Implementing Cost-Effective Educational Technology: Some Reflections

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In accepting the invitation to submit an article for this issue on "Better Schools for Less Money," a rather incongruous yet appropriate title, we agreed to share some observations based upon a decade of attempting to implement cost-effective educational technology in public schools. To be sure, strides have been made in the more effective use of instructional techniques, such as individualized instruction, computer managed instruction and media based approaches (cassettes, etc.). However, the expectations of the 1960s that educational technology would radically change and improve education in a cost-effective manner have yet to be fulfilled. While the problems encountered and barriers erected were myriad in the past, and still exist in many respects, advocates of educational technology continue to claim that its widespread use is inevitable. Not so. Radically new approaches may not be feasible, forcing a reliance once again upon an evolutionary, if not piecemeal, approach. The best hope may be that this approach can be taken in a more systematic manner than has been the case to date.

Below, an attempt has been made to identify many of the conceptual, institutional, political and other barriers which impede the cost-effective application of "educational technology," broadly defined, in public schools. We have included in our discussion of such barriers the public's understanding of the issues involved, the traditional administrative rather than management mind-set in public schools, the existence of dysfunctional incentives, and teacher unionization. With the increasing institutionalization of many of these barriers, one can legitimately ask whether a total overhaul of the public school system through the incorporation of educational technology is the feasible and desirable approach which may be viewed as a necessity by other contributors to this issue. Two policy approaches, one based upon recent studies conducted by Education TURNKEY Systems, Inc., and a second, based on a limited number of other research studies, are also explored, and a summary perspective of the authors is offered.

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Public Perceptions

Earlier a comment was made that the title of this issue was "incongruous yet appropriate." In technical parlance, one cannot maximize effectiveness and minimize cost in developing any long-run plans. Rather, one has to consider a level of performance as being fixed while minimizing cost, or cost as being fixed while maximizing performance, Yet such a title is appropriate in education, where jargon prevails, loose thinking exists, and general lack of knowledge on the part of the public appears to be the rule rather than the exception when one discusses school system operations.

In recent years, the annual Gallup surveys of public attitudes toward public schools has disclosed that finance problems continually are listed as critical concerns along with issues like busing and discipline. An obvious question that derives from this public concern with school budgets is "Where shall costs be cut when local boards are forced to reduce total budgets?" In 1971, this survey specifically asked the public how school costs should be cut when such cuts were necessary. Suggestions which the public did not like were:

- —Reduction in special services such as speech, reading and hearing therapy.
- —Reduction of the number of teachers by increasing class sizes.
- —Reduction of all teachers' salaries by a fixed percentage.
- —Reduction in janitorial and maintenance services.

By comparison, the public favored cuts such as:

- —Reduction in the number of administrative personnel.
- —Reduction in the number of staff counselors.
- —Charging a rental fee for textbooks rather than providing them to students free of charge.

Those familiar with school budgets and costs will recognize that the sacrosanct list of possible actions greatly outweighs the preferred list in cost-savings potential. However, in order to quantify these feelings, TURNKEY applied its COST-ED Model (a computerized education program cost simulator) to each list, using available data for secondary school operations nationally (Blaschke, 1971). For the preferred list the following actions were simulated:

- —District administrative staff cut by 10 percent.
- —The average number of counselors at each school cut by 10 percent.

—Rent amounting to one-third of the total cost of textbooks and library books charged to students.

Taken together, these actions would result in a savings of 0.7 percent in total secondary education costs.

By contrast, the following actions were simulated from the less favored list:

—Increasing the average class size by 10 percent.

—Reducing the average teacher salary by 10 percent.

—Reducing janitorial and maintenance services by 10 percent.

Taken together, these actions would result in a savings of 8.8 percent in total secondary education costs.

As this particular article concluded, if technology-based systems are to be incorporated into public schools,

> . . . school administrators and board members will need to have costs and other information reported in a format which can be used for management rather than administrative purposes *and* for educating the taxpayer, if not for countervailing the public relations of national teachers' groups.

