R E P O R T R E S U M E S

ED 020 741 JC 680 250

PLANNING FOR THE FUTURE--FORECASTING IMPLICATIONS DUE TO TECHNOLOGICAL CHANGE.

BY- ANDERSON, RICHARD T.

PUB DATE JAN 68

EDRS PRICE MF-$0.25 HC-$0.92 21P.

DESCRIPTORS- *ELECTRONIC DATA PROCESSING, *COMPUTERS, *DATA ANALYSIS, *ELECTRONIC EQUIPMENT, DATA PROCESSING, INFORMATION PROCESSING, TECHNOLOGICAL ADVANCEMENT, EDUCATIONAL METHODS, CURRICULUM DEVELOPMENT,

TECHNOLOGICAL FORECASTING (PROJECTING FUTURE TECHNOLOGICAL POSSIBILITIES AND PROBABILITIES IN RELATION TO CURRENT KNOWLEDGE AND RESEARCH AND IN RELATION TO POTENTIAL INTERACTIONS WITH SOCIETY, WITH THE ECONOMY, AND WITH THE NATURAL ENVIRONMENT) BY MEANS OF COMPUTER UTILIZATION HAS IMPLICATIONS FOR THE DEVELOPMENT OF NEW METHODOLOGY AND CURRICULUMS IN EDUCATION. DATA SHOULD INCLUDE CURRENT TECHNOLOGICAL CHANGES, CHANGES CURRENTLY UNDER RESEARCH, AND SECONDARY IMPLICATIONS OF BOTH TYPES OF CHANGES. SOURCES OF INFORMATION INCLUDE TRADE, TECHNICAL, OR PROFESSIONAL PUBLICATIONS, GOVERNMENT PUBLICATIONS, EDUCATIONAL REPORTS, RESEARCH ORGANIZATION PUBLICATIONS, NEWSPAPERS, AND COMMERCIAL MAGAZINES. PERTINENT DATA SHOULD BE CLASSIFIED, SYSTEMATIZED, AND EDITED. ANALYSIS OF THE DATA SHOULD INCLUDE TABULATIONS AND FREQUENCY DISTRIBUTIONS, TABLES AND GRAPHS, AND STATISTICAL CALCULATIONS. CONCLUSIONS SHOULD BE CONSTANTLY REEVALUATED BECAUSE THE DATA ARE EVER CHANGING. TWO-THIRDS OF THE PAPER IS DEVOTED TO THE DEVELOPMENT, OPERATION, AND USE OF ELECTRONIC COMPUTERS WITH EMPHASIS BEING PLACED ON THEIR GROWTH FROM 1951, WHEN THE FIRST COMMERCIAL INSTALLATION WAS MADE TO THE END OF 1967, WHEN AN ESTIMATED 44,000 COMPUTERS WERE IN SERVICE. COSTS OF COMPUTERS, SIZE OF THE EQUIPMENT, AND EXAMPLES OF COMPUTER DIVERSIFICATION ARE DEPICTED. USES FOR COMPUTERS IN EDUCATION INCLUDE PAYROLL TABULATIONS, SCHEDULING, TEACHING, AND COUNSELING. (DG)

PLANNING FOR THE FUTURE--

FORECASTING IMPLICATIONS DUE TO TECHNOLOGICAL CHANGE

By

Richard T. Anderson
Director of Instruction
Waukesha County Technical Institute

Waukesha, Wisconsin
January 1968

TABLE OF CONTENTS

PLANNING FOR THE FUTURE--

FORECASTING IMPLICATIONS DUE TO TECHNOLOGICAL CHANGE

The effort at technological forecasting--that is, projecting future technological possibilities and probabilities in relation to current knowledge and research and in relation to potential interactions with society, with the economy, and with the natural environment--can provide important guides to the identification of new goals for applied research, and in alerting educators to new methodology and curriculums. Technological forecasting is, however, a relatively new field and its methods are subject to further improvement. Many authorities feel it can do more harm than good for educational planning if its results are treated as more than rough first approximations. The purpose of technological forecasting is primarily to identify for applied researchers the many future options open to society, and expand these options rather than to foreclose them.

