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ABSTRACT

The content of this report is based primarily on an assessment of the activities and plans of large companies currently involved in various phases of instructional technology, on an extensive review of reports published on the subject, and on the knowledge and experience of the author with similar studies. The report examines broad areas of industrial technological advancement likely to occur in the next ten years. It notes that almost anything of a technological nature that is desired can be done. Examples are cited of specific new products to be expected. A number of factors likely to affect the nature and extent of change in instructional technology are examined. The report notes two basic factors required for innovation: recognition of the need for change, and a conviction that the proposed innovation meets the need on the basis of cost related to benefit. The final section of the report suggests some of the basic problems which hinder the use of instructional technology in meaningful ways in education. (JY)

Innovations in Industry Likely to Affect Instructional Technology During the Next Ten Years

by Hugh Beckwith*

This report undertakes to examine technological developments likely to occur in the next ten years as a result of industrial innovation that can have a significant effect on instructional technology.

The content of this report is based primarily on assessment of the activities and plans of large companies currently involved in various phases of instructional technology; on extensive review of reports published on the subject; and on the knowledge and experience of this organization acquired in similar studies.

Every attempt has been made to make this report realistic. Yet it is only prudent at the outset to state several important caveats that should be applied to assessing its content.

1. The technological innovations described as likely to occur are not certain to occur. The pace of technological breakthrough and development is so rapid that progress can be a matter of leap frog advances rather than orderly progression from one point to another. The full benefits of a breakthrough often so far exceed the expectations of

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those who accomplished it that it has been necessary to coin words such as synergism and serendipity to describe the results.

2. While the companies from whom major innovations can reasonably be expected plan their activities well into the future, all plans are subject to change because of change in motivation, unexpected breakthroughs, new insights. There is also, of course, the possibility that significant innovations may come from sources other than those surveyed in this study.

3. The accomplishment of the technological developments described in this report does not necessarily assure that these developments will prove really useful as instructional technology. Nor would their usefulness necessarily mean that they would be widely used. Many developments in the past that seemed to hold high promise have not found widespread use in education. The reasons for this are rooted in such factors as economics, social attitudes, and human behavior.

This report is organized into five sections:

1. Broad Areas of Technological Advance

2. Examples of Specific New Products to be Expected

3. Innovation in Areas Indirectly Related to Instructional Technology

4. Basic Factors Required for Innovation to Occur in Education

5. Basic Problems in Accomplishing Innovation in Education

It is recognized that the scope of the work assigned to this organization could be encompassed in the first two sections listed above, and this is where major emphasis has been placed. However, consideration of technological advance alone without taking into account the implications of its application can result in distortion in its evaluation. Therefore, we have broadened the scope of our work to include Sections Three through Five.

BROAD AREAS OF TECHNOLOGICAL ADVANCE

This section examines the broad areas of industrial technological advance likely to occur in the next ten years.

It also introduces a theme which will recur throughout the report. Most people interested and involved in the developments that are to come share a common conviction. Almost anything of a technological area that it is desired to do can be done.

All of the developments which are treated in the following pages are part of the evidence that supports this belief. Further, as these developments are considered, it is possible to see the dependence of one development on another, and the relationship of one step forward to every other step.

Perhaps the single most important factor in the near and long term future of technology, including instructional technology, will be the computer.

More and more of our present activities will be computerized and new activities will grow out of the increased ability to computerize. The use of computers will proliferate to a point where a "computer utility industry" will evolve as basic to the country's economy as the power utility industry is today.

As this occurs, remote input and output devices tied to giant central computers, and in some cases individual computers, will become essential to the operation of businesses, schools, and, quite probably, homes. The skill to use these devices will become as essential and as commonplace as the skills required to use a telephone or drive a car are today.

Currently, the cost of using computers in many of the ways envisioned for the future is prohibitive. This is changing rapidly. The accelerating progress of the basic electronics technology used in computers is already making significant cost reductions possible. For example:

It has only been twenty years since the first practical application of transistors was made, only ten years since the first integated circuits were developed and only about one year since large scale integration of circuits was accomplished. The results of these three developments has been remarkable. They have:

Decreased the cost of electronic circuits by 100 times or more.

