms describing the query with those used as input descriptors can be accomplished. The controlled vocabulary used in the MEDLARS system is an example of one of the more successful efforts to reach this goal. This vocabulary consists of approximately 7000 medical subject headings (Medical Subject Headings — MeSH) and includes a significant hierarchical structure to assist in both indexing for input and assigning terms for retrieval.

The NLM computer capability also supports the publication of a series of products in addition to *Index Medicus*. The MEDLARS file is used to produce a monthly *Bibliography of Medical Reviews*, including articles from publications such as the *Annual Review* series and *Nutrition Reviews* and articles termed "review" in such journals as the *New England Journal of Medicine*. These are of great value to students and to individuals entering a new field of medical endeavor.

Retrospective literature searches that are accomplished in MEDLARS are also published for general distribution when their subject matter is judged to be of relatively wide interest. For example, NLM has published a literature search titled *Computers in Medicine and Biology* that contains 327 citations to articles indexed for MEDLARS from mid-1964 through December 1967. A sampling of titles of other published searches includes *Tumors of Cold-Blooded Vertebrates, Neoplasm Models, Clinical Studies Involving Estrogens, Epidemiology of Suicide*, and *Exercise and the Electrocardiogram*.

The *NLM Current Catalog* is a product of particular importance to the country's medical libraries. It is issued on a biweekly basis and citations are cumulated quarterly. The biweekly issues contain citations to publications cataloged by NLM which have an imprint date of the current or two preceding years. Cumulations include citations to all publications cataloged by the library, regardless of the date of imprint, except for titles published before 1801 and certain other special publications. In accordance with the Library's goal of improving and enhancing access to significant biomedical literature, the 1968 *Current Catalog* contains, for the first time, separately listed citations to technical reports which have been acquired for the NLM collection.

The National Library of Medicine is currently developing a complete automated system as a second generation to the present MEDLARS. The contractor is being selected to perform the systems design, hardware installation, and program implementation – a project that is scheduled over a five-year period. The new system will meet future data processing and information system requirements for: 1) an increase in the level and speed of MEDLARS bibliographic services provided, including demand searches and recurring bibliographies; 2) an automated acquisitions and cataloging system; 3) an on-line augmented Medical Subject Headings vocabulary to aid those responsible for indexing and searching; and 4) a drug literature program with search capabilities on chemical compounds. In addition, the new equipment will be capable of expansion to accommodate computer processing required by a graphic image storage and retrieval system closely linked to the MEDLARS search capability.

Another development recently begun in computer application at NLM is the automation of film distribution activities at the Library's National Medical Audiovisual Center in Atlanta. A computerized system is being developed for booking films, preparation of shipping documents, inventory and suspense control, collection of utilization data, and reports to program sponsors. Plans call for a system which would combine source data automation and data processing techniques for maximum manipulation of data to produce the necessary reports, and for handling loan transactions with maximum speed and efficiency.

There is significant developmental work being conducted in other medical libraries to apply the new computer technology. The organization of a new medical school library at the University of New Mexico has offered a unique opportunity to develop machine methods of bibliographic control and to use electronic data processing for library functions. The University has been the recipient of a research grant from the National Library of Medicine to develop a total system of library operation based upon such automated support. The development program has included the functions of acquisitions, cataloging, serials control, accounting, circulation and interlibrary loan. The serials control program has shown successful use of EAM equipment for the past four years for the activities of ordering, receiving and processing, claiming, producing current listings, and others. The circulation program includes the use of the IBM 357 Data Collection System for control purposes. A borrower presents a prepunched plastic identification card and this with a prepunched book card generate a transaction record. This is reported to be an effective, accurate, fast and relatively simple process. Preparation of overdue notices is done in a matter of minutes and management information about circulated items, borrowers, etc., is made readily available.

Current work is being conducted on adapting to improved machine capabilities at the Washington University School of Medicine Library, St. Louis, a leader in library automation. (14) In 1963, this library was reporting efforts in the area of automation, specifically the printing of acquisition lists from magnetic tape files and the publishing of periodical holdings first from cards and later from tapes. A year later reports were released on the operational circulation records and control system and more recently this library has described its system for producing book catalogs from a single punched card input, manipulated by a computer under the control of programs written for the task. Work continues to improve these operations and to expand the support received from automation. For example, the acquisitions and cataloging records stored on magnetic tape have been examined to determine frequency and average length of record components and their alphabetization requirements in a book catalog. Data from this study are being used in adaptation of the library's computer-based cataloging system to greater machine capabilities.

The State Universities of New York (SUNY) have undertaken a series of projects in the various areas of library automation. A principal effort was the use of a computer to support the publication in 1965 of a State University Union List of Serials intended to facilitate the sharing of serial resources. The first edition was published in the fall of 1966 and contained 17,000 titles; the second edition, dated December 1967, included 25,000 titles. This publication has triggered a significant increase in intercampus exchange — or interlibrary loan. The interuniversity transaction at the Upstate Medical Center rose from almost zero to 15-20% of the total activity at that library. SUNY has also assumed a role of leadership in the development of a biomedical communications network, described later in this report.

The medical libraries of Columbia, Harvard and Yale collaborated on a computerization project including the printing of catalog cards and bibliographic lists. Their first product was a monthly accessions list that appeared in October 1963. Although this project has since been terminated, it represented a significant effort in cooperative library activity based on computer support. The Yale University Medical Library, continuing with a computerization project, developed a program in 1966 to produce book-form catalogs and catalog cards, using the IBM 7094-7040 Direct Coupled System. An acquisitions and in-process control system utilizing computer support has also been designed by Yale covering the activities from request for purchase to cataloging and shelving.

Information System Evaluation

Are our efforts to automate accomplishing the intended purpose? Have we spent money for apparent sophistication but not really improved in the efficiency of our job, the quality of our work or, the most important criterion, the service to our customer? In many cases, the only honest answer is we don't really know. The capability to evaluate the results of our efforts scientifically has proved to be a very difficult task. As Ruth Davis, Associate Director of Research and Development at NLM, has stated . . . "The hopes or wishes of those concerned with the evaluation of information systems is to apply methods of the physical sciences to such evaluations." (15) She goes on to point out the fallacies of such approaches for systems where the human being – both as an observer and user – plays such a dominant role. Observation itself can effect change. The user of the information system is often considered a part of the system itself and yet represents an area of many unanswered questions. On the other hand, John Tukey of Princeton expressed the opinion that there are, in the information systems area, things to do that are obviously useful enough to need no formal detailed testing. He has conjectured that "the real proof of the value of change is how much it hurts if you try to return to the old ways." (15)

There have been a limited number of cases where major operational information systems have been subjected to large-scale evaluation efforts. A national conference on Electronic Information Handling was held in Pittsburgh in April of 1967. It was designed to focus attention on new ideas, research and development in the techniques of testing and evaluating electronic information handling systems. The report of the conference is contained in the publication titled *Electronic Handling of Information: Testing and Evaluation*, edited by Kent, Taulbee and Belzer. (15) It is recommended as an excellent reference on this difficult subject. In addition, a chapter has been devoted to the subject of Evaluation of Information Systems and Services and written by Alan Rees in the *Annual Review of Information Science and Technology*, Volume 2. (16) This covers a general discussion of testing and evaluation as well as a review of the efforts in laboratory-based testing and evaluation, tests of operating systems, and research in problem areas.

One of the few major information systems to "bare its soul" to the public is the MEDLARS system. The evaluation of this system is the most elaborate and sophisticated performance study to date of an operational system. A complete report of this study by Lancaster is now available through the Government Printing Office. (17)

The study concentrated on the evaluation of the demand or retrospective search function. Over 5,000 searches per year are performed at NLM with additional searches being run at decentralized centers in the United States and in England and Sweden. The principal objectives of the test were: 1) to study the demand search requirements of the MEDLARS users; 2) to determine how effectively and efficiently these requirements are being met; 3) to recognize factors adversely affecting the system; and 4) to disclose ways improvements can be made. The evaluation was a complete system evaluation since it included all components affecting the performance of the system as measured by the satisfaction of the MEDLARS users. The study was guided and reviewed by an external board of advisers, who were selected for their pre-eminence in the fields of information science and/or statistics.

The analysis of a carefully selected sample of 300 searches revealed that for an "average" search somewhat over one-half of the citations in the file that were relevant to the request were retrieved and that of those citations that were retrieved between one-half and two-thirds were judged to be relevant by the requestor. These are considered to be good results when compared with the performance of other systems, although such results are difficult to compare because of the variety of methods used to arrive at the expressions of performance.

