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AUTOMATION AND TECHNOLOGY IN EDUCATION

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LETTER OF TRANSMITTAL

AUGUST 9, 1966.

To the Members of the Joint Economic Committee:

Transmitted herewith for your consideration and use and for the use of other Members of Congress and other interested parties, is a report entitled "Automation and Technology in Education," prepared by the Subcommittee on Economic Progress.

The report is an outgrowth of hearings which the subcommittee held in June as part of its broad study of investment in human resources. The Joint Economic Committee has pioneered in assessing the effects of automation on our society, and it is only fitting that current efforts be devoted to appraising the effects of automation on the vital field of education. The fact is that developments in the storage, processing, and communication of information arising from the new technologies are creating the prospect of a revolution in our system of education. Moreover, it makes it possible to reduce drastically adult illiteracy and low earning power caused by inadequate education, thus aiding the war on poverty.

The movement is in its early stages and there are many problems that will have to be resolved before our society can take full advantage of the new technology for educational purposes. This report has been prepared in the hope that it will serve to point up recent developments and delineate some of the current issues in this field.

Sincerely,

WRIGHT PATMAN,
Chairman, Joint Economic Committee.

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AUTOMATION AND TECHNOLOGY IN EDUCATION

Introduction

The Nation has long recognized the great importance of universal education and rapid technological advance both to the health of our free political institutions and to the prosperity and growth of our economy. Only recently has it become obvious, even to experts, that these two forces in American life are merging. Developments in the storage, processing, and communication of information arising from the new technologies are creating the prospect of a complete revolution in our system of education, both public and private.

The Federal Government's activities in the fields of training and education have expanded appreciably in the past few years. The Federal budget contains substantial aid for scientific and technological education and provides extensive support to schools at all levels. The poverty program has added to the demands on our educational resources: success of the Youth Corps, the Job Corps, and the adult basic training programs, particularly, depends primarily on learning.

In his message of March 1, the President characterized the education of our people as a national investment and set for the future the goal of full education for every citizen up to the limits of his capacity to absorb it. The President has proposed for the coming year a total Federal investment in education and training of over $10 billion. Among the elements in the program are the adoption of special educational aids for approximately 12 million children who are handicapped physically or culturally; elimination of illiteracy within a decade; reduction by half in the number of school dropouts; provision of public library services to 15 million Americans who do not now have them; guaranteed opportunities for higher education on the basis of ability to learn; and construction of facilities needed to take care of 9 million college students by 1975. In addition, the President has recommended to the Congress expansion of the Headstart program for preschool children; strengthening of the Elementary and Secondary Education Act of 1965; expansion of Federal assistance in higher education; and improvement of the Nation's libraries. That a predominantly bipartisan effort in the Congress has resulted in an expansion of these programs is indicative of the national concern and support for educational growth and modernization of our educational plant.

The National Commission on Automation, Technology, and Economic Progress observed, in its recent report, that unemployment tends to be concentrated among those workers with little education—"not primarily because technological developments are changing the nature of jobs, but because the uneducated are at the 'back of the line' in the competition for jobs." In this connection, the Commission stated that "adequate educational opportunities should be available to all" in order to facilitate adjustments to change, as well as to

improve the quality of life. Recommendations in the report include compensatory education for those from disadvantaged environments, improvements in the general quality of education, universal high school education and opportunity for 14 years of free public education, elimination of financial obstacles to higher education, lifetime opportunities for education, training, retraining, and special attention to the handicaps of adults with deficient basic education.

The Employment Act of 1946 directs the Joint Economic Committee to make continuing studies of matters relating to employment, production, and purchasing power. In the course of its many studies since the act was passed, the committee has periodically examined the effects of automation on the performance and development of our economy, particularly its implication for production and manpower. Recently many applications of automation have focused on the communication of information and its measurement, translation, and retrieval. In line with this new trend, a substantial amount of business investment and resources has been devoted to the possibilities of applying technological innovations to the rapidly expanding requirements of education.