Decreased their size by a factor that may approach 10,000 times.

Increased their reliability by a factor of 1,000 or more times.

This kind of progress means that it will soon be feasible to use computers for any desirable purpose. Specifically, in education the possible uses for computers and the implications of their use seem to fall into three areas:

As data processing tools, for scheduling, grade reporting, billing, payroll handling, facilities utilization analysis, etc.

As a subject field to be included in the curriculum.

As an instructional medium, probably in several variant forms such as computer assisted and computer administered instruction.

In addition to these principal areas of anticipated use, computers are likely to be employed for such purposes as analysis of the use and effectiveness of instructional materials and of the techniques of preparing such materials.

The subject of computer assisted instruction is treated specifically later in this report. From a broad technological standpoint two points should be made in summing up the potential for computers. First, they will play a major role in the most fundamental changes in technology for the rest of this century. Second, education will share in the change and will be changed by it.

Another broad technological innovation likely to affect instructional technology in the next decade is holography. This photographic technique, which may employ lasers, records wave fronts of light from an object. These are then used to reconstruct an image of the object in true three-dimensional form. This will make possible three-dimensional photographs, printed illustrations, projected slides, motion pictures, televised pictures, images at computer terminals, and microscopic slides. While the theoretical use of holography has been possible for some time, the employment of lasers is a recent development and represents a real breakthrough. "Scientific American" commenting on the development, states that a "holograph may prove as useful, for optical purposes, as the actual object itself...perhaps even more useful." Refinement of present capabilities in this area will greatly increase the effectiveness of all visual communication.

Lasers, which play a part in holography, will have a great effect on a wide range of human activities. The most important area may prove to be in the field of data transmission. Lasers utilize frequencies much broader than those used by current broadband communications. This will make it possible to transmit enormously increased amounts of information, perhaps as much as one million times more information, at far less cost.

Ultimately lasers may make it possible to transmit data, in such forms as three-dimensional television, facimile, voice, etc., in quantities great enough to accommodate any reasonable demand.

When this ability to transmit data becomes a reality it will, of course, be necessary to greatly increase the capacity to manage what is transmitted, to store and retrieve it easily in meaningful form. This demonstrates the interlocking nature of technological innovation, one breakthrough demanding another and making possible still another.

The use of computers will make management of data transmission and its storage and retrieval a great deal easier. So will another development ... microforms.

Microforms have already moved into the second stage of their development, microfiche, and are moving to a third stage, ultra microfiche. The effect of this development on the capacity to store information is so great that it is difficult to comprehend. It is presently possible to store the contents of 20 average sized volumes on a 4" x 6" film strip. It has already been demonstrated that using lasers to reduce data signals, as many as 20,000 volumes can be stored in an area of 8" x 10".

Obviously the use of computers to catalogue and retrieve data, along with improved low cost data transmission systems and low cost printers and readers that are convenient to use, can revolutionize libraries in terms of what they can contain and how they can be used.

The next ten years are likely to see much more widespread and more sophisticated use of communications satellites for direct broadcasts to schools and homes. The previously described breakthroughs in the use of lasers, improvements in data transmission, storage and retrieval, will play a part in the increased use of communications satellites. This, along with improvements in computers, tape players, and film projectors, will greatly increase the potential for individualized instruction in audio and video forms, programmed and non-programmed.

It is the intent of this report to highlight the significant breakthroughs in technology likely to occur in the next decade. The developments discussed thus far have, therefore, been treated as just that, highlights, described in brief detail. Nevertheless, it is possible to see ample demonstration of the fundamental accuracy of the belief, widely held by those who are seeking technological breakthroughs, that; Almost anything of a technological nature that it is desirable to do can be done.

Hopeful as that statement may seem, there are thoughtful people who are disturbed by what it can mean. Such people fear that our ever-growing technological capabilities will so far outstrip our ability to manage what is accomplished that we may be confronted with chaos instead of progress.

The concern is not without basis, and the question is dealt with in somewhat more detail later in this report. It can be pointed out here, however, that there is already technology in existence, likely to be improved, that can help to deal with revolutionary change not as an avalanche but as a tide of progress.