A principal cause of the failure to retrieve a relevant item was that the indexing was not exhaustive enough. Retrieval of irrelevant items was due, at least in part, to lack of specificity in searching. However, the greatest potential for improvement was judged to be the interface between the user and the system. Over 20% of the system failures were traced to defective interaction in this area. There is need for more intellectual effort and care in the statement of the requirements on the part of the user. Other results highlighted include: 1) need for improved vocabulary control and updating; 2) 45% of input effort required for foreign language material with comparatively small acceptance of users; 3) bibliographic record as output to the user is not adequate to indicate article content; and 4) the need for a continuing quality control mechanism for the future. These areas are all under present consideration by the management of NLM.

Networking and Cooperative Activities

There is little evidence in the literature that there has been a change from the absence of a "total system" concept of library automation as noted by Black and Farley in their review of the 1965 literature. (8) They expressed the opinion that . . . "Were a total system concept ever to be implemented within a library, it would certainly blur the distinctions between such traditional departments" . . . (circulation, acquisition, cataloging, serials, etc.). They continued . . . "This leads one to suspect that much of the reluctance on the part of many librarians to undertake work in automation may stem from the fear that automation will force significant changes in existing organizational structures. That fear is certainly justified. However, the continued fragmentation of library operations tends to isolate the operating divisions from their goal, which is, of course, service to a group of users."

It is recognized as difficult to make radical changes in large operations but the real advantages to be offered by automation will not be realized until the entire library is recognized as a single system and treated accordingly. In reality, this is not even a broad enough outlook. The individual medical library should be considered as a subsystem, or component, of a much larger system — the national biomedical communications network. We believe that the local library can be developed into a responsive biomedical communication resource as an integrated part of an expanded comprehensive service network. A stronger national network is urgently needed to serve the information needs of all personnel in the medical sciences. Its aim should be to permit equal and rapid access to all types of biomedical information.

Networks to librarians are nothing new. Well before this word became fashionable and before the advent of modern computers and electronic communication systems, interlibrary loan networks among libraries on a regional and national scale were created and operated by members of the profession. The complex systems of national and regional bibliographic control in the form of union lists and catalogs, of interim source referral services, and the large and growing traffic in interlibrary loans clearly identify the library system as a viable *de facto* network, not ordinarily recognized as such by its patrons. But with the newer tools provided by our advancing technology, the network takes on a completely new dimension.

The planning, design and implementation of the Biomedical Communications Network has become a principal task of the new research and development office at the National Library of Medicine. This Network is the embodiment of NLM's plans to provide improved access to information within the medical community for the support of continuing education, individual practitioners and researchers, and institutions such as hospitals, clinics, and research centers.

At least for initial planning purposes, the Network has been divided into several components by type of service to be provided. These components are for library services, specialized information services, specialized educational services and audio and audio-visual services. Supporting these four service areas will be the data processing centers and transmission facilities.

Planning is most advanced for the library component, as might be expected. Predating this formalized program was the establishment of decentralized centers at UCLA, Harvard, University of Michigan, University of Alabama, University of Colorado, and Ohio State for MEDLARS searches. Search formulation is accomplished at all of these centers, with cards punched for computer input. Some of the centers are actually running their own machine searches using MEDLARS computer tapes provided by NLM and some are sending the punched cards for searches to be made on NLM's equipment. Several are now transmitting the search requests to NLM through card readers and telephone communications links, thus, creating a duplicate card deck at NLM for input to its computer.

An early part of the research and development program has been the establishment of a Remote Information Systems Center to serve both the library and specialized information components of the Network. This Center is the terminal facility at the Library for communications links to a variety of data systems and provides remote access to several computer centers and to the decentralized MEDLARS centers. The purposes of these links are to provide access to remote data banks, support experimentation with the research and development of others in the information and computer sciences, provide a capability to demonstrate techniques and the state-of-the-art in information storage and retrieval, and to assist in the data manipulation needs of the Library. The ability to sit at a teletype in the Center and to query a file of citations stored on a computer in California, to receive almost instantaneous response with the citation requested typed in front of you by data transmission from the computer is truly a remarkable experience. And yet this is unsophisticated input/output compared with the cathode ray tube devices now available. Such remote query capability utilizing computer time-sharing will be a principal element of the planned services and, hopefully, in the not-too-distant future. The establishment of this center represents the first tangible manifestation of communications network activity at the Library. It will serve as an operating input/output point for the Library and specialized information service components of the Network.

The planning for the specialized educational services places an emphasis on the needs of continuing medical education but includes the needs of the medically uninformed, particularly those without the knowledge of basic and essential family health rules. Television is the principal medium being considered and plans include the use of satellites to aid in transmission. This is a radical departure from the traditional activity of a library, and is an example of a need that has been expressed for the applications of new technology to the medical information requirements of society.

Biomedical communications network planning and experimentation is also underway in the State Universities of New York (SUNY). In 1965, the SUNY administration received a proposal from a task force recommending the establishment of a biomedical communications network. This network was to link the Health Sciences Library at Buffalo, the Upstate Medical Center at Syracuse and the Downstate Medical Center at Brooklyn. It was proposed as a computer-centered network and recommended to serve as a prototype for the University-wide library system which includes 58 separate libraries. The stated purpose was to retrieve bibliographic information relating to books and journals owned by the three libraries and by the National Library of Medicine. Later plans called for the addition of material in related sciences and, finally, for automation of in-house routines of the libraries, leading to cooperative or coordinated acquisition and processing of new materials. SUNY accepted the proposal and designated it as a pilot study. The network is to begin operations in the fall of 1968.

Network development and plans are underway in several other state library groups. For example, medical librarians have recently organized the Texas Council of Health Science Libraries to improve their cooperative, interlibrary activities, and they are looking ultimately to some type of network interconnection. Teletype services are already being used to support interlibrary loan activities among five of the institutions in the North Texas Interuniversity Council, and in the Gulf Coast area a Regional Information and Communication Exchange centering on Rice is experimenting with teletype and computer services to participating libraries in all of the coastal counties.

Cooperative actions among libraries of the United States have too frequently been limited to interlibrary loaning of materials, discussions at conventions, and discussions in the literature of common operating problems. Automation has increased the awareness of the need for improved and extended cooperation because of the potential advantages of sharing work and resources through exchange of records and linking by networks. A new era in library cooperation was opened in June 1967 when the directors of the three national libraries — the Library of Congress, the National Agricultural Library and the National Library of Medicine — announced the establishment of the National Libraries Task Force on Automation and Other Cooperative Services. The purpose — to speed the flow of research information to the nation's libraries and to the scholars and researchers who use them.

The Task Force has issued its first progress report which contains a list of desirable products and services to be derived from the combined efforts of the three libraries, including book catalogs, machine-readable cataloging data, demand bibliographies and coordination of classification, acquisitions and reference services. The report's recommendations are now being used as a basis for further discussions. Working groups have been established to attack each problem or functional area and there are signs of real progress toward unified action.

Special mention should be made of the progress toward the establishment of a standard format for machine-readable cataloging (MARC) and the distribution of catalog tapes in that format by the Library of Congress. Much of this work on MARC was accomplished by the Library of Congress prior to the establishment of the Task Force but now is included in its program. Details of the project are covered in the reports authored by Henriette Avram and others listed in the references. (18) (19)

Representatives of the three libraries are also meeting to discuss and plan for a system framework within which to place the total effort. It is hoped that not only will this work lead to a forerunner of a truly national library network but that it will stimulate others in the library community to increase their cooperative efforts.

Summary

The use of computers in libraries can be summarized as supporting two main purposes: the handling of records generated in the library's operation, and the automatic extraction and codification of information in the library's files for use by clients. The feasibility, utility, or technical availability of the former application is well documented. The latter task requires considerably more research before practical application will be common.

The emphasis that has been placed on automation, computers and the advances in information science should not leave the reader with false impressions concerning the future of the medical library. In spite of the impressive changes in the technology of information storage and retrieval, the traditional library will continue to serve as a vital instrument in the educational process.

In the report prepared by the Library Study Committee of the Association of American Medical Colleges titled the *Health Sciences Library: Its Role in Education for the Health Professions*, this position was supported by a listing of several cogent reasons. (20) Included were the need for the display of the printed word through traditional methods, the requirement for the housing of certain documents that are classics or original in their presentation, and the need for the older portion of the scientific record that will probably not be economical to transfer to some newer media.