Most authorities agree that technology will change and that the changes will affect every level and aspect of society; also most authorities agree we cannot predict the exact forms which this change will take, primarily, because if we would predict the exact change we would have it now. Therefore, an <u>accurate</u> forecast cannot be made.

KIND OF DATA REQUIRED

The necessary data (which is ever changing) required to make a tech-

nological forecast must be the result of rational study and consist of an analysis of available pertinent information. This data includes: current technological changes, changes currently under research, and secondary implications of both the forementioned (which may be of more importance than the original change). The specific data required to make a forecast is variable depending on the area of technological change under research.

The scientific method of research is probably still the most reliable means available to determine the solution of the problem.

SOURCES OF INFORMATION

The data required to make the forecast can be found in many places. Most every trade, technical or professional occupation in the world has formed some type of organization and publishes some type of journal. Upon examining the table of contents of over 100 such journals (see appendix) it was found that the great majority had a research, new ideas, or new products section. A great many technological changes and research projects are announced in this manner. Other sources of information are government publications, educational reports, research organization publications, newspapers, and commercial magazines.

ANALYSIS AND INTERPRETATION OF DATA

The analysis and interpretation of data involves as much objective material as the forecaster is able to accommodate and his subjective reactions and desires to derive from the data the meanings of the assembled information. Because the data is ever changing, the conclusions must be constantly re-evaluated.

The method of interpretation of data should consist of the standard

procedures: classification of data, systematizing and editing, assumptions and hypotheses, and the standard metnods of analysis, including; tabulations and frequency distributions, tables and graphs, statistical calculations, etc.

THE FORECAST

After reviewing hundreds of sources of information concerning technological change, it became readily apparent that the electronic computer will be the basis for much of the applied technological change in the future. The great technological accomplishments of the last few centuries have centered largely about the harnessing of physical energy to control our environment. Our fabulously increased ability to move about and manipulate objects can be viewed mainly as the result of the development of tools for improving upon our unaided muscular and sensory apparatus.

The electronic computer is a radically new type of machine--not simply an extension of our limbs and our senses. It can be conceived, in a sense, as an appendage to our central nervous system. Automatic data processing machines assist us in remembering and organizing external stimuli, in coordinating the tools which give us power over our environment, and in probing more deeply into the foundations of the sciences. The storage of data and its ready access will cause the computer to become an extension of the human brain, to be used as required in the solution of complicated problems and in the rapid transmission of data. The computer will be used in every phase of business, industry and education; and will alter methods, processes and procedures beyond our wildest expectations.

To forecast the future of the computer to technological change, the available pertinent data was classified in two areas.

1. Growth in the computer industry to date and in the near future including requirements for operating personnel.
2. Technological progress due to the use of electronic computers in many areas of business and industry.