For instance, the science of cybernation, the development of systems which can control, extend and correct themselves, is keeping pace with the other areas of technological progress. This is likely to make possible the creation of highly complex systems of much greater reliability, systems which will employ automation to develop one-of-a-kind variations. Such systems will, it is likely, be capable of empirical self-analysis and of self-adjustment to perform in the most appropriate and effective ways.

So far automation and cybernation have found their widest use in manufacturing processes. But there have already been significant breakthroughs in the use of these remarkable tools in the business management area. These developments may well find a place in the management of the educational process with a resultant improvement in the understanding and control of learning environments and activities.

The development of this capability will not, however, guard against the human frailty of doing things that are possible but not sensible.

There are many instances today where technology is misused, where its use interferes with rather than enhances the educational process, and where people could accomplish the objective better and at lower cost than machines do. Unless the intended use of technology is put to rigorous examination, the phenomenon of technological misuse is not likely to disappear.

There is yet another area of development which must be noted. Progress in the chemical, physical and biological sciences seems to have opened the door to the possibility of literally changing human beings, in the genetic and later stages of life, to provide increased capacity and motivation for learning. While this possibility raises highly complex moral, ethical and sociological questions, no one exploring the future can ignore the implications. Certainly any such improvement in the human capacity to learn, remember and apply knowledge, would have incalculable impact on education in the future.

EXAMPLES OF SPECIFIC NEW PRODUCTS TO BE EXPECTED

Almost all the hardware now in use in instructional technology will become more reliable and offer greater flexibility in application. Such hardware will be easier and more convenient to use and, in relationship to what it will be able to do, less expensive than is presently the case.

There will be new products on the scene and the usefulness of existing products will be extended to permit new uses as well as improvements in present applications. Some of the things that may be expected are:

Rapid, high quality copying of printed material at low cost, perhaps as low as $.01 per page, in black and white and subsequently in color.

Large screen television display systems at acceptable costs.

Combination television receivers and motion picture projectors. Association or combination of video tape and film technologies to produce more flexible formats at lower costs.

Packaging of software in relation to hardware to produce more convenient, reliable, accessible use.

Long lasting, inexpensive (perhaps $20 or less) television receivers that can be optionally operated on battery power.

Inexpensive, easy to operate video tape players and recorders.

More rapid, lower cost copying of video tapes, and perhaps film, possibly with equipment which can logically be located at school sites rather than in central processing centers.

Small, battery operated, two-way telephones.

Light-weight, small, perhaps textbook size, microfilm and microfiche readers.

Use of microfiche technology to provide rapid random access, large capacity slide projection.

Television screens which will be able to receive an image and retain it as long as desired without the need to regenerate the signal. These screens will also make possible the display of overlays or other images.

Stand alone devices which will be, optionally, computer interfacable and will present audio and video information which can be programmed to require and measure student response.

Much lower cost computer terminals. Substantial progress should be made in this field within five years.

The foregoing list relates primarily to items that are commonly called hardware. In addition to these developments and others which will undoubtedly come, it can be expected that greatly simplified methods for preparing various kinds of software will be developed.

Of all of these developments perhaps most important of all will be the creation of large quantities of instructional materials which will have precisely stated objectives and will include diagnostic preinstruction tests and criterion achievement tests.

These materials will be available in many of the forms listed above and others, including books. Many of these materials will involve the student in the learning process, require active response from him, permit him to progress at his own rate, and will allow him considerable control and direction of his learning activities.

When new instructional technology is considered, books frequently get little attention. Yet these oldest of instructional tools are likely to share in the benefits of much of the technological progress cited above. More economical and rapid techniques for printing are in the offing which will make it possible to publish a greater variety of printed materials, and make it more economical to use color illustrations.

INNOVATION IN AREAS INDIRECTLY RELATED TO INSTRUCTIONAL TECHNOLOGY

A number of factors are likely to affect the nature and extent of the changes in instructional technology in the next ten years. These factors include:

Changes or lack of change in other aspects of education.

Access to the educational environment...that is the location of the school, the ease or difficulty with which it can be reached, the ability to place some of the educational environment in the student's home.

The management and regulation of the educational process.

Among the innovations that seem most likely to affect instructional technology in indirect ways are these:

Educational Environment

More sophisticated architectural engineering, accomplished at least in part through utilization of computerized analysis, which will result in such things as stressed shells, pressurized skins, and geodesic domes.