This convergence of expanding demands on our educational system and the dramatic breakthroughs in the field of communications technology during the past decade has far-reaching implications for the economy. For this reason, the Subcommittee on Economic Progress devoted 3 days of hearings to the subject early in June 1966. Eight witnesses were heard, representing the industries engaged in developing new technology for education; experts in the field of educational research; and officials of Federal, State, and local government. The hearings served to highlight the challenge of educational requirements for public policy, as well as our great need for coordination and imagination in adapting our skills and knowledge to the expansion and improvement of learning.

This report is necessarily selective in its review of issues which were raised in the hearings. In addition to providing greater detail concerning some topics discussed here, the record of the hearings—published in a separate volume—deals with other recent or prospective developments in automation and technology as they affect education.

Dimensions of Educational Needs

Expenditures on education constitute a significant part of our gross national product—approximately 6 percent. Moreover, they are growing rapidly. Direct expenditures for formal education in elementary schools, high schools, and colleges increased from approximately $18 billion a year in 1955 to a current level close to $40 billion. By 1975, these outlays are expected to increase by another 50 percent, reaching $60 billion a year (in 1963–64 dollars). The rise is caused mainly by increases in enrollment at all levels of education, especially high schools and colleges, and rising costs, including, of course, teachers' salaries.

Tables indicating anticipated increases in expenditures for education by level of instruction and the increases in enrollments through 1975 are included in the record of the hearings in the Appendix (pp. 209–225). These tables were prepared by the Office of Education, Department of Health, Education, and Welfare, and published as part of its projections of educational statistics to 1974–75.

According to the Office of Education analyses, annual current expenditures per pupil in public elementary and secondary schools increased from $321 per pupil in the school year 1954–55 to $478 in 1964–65, and are expected to increase to $660 by 1974–75. Figures are in 1963–64 dollars.

The annual cost per student in institutions of higher learning rose from $881 in 1954–55 to $1,220 in 1964–65, and is expected to climb to $1,537 by 1974–75. These costs also are expressed in 1963–64 dollars. They relate only to education expenses, omitting auxiliary items, organized research, and other related activities of the institutions.

Total enrollment in U.S. educational institutions rose from 36 million in 1954 to 53 million in 1964 and is expected to be 63 million by 1974. This total covers regular public and nonpublic elementary and secondary schools and degree credit enrollments in institutions of higher learning, but does not include private vocational schools or enrollment in noncredit courses at institutions of higher learning.

Federal Government Role

An appreciable part of the Federal budget is devoted to education. As is evident in tables in *Special Analysis G of the Federal Budget for 1967*, these expenditures are reflected throughout the spectrum of Government functions. Expenditures from Federal budget and trust funds for education, training, and related programs were $5.2 billion in fiscal year 1965. They were estimated to rise to $8.4 billion in the current fiscal year—nearly 6 percent of all budget and trust fund expenditures.

During 1964–65, four-fifths of all U.S. outlays for education were financed through governmental budgets, local, State, and Federal. Major responsibility for public financing of education has rested traditionally on local governments, but the States and the Federal Government have increased their contributions substantially in recent years. The Federal Government provided 11.5 percent and State and local governments financed from their own revenues 68.5 percent of all educational expenditures in 1964–65. The rest was private expenditure by institutions, organizations, and individuals.

The Office of Education's projections suggest that the public share of the national total will recede slightly, to about 77 percent, and the nonpublic share will rise to 23 percent over the next decade.

If recent trends in governmental financing continue, the Federal Government is likely to be financing in 1975 significantly more than its present 11.5 percent share of all U.S. educational expenditures. But even if the Federal share remains unchanged, this portion of the $60.9 billion total estimated for 1975 would add some $2.6 billion a year to Federal Government expenditures (in 1963–64 dollars).

Research and Development

It has been said that even now, when we are in the midst of the current "knowledge explosion," the education "industry" of this country devotes less than 1 percent of its annual outlays to research and development. An industrialist, who is also a school board president, has been quoted as saying, "The aircraft industry would go out of business in 2 years if it changed as slowly as education."