This is not to end, however, on a note of status quo for the libraries. They must begin an active period of research into the most effective ways to disseminate material that is of particular interest to the individual scientist and material that is new. The libraries must be willing to accept an educational role that is much beyond where they stand today. This should include at least the education of the student of the health sciences with the form in which the scholarly record is contained and the means by which one gains access to it, and to identify, attract, and educate new talent for the increasingly specialized field of information management. Finally, the health science library will have to adopt a new philosophy in the area of service. It must include eventually the provision of linkages between people and information as well as between people and documents; availability to the latest significant current events in professional societies, conventions, meetings, hospitals and laboratories; and development of selective dissemination services. The challenge is before the libraries and the scientific and technical community is demanding that they accept it.

REFERENCES

1. Price, D. J. Science since Babylon. New Haven, Yale University Press, 1961. 149 p.
2. Bush, Vannevar. As we may think. Atlantic Monthly: 101-8, July 1945.
3. Dryer, B. Lifetime learning for physicians. J Med Educ 37 (6, pt.2), 1962.
4. Cushing, Harvey. The medical career and other papers. Boston, Little, Brown and Co., 1940. 302 p.
5. Osler, William. Selected writings of Sir William Osler. London, Oxford Univ. Press, 1951. 278 p.
6. Truesdell, L. E. The development of punch card tabulation in the Bureau of the Census, 1890-1940. Washington, U. S. Bureau of the Census, 1965. 221 p.
7. Garrison, F. H. John Shaw Billings: A Memoir. New York, Putman, 1915. 343 p.
8. Cuadra, C. A., ed. Annual review of information science and technology. Vol. 1. New York, Interscience, 1966. 389 p.
9. Clapp, V. W. The future of the research library. Urbana, Univ. of Illinois Press, 1964. 114 p.
10. Becker, Joseph and Hayes, R. M. Information storage and retrieval: tools, elements, theories. New York, Wiley, 1963. 448 p.
11. Creative Research Services, Inc. The use of data processing equipment by libraries and information centers. Chicago, American Library Association, 1966. 160 p.
12. Jackson, E. B. The use of data processing equipment by libraries and information centers—the significant results of the SLA-LTP survey. Spec Libr 58: 317-27, 1967.
13. Adkinson, B. W. and Stearns, C. W. Libraries and machines, a review. Amer Docum 18: 121-4, 1967.
14. Roberts, Justine. Mechanization of library procedures in the medium-sized medical library. IV. Physical characteristics of the acquisitions - cataloging record. Bull Med Libr Assn 56: 59-70, 1968.
15. Kent, Allen, Taulbee, O. E., and Belzer, Jack. Electronic handling of information: testing and evaluation. Washington, Thompson Book Co., 1967. 313 p.
16. Cuadra, C. A., ed. Annual review of information science and technology. Vol. 2. New York, Interscience, 1967. 484 p.
17. Lancaster, F. W. Evaluation of the MEDLARS demand search service. Bethesda, Md., National Library of Medicine, 1968. 276 p. (In Press)
18. Avram, H. D. Implications of the library of Congress MARC project. In: Proceedings of the Preconference Institute of Library Automation, San Francisco, 1967. (In Press)
19. Avram, H. D. and Markenson, B. E. Library automation and Project MARC: an experiment in the distribution of machine-readable cataloging. In: Harrison, J. R. and Laslett, P., eds. The Brasenose conference on the automation of libraries; proceedings of the Anglo-American conference on the mechanization of library services held at Oxford, 1966. Chicago, Mansell Information Pub. Ltd., 1967. p. 97-126; discussion, p. 126-7.
20. DuVal, M. K. The health sciences library: its role in education for the health professions; report to the National Library of Medicine, January, 1967. J Med Educ 42 (8, pt. 2), 1967.

BIBLIOGRAPHY

This list includes merely a few of the many articles and books on libraries and automation, with particular emphasis given to those items related to medical libraries and their role in medical education. These references have been grouped under subheadings to assist those who might wish to explore the literature more completely and in greater depth.

Libraries and Information Sciences – General

Anthony, L. J. Library planning. In: Ashworth, Wilfred, ed. Handbook of special librarianship and information work. 3d ed. London, Aslib, 1967. p. 233-73.

Foskett, D. J. Science humanism and libraries. London, Crosby Lockwood & Son Ltd., 1964. 246 p.

Kent, Allen, ed. Textbook on mechanized information retrieval. 2d ed. New York, Interscience, 1966. 371 p.

Licklider, J. C. Libraries of the future. Cambridge, Mass., M.I.T. Press, 1965. 219 p.

Lipetz, B.A. Information storage and retrieval. Sci Amer 215: 224-8, passim, 1966.

Overhage, C. F. Science libraries: prospects and problems. Science 155: 802-6, 1967.

Salmon, S. R. Information science and automation: the newest division. ALA Bull 61: 637-42, 1967.

Taylor, S. The interfaces between librarianship and information science and engineering. Spec Libr 58: 45-8, 1967.
Wooster, Harold. Books and libraries in the scientific age. Arlington, Va., Air Force Office of Scientific Research, Office of Aerospace Research, Jan 9, 1967. 23 p. (AD-645 217)

Medical Libraries – General

Armitage, B. The present provision of medical libraries in hospitals. Postgrad Med J 42: 609-12, 1966.
Ash, Lee and Bruette, V. R. Interlibrary request and loan transactions among medical libraries of New York area. New York, Survey of Medical Library Resources of Greater New York, 1966. 199 p.
Cheshier, R. G. Medical Libraries: a changing visage. Chicago Med Sch Quart 26: 98-100, 1966.
Cummings, M. M. The National Library of Medicine: new programs in support of medical education, research, and practice. Clin Anesth 1: 115-23, 1966.
Doe, Janet and Marshall, M. L., eds. Handbook of medical library practice. 2d ed. Chicago, American Library Association, 1956. 601 p.
Langner, M. C. The National Library of Medicine's services: initial observations on indexing, interlibrary loan, and reference. Bull Med Libr Assn 55: 31-7 ,1967.
Miller, J. G. Design for a university health sciences information center. J Med Educ 42: 404-29, 1967.
Oppenheimer, G. J., ed. Regional medical library service in the pacific northwest. Seattle, Univ. of Washington, 1967. 168 p.
Orr, R. H. Communications problems in biomedical research: report of a study. Fed Proc 23 (5, pt.1): 1117-91, 1964.
Pings, V. M. Library service for health care. Report No. 34. Detroit, Wayne State University. School of Medicine, Library, Biomedical Information Service Center, 1967. 10 p.
Services of the Boston medical library. New Eng J Med 276: 58, 1967.

Libraries and Medical Education

Adams, Scott. Medical library resources and their development. J Med Educ 38: 20-7, 1963.
Bloomquist, Harold. The status and need of medical school libraries in the United States. J Med Educ 38: 145-63, 1963.
Estersquest, R. T. Improving the quality of the medical school library. J Med Educ 29: 451-8, 1964.
Guidelines for medical school libraries. J Med Educ 38 (1, pt.1), 1965.
Harris, Oren. Medical libraries and medical education. J Med Educ 41: 84-90, 1966.
Jeghers, H. Medical care, education and research. Philosophy and technics of self-education of the medical student. New Eng J Med 271: 1297-301, 1964.
Long, E. C. The medical library and the medical student. Bull Med Libr. Assn 52: 568-74, 1964.
Ravdin, I. S. The importance of the library in medical education. Bull Med Libr Assn 53: 505-9, 1965.
Sanazaro, P. J. The unmet responsibility of academic medicine to its libraries. J Med Educ 40: 65-6, 1965.
West, K. M. Role of the library in learning to learn clinical medicine. J Med Educ 39: 910-7, 1964.
Wilson, M. C. and Cummings, M. M. The National Library of Medicine: relationships to medical education and research. J Med Edu 40: 225-32, 1965.

Libraries and Systems Analysis

Bolles, S. W. The use of flow charts in the analysis of library operations. Spec Libr 58: 95-8, 1967.
Corrigan, R. E. and Kaufman, R. A. Why system engineering. Palo Alto, Calif., Fearon, 1966. 72 p.
Covill, G. W. Librarian plus systems analyst = teamwork? Spec Libr 58: 99-101, 1967.
Markuson, B. E. System development study for the Library of Congress automation program. Libr Quart 36: 197-233, 1966.
St. Pierre, P. L. and Chapman, E. A. Library systems analysis and design. In: Proceedings of the Preconference Institute on Library Automation, San Francisco, 1967. (In Press)

Automation and Computers – General

Favret, A. G. Introduction to digital computer applications. New York, Reinhold Publishing Corp., 1965. 246 p.