Improved building materials which will affect building exteriors and interiors, providing such things as more efficient and economical lighting, temperature, and ventilation.

As a result of factors like those listed above much lower cost buildings.

Much more economical and efficient methods, perhaps utilizing lasers, for making excavations that will make underground building far more feasible than it is today.

Physical Access to Education

Much more prevalent and convenient mass transit, perhaps including moving sidewalks.

New forms and uses of underground transportation.

New power sources for transportation from new forms of storage batteries, power cells, etc.

Another approach to access to education may entail the use of equipment which the student can take home to recreate part of the environment found in school.

Management and Regulation

The purpose of this brief section is not to debate the issue that if education were run like business, business would be out of education (or conversely that education would be out of business). It is demonstrable, however, that there are managerial techniques used in business whose use in education will be innovative and are likely to occur.

Two of the more obvious of these relate to procurement methods and to cost/effective measurement.

<u>Equipment Procurement and Leasing</u>

Currently, education buys most of its equipment. Obtaining funds for the purchase of new equipment, particularly equipment related to instructional technology, is difficult. Procurement is further complicated by educators' concerns that the equipment to be purchased may become obsolete before it has been used long enough to justify its cost.

In many instances both of these problems could be solved, or at least ameliorated, if equipment were leased instead of purchased. If acquisition of equipment were analyzed from the standpoint of use rather than ownership, the funding requirements could be quite different. They might, for instance, be related to operating funds rather than capital funds. Where there are concerns about obsolescence, renewal options could be built into leases which would allow schools to trade equipment in on newer models or to get rid of it.

Many variations of leasing are in common use in business today. Further effort on the part of education to develop leasing methods which best suit its needs would, in our judgment, meet with cooperation and flexibility from most companies which provide products for education.

With regard to instructional technology, leasing would seem likely to apply more to hardware than software. However, looked at from another standpoint, great improvement in the ability to duplicate many published materials will also tend to make it possible, and perhaps essential, to approach the acquisition of some kinds of software from the standpoint of paying for its use rather than for its purchase.

Analysis of Costs and Benefits

As pointed out in the July 1968 Committee for Economic Development Report: "Innovation in Education" and in other authoritative sources, greatly increased use of appropriate instructional technology requires more effective and specific analysis of the costs and benefits involved. This means analysis not only of new or proposed technology but also of current practice and costs.

One disillusioned instructional technologist has described the problem implied in the foregoing as follows: "The reason so little instructional technology is used in education today is that its visible faults always end up being compared with teachers' invisible virtues."

Methodology and technique for analyzing the cost/effectiveness and cost/benefit of alternative and new courses of action, including intangible factors, exist today and are frequently used in business to evaluate such things as research and development projects, marketing operations, etc.

Analysis of the management techniques developed by business, and application of those methods and techniques appropriate to education, will result in innovative improvements in education's decisions on whether, what, and how to use instructional technology.

It is not this report's intent to oversimplify the problems involved in making realistic cost/effective studies of instructional technology and of current educational practices, but it is the intent to:

1. Reinforce the point made earlier that enough products have already been developed to lend credence to the proposition that almost anything of a technical nature that is really desired from technology can be accomplished.

2. The means to evaluate current educational practices and instructional technology on cost/effective and cost/benefit bases largely exist and are currently applied in other fields.

3. Developing and applying the appropriate ways for education to evaluate what's old and what's new can be done right now. Doing this, in our judgment, holds greater promise, both in the short and long range, for introducing and expanding instructional technology in meaningful ways than almost any technological discovery or invention that can be envisioned.

BASIC FACTORS REQUIRED FOR INNOVATION TO OCCUR IN EDUCATION

For innovation in education to occur in any significant way, particularly for new instructional technology to be adopted, there must first be a recognition of the need for change and a conviction that the proposed innovation meets the need on the basis of cost related to benefit.

For there to be useful innovation, the educational community must believe strongly that there is a definite need to do something new or to change something old. At the same time the general community which supports education must also recognize the need and be prepared to pay for the efforts to meet it. Unless there is a clear and definite recognition of need, the taxpayer will be reluctant to see money spent on innovation while the educator will be hesitant to encourage it because of the disruption that change usually brings.