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Dr. Richard Louis Bright, Associate Commissioner of Education for Research, was among the witnesses heard by the subcommittee. He has reported, in a recent article, the estimates of some experts that there is a 30-year lag between innovation in education and widespread adoption of the innovation. In fact, Dr. Bright noted, it takes about 15 years for the first 3 percent of school districts to make any given change.

"This," he said, "is a tragic truth in a time when education has come to be regarded as the heart of our society; tragic in a time when, for instance, innovation in medicine takes only 2 years to be universally adopted."

The Elementary and Secondary Education Act which the Congress enacted in 1965 has added a great new impetus to the invention and adoption of new techniques and new ideas for improving the productivity of educational processes and programs. The Higher Education Act of 1965 provides increased assistance for postsecondary education. Yet it appears that only the initial steps have been taken in this direction and that there remains a long and tortuous path from the research and development which produces valid new techniques to their effective general application in the learning process.

Prospective Demands in Relation to Capacity

The Office of Education's projections of aggregate educational outlays appear to be minimal. They do not take account of the need for great qualitative improvements. They provide for some reduction of the number of overcrowded or unsatisfactory public school classrooms but not for the full correction of such substandard conditions. They assume the continued use of many facilities which already are obsolete or inefficient or will become so during the next decade.

Moreover, the amount of knowledge to be communicated during the process of education is increasing in geometric progressions year after year. There have been estimates that as much technical knowledge will be developed in the next 30 years as has been accumulated in the entire past history of mankind. In this country alone, we produce approximately 25,000 technical papers every week, along with 400 books and 3,500 articles. Added to these rapidly growing demands on our educational system is the impetus of the civil rights quest, which devolves in considerable measure, on the schools.

Facing such prospective requirements, our educational system is threatened by a decline in relative effectiveness unless improved productivity can be brought to its aid. The majority of the witnesses before the committee expressed concern that it will not be possible to meet the rapidly increasing demands and to expand our educational enterprises adequately by traditional approaches—e.g., conventional buildings and facilities, traditional methods of utilizing teachers and other personnel, and existing organizational structure.

Technological Innovations

From such considerations springs the enthusiasm and the high expectations which most of the witnesses expressed for the application of rapidly developing communications technology—a technology

which appears to offer to educators many useful devices and combinations of devices. At the same time, these witnesses raised questions and emphasized the need for cautious appraisal—including most especially the clear definition of the objectives of educational efforts and evaluation of proposed innovations in the light of those objectives.

It seems clear that rapid and effective application of these devices and new techniques will require important adjustments within the educational system. The role of teachers and other educational personnel may be altered. Application of the new technology will require much more specific planning for the teacher-pupil relationship, with some departures from past dependence on improvisations and intuitive insights. It could result in a considerable rise in the proportionate importance of capital equipment employed in the national educational enterprise; and this, in turn, could have significant implications for the economical and efficient size of school attendance areas and administrative districts, and the financing of education.

Acceptance of such changes presupposes careful assessments of social and economic benefits and disadvantages associated with each proposed innovation. It requires clear demonstrations that the benefits of particular changes exceed their costs, both direct and indirect. Among costs and benefits to be considered are the possibilities that adaptations to future changes in educational requirements may be either hindered or facilitated by each current commitment.

Kinds of Equipment

The technological aids that were brought to the committee's attention include educational television, both open and closed; video tape; computerized instruction; the use of computers for student testing, guidance, and evaluation, and the storage, retrieval, and distribution of information; programed courses of instruction, teaching machines, particularly the "talking typewriter"; the use of microfilm and microfilm viewing equipment; and language laboratories. Also stressed was the "systems" approach to the development and utilization of educational technology. By this is meant the creative combination of a variety of skills and devices to produce desired results, an approach that is proving highly successful in the military sphere.

It was pointed out that computers can provide lessons tailored to individual needs so that the student can control the speed of presentation in accordance with his own progress. The presentation can be in written form, through pictures, either moving or still, by voice, or by various combinations of these. Likewise, the student responses can be made by typewriter keyboard, by pressing buttons, or by simply pointing a wand at a tube.