Gruenberger, Fred., ed. Computers and communications – toward a computer utility. Englewood Cliffs, N. J., Prentice-Hall, 1968. 219 p.

Karplus, W. J., ed. On-line computing; time-shared man-computer systems. New York, McGraw-Hill, 1967. 336 p.

Parkhill, D. F. The challenge of the computer utility. Reading, Mass., Addison-Wesley, 1966. 207 p.

Pyke, T. N. Time-shared computer systems. In: Alt, F. L. and Rubinoff, Morris. Advances in computers. Vol. 8. New York, Academic Press, 1967. Chapt 1, p. 1-45.

Library Automation – General

Ashworth, Wilfred. A review of mechanical aids in library work. In: Ashworth, Wilfred, ed. Handbook of special librarianship and information work. 3d ed. London, Aslib, 1967. p. 524-53.

Batty, C. D. Library and the machine: selected papers and discussions from a study conference held at Nottingham, April 19-22, 1966 on library applications of computers and data processing equipment. Scunthorpe, Linc., Library Association, North Midlands Branch, 1966. 58 p.

Becker, Joseph. Current trends in library automation. In: Proceedings of the 1966 Clinic on Library Applications of Data Processing. Champaign, Illini Union Book Store, 1967.

Becker, Joseph. The future of library automation and information networks (Keynote Address) In: Proceedings of the Preconference Institute on Library Automation, San Francisco, 1967. (In Press)

Christianson, E. B. Automation and libraries. Spec Libr 57: 101-2, 1966.

Clapp, V. W. Closing the circuit: automation and data processing for libraries. Libr J 91: 1165-71, 1966.

Covill, G. W. Automation in the library: a review of the state of the art. Spec Libr 57: 332-5, 1966.

Cox, N. S. and others. The computer and the library: the role of the computer in the organization and handling of information in libraries. Hamden, Conn., Archon, 1967. 95 p.

Fasana, P. J. Determining the cost of library automation. ALA Bull 61: 656-61, 1967.

Fussler, H. H. University of Chicago library automation program. In: Association of Research Libraries. Minutes of the sixty-ninth meeting. Chicago, Univ. of Chicago Press, 1967.

Geddes, Andrew. Library Automation: an essential service. ALA Bull 61: 642-6, 1967.

Genung, Harriett. Can machines teach the use of the library? Coll Res Libr 28: 25-30, 1967.

Gull, C. D. The present state of library automation: a study in reluctant leadership. In: Proceedings of the 1965 [illegible]ic on Library Applications of Data Processing. Champaign, Ill., Illini Union Bookstore, 1966.

Harrison, J. R. and Laslett, P., eds. The Brasenose conference on the automation of libraries; proceedings of the Anglo-American conference on the mechanization of library services held at Oxford, 1966. Chicago, Mansell Information Pub. Ltd., 1967. 173 p.

Harvey, John, ed. Data processing in public and university libraries. Washington, Spartan, 1966. 150 p.

Hayes, R. M. Final report on mechanized information services in the university library. Phase I – Planning. Los Angeles, Univ. of California, Institute of Library Research, Dec 15, 1967. (NSF Grant GN-503)

Holzbaur, F. W. and Farris, E. H. Library information processing using an on-line, real-time computer system. Poughkeepsie, N. Y., International Business Machines Corp., 1966. 47 p. (TR 00.1549)

Institute on Library Automation, San Francisco, 1967. Library Automation; a state of the art review. Proceedings of the Pre-conference Institute on Library Automation held at San Francisco, June 22-24, 1967. Ed. by S. R. Salmon. Chicago, American Library Association, 1968. (In Press).

Jackson, I. F. An approach to library automation problems. Coll Res Libr 28: 133-7, 1967.

Kent, Allen, ed. Library planning for automation. Washington, Spartan, 1965, 195 p.

Lilje, Pauline and Penniman, W. D. Initiation to automation. Spec Libr 57: 697-700, 1966.

Lynch, M. F. Computers in the library. Nature (London) 212: 1402-4, 1966.

Markuson, B. E., ed. Libraries and automation, Washington, Library of Congress, 1964, 268 p.

Markuson, B. E. The Library of Congress automation program: a progress report to the stockholders. ALA Bull 61: 647-55, 1967.

McCune, L. C. and Salmon, S. R. Bibliography of library automation. ALA Bull 61: 674-5, 678-94, 1967.

Overhage, C. F. Plans for project Intrex. Science 152: 1032-7, 1966.
Planning Conference on Information Transfer Experiments, Woods Hole, Mass., Aug 2-Sept 3, 1965. INTREX. Cambridge, Mass., M.I.T. Press, 1965. 276 p.
Salmon, S. R. Automation of library procedures at Washington University. Missouri Libr Assn Quart 27: 11-4, 1966.
Seminar on Automation in British Columbia University Libraries, 3d, Vancouver, 1966. Report. Vancouver, Univ. of British Columbia, 1967. 8 p.
Shera, J. H. Libraries against machines. Science 156: 746-50, 1967.
Stewart, Bruce. Data processing in an academic library. Wilson Libr Bull 41: 388-95, 1966.
Stuart-Stubbs, Basil. Conference on computers in Canadian libraries, Universite Laval, Quebec, March 21-22, 1966. Report. Vancouver, Univ. of British Columbia Library, 1966. 13 p.
U. S. Library of Congress. A preliminary report on the MARC (Machine-Readable Catalog) Pilot Project. Washington, 1966. 101 p.
Warheit, I. A. Current developments in library mechanization. Spec Libr 58: 420-6, 1967.
Working conference on computer applications for public libraries; proceedings. Aslib Proc 18: 238-70, 1966.
Medical Library Automation – General
Brodman, Estelle. Machines in medical libraries. Med Biol Illus 16: 238-42, 1966.
Cain, A. M. Steps toward a computer-based library network: a survey of three medical libraries. Bull Med Libr Assn 55: 279-89, 1967.
Divett, R. T. There's nothing like pushing a button. Bull Med Libr Assn 55: 324-8, 1967.
Pings, V. M. Obstacles in automating the health science library. Hospitals 41: 55-8, 166, July 1, 1967.
Pizer, I. H. Automation in the library. Hosp Progr 47: 65-72, 1966.
Library Automation – Acquisitions
Dunlap, Connie. Automated acquisitions procedures at the University of Michigan library. Libr Resources Tech Serv 11: 192-202, 1967.
Dunlap, Connie. Automated acquisitions systems. In: Proceedings of the Preconference Institute on Library Automation, San Francisco, 1967. (In Press)
Miller, E. F. and others. Automated book ordering and receiving. Spec Libr 57: 96-100, 1966.
Weiss, I. J. and Wiggins, E. V. Computer-aided centralized cataloging at the National Library of Medicine. Libr Resources Tech Serv 11: 83-96, 1967.
Library Automation – Cataloging
Cartwright, Kelley. Automated production of book catalogs. In: Proceedings of the Preconference Institute of Library Automation, San Francisco, 1967. (In press)
Cronin, J. W. Centralized cataloging at the national and international level. Libr Resources Tech Ser 11: 27-49, 1967.
DeGennaro, R. Strategy for the conversion of research library catalog to machine readable form. Coll Res Libr 28: 253-7, 1967.
Kilgour, F. G. Library catalogue production on small computers. Amer Docum 17: 124-31, 1966.
Kilgour, F. G. Mechanization of cataloguing procedure. Bull Med Libr Assn 53: 142-62, 1965.
Lane, D. O. Automatic catalog card production. Libr Resources Tech Serv 10: 383-6, 1966.
Roberts, Justine. Mechanization of library procedures in the medium-sized medical library. V. Alphabetization of the book catalog. Bull Med Libr Assn 56: 71-9, 1968.
Simonton, Wesley. Automation of cataloging procedures. In: Proceedings of the Preconference Institute on Library Automation, San Francisco, 1967. (In Press)
Library Automation – Circulation
Pizer, I. H. Mechanized circulation system. Coll Res Libr 27: 5-12, 1966.
Stockton, P. A. IBM 357 circulation procedure. Coll Res Libr 28: 35-40, 1967.
Library Automation – Citation Retrieval
Adams, Scott. MEDLARS: performance, problems, possibilities. Bull Med Libr Assn 53: 139-151, 1965.
Cox, N. S. and Grose, M. W. Organization and handling of bibliographic records by computer. Newcastle upon Tyne, Oriel, 1967. 187 p.
Darling, Louise. The MEDLARS regional center at UCLA: a progress report. Bull Med Libr Assn 54: 311-5, 1966.
Hogan, Rose. An evaluation of MEDLARS output: demand and recurring bibliographies. Bull Med Libr Assn 54: 231-4, 1966.