Obtaining maximum value from instructional technology also requires coordination of all of the elements which are likely to affect and be affected by it. That is, faculty, administration, physical site, available software and hardware, must all be seen as a part of the total picture. Only by doing this can appropriate and realistic goals be identified, pursued and accomplished.

It is apparent that a great deal of instructional technology, with the capacity or the potential to improve the educational process, already exists. Whether or not it will be employed to accomplish that improvement depends on the ability to recognize the need for innovation and to evaluate the worth of the various approaches to accomplishing it. In short, the real need for innovation may be in areas of how instructional technology is introduced, managed and measured.

BASIC PROBLEMS IN ACCOMPLISHING INNOVATION IN EDUCATION

This final report section does not presume to reflect all the views or even the majority of the views and frustrations of people in industry who attempt to provide products for education. It is reasonable to believe that various people in industry who are knowledgeable about current educational practice would disagree with some of the statements that are about to be made. What this section of the report does attempt to do is state problems which many people believe exist. The solution of these is fundamental to making the use of instructional technology more meaningful in education.

Foremost among these problems, many people believe, is education's unwillingness or inability to accept and use instructional technology already available.

There are a great many reasons why some educators delay accepting new technological possibilities. Some of these reasons are rooted in common sense and others are completely invalid. Because they may wish to wait for the next product or service or improvement before acting, and because there is always a "next product" in the offing, some educators wait forever without acting...even when the value of an innovation has been demonstrated and its economic practicality is clear.

It is recognized that the NIH (Not Invented Here) syndrome is common in business, particularly among people engaged in trying to find new technological approaches. Some people contend, however, that there is a particularly virulent case of NIH in educational circles, causing automatic rejection of a new idea or, at the least, violent tampering with technology developed and proven in some other institution or setting.

There are, in some educational circles, doubts as to whether instructional technology means teacher extension or teacher extinction. Examination of the implications of valid instructional technology will, of course, show that it is not only not a threat to good teachers but is instead a way of enhancing the importance, effectiveness and satisfaction of their job. Nevertheless, if those who feel threatened by technology are not reassured, their fears can be as destructive to innovation as if they were well founded.

There is, of course, another side to this. Many new teaching approaches coming from technology have been presented as the means to replace teachers. This has turned out to be nonsense. But if industry persists in offering products of technology as teacher replacers and not as teacher extenders, then teacher fear of technology will also persist.

In more specific ways, basic current problems of introducing instructional technology can be listed as follows.

There is fundamental need for agreement on learning objectives stated in performance terms, to make achievement of these objectives measurable, and to make possible comparison of new and current practices.

More effective means of testing, guiding, and measuring each student's progress are required.

Development of enough instructional material of high enough quality to permit individualized instruction is needed. The amount of media used by a student in an individualized learning program is many times greater than that required by a conventional program. This material can, and in due course will, be produced. However, until substantial use is made of material already available and proved effective, large quantities of additional material cannot be expected from publishers. Nor is it reasonable to assume that this need will be adequately filled by education itself.

A further aspect of this problem is the need to develop adequate copyright protection so that producers of instructional materials can be recompensed on their use rather than on the sale of material of which duplicate copies are then made.

The whole question of teacher training, pre-service and in-service, presents substantial problems in relation to instructional technology, particularly as it relates to individualized instruction.

Effective individualized programs depend in large measure on pre-testing of students, diagnosis of learning problems and accomplishment, prescription of appropriate instructional materials, and tutorial instruction. Teacher training programs currently do not emphasize these matters, and the requisite skills to deal with them are not acquired by future teachers in their training. This problem is, of course, complicated further for the new teacher who may also be asked to understand the use of such materials in conjunction with relatively complicated hardware.

The problem of in-service teacher training is similar, but because of the logistics of geographic dispersion and time even more difficult to solve. One course of action that appears likely to occur is much greater involvement in teacher training by producers of instructional materials. This may lead to the further development of private industry undertaking to market to education teacher training services related to instructional technology.

The viability of such an effort will depend not only on the quality and relevance of such services but as importantly on their acceptance and economics, as, in fact, will the participation of industry in all of the areas of instructional technology. Business must show a profit. It will pursue those markets where profit is possible.