It is possible, through the computer, to provide students and teachers with a record of progress at any point in a course of instruction. It is also possible for the teacher to get analytical reports on the progress of students, so as to show areas of difficulty and rates of progress. Students can simulate the real decision-making process, such as running a business or a legislature. Perhaps one of the most exciting prospective uses is the possibility of establishing centers of information which a student could reach by a telephonic device and

receive a lesson or a formula, see a film, or obtain language instruction; in other words, obtain information in almost any form and in various media. The so-called talking typewriter, which some experts regard as impressively effective in teaching children to read, combines sight, sound, and touch in one device. Copying machines are proving very useful as an educational aid. Video tape, though still relatively expensive, makes it possible for groups to view themselves and analyze their performances. The use of film cartridges in individual projectors, particularly, could be an aid in biology where it would be possible to see growth speeded up, or in physics where events may be slowed down to permit study. In addition to teaching possibilites, computers will become increasingly necessary in the administration and recordkeeping of schools and in the management of libraries.

A majority of the witnesses heard by the subcommittee were of the opinion that technological teaching aids, properly used, can help substantially to improve both the quality and quantity of education. They can do so by providing more flexibility in both the organization and the operation of schools and permitting each student to realize more fully his unique talents and capacity. They also serve to relieve teachers of much of the drudgery and drill that is now part of the educational scene, and permit them to give more time and talent to those teaching responsibilities and on-the-spot complications that require personal attention to individual pupils.

Automation is expected to help particularly those students engaged in independent study because it makes it possible to receive programed instruction when and where it is needed. This prospect increases greatly the opportunities for continuing education throughout the adult years. As one of the witnesses stated, it will

> make possible, from the standpoint of personal facilities, cost, and convenience, the magnitude, the diversity, and the quality of education that will be demanded and required by a society that is fast becoming a continuous learning society, and thus expand educational opportunities—downward, upward, and throughout the age range of our population.

In summary, it may be said that technology makes it possible to convey information in a far more flexible and, potentially at least, effective way than can be managed by an overburdened teacher, standing in front of the classroom. However, there is one big proviso: equipment must be properly programed inasmuch as its performance depends entirely on what is put into the machine. The pressing need for adequate educational "software" to be constructively employed by the new machines was repeatedly stressed. Moreover, equipment is still highly developmental and experimental. Most witnesses cautioned about the need for considerably more research and more imaginative use of existing techniques, as well as for the development of competence in programing.

Fundamental Prerequisites

The testimony indicated clearly that the application of technology to education is in an elementary stage. Much programing of teaching devices was described as poor, and the equipment now in use apparently is still fairly primitive. There is great need for more research,

not only on the application of technological devices, but also on the learning process itself. The subcommittee was impressed with the emphasis placed by most of the witnesses on the great need for knowing more about human psychology, particularly how the individual learns. In the circumstances, the formulation and adoption now by the educational community of guiding principles for development and application of educational technology would contribute immeasurably to health development of new systems and would help avoid waste of resources. A number of general problem areas were discussed in the course of the hearings.

For one thing, there is insufficient coordination between industrial firms which are developing educational equipment and machinery and the educators who are concerned with communicating knowledge and "opening the minds" of the young so that they may be prepared to originate and evaluate new ideas. It appears that the vital function of programing—preparation of the content of education—is falling too frequently to the "hardware" manufacturers when it should be handled by educational experts. What is needed is a better fitting of means to objectives.

Educational technology is now a major field of corporate research and investment. It is not only the business equipment manufacturers who are involved, but a great variety of corporations, many of them among the giants, ranging from steel and chemicals to publishing firms, who are directing their efforts more to the burgeoning education market. One witness stated:

> The American economy was built around the railroads in the last half of the 19th century, around the automobile in the first two-thirds of this century, and it will be built around education in the balance of this century.

What seems to be called for is broader and better research into the means whereby schools can be made more effective, utilizing the available range of technology, and taking full advantage of what we do know about the learning process. With this must come an establishment of institutions for coordinating the development and evaluation of new educational programs and equipment, thus permitting the schools to utilize them in the most effective way.