Kilgour, F. G. Symbol-manipulative programming for bibliographic data processing on small computers. Coll Res Libr 27: 95-8, 1966.
Mathews, W. D. The TIP retrieval system at M.I.T. In: Schechter, George, ed. Information retrieval—a critical review. Washington, Thompson Book Co., 1967. p. 95-108.
The MEDLARS story at the National Library of Medicine. Washington, U. S. Dept. of Health, Education, and Welfare, 1963. 74 p.
Rogers, F. B. MEDLARS operating experience at the University of Colorado. Bull Med Libr Assn 54: 1-10, 1966.
Rogers, F. B. MEDLARS operating experience: Addendum. Bull Med Libr Assn 54: 316-20, 1966.
Truelson, S. P. What the *Index Medicus* indexes, and why. Bull Med Libr Assn 54: 329-36, 1966.

Library Automation – Serials

Curran, A. T. Mechanization of the serial records for the moving and merging of the Boston medical and Harvard medical serials. Libr Resources Tech Serv 10: 362-73, 1966.
Lebowitz, A. I. The AEC library serial record: a study in library mechanization. Spec Libr 58: 154-9, 1967.
Payne, L. M. and others. Mechanization in a new medical school library: serials and circulation. Bull Med Libr Assn 54: 337-50, 1966.
Stewart, Bruce. Automated serials system. In: Proceedings of the Preconference Institute on Library Automation, San Francisco, 1967. (In Press)
Wilkinson, W. A. A system for machine-assisted serials control. Spec Libr 58: 149-53, 1937.

National Plans and Networks

Brown, G. W., Miller, J. G., and Keenan, T. A. EDUNET; report of the summer study on information networks conducted by the Interuniversity Communications Council. New York, Wiley, 1967. 440 p.
Cummings, M. M. The biomedical communications problem. In: DeReuck, Anthony and Knight, Julie, eds. Ciba foundation symposium on communication in science: documentation and automation. London, J. & A. Churchill, Ltd., 1967. 110-22 p.
Mohrhardt, F. E. and Oliveri, B. L. A national network of biological-agricultural libraries. Coll Res Libr 28: 9-16, 1967.
Pizer, I. H. The State University of New York computerized biomedical information resource. In: Harrison, J. B. and Laslett, P. eds. Brasenose conference on the automation of libraries; proceedings of the Anglo-American conference on the mechanization of library services held at Oxford, 1966. Chicago, Mansell Information Pub. Ltd., 1967. p. 151-62; discussion, p. 162-4.
Skipper, J. E. Interinstitutional cooperation in library services. Liberal Educ 51: 65-72, 1963.
Weinstock, Melvin. Network concepts in scientific and technical libraries. Special Libr 58: 328-34, 1967.

SUMMARY

COMPUTERS IN MEDICAL LIBRARIES*

Panel: Martin M. Cummings, M.D., Chairman, Irwin Pizer, Robert T. Divett, Leonard Eddy.

The panel on Computers in Medical Libraries was pleasantly surprised to find an audience of approximately 30 participants, and the word "participants" should be emphasized because more than half of the alloted time was spent in active dialogue between participants and panel members. In an attempt to meet the charge, a statement of general purpose has been developed.

The importance of the medical library as a learning resource for education is reflected in many ways. Local, state and federal institutions and organizations are deploying more funds and manpower in an effort to restore this instrument of education and learning to a tool of effectiveness and efficiency geared to match the expansion of the total educational needs of our nation. Libraries are seizing this opportunity to use the computer and related new technologies to solve some of the existing information problems. There is still need, however, for refinement and further discrimination in application of computers to this enormous set of communications problems. The most encouraging evidence that success is close at hand comes from conferences such as this one in which educators, administrators and librarians are sharing views, experiences and relationships critically, candidly and cooperatively. To share resources on a national basis, plans for developing local, regional and national library networks seem to be advancing at a rapid pace. The need to consider standards for compatibility among computer systems has been recognized and much work is underway to bridge program and hardware disparities in an effort to effect economy and efficiency of operations.

It has been estimated that more than 90% of all health personnel that have ever dedicated their lives to research are alive and working in laboratories and clinics today. As a result, the immense growth of knowledge and printed matter since World War II has caused a great concern among those who need to find and use this information. In 1963, it was estimated that the growth rate of publications over the previous 20 years had been about 3.1% per year, doubling every 22 years. More recent estimates reflect a doubling every 11 years. It was further estimated that information in the world's libraries is growing at a rate of 2 x 10^4 bits per second (a bit in this context being approximately equivalent to half of one letter or one numeral). This growth has created severe strains that are beginning to break down the efficiency of all methods of information handling that heretofore have been reasonably adequate. As a result, a new methodology of information handling is developing. This methodology is based upon the ability of computers to perform some of the routine functions of information management and processing

*Presented by Martin M. Cummings, M.D., Panel Chairman, at the closing plenary session of the conference.

previously handled by man alone. The predecessor of the computer was the punch-card accounting machine developed by Hollorith and Billings, and the use of the punch-card equipment in libraries goes back to the early 1930's. Since that time, a few libraries have been using this methodology for some of their routine library procedures. Among the first libraries to use punch-cards was the University of Texas where Ralph Parker developed a punch-card circulation system, since adopted by many other places.

There have been two schools of thought concerning the use of computers in information handling. The librarian, for the most part, has looked at the computer simply as a means of accomplishing the traditional tasks of librarianship. The documentalist, on the other hand, has looked at the computer as a potential means of storing, retrieving and manipulating information of all types. Vannevar Bush in 1945 published the provocative paper which has led to the most revolutionized thinking of those who are concerned with information management. From his report has germinated the concept of fact retrieval as opposed to citation retrieval, which has always been the librarian's approach. The ability to retrieve citations is a necessary prelude, however, to any effective machine retrieval of actual fact. Except in a very few cases, the technology of information science has not yet developed to the point where there can be fact retrieval by machine. The National Library of Medicine has had some success with its medical literature analysis and retrieval system, but its principal contribution has been to introduce computer technology on a fairly extensive scale within the library setting. It is now planning the development of a second MEDLARS system which will allow the use of time-shared computers in retrieving not only references or citations, but abstracts and selected portions of total text as well.

Serious investigation of the use of computers for all library operations began with the development of the new campus of the University of Illinois in Chicago. Shortly thereafter, one of the leaders of the team at Illinois accepted the position as Director of Library and Information Services at the new Florida Atlantic University in Boca Raton. Dr. Heiliger put into effect at Florida Atlantic the plans previously developed at the Chicago undergraduate campus at the University of Illinois. I think we should point out that the Florida Atlantic project was not an unqualified success. In fact, some would say it was an abysmal failure and the panel believes that reference to failures is important to recall and that we should not overemphasize our successes. Shortly after the Illinois report Dr. Estelle Brodman and Mr. Irwin Pizer began a project aimed at total system library operations at Washington University School of Medicine in St. Louis.

Selected library operations in this project have been developed successfully using the batch mode of computer operations. About the same time, Fred Kilgour, Librarian at the Yale Medical Library, conceived of a project that would place the holdings of his great Library, those of the Harvard Medical School Library, and those of Columbia University Medical Library onto a central computer storage device connected to each library by leased lines and typewriter terminals using time-sharing principles. Although Kilgour had apparently worked carefully and meticulously to develop the software for this program, this effort failed for an entirely different reason. Harvard withdrew from this project, presumably for administrative or organizational reasons, so there is a second evidence of failure, but in this case apparently not caused by a lack of technical planning.

One cannot attempt to review developments in this field without making reference to the exciting work which has been taking place at the Massachusetts Institute of Technology during the past decade and, in the interest of time, will only refer to the accomplishments of project MAC and its related and subsidiary project TIP which has demonstrated the ability of users to work on-line with massive data files generated, in fact, by the users themselves. The concepts emerging from this experiment have been seized upon by other groups in the evolution of subsequent on-line library and data-based information developments and perhaps the most significant of these is the second M.I.T. project, INTREX, which will attempt, between now and 1975, to develop a fact retrieval library-based information system within the field of interest of engineering and other hard sciences.

