

exchanging hands. Even the soil will be computerized. The long-range outlook for agriculture includes new sensing devices that will be placed on larger farms, feeding information to the computer on soil moisture, temperature, weather outlook, and other details. The computer will calculate the best crops to plant, the best seeding times, the amount of fertilizer, and even the correct harvesting time for maximum yield.

Some of the most profound changes wrought by the computer will be in education. Here, the machine will do more than assist students to solve problems and to locate up-to-date information: It will fundamentally improve and enrich the entire learning process. The student's educational experience will be analyzed by the computer from the primary grades through university. Computer-based teaching machines, programed and operated by teachers thoroughly trained in electronic data processing techniques, will instruct students at the rate best suited to each individual. The concept of mass education will give way to the concept of personal tutoring, with the teacher and the computer working as a team. Computers will bring many new learning dimensions to the classroom. For example, they will simulate nuclear reactors and other complex, dangerous, or remote systems, enabling students to learn through a form of experience what could formerly be taught only in theory.

The computer's participation in the field of learning will continue long after the end of formal education. The government estimates that 50 percent of the jobs to be held 10 years from now do not even exist today. With this tremendous rate of occupational obsolescence, future generations of Americans may pursue two or three careers during their lifetimes. The home computer will aid in developing career mobility by providing continuing self-instruction.

Just as it is recasting the educational process, the computer is also fundamentally changing the production and distribution of the printed word. Five centuries ago, Gutenberg broke words into individual letters. Electronic composition now breaks the letters into tiny patterns of dots that are stored in the computer's memory. Any character can be called up by the computer, written on the face of a cathode ray tube, and reproduced on film or paper in thousandths of a second. Nothing moves except the electrons.

When the electronic computer first appeared in composition rooms and printing shops several years ago, its job was to hyphenate words and justify text. But the computer, working at speeds of thousands of words a minute, was driving mechanical typesetting devices capable of setting only a few words per minute. Now, the development of computerized composition makes it possible to set text at hundreds of lines per minute. Photographs and drawings will be set the same way. Since the printed picture is itself a dot structure, the computer can electronically scan any photograph or drawing, reduce it to dots and store it, then retrieve it and beam it on a cathode ray tube for immediate reproduction.

In the future, electronics will develop processes that will make it possible to go from final copy and illustrations to printing in one integrated electronic process. One result will be that newspapers, in the foreseeable future, will no longer be printed in a single location. Instead, they will be transmitted through computers in complete page form to regional electronic printing centers that will turn out special editions for the areas they govern. Local news and advertising will be inserted on the spot. Eventually, the newspaper can be reproduced in the home through a small copying device functioning as part of a home communications center.

Basic changes also will come to other areas of the printed word. For example, of the more than one billion books published every year, almost half are textbooks. The growth of knowledge and the factor of obsolescence mean that these texts must be supplemented by a professor's mimeographed notes. Today, these notes have a small distribution of only a few hundred copies. Computers will make it possible to catalog this information and thus broaden its availability.

At the turn of the century, most large universities will not only have electronic composition systems that allow them to reprint original research, theses, or course notes upon demand; they will also have a computerized information retrieval library. This process of information retrieval can be duplicated in almost any other field. The scientist will have the latest technical papers culled by the computer and reproduced in the laboratory or home. The computer will bring to the attorney all the pertinent laws, decisions, and precedents on any case that concerns him. The business executive need not rush to the office every morning; most of the information he will need to conduct his business will be run off for him at home, and he will have a two-way national and global closed-circuit television, via satellites, for meetings and conferences.