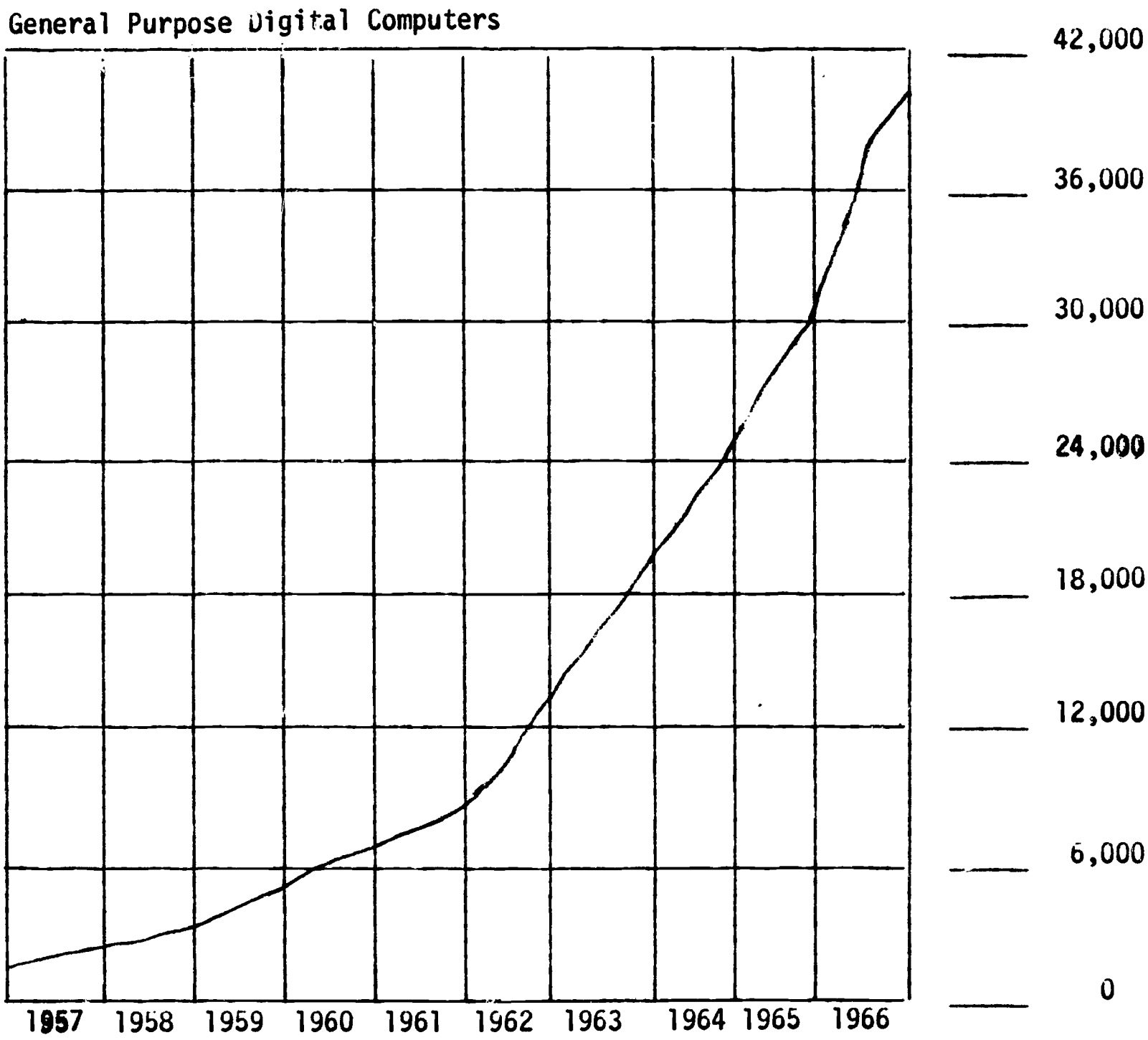
GROWTH OF THE COMPUTER INDUSTRY

Man's attempts to use a machine for calculations go back more than 2,000 years--at least to the origin of the abacus. Development of the modern computer, however, first began toward the end of World War II, and the first commercial installation was made in 1951. In the 16 years since then, computers have permeated almost every aspect of daily life and have been produced in astonishing numbers confounding many early developers of the machine who foresaw only specialized applications. With an estimated 44,000 computers in service at the end of 1967, it is difficult to believe that in the 1940's some experts envisioned the nation's entire needs being served by a handful of machines. Chart #1 shows the great rate of increase which has taken place in the number of computer installations in the United States.

The rapid growth of this industry has occurred for two basic reasons. First, was greater and ever expanding application (which will be expounded upon later) and second, was the reduction of the cost of data processing. Back in 1950, the cost of processing 35,000 computer instructions was one dollar. Today, one dollar processes 35 million instructions. This was accomplished primarily by reducing the size of the equipment.

CHART #I

COMPUTER INSTALLATIONS IN THE UNITED STATES



Data: The Diebold Group, Inc., 1967

Dr. A. Triebwasser, researcher for IBM Corporation states:

> "Smaller parts mean faster computer speeds because the electronic impulses travel a shorter distance--more work in less time. In the last ten years, competitive research in the industry has taken computers from bulky vacuum tubes to transistors so tiny that 50,000 of them would fit in a thimble. As the parts have shrunk, so have the costs."[1]

A tube of glass fibers has been developed sensitive enough to take light from a candle, curve it around a corner, and use it to "read" documents. Such a technique is now incorporated in two different IBM data processing machines. These computers use fiber-optic bundles to transmit light from a central source around internal assemblies to scanning stations. Each bundle contains hundreds of extremely fine glass fibers, several feet long, but far thinner than a human hair. Acting as tiny light pipes, the fibers carry beams of light which activate photosensitive elements and register data on punched cards. And ways are being found to make date processing even more economical. Electronic components for a miniaturized computer, which weighs less than 200 pounds and occupies only four cubic feet of space, are being tested by Sylvania engineers.