Returning to medicine, in 1963 the University of New Mexico began to establish their new school. The University of New Mexico School of Medicine is a relatively young school, graduating its first class in June, 1968. The School of Medicine Library was faced with the task of building an adequate library in a short time. It was early decided to utilize machine methods to the fullest extent possible. The first few months were spent in designing a punch-card system and in putting records in machinable form. It was found that no total system was available for use in the Library. It was necessary to borrow, modify, and redesign several programs to arrive at usable solutions to problems encountered. This punch-card system has been gradually phased out in the past months, and is being replaced by batch processing on an IBM 360 Model 40 Computer.

New Mexico is now doing research to design a total library on-line system — one which can, with only slight modification, be used in other libraries. One requirement is that these programs be written as nearly as possible in a universal language. An IBM 357 Data Collection System is now being utilized for circulation procedures, and a daily printout is obtained, much as is done in many libraries across the country.

Planning and implementing of on-line procedures is well under way. Two IBM 228 CRT Terminals will be installed in the Library in June of this year, to be connected to the IBM 360 Computer. These terminals will be utilized in acquisitions and cataloging processes, as well as for serials control and circulation procedures.

Acquisitions and cataloging programs will be closely interrelated when the CRT Terminals are in operation. On receipt of a book request, the acquisitions librarian will place this record on the computer. From this time until final cataloging, the original record will be recalled and supplemented or corrected as necessary on the CRT Terminal.

The serials control program is similar to acquisitions procedures. A descriptive catalog entry will be made for each serial title. Receipt of a serial will be recorded on the CRT much as is now done in a Kardex file. Claiming procedures are more difficult. The vagaries of publication and distribution of serials make necessary the development of a man-machine interface to effectively accomplish this necessary claiming operation. There is an anticipation period for each serial, a time period within which a particular issue is expected to arrive. This period might be 30, 60, or 90 days, for instance. Should the item not be received during the anticipation period, this fact will be brought to the attention of the serials librarian. She will decide whether to claim any particular serial, and a completed claim will be produced when required.

The primary impact on the user of the Library will be that, instead of going to a card catalog, he will go to a cathode ray tube terminal to begin a literature search. The computer will be programmed to ask questions of the user. These questions and his answers will, hopefully, duplicate the thought processes which take place in use of a traditional catalog. The user should be able to locate needed information in less than a minute. Appropriate citations will then be displayed on the terminal or printed out on an attached printing unit as desired. One additional search method will be possible with the software being developed – a TWX search. Any teletype station should be able to dial into the computer system and do a literature search to any depth.

For all practical purposes, the computer system and library being developed by the University of New Mexico School of Medicine is not a local system, but rather is a statewide or even regional information center.

This model was discussed in some depth by the panel with a view of determining whether a system developed at one new medical school might be translated or transferred to other new medical schools.

The panel then spent much time reviewing the interesting developments on a state-wide medical library network which is being developed by the State University of New York.

The State University of New York Biomedical Communications Network began in 1965. The Network now links State University Medical Center Libraries at Buffalo, Syracuse, Brooklyn and Stony Brook. In addition, the University of Rochester Medical Center and Albany Medical Center Libraries have joined the Network. The collections of these libraries total more than 600,000 volumes and more than 9,000 serials are currently received.

An IBM 360 Model 40 Computer with IBM 2740 Communication Terminals are utilized in the Network. Exchange of interlibrary loan data, reference requests and other administrative messages concerned with the libraries and the Network are facilitated as secondary applications of the Network.

The Network is primarily oriented to the user with goals and functions clearly stated as follows:

1. Production of a computerized catalog of monographs in the three SUNY medical libraries, published from 1962 onward.
2. Production of union lists of serials and books with periodic updating (this may include the medical libraries, the entire 58 campus SUNY Library System, or a combination of libraries within the system).
3. Search of the combined catalogs for all libraries for monographs bearing imprint dates of 1962+. Eventually 10 years of book data will be stored on-line. The initial data base consists of approximately 20,000 records. These can be searched by author, title, subject, and other special fields if desired.
4. Search of 5 years of MEDLARS data, to be obtained from the National Library of Medicine. This amounts to approximately 1,000,000 records, also stored on-line. These will be able to be searched by author (name) or subject, with the usual limiting parameters of time, language, sex, date, etc.

5. Search of the SUNY *Union List of Serials* data consisting of over 20,000 current and non-current periodical titles

held in the 60 libraries of the State University, plus Syracuse University, Hamilton College, Colgate University, and several smaller schools and special libraries.

6. Preparation of lists of currently received titles for each campus, or the entire system, of books — arranged by author or subject, and of journals — arranged by title or subject, or any desired combination. The information dissemination aspect of this phase is of great importance to all faculty, research staff, and student users.

7. Education and training of library personnel and orientation and training for users.

8. Current awareness services — Selective Dissemination of Information (SDI). Individual faculty members or research groups could be notified of new articles and books in their specialized fields of interest as each new MEDLARS tape is received and as catalog information is added to the master files.

9. Key Word in Context (KWIC) indexing of appropriate local research data, and, if desired, of journals not covered by the major indexing services.

10. Recurring bibliographies, e.g., monthly for a specific research group or project.

11. Research and development of techniques for information storage and retrieval (see below).

The major elements of the data base will be augmented by the circulation records for the Upstate Medical Center Library and the other libraries as they develop automated circulation systems.

The user will query the system himself, not through an intermediary, in his own terms, which will be translated, if necessary, internally. Within two minutes of the completion of his query statement he will begin receiving the responses.

NLM Shared Cataloging Program

In 1966/67 the National Library of Medicine negotiated agreements to begin expanding the scope of the *Current Catalog*. As stated in the 1967 fiscal year *Annual Report* of NLM:

Negotiations were completed for a manually shared cataloging project which will result in the Francis A. Countway Library's acquisitions being included in the CURRENT CATALOG. In FY 1968, the Francis A. Countway Library will begin submitting master forms of their catalog citations for inclusion in the CURRENT CATALOG. Those which are added to the catalog will reflect the NLM classification and MESH subject headings, as well as the Countway Library symbol, MBCo.

In addition,

SUNY/NLM Shared Cataloging Project arrangements were completed with the SUNY Upstate Medical Center, Syracuse, New York, to:

A. Convert NLM current cataloging tapes to IBM 360/40 and to reformat the NLM data according to the current tape formats to project MARC of the Library of Congress.
B. Provide programs for searching of the resultant tapes using IBM's GIS document handling module.
C. Experiment with batch searches of the resultant tapes.
D. Share input in machine cataloging data.
E. Cooperate in designing a shared cataloging system.

Beginning in April, 1968 both Countway and SUNY items will appear in the *Current Catalog*, and the contract between SUNY and NLM has been renewed in order to compile and search a master data base consisting of NLM, Countway, and SUNY machine readable records.

A total of 32 full-time persons are currently engaged in the implementation of the Network, in addition to the existing staffs of the component libraries who number 92 and who may be thought of as resource persons for the Network program.

Paralleling this development of mechanization of traditional library procedures has been a significant change in the concept of librarianship, especially medical librarianship. The library function has been defined as the conscious interruption of the total stream or flow of recorded ideas and information, the selective drawing off of manageable amounts for storage, later retrieval and distribution to individuals or groups in whatever media forms or formats might be required and are appropriate to satisfy known or anticipated needs. In other words, libraries will be increasingly concerned with management of information in whatever format it is in or the media used to disseminate it.

In response to the question "What will libraries look like in the future?", Stone has stated the library of the future is not wisely conceived as a single place at all, but rather as a far-flung network composed of units of various sizes and shapes, each of which may perform similar as well as different functions, but all of which will be linked together electronically or mechanically. In the future, it will probably be less necessary to have all of the pieces of a library program in one place so long as the program parts can be linked together. In other words the concept has developed that the library should be a place from user, rather than a place where the user which information is disseminated to the must come to acquire the information.

The trend seems to be developing, particularly in newer medical schools, toward the centralization of administration of all agencies concerned with the management and communication of information. Among those places where computers, medical illustration activities, educational media development and library science operations are consolidated under one administrative head are the University of New Mexico School of Medicine, the University of Texas Medical Schools in Dallas and San Antonio, the California College of Medicine of the University of California, the University of Arizona School of Medicine and more recently, the University of Alabama Health Center. In those cases where librarians are qualified to serve as information scientists, the librarians have been placed in charge of this administrative unit. In other places, men from science or medicine who have become interested in the modalities of information transfer are assuming this important role.