As of now, it is pretty much on a catch-as-catch-can basis between individual companies and individual school districts. By and large, educational systems throughout the Nation have little means of evaluating new developments, let alone obtaining and putting them to use. The result was described by a witness as "a shallow penetration by the technologists into education." Coordination would also make possible the development of systems—integrating a variety of mechanisms and skills—in order to achieve defined objectives in education. The so-called systems approach to defense production requirements has been an outstanding success and has involved a high degree of cooperation between large numbers of specialists and the producers of a broad variety of industrial skills and products.

At present, it appears that we do not have any established procedures for translating new techniques and technologies from the design stage to the classroom—at least not on an appreciable scale. Nor is there evidence of extensive long-range planning among educators themselves. Clearly there is great potential in the use of electronic

and other modern communication skills to advance education. But before this can be done, there must be much more imaginative work done in matching equipment and capabilities to learners' capacities and aptitudes, as well as social objectives and individual needs. Witnesses stressed that this undertaking will require the best thinking of our culture and should enlist the combined resources of the schools, the universities, the industries producing educational technology, and related enterprises.

In essence, the potential contribution of technology to our educational needs will be governed by the following factors:

(1) Effectiveness of research in learning theory and its application to the development of education;

(2) Improvement of curriculum programing, particularly in respect to defining and meeting educational objectives;

(3) Organization of our school systems and intelligent planning of curriculum;

(4) More effective use of teachers; and

(5) Recognition on the part of teachers and educators of the great potential inherent in the new communications technology.

The foregoing requirements will be fostered by a cooperative participation of educational institutions, government agencies, and the affected private industry. They will have to collaborate both in planning and producing systems of technology that are geared to the genuine needs of the students.

Economic Effects

Traditionally, education has not been capital intensive. Expenditures for the most part are in terms of salaries and other personal services. Capital investment has been almost wholly in real estate, furniture, and books.

The prospective increased use of expensive communication equipment and systems involves much greater capital investment in equipment, and the employment of technicians to install and maintain it. This is a new phenomenon in the field of education. Educators who think primarily in terms of operating costs for classroom teaching will be required to change their accounting notions to accommodate certain fixed costs for instructional equipment to be amortized over time.

It was indicated in the course of our hearings that experiments in the use of computer systems reveal that to receive widespread application the amortized cost of computerized instructional equipment should not exceed 25 cents per student-hour in elementary schools and 50 cents per student-hour for special education. Converting these student-hour costs into initial-capital costs, the experimenters have come up with a figure of somewhere between $2,000 and $4,000 per student console as the feasible price range. It was predicted that this price objective might possibly be reached in a few years. It was also estimated that after specific curriculum objectives are established, the proper programing of such equipment would cost approximately $4,000 to provide material for 1 hour for an average student. However, once invested, this sum could be spread over any number of students using it over a considerable period of time—provided, of course, the initial programing is done competently and is not rendered obsolete by extraneous developments.

Proper use of technology will call for the revamping of conventional organization and construction of schools. Significantly, new technology has brought about major revisions in the construction of industrial plants, as well as in their location, management, and mode of operation. Unless there are similar accommodations to new technology in the education field, our schools shall fail to achieve their true potential. Also, it should be noted that increased capital costs for schools will tend to widen the gap between the education offered by the wealthier school districts and that offered by the poorer school districts.

Manpower

A reassuring prospect on the educational scene is the outlook for an increase in the available supply of teachers, relative to demand. During the past decade there has been some improvement in the pupil-teacher ratio in both public and nonpublic schools, elementary and secondary. Recent studies indicate that for these schools in the decade ahead there will be larger numbers of qualified teachers in proportion to enrollments than at present.

For higher education, trends and prospects differ somewhat. The decade ahead is expected to bring an increase of about 3.8 million students, to an enrollment of 8.7 million in 1974. A continued shortage of teaching staffs is expected through 1970, as severe as that of 1960–65. After 1970, however, the potential supply of college teachers should be larger relative to enrollments. This result is expected because the rate of growth in enrollment will slow down and the output of doctors of philosophy will be expanded greatly.