One of the most basic problems is that of school organization and administration. Questions of certification, accreditation, allocation of funds between salaries and media, all pose limitations and restrictions even in areas where there is strong motivation to innovate.

Given the motivation to do so, it is probably possible to deal with and change these matters in due course, but many people wonder how this motivation in a sufficiently massive way will develop. As long as teachers are trained to perform in a conventional setting, and this setting is administered by former teachers who were also trained and are now ingrained in the conventional ways, it is difficult to see how education will ever be able to change itself. If not, the further question is raised whether change can or should be brought about by forces outside of education such as government and business. If the latter, a whole new set of troublesome problems is raised.

The direct involvement of government and business has, of course, occurred in some specialized educational efforts, the Job Corps, for instance. The successful aspects of this program might serve as a model for taking the effort further. However, problems such as how to apply elements of another program, like the Job Corps, to already existing schools appear to b^ particularly sticky.

A particular area of instructional technology which has received a large amount of attention is computer assisted instruction. In the minds of some people CAI has now run the full gamut from panacea to the opprobium formerly reserved only for teaching machines.

As the most sophisticated form of instructional technology now known, a brief examination of its past and present and some speculation about its future should shed light on the subject itself and on other aspects of instructional technology.

It was presumed by many early enthusiasts that CAI would take over most teaching on an individualized basis, not only in drill and practice and tutorial forms, but also in flexible dialogue modes that would allow the student not only to control his own progress rate but also to control the paths of progress in diverse and relevant ways. This has not occurred.

Some of the early enthusiasts have now not only backed away from this concept but have relegated the computer in education solely to administrative housekeeping tasks. Why has there been failure to achieve the early dreams and why the disillusionment?

There are a number of reasons. The development of programs which have instructional validity has turned out to be extraordinarily difficult. Communication between student and computer has been awkward. Costs have been prohibitive. With these problems and others, acceptance in education has been minimal. Is this the end of the road? We do not believe so. For instance, work being done on computer based education in the PLATO Project at the University of Illinois has these guidelines.

"1. Normally the computer should only be used when it is the best method of presentation. Less expensive methods such as program texts, films, slides, tape recorders, etc., should be used when appropriate.

"2. The computer should be used as much as possible to simulate results in models built by the students rather than simply turning pages.

"3. The system must be flexible and adaptable. It must be able to teach many subjects and present the lesson material by a variety of teaching strategies. The system must change to meet the needs of the students and teachers, and not be limited to off-the-shelf items presently available.

"4. The system design must consider its method of integration into the educational system. For example, a school should be able to start with a single terminal for the incremental terminal cost instead of having to invest large sums of money just to determine if they want or need computer-based education.

"5. The cost of computer-based education should be comparable with the cost of teaching at the elementary grade school level. Cost effectiveness should be determined by an hour to hour cost comparison."

We believe that the work being done in Project PLATO holds promise that these guidelines can be met from a technical standpoint. Key among the guidelines, in our judgment, is the first one: "Normally the computer should only be used when it is the best method of presentation. Less expensive methods such as program texts, films, slides, tape recorders, etc., should be used when appropriate."

Looked upon this way, we believe the computer, as a result of work being done in many other places as well as in Project PLATO, will find a highly significant place in the educational process. Its acceptance in education, however, will be affected by many other factors which have been referred to earlier.

This report has suggested in a number of places that the key to the amount of instructional technology that will be used in education is the ability and motivation of education to accept it. Despite prime consideration given to this point, it seems appropriate to conclude with the further point that even given sufficient ability and motivation to employ appropriate instructional technology, adequate funds will be essential. New money and reallocation of funds currently expended in education for other purposes, must be made available for research in appropriate subject fields and for the introduction of new educational systems which utilize instructional technology. Such systems must hold the promise of doing the job better and/or at lower cost.

New methods, techniques, technology in all fields almost always cost more and fail to perform as well <u>initially</u> as the old, proven ways of doing things. It is only after new ways have been used long enough to be refined and long enough for people to get used to them that the promise that caused them to be tried is realized.

It is unreasonable to expect education to prove to be the exception to this rule.