The consolidated operation lends itself toward the development of the techniques of information handling that are now on the horizon, but not sufficiently developed for implementation for five or ten years in the future. Among these are the methodologies of fact retrieval earlier referred to. Such techniques may use microfilm, microform, video tape, motion pictures, facsimile transmission and other media. If there is no central management, implementation and development of medical information systems will be hampered and, indeed, might be chaotic in terms of potential linkages.

At the national level, the National Library of Medicine has underway a massive systems design for biomedical communications which involves several major information components. They are (1) an automated document handling library network, (2) the development of a network involving the National Medical Audiovisual Center and its concern with other learning resources, (3) systems management through monitoring, control feedback and application of control system procedures, (4) evaluation of systems operations so as to extract systems parameters, (5) systems inadequacies and component coupling, and (6) the support of education through automated information and communication networks, including the possible use of satellites for public as well as for medical education. All of these efforts are related to establishing compatibility among the three national libraries, as well as with specialized information centers and other emerging national information programs. Medicine presently is in the forefront of these efforts and intends to share fully its experience with other disciplines of science and technology. The methods developed by NLM for decentralizing its computer-based information programs and, particularly, its extension into all levels of support for medical research, education and practice has led the President to include it as a prototype for the developing "knowledge network." In this context, medical schools, professional societies and other health related organizations must participate by providing evaluated substantive input of high quality and pertinence to the major health problems of the nation.

It was clearly demonstrated at the panel meeting that medical libraries have been in the forefront in the investigation and installation of modern machine methods to cope with the rising flood of materials being published. Librarians have felt the need to prepare themselves to more fully utilize computers in documentation and control of documentation. It was suggested that the librarian take advantage of computer training on his own campus, because from the expressions at this meeting it became clear that computer center personnel are excellent sources of information and support. In addition, attendance at computer courses, workshops and other outside advanced training programs should be encouraged whenever possible. Libraries should seek to employ systems and programming personnel as early as possible in any computer planning development. Sharing of information, ideas and programs has given impetus to the development of several important cooperative ventures.

Although some librarians apparently still believe that students, faculty and other library users might resist the use of computer terminals in their search to locate information, it was pointed out that these students are now being early introduced into instrumentation and computer technology in their medical school careers. Therefore, the library should be considered as another resource to acquaint the student with different types of equipment with which he may be interacting in his future work.

The final recommendation of the panel was that continued federal – private interest and support for improved medical library service should be sustained and, wherever possible, expanded. However, careful review of on-going systems development in libraries should be made to avoid duplication of effort and thus avoid unnecessary expenditures.

The panel was impressed that cost sharing and program sharing is now taking place at all levels in the tradition of library cooperation which has developed over the past century. Although software and hardware are becoming easier to acquire, more attention should be given to the development of the "liveware", the people, needed for the effective use of these systems.

A PROGRESS REPORT OF COMPUTER ASSISTED INSTRUCTION AT THE UNIVERSITY OF OKLAHOMA MEDICAL CENTER*

Panel: William G. Harless, M. S., Chairman, Thomas N. Lynn, M.D., Robert C. Duncan, Ph.D., Eugene D. Jacobson, M.D., James A. Cutter, M.D., Arthur W. Nunnery, M.D.

In the fall of 1966 the University of Oklahoma Medical Center Computing Facility initiated implementation of computer assisted instruction (CAI) as an educational capability for the faculty. The first year was used primarily for the indoctrination of a staff and the exploration of the pedagogical possibilities of the CAI technique. These activities have been previously reported.

The first step in a new installation must be to define computer aided instruction from a philosophical point of view. When this is done two very pragmatic problems become apparent, WHERE and HOW it fits into the academic goals and activities of the University. These questions must be answered before any significant implementation takes place. This answer requires a taxonomy of medical education. For convenience we have divided it into four major areas:

1. Graduate education in the medical sciences
2. In-service training in health related fields
3. Undergraduate medical education and house staff training
4. Continuing medical education

Our plans include activity in all of these areas. The following discussion will concern the various activities of CAI in several disciplines and reflects the interest in the four areas mentioned above. Only information concerning material presently developed and operational is discussed.

The use of CAI in graduate education in the medical sciences had its beginning in a course called "Medical Backgrounds." The course was developed three years ago to accommodate the increasing enrollment in the graduate division of the Department of Preventive Medicine and Public Health. Students entering the disciplines of environmental health, health administration and biostatistics needed additional background in order to converse with physicians and other persons in the health professions. The course, "Medical Backgrounds," was therefore designed primarily to facilitate communications between these students and others in the health profession. The course evolved into a two-hour didactic course lasting one semester.

The IBM 1401 Data Processing System was restructured to permit implementation of computer assisted instruction utilizing four 1050 typewriter terminals. It was decided that "Medical Backgrounds" was appropriate to augment the instruction by means of this educational technique. Ten lessons were developed utilizing the drill approach to reinforce the material covered by traditional lecture. Participation in the computer assisted instruction portion of the course was voluntary, and the student reactions were mixed. Some students

*Presented and demonstrated by faculty members involved in computer assisted instruction.

found it fascinating; others resented it. Many mechanical failures such as the paper getting jammed in the typewriter terminal and programming systems failures were constant sources of frustration to the students.

The following year the IBM 1500 Instructional System was available for the reinforcement drill sessions. This eliminated many of the machine problems of the first year and proved to be a much more effective presentation. The greater flexibility in presentation afforded by the cathode-ray tube displays made the whole effort a much more palatable one for the students.

There was an effort at evaluation of the results during the second year. The following observations were made concerning grade distributions and their relationship to the number of CAI lessons taken:

Grade	Number of Students	Average CAI Lessons Taken
A	10	8.8
B	24	6.45
C	10	5.5
D	1	2.0

Perhaps the most plausible explanation for this supportive data is that the A students were the more highly motivated students who can be expected to avail themselves of any educational materials available.

The following is a list of the drill sessions available to the students in Medical Backgrounds: 1. Medical Terminology; 2. Cellular Structure; 3. Dermatology; 4. Muscular-Skeletal System; 5. Hematology; 6. Respiratory System; 7. Endocrine System; 8. Cardiovascular System; 9. Gastrointestinal Tract; 10. Urogenital System.

There is a lesson presently under development concerned with the spinal cord. It is a tutorial approach to the teaching of the basic components and functions of the spinal cord, and is designed to replace a lecture as opposed to the previous ten which serve as supplementary drill sessions for material presented by lecture.

One of the more promising areas of computer assisted instruction seems to exist when a student is allowed to project his existing knowledge of a subject into a simulated situation. This area is relatively unexplored for many reasons. Currently it is technically difficult to interface effectively the problem solving and tutorial techniques in the CAI environment. Another difficulty is the inability of the author to adequately define the pedagogy involved in such a technique which results in dangerously nebulous goals for the session. One further important problem that inhibits the progress of such development is the total involvement required of the professor during the development of the session.

In an attempt to transcend these problems and provide an effective learning tool, the Department of Biostatistics and Epidemiology of the School of Health is responsible for preparing a lesson in sampling theory involving a dynamic model of a population. The lesson requires an interface between the Coursewriter language for a tutorial mode and the MAT language for a problem solving mode. The simulated situation is developed for the student in the Coursewriter mode. He is allowed to pick what he considers to be the appropriate analytical methods needed to solve the sampling problem presented. Once this is accomplished he is directed to switch to the MAT mode. Utilizing Monte Carlo methods in this problem solving mode, a sample is generated. The student's procedural choice in phase one is used, and the appropriate subroutines are called by the student to analyze the generated data. When the analysis is complete, the student switches back to the Coursewriter mode where structured interaction occurs between the student and the computer concerning the appropriateness of the student's analysis and other aspects of the problem. This is the critique phase of the student's problem solving experience and the tutorial mode will again be in effect. If the student choose the appropriate methods, he will be reinforced. If his chosen methodology was inappropriate, he will be told so and a proper method suggested. The problem may then be extended or a new problem introduced and a branch is executed back to phase one for another choice of methodology by the student. The plans are for various data to be copied by the student and brought back for class discussion. This allows for many different sampling situations to be presented and facilitates class discussion.