At the Business Equipment Manufactuers Association annual show this year in New York City, W. C. Doud,[2] IBM's director of commercial and patent relations, who is chairman of BEMA's data processing group, outlined the advances made by the computer industry in only 16 years. He noted that there are now more than 400 software companies, which underscores the great number of ways in which computers are used. He said that today's computers perform

---

1 A. Triebwasser, "Miniaturizing", News Week (January 26, 1968).
2 W. C. Doud, "Industry News", Business Automation (October 1967) p. 74.

150 times faster than the computers of the early 50's at only 1/40th of the cost. Doud also stated that computer manufacturers now employ more than one million persons and that there are at least 200,000 programmers as opposed to only a handful 16 years ago.

T. A. Smith,[3] executive vice-president of corporate planning for RCA and BEMA's chairman of the board, cited the growth of the data processing industry in the past 10 years as 860 percent.

Chart #2 summarizes the growth of the industry via the trends in estimated personnel requirements for United States data processing positions.

The computer industry seems destined to become one of the largest industries in the world within the next 10 to 15 years. Its growth in the future promises to be even more dramatic than its impressive development to date. A somewhat superficial survey of the past and now of the computer industry indicates that this machine can cause rapid advancements in the knowledge and material production of most every field. But to forecast specifically how fast or in what specific fields is practically impossible. There are too many factors involved in technological change in addition to knowledge, and the knowledge variable is inconsistent itself.

Boulding states:

> "The fact that the growth of knowledge has so many parallels to the evolutionary process renders it incapable of exact perdiction. We can predict with some confidence that if the present system continues, knowledge will increase, not only because it has increased in the past but because we have a very large apparatus for increasing it. On the other hand, we run into a fundamental dilemma in attempting to predict the content of future knowledge, because if we knew the content of future knowledge, we would know it now, not in the future. That is, if we knew what we were going to know in twenty-five years, we would not have to wait twenty-five years for it. Consequently, the growth of knowledge must always contain surprises, simply

3 T. A. Smith, "Industry News", Business Automation (October 1967) p. 74

CHART #2

TRENDS IN DATA PROCESSING

ESTIMATED PERSONNEL REQUIREMENTS FOR U. S. A. DATA PROCESSING POSITIONS

	MANAGERS & SUPERVS.	SYSTEMS ANALYSTS	PROGRAMMERS	OPERATORS	TOTAL
1966-28,000 Systems					
1. Requirements	40,000	95,000	175,000	80,000	390,000
2. Available	30,000	60,000	120,000	80,000	290,000
3. Shortage	10,000	35,000	55,000	---	100,000
1970-55,000 Systems					
4. Requirements	85,000	190,000	220,000	150,000	645,000
5. % Change	183.3	216.7	83.3	87.5	122.4

DATA: "Jobs and Careers in DP"

Computers and Automation - September, 1966

> because the process itself represents the growth of improbable structures, and improbability always implies potential surprise. The whole idea of knowledge as a capital stock of information implies, therefore, that in detail its growth cannot be predicted."[4]

Technology is an offshoot of knowledge, and although there is a somewhat stable relationship between knowledge and technology, it is extremely difficult to predict how and when the two will come together. As Boulding further states:

> "The fact that fortunes are made as well as lost in new technologies suggests that the uncertainties of prediction here are very great, and that the relation between present knowledge and future technology is not really stable enough to admit of any very secure predictions."[5]

TECHNOLOGICAL PROGRESS

Technological progress due to the use of electronic computers is seen in many areas of business and industry.

