DOCUMENT RESUME

ED 279 319 IR 012 563

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TITLE Toward Transformation: How the Use of Technology to Improve Instructional Productivity Depends on Classroom Structural Reorganization.
PUB DATE 25 Oct 86
NOTE 9p.; Paper presented at EDUTEC '86, the All Japan Annual Educational Technology Research Congress (12th, Tokyo, Japan, October 25-27, 1986).
PUB TYPE Information Analyses (070) -- Viewpoints (120) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Audiovisual Aids; Computer Assisted Instruction; *Cost Effectiveness; *Educational Technology; Elementary Secondary Education; *Instructional Systems; Microcomputers; *Productivity; *Systems Approach; *Teacher Role

ABSTRACT

Although both the products and processes of technology have provided many means for better and faster learning at a lower cost, technology has not been implemented enough in elementary and secondary schools to make a difference in overall productivity. This is due to a basic contradiction between the organizational structure of today's schools and the organizational structure necessary for the implementation of technology in a cost-effective manner. Studies documenting the use of technology in schools have found that: (1) students use audiovisual and computer media a very small proportion of school time; (2) software typically used does not match curriculum objectives; and (3) teachers choose simpler media because of the many complex tasks they must perform. Technology will never be able to improve cost-effectiveness as long as school structures are based on instruction being controlled and delivered by teachers. What is needed is an instructional system in which: (1) classrooms are reorganized so that the tasks of teaching can be redistributed among different specialized workers; (2) computer-assisted instruction (CAI) and/or computer-aided design (CAD) are used to reduce costs; and (3) materials that have been tested and validated can be shared through mass media, rather than having each teacher design, produce, and implement materials just for his or her own classroom. (DJR)

TOWARD TRANSFORMATION: HOW THE USE OF TECHNOLOGY TO IMPROVE INSTRUCTIONAL PRODUCTIVITY DEPENDS ON CLASSROOM STRUCTURAL REORGANIZATION

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Presented at

EDUTEC '86
Tokyo, Japan
October 25, 1986

INTRODUCTION

At conferences such as this one on Educational Technology, the tone is usually uniformly positive, emphasizing the potentials of Educational Technology to improve teaching and learning. This is certainly appropriate because there are indeed many ways in which the products of technology and the processes of technology can contribute to better education.

However, before we can make an honest, accurate assessment of the future of Educational Technology we have to take a hard look at its past and present. When we do that we find a trail of unfulfilled promises. We find communication technologies such as film, radio, and television which have achieved marvelous technical success and commercial success but which have made little impact on formal education. We find information technologies such as computers which have revolutionized many aspects of our lives in terms of their effects on banking, shopping, automobiles, and industrial productivity. But they still play only a peripheral role in schools.

Looking deeper, we find technological processes such as the "systems approach" to instructional development, which has been adopted on a large scale in the United States for business, industry, and military training but which is hardly known yet in public schools. In short, the products of technology and the processes of technology have provided many means for achieving better learning, faster learning, at a lower cost. These capabilities have been demonstrated in hundreds of cases on a trial basis. But in elementary and secondary schools technology has not been implemented widely, deeply, or permanently enough to make a difference in the overall productivity of the organization. Why not?

The theme of my presentation is that there is a basic contradiction between the organizational structure of today's schools and the organizational structure necessary for the implementation of technology in a cost-effective manner.

SYMPTONS OF THE PROBLEM

Many studies have documented the low level of use of technology in American schools; among the most recent are surveys by Seidman (1986) and Smith & Ingersoll (1984a, 1984b). The general finding of such studies is that students are exposed to audiovisual and computer media for a very small proportion of their school time (less than 10%) and that the software used typically does not deal with central objectives of the curriculum. Regarding microcomputers, for example, the average American student has access to a terminal--on the average--for only a few minutes a day, and he is most likely to be using programs related to computer literacy (i.e. programming) or enrichment activities.

Further, these studies indicate that teachers, when they do use technological media, tend to select simpler media rather than more complex media. As I shall point out later, this supports the "principle of least effort"--the idea that humans in general tend to select means that require the least expenditure of effort. For most teachers most of the time, conventional methods--lecture, chalkboard, and seatwork--are perceived to require the least effort.

There is also ample evidence to show <u>why</u> teachers follow the path of least resistance. The job of "teacher" as it has evolved over the past 100 years has become exceedingly complex. Elementary and secondary teachers are expected to play the roles of analyst, diagnostician, designer of instruction, evaluator, prescriber, guide to discovery, role model, clerk, and accountant, to name just a few. It is no wonder that we observe a high rate of "dropout" and "burnout" in the teaching profession. In fact, in the U.S. we are approaching a crisis in terms of attracting and retaining able people in the teaching profession.

But even if we were able to attract and hold good teachers, the economic forecasts for the future indicate that we will not be able to afford to pay them. The problem is that labor costs have risen about 7% per year over the past decade while the efficiency of that labor has remained virtually constant. Labor costs in education are

growing faster than public income. Unless there is some breakthrough in productivity, education will eventually demand more money than there is in the total national treasury.

ANALYSIS OF THE PROBLEM

Technology will never be able to be applied to instruction in such a way as to dramatically improve cost-effectiveness as long as the current "rules of the game" remain in force. The very organizational structure of the school is based on the assumption that instruction is controlled and delivered by teachers. Further assumptions are that:

a) students are clustered into relatively large groups (about 15-30 on the elementary level, about 25-50 on the secondary level) in classrooms
b) each classroom is supervised by one teacher
c) each teacher is a member of a rather homogeneous professional group in terms of training, certification, salary, and job description
d) the teacher decides what will happen in the classroom--who will receive what instructional treatment at what time.