These prospects for relative improvement in the number of qualified teachers, if realized, will relieve to some extent the pressures which might otherwise arise for introduction of new technological devices as a means of alleviating teacher shortages. Nevertheless, this development is not expected to reduce the importance of automation as a means to improve the quality of education and to permit more productive uses of teachers' time.

Information Centers

It was pointed out to the subcommittee that there is now no disinterested center of comprehensive information for educators about the availability and usefulness of new techniques and technology. There is no pooling of information, although there is obviously a great need among educators for some kind of clearinghouse to keep them posted on innovations. It was proposed that a major clearinghouse in the nature of a data bank be established to provide a registry of educational research and a file of completed research findings. Such an institution could also serve to make available an indexed locator file of educational programs, computer or otherwise, and possibly to store programs. It could act as a referral center for agencies and businesses to undertake development of specified programs and systems. Such an organization might also provide a useful source of stimulation to needed research and development and might maintain a file of experts and consultants. The subcommittee is impressed with the great

value that might inhere in the establishment of a data bank of this kind, utilizing the most advanced data processing and communicating techniques and equipment.

Special Application: Adult Education

The subcommittee is impressed with the fact that talking typewriters and other communications equipment now in the developmental stage are particularly well suited to teaching adults. They permit privacy of study and flexibility as to time and place of utilization. As one of the more immediate objectives of technological innovation, our Nation might well concentrate on the elimination of adult illiteracy. We know that illiteracy is a major drag on our economic progress and a heavy expense.

Several economic studies have established that higher education has a measurable economic value in our society—a value which generally takes the form of higher lifetime productivity and earnings for individuals with higher education than for those without it. Estimates relating to elementary and secondary education are more limited in scope, but studies in this area likewise suggest that schooling adds appreciably to individual productivity, and, earnings and yields a high rate of return on investments made by families and society in education.

Specific measurements of the costs of illiteracy and the benefits which might be gained from its elimination are not available, but it seems certain that elimination of illiteracy will prove a highly productive social investment for the United States. It would change people who are now a burden on the community into productive workers. Illiteracy is closely correlated with social maladjustment and is clearly an aggravant of social ills. Its elimination warrants high priority in the list of national objectives. It is a prerequisite to the effective elimination of poverty.

There are convincing indications that imaginative application of existing technology can do much to facilitate progress in overcoming illiteracy, and it is hoped that research and pilot projects will concentrate more on this subject than they have to date. Certainly, Federal aid programs in the fields of labor, manpower, welfare, poverty, and education should foster this objective. In these circumstances this subcommittee recommends that the administration marshal all available force promptly to eliminate this unnecessary and harmful blight, and submit to the Congress at an early date a coordinated program for achieving that objective.

Guiding the Revolution in Education

It is obvious that major corporations have moved into the field of educational technology and that in some cases, through default, they have taken over the crucial function of preparing the content of educational programs. The development of educational technology by corporations has produced a rash of mergers in order to combine skills and know-how to meet the needs of this newly developing market.

It is essential, of course, that the tremendous technical know-how of our society be directed toward solving problems in this area of great

social need. There is danger, however, that many school systems and educational institutions may be committed for many years to unsuitable or inadequate teaching equipment and programs, simply because the large investments required to produce and install any equipment and program, and to train teaching personnel to use them, will preclude reconsideration of choices once they are made.

Options for change must be held open. It would be tragic if control of curriculum and the content of courses were to pass by default into the hands of large corporate producers in the "hardware" or "software" end of the business. Teaching aids and devices should be developed to meet explicit educational objectives and needs, rather than to broaden markets for particular products.

It is imperative that educators maintain and safeguard their proper role as formulators of educational policy. In the years ahead, it should be a primary concern of public policy to safeguard this role while promoting the utmost improvement of productivity in our educational programs through the studied application of the new technology.

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