The computer's single most important area of use today is the broad field of business data processing. This field includes such applications as preparing payrolls, handling accounts receivable and payable, performing cost analysis, keeping track of inventories and sales, and performing a variety of other clerical tasks. In order to compete effectively, the modern business man must have readily available a wealth of information about his company's operations. In the banking industry, computers are used for check-processing, posting of checking and savings accounts, installment-loan and mortgage-loan accounting, trust accounting, and stock-

---

4 K. E. Boulding, Prospective Changes in Society by 1980 (Designing Education for the Future - An Eight State Project, Denver, Colorado, 1966) p. 205.

5 Boulding, Loc. cit., p. 210.

holder record-keeping.

The insurance industry uses electronic data-processing equipment for calculating and billing premiums, processing claims, calculating reserves, computing mortality tables, determining agents' commissions, and analyzing dividends.

Financial institutions find applications in monthly customer statements, stock-market data transmission, security analysis and information transmittal, portfolio analysis, and security transfers. The closing prices of stocks over a period can be plotted on the screen of a display unit by a computer. Information is previously fed to the computer by means of the light pen and two keyboards. This eliminates the painstaking manual plotting of pointer usually required to draw graphs. Any numerical field can be plotted against any other numerical field, making the number of graphs which can be generated from the various combinations almost infinite. Scaling--making the graphs the right size for the variables being plotted--is done automatically by the computer. Several plots can also be shown simultaneously on one graph, using either solid or dotted lines.

Government uses computers on a broad scale in the handling of tax information, Social Security records and payments, census analysis, budget control, and weather forecasting not to mention various military and space applications, which often call for maximum EDP capabilities. An improved model of a film optical sensing device for input to computers has been completed by the National Bureau of Standards for use with computers of the National Weather Records Center in Asheville, N. C. The device reads data on past weather conditions from microfilms of punched cards and selects data to be tape recorded. This permits ready comparison of past and pres-

ent weather data and should result in improvements in weather predictions.

State and local governments are increasingly recognizing the potentials of these machines. In the field of transportation, computers are used in air-traffic control, railroad-car movement, and automobile-traffic control.

A new experimental system is now automatically controlling traffic signals at 32 intersections along a major three-mile highway and adjacent streets leading into the downtown section of San Jose, California. The system uses 400 vehicle-detecting devices that feed information to the computer about the speed and density of traffic. Preliminary results show a significant improvement of the methods of handling the flow of 35,000 cars that use the highway daily. Subsequently, some 28 traffic signals in the downtown area will be controlled by the EDP control system that is used. Airline reservation systems are becoming more efficient and more highly automated as a result of the computer, and EDP equipment is utilized in the training of pilots and simulation of flights. Farmers too, are turning to computers to realize optimum use of land and livestock resources.

Specialized systems for process control are employed by the power-generating, petroleum, chemical, paper, cement, and steel industries. The nation's first completely computer-controlled hot sheet mill has been put into operation at Bethlehem Steel's new $400 million plant at Burns Harbor, Indiana. The computer system takes production from the time the hugh slabs enter the mill until the hot rolled sheet coils reach the delivery area. As the nation's most powerful sheet mill, the facility uses motors totaling 108,000 horse power and is capable of speeds of 3460 feet a minute. The 80-inch mill's own electrical substation could supply the needs of a city

of 100,000 persons.

Electronic controls for one of the largest coal chemical process-control systems are now undergoing final simulation testing. To be installed at U. S. Steel's Clairton Works, near Pittsburgh, the supporting system will monitor the production of anhydrous ammonia and the extraction of other chemicals from coke-oven gas produced by the large coke oven installation at the plant. Fuel gas will also be produced. A constant check on the installation will be provided by electronic analog instrumentation and eight hugh graphic panels totaling 400 feet in length, along with five Westinghouse computers.

Machine tools are controlled by computers as are many production operations. An electro-mechanical electronically controlled industrial robot was shown working as a lathe operator in a factory of the future. The demonstration was set up in a mirrored room at Expo 67's "Man the Producer" pavilion. The robot, now in production by Unimation, Inc. is an all-purpose automated machine that can lift an article weighing up to 75 lbs. and move it to another location within a 350-cubic-foot working area with an accuracy of 0.050 in. in any direction. Up to two hundred sequential commands can be recorded and stored in the robot's magnetic memory. It can also be interfaced with separate computer.