Under these conditions teachers are under heavy psychological and logistical pressure to expend their efforts as economically as possible. Prediction of human behavior in such circumstances can be guided by the rule stated in 1949 by George Zipf as the "Principle of Least Effort:"

> a person in solving his immediate problems will view these against the background of his probable future problems, as estimated by himself. Moreover he will strive to solve his problems in such a way as to minimize the <u>total work</u> that he must expend in solving both his immediate problems and his probable future problems. (Zipf, 1949, p. 1)

What does this imply for the teacher? We would expect to see the teacher managing his students as a group (rather than as individuals), spending little time in preparation, and choosing convenient teaching methods, that is, methods that are easy to deliver and that will not provoke more work for himself.

A recent major study of life in American high schools revealed exactly this pattern of behavior. Powell (1985) spent three years visiting 15 high schools, compiling 1400 classroom observations and interviews. He found that teachers dealt with their exhausting task by making several subtle accommodations with their students. He used the shopping mall as an analogy: in the shopping mall high school students have a wide variety of choice available in terms of curricular and extra-curricular opportunities. The availability of choices keeps the "consumer" happy but it also evades responsibility for guiding the student toward choices that are in his own and society's best interests. More importantly, Powell found that in the shopping mall high school teachers tended to forge unwritten treaties with their students: I, the teacher, will not make great demands on you, the student, if you don't make great demands on me. Neither students nor teachers want to work harder, so a very low level of intensity is found on both sides.

Looking at this organizational situation from the standpoint of the history of technology, Heinich (1984) describes the position of teachers as analogous to craftsmen working in a craft union. Each craftsman has control of his own tools and decides when and how to use those tools in hand-crafting his own products. The authority to choose the means of production is in the hands of the teachers. They are rewarded or punished based on their own individual performance, not on the effectiveness of the total organization. Therefore, they have no incentive to recommend that a totally different system of production be introduced. Right now what we need in public education is a modernized system, one that is redesigned from the ground up as a total system.

RESOLUTION OF THE PROBLEM

If we are going to achieve greater productivity in public education we need to implement an instructional system that is amenable to at least two fundamental elements of the Industrial Revolution: division of labor and economy of scale. This means reorganization of the classroom so that the many tasks listed earlier an be redistributed among workers practicing different specializations--some as diagnosticians, some as designers, some as lecturers, some as tutors, some as evaluators, and so on. In order to be affordable, the total cost of this work must be less than in todays system. This can be achieved by using machine mediation--e.g. computer-aided design and computer-assisted instruction, volunteers, and paraprofessionals, preserving a smaller number of highly qualified professionals to do jobs that demand a high level of professional judgment.

Second, the new, modernized instructional system should allow economies of scale. This means the distribution of well designed materials over large numbers of students, rather than having each teacher design, produce, and implement materials just within his own classroom. Replicable materials in the form of film, radio, television, and computer software are already widely available. These need to be rigorously tested in terms of their actual instructional validity and the best materials shared widely through mass media of distribution. Again, to be affordable, the cost of such refined design and distribution must be included in the basic equation of the total instructional system. Money must be saved on the labor side in order to fund technological delivery.

Larry Cuban described the needed organizational change succinctly:

> To align the classroom setting to a student-centered pedagogy, reformers will have to attack the organizational arrangements that largely govern teacher routines, that determine the use of time and space in schools and classrooms, and that shape how and by whom instructional

> decisions are made. Until they attack these organizational arrangements, reformers eager to alter the prevailing core of teaching practices that sprang up over the last century in response to mind-numbing working conditions will fail. (Cuban, 1986, p. 10)

Fortunately, the outlines of the new school organizational structure of the 21st Century are beginning to emerge. In an article published just a few weeks ago, Douglas Ellson provides an extensive directory of the alternative pedagogical methods that will be used in the school of the future. His list is based on an analysis of hundreds of well controlled research studies; Dr. Ellson was looking for pedagogical techniques that consistently yielded achievement at least twice as high as conventional lecture instruction. Among the techniques that are both more effective and potentially less expensive are self-instructional programs, structured peer tutoring, programmed teaching by paraprofessionals, and total systems developed through performance-based design processes.

Ellson goes on to do an extensive analysis of each of the technologies in terms of its sensitivity to economy of scale. The calculations are too complicated to present here, but he enumerates a half dozen instructional configurations that would cost far less per pupil-hour then today's conventional labor-intensive methods.

There is also an available model for the overall classroom organization. It has been developed by the Institute for International Research under the family name "low-cost learning technology," a name describing various organizational schemes that have been tried out in a number of developing countries, including the Philippines, Liberia, Thailand, and others. The basic idea of low-cost learning technology involves differentiated staffing and a wide variety of small-group, large-group, and independent study techniques. Instead of one teacher responsible for thirty students we find an instructional supervisor responsible for a hundred students with the assistance of paraprofessionals and volunteers. The total labor cost for this system is less than that for

conventional classrooms. Student time is distributed among large-group lecture-discussions conducted by paraprofessionals using structured guides; small-group drills, games, and simulation games guided by structured materials; student-to-student tutoring guided by well designed materials; and independent study guided by self-instructional modules.

In a system of this sort, students actually spend more time in personalized contact with tutors; their instruction is more demanding in terms of required interaction; and both materials and techniques are more adapted to individual needs and abilities. Actual field tests indicate that this technology-based system yields higher achievement than the former system at lower cost (in the case of the Philippines, less than one-half the former cost).

The point is that the adoption and refinement of a new classroom organizational scheme does not demand a leap into the unknown. Many of the means are already available and well tested. What is needed is to put the pieces together in a way that makes sense in a given cultural setting within its particular economic constraints. . .and remaining flexible to continual adaptation as we observe the results.