It is important that the students appreciate the dynamic nature of the situation. They must not feel that the situation is so structured that there is a single solution to any problem presented. This system gives him the feeling of problem solving in real time: a live situation rather than guessing with the machine or the professor concerning the answer to a structured problem.

These techniques may be utilized in other areas of medicine such as diagnostic procedures, patient management, computation of water and electrolyte balances, drug therapy and the complications of misuse of drugs, and possibly in epidemiology concerning the investigation of contagious disease models.

It is very difficult indeed to measure the efficiency of such an educational approach and, as has been stated earlier, the total involvement required of a professor is an inhibiting factor to this approach. But the knowledge that one is teaching things that are difficult to teach under the current system is perhaps justification enough for the effort. More work needs to be done concerning technique development before appropriate evaluations and traditional efficiency measures can be made.

The Department of Pediatrics has elected to use the tutorial approach in programming lessons concerning the principles of feeding in infant nutrition for junior and senior medical students. Under the current curriculum the third year students rotate in groups of 12 or 13 for five weeks on the pediatrics service. It is during this period of time that they are exposed to the computer assisted instruction material covering infant nutrition. The fourth year medical students rotate in groups of two for one week in the newborn service. These students are responsible for talking with the mothers of the newborn with reference to the feeding requirements, selection of the formula, and explaining the appropriate preparation procedures. The computer assisted instruction lessons on formula feeding and infant nutrition are used as orientation sessions for these students. The decision has been made to pursue infant nutrition in greater depth utilizing CAI techniques. Information concerning molecular nutrition taught by the Department of Biochemistry will soon be available utilizing the computer assisted instruction facility. Ultimately, it is envisioned that by the time a freshman medical class reaches the third year, all of the information concerning these matters related to infant nutrition in the basic sciences will be available to the students for reference or as refresher courses. Hopefully this will help to bridge a gap between the basic science education and the clinical experience.

Generally, at this point, the acceptance by the students involved is favorable. Previously a two-hour-a-week tutorial session was required in infant nutrition by the Pediatrics instructors with the fourth year students. This has been cut to about ten minutes a week.

One of several unique features added to the course in medical physiology for the academic year 1968 is the use of computer assisted instruction to teach two lessons. The lessons concern "the action potential" and "pancreatic secretion." The Physiology Department has moved cautiously into the area, carefully building in evaluation procedures for academic effectiveness. For the material concerning the action potential, one half of the class is randomly selected to take the lesson on the computer; the other half of the class takes the lesson by traditional lecture. Some weeks later for the material on pancreatic secretion the two halves of the class are reversed so that the group that had the first computer lesson now gets the lecture by traditional means and the other group gets the computerized material. Each half of the class will be tested by the same examination. This type of design will obviously allow the students to be their own controls and a comparison of the lecture versus the computerized material can be made for the entire class.

One of the most attractive things about CAI to the Physiology Department concerns the available literature today which seems to indicate that the less endowed students receive the most benefit from the technique. The students at the top of the class do about as well regardless of the method of material presentation. It is the feeling of the Physiology Department that the computer could, at the very least, provide a supplement to the traditional educational system which would be helpful to the students having difficulty with the traditional system.

In the Department of Anesthesiology there is a lesson developed from a paper authored by Dr. Joseph M. White and Dr. James A. Cutter concerning resuscitation and anesthesia in crushed chest patients. This is an approach to the use of computer assisted instruction in the continuing education of physicians. The material is in a tutorial mode and explores the latest techniques in emergency cases concerning resuscitation and anesthesia. The method of implementing this lesson involved the direct programming of a paper which appeared in the JOURNAL OF AMERICAN SURGERY entitled "Resuscitation and Anesthesia in Crushed Chest Patients". The lesson has been presented to a group of 16 general practitioners who attended a two-week course at the University of Oklahoma Medical Center in postgraduate clinical anesthesia. Incorporated in the course is the possibility of selecting any area of the subject the student wishes to review by simply typing "outline". This causes the outline of the material covered in the lesson to appear on the screen. This capability is available to the student at any point during the lesson. The lesson has also been programmed for the word "Comment" to be recognized by the computer anytime it is entered by the student. The screen is immediately cleared and the student is allowed to type whatever he likes. His message is recorded on magnetic tape and the program subsequently branches back to the point reached in the lesson when "Comment" was requested. This gives the student the ability to disagree with any portion of the lesson or to make comments to the author at any time. There are strong indicators at this point that computer assisted instruction will be a significant factor in the future of continuing education of physicians. Many of the traditional problems, such as distance of the physician from a learning center and lack of time for extensive blocks of continuing education effort, are transcended by the very nature of computer assisted instruction. It is entirely conceivable and practical at this point for a terminal to be placed in a remote station and tied by voice grade telephone lines to the computing facility in a learning center such as the University of Oklahoma Medical Center.

Certainly one of the requirements of the successful development of a computer assisted instruction effort is that the faculty understand and want the facility. These requirements are met at the University of Oklahoma Medical Center. The faculty is not only interested but they are also permissive in allowing the other disciplines (computer theorists and learning theorists) to develop their techniques which are fundamental to an effective system. An effective marriage must exist between the computer scientists, the learning theorists and the faculty. Real success can ultimately be realized only when these individual efforts are integrated in an environment of efficient and effective learning for the student.

Summary

The following is a summary of the CAI material made available to the conferees during their visit to the University of Oklahoma Medical Center:

1. THE CARDIOVASCULAR SYSTEM (School of Health) – A drill session concerning basic cardiology. This is an excerpt from the lesson on the cardiovascular system presented to the graduate class in Medical Backgrounds taught by Dr. Thomas N. Lynn.
2. THE HUMAN SPINAL CORD (School of Health) – A tutorial approach to the teaching of the basic components and functions of the human spinal cord. This is an excerpt from a lesson by Dr. Thomas N. Lynn for the Medical Backgrounds class.
3. INFANT NUTRITION (Pediatrics) – Two lessons concerning feeding principles and infant nutrition in a tutorial mode were prepared by Dr. Arthur W. Nunnery of the Department of Pediatrics. One lesson discusses breast feeding and the other, formula preparation. The material is used by junior and senior medical students.
4. ACTION POTENTIAL (Physiology) – A tutorial exposition concerning the action potential in Physiology. This lesson is being used by freshman medical students. The professor is Dr. Roger Thies of the Department of Physiology.
5. PANCREATIC SECRETION (Physiology) – A tutorial approach to the teaching of pancreatic secretion by Dr. Eugene D. Jacobson of the Department of Physiology. This lesson is is being used by freshman medical students.
6. SAMPLING THEORY (Biostatistics) – This lesson is an integrated approach utilizing tutorial and problem solving techniques in computer aided instruction. The professor is Dr. Robert C. Duncan of the Biostatistics and Epidemiology Department. The lesson is to be used by graduate students in the Department of Biostatistics and Epidemiology.
7. RESUSCITATION IN ANESTHESIA AND CRUSHED CHEST PATIENTS (Anesthesiology) – This lesson is designed to explore the possibilities of the use of CAI techniques in research reporting. The material was authored by Dr. Joseph M. White and Dr. James A. Cutter. It is envisioned as an approach to the use of computer aided instruction in the continuing education of physicians.

CLOSING COMMENTS

This conference has been concerned with the role of computers in medical education. Past and present experiences of knowledgeable leaders have been presented and discussed as well as new theories and ideas. Plans for the future solution of problems and expansion into operational services to education have been expressed, and it appears that the tools are available to meet the challenges presented here. Our ability and desire to do the job remain to be garnered.

Two resolutions were presented and endorsed by those in attendance, and they are reproduced here.

1. "The heart of this conference has been interaction among knowledgeable people. It was the first of its type in this respect and dealt with an important topic, computer aided instruction in medical education. Be it resolved that a conference utilizing the interactive format and discussing computers in medical education be held on an annual basis."
2. "Be it resolved that we commend the University of Oklahoma Medical Center and the United States Public Health Service for their conduct and support of this conference and in particular that we commend Dr. James L. Dennis, Dr. Joseph M. White, Dr. Edward N. Brandt, Jr., Mr. William Harless and Miss Elizabeth Ray of the University of Oklahoma Medical Center, and Dr. Frank McKee, Mr. Norman Tucker and Mr. Norman Rydland of the United States Public Health Service and the most efficient supporting staff."

The conference was adjourned at noon on Friday, April 5, 1968.

CONFERENCE ON THE USE OF COMPUTERS • IN MEDICAL EDUCATION •

UNIVERSITY OF OKLAHOMA MEDICAL CENTER