By linking computer and television technicques, RCA has developed a unique electronic type composition system, called Videocomp, that sets text at speeds up to 900 lines a minute. A punched paper tape is used to generate the letters. Each of the holes in the paper tape provides information on the position of dots needed to form a character. In the new typesetter any letter that has been stored in the machine's electronic memory can be recalled and produced in thousandths of a second. An entire news-

paper can be composed in two minutes in this way. The computer memory can store up to four type fonts ranging in size from 5 to 24 points. Original copy is fed into the computer, which hyphenates and justifies it and produces output tape. Under program control, up to 600 characters a second are written with an electron beam on the face of a high-resolution CRT. These characters are exposed through precision lens directly onto sensitized film or paper for subsequent printing by offset, letterpress, or gravure.

A service technician can run a sequence of automobile engine and electrical system tests on a new automotive computer. An individual program card with performance standards for the model being tested is fed into the computer console. Computerized results are transmitted to a printer readout in the customer lounge. The entire process is completed in seven to fifteen minutes. The computer, which employs integrated circuits, is produced by Allen Electric for use in car-care centers, service stations, or auto garages.

And more and more products are being designed by computers. Buildings, bridges, and dams are planned with their help. By means of "light pens" on display screens, rough lines are translated into precisely drafted drawings. Using a computer-controlled display screen and a special "pen" that writes with light, an engineer can lay out the design for electronic-computer circuit. After he has experimented with various patterns and is satisfied with the final design, the computer produces a precise scale drawing of the circuit. Intermediate drawings, which must be redrafted when the engineer modifies his design, can be eliminated.

By the use of pre-recorded sounds, some computers answer inquiries vocally. In communications, computer-like electronic systems handle the

problems of heavy telephone traffic. In fact, the sale of electronic data-processing equipment is increasingly involving the sale of communications equipment.

The many current uses of electronic data-processing equipment and the dramatic growth of the industry to date raise the question of whether the market is now saturated--or whether it may be approaching saturation. Many experts believe that neither situation is the case. Most applications cited will require the use of many more computers in the years ahead. Numerous other uses for computers appear to be in their infancy. The development of still other applications has been limited by technological bottlenecks that gradually are being removed.

THE EFFECT ON EDUCATION

Electronic data-processing, based on the computer is rapidly causing society to become computer assisted. There are few areas in our lives which are not affected by these amazing machines which appeared less than 20 years ago. We have shown early in this paper some of the effects these machines have had on business, industry, and government. The impact on education is just beginning to be noticed.

In the November 1967 issue of American Education, Dr. R. L. Bright[6] provides an extremely bright picture for computers in education. He cites their uses from payroll and scheduling through teaching and counseling. He further states that every student from grade school on through college should receive the opportunity to learn how to use modern data-processing techniques. Dr. Bright counters the impersonalization claim against EDP by showing how students needs are met more rapidly and accurately with EDP and through this increased efficiency they receive more personal assist-

6 R. Louis Bright, "The Time Is Now", American Education.

ance and counseling by their teachers.

New approaches to teaching are slow to be accepted by many educators and the public. Being unable to verify the efficiency of Computer Aided Instruction (CAI) in advance of use, they have been reluctant to give it a trial. At the same time, they have been unable to affirm the validity of CAI.

Until recently there has not been too much valid research published concerning CAI. Dr. Dutrick C. Suppes[7] and his associates at Stanford University through the Brentwood project have provided us with an operating CAI system which, it is anticipated, will lay the foundation for rapid advances for CAI.

IMPLICATIONS TO OTHER AREAS

The implications of technology to other areas have also been delimited to EDP. The rapid transmission of data and through this transmission, the rapid ability for complex decision making will cause startling changes in all areas of life.

In the health field, EDP will greatly increase the efficiency of handling medical records, assembling research data, and in providing training aids. The University of California's School of Medicine has a simulated patient used in training anesthesiologists. The manikin is sufficiently lifelike to represent a human patient awaiting surgery on an operating table. With it, residents can attain proficiency in various techniques without risk to human life.

Sim One[8] is programed to give humanlike response to the injection of

---

7 Enoch Hoga, CAI: "A Commencement" Business Automation (November 1967) p. 49

8 "The Versatile Computer is a Patient", American Education(November 1967) p. 16

varying doses of four different drugs. Its electronic "organs" simulate virtually all the symptoms and physiological responses tne anesthesiologist mignt encounter in an actual operation. For example, when the muscle relaxant, succinylcholine, is injected, the manikin twitches just as a human being might. Under otner drugs or conditions, the eyes open and close, the pupils dilate and contract, and the mouth opens and closes to reveal tongue, teeth, vocal cords, trachea, and bronchial tubes. Sim One also has a heartbeat, a pulse, and a varying blood pressure. This extraordinary computer-controlled simulator nas many advantages as an educational tool. At any point an instructor can introduce unexpected developments. This affords tne student training in a number of emergency situations that he might rarely, if ever, encounter in a normal residency. This, in turn, helps cut the time needed to reach the professional level of performance that USC's J. S. Denson, co-director of tne Sim One Project, says resident anesthesiologists should attain.

This is but one small example of the changes computers will cause in the health field.

The mass transmission of data is beginning to affect all areas of activities and life. It is anticipated that in the 1980's decisions that were once based on calculated guess will have the benefit of the memory and logic of the computer to narrow the guess to a fraction of what it is now.

Computers will be used by everyone, from housewife to general and from worker to legislator.

APPENDIX

Accountants Digest

Accounting Review

Administrative Management

Adult Leadership

Advertising Age

Ambassador

American Education

American Machinist

American Vocational Journal

Balance Sheet, The

Blue Printer

Business Automation

Business of Building

Business Conditions

Business Education World

Business Management

Business Review

Business Teacher

Business Week

Chain Store Age

Changing Times

Co-Ed

Construction Equipment and Materials

Consumer Reports

Contractors and Engineers Magazine

Data Management

Datamation

Design News

Display World

Dun's Review

Education Age

Electrified Industry

Electronic Engineer

Electronic Industries

Electronic Science Review

Electronic Technician

Electronic World

Employment Service Review

Engineer

Engineering Graphics

Engineering Opportunities

Harvard Business Review

Hydraulics Pneumatics

IEEE Spectrum

Industrial Arts & Vocational Ed. IAVE

Industrial Distribution

Iron Age

Journal of Accountancy

Journal of Data Management

Journal of Human Resources

APPENDIX

Journal of Marketing

Library Journal

Life

Machine Design

Media Scope

Merchandiser

Metal Product News

Metal Progress

Metals Engineering Quarterly

Metals/Materials Today

Metals Review

Metalworking

Modern Machine Shop

Modern Office Procedures

Monthly Labor Review

National Geographic

Newsweek

Occupational Outlook Handbook

Opportunity (Salesman)

Plan and Print

Plastics World

Popular Mechanics

Power Transmission Design

Precision Metal

Precision Metal Molding

Price Waterhouse Review

Printer's Ink

Production

Purchasing

Radio-Electronics

Readers Digest

Research/Development

SEA Journal

Sales Management

Sales Meeting

Saturday Review

School Shop

Scientific American

Steel

Steel Horizons

Steelways

Stores

Taxes

Technical Education News

Time

Today's Business

Today's Health

Today's Secretary

Transactions Quarterly

U. S. News and World Report

Verticle File Index - Wilson

Window Vues

Wisconsin Journal of Education

Wisconsin Library Journal

BIBLIOGRAPHY

A. Triebwasser, "Miniaturization", News Week (January 26, 1968)

W. C. Doud, "Industry News", Business Automation (October, 1967) p. 74

T. A. Smith, "Industry News", Business Automation (October, 1967) p. 74

K. E. Boulding, Prospective Changes in Society by 1980, (Designing Education for the Future - An Eight State Project, Denver, Colorado, 1966) p. 205

Boulding, Loc. cit., p. 210

R. Louis Bright, "The Time Is Now", American Education (November, 1967) p. 12

Enoch Hoga, "CAI: A Commencement", Business Automation (November, 1967) p. 49

"The Versatile Computer Is a Patient", American Education (November, 1967) p. 16