"Administrative" Tradition

While the public's perceptions can be overcome (a task made more feasible by soaring local property taxes), those of school administrators may be more difficult to modify, especially perceptions which are alien to the application of cost-effective techniques. One of the quickest ways to "tune out" a group of educators is to discuss a problem from a "management point of view." The concept of management is anathema to education generally; rather, a narrow administrative or caretaker philosophy still prevails. Traditionally, budgets have been developed by increasing line items by some percentage annually (the percentage depending basically on funding availability), with little consideration of economic trade-offs or reallocation of resources to areas which would result in improved educational outcomes. Indeed, the growing resentment and opposition to standardized tests reflects not only technical questions regarding their accuracy and reliability but also a general reluctance to measure performance by *any* criterion.

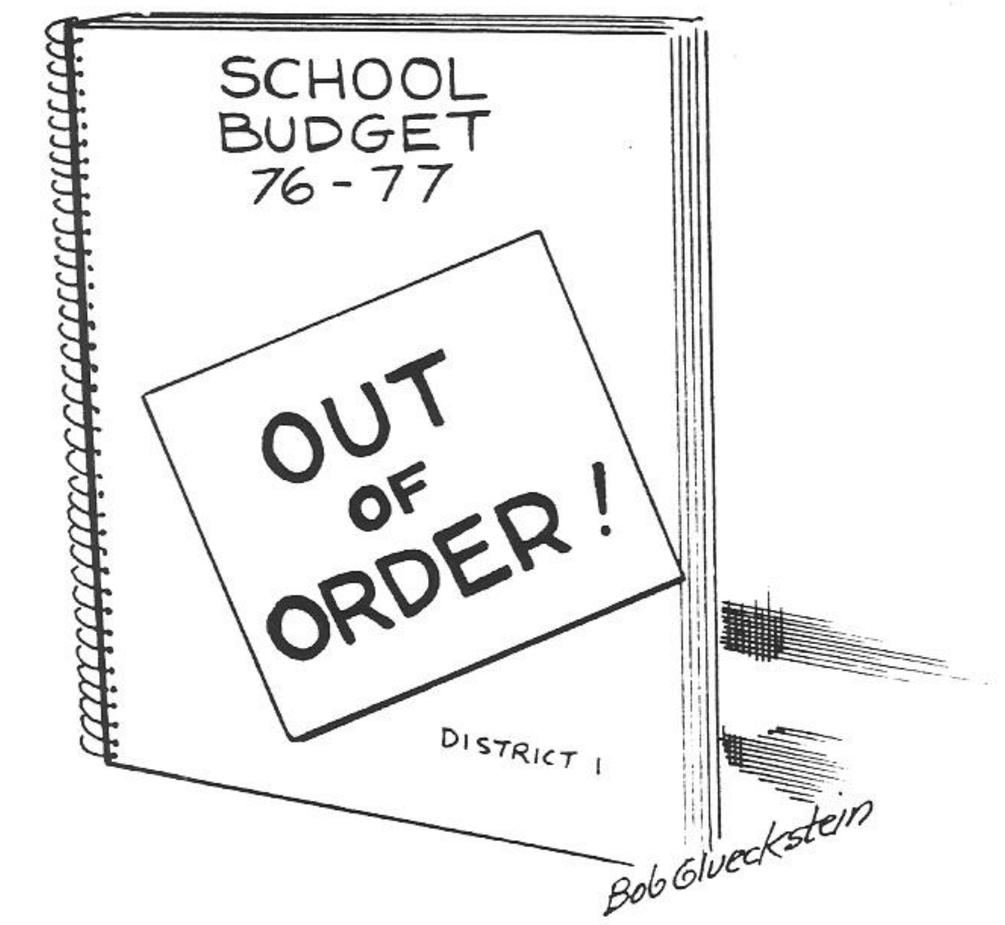
Slowly but surely a management philosophy (though still perceived by many as inappropriate) is overtaking this administrative model in our public schools. Over the last five years a large number of school systems have increasingly turned to individuals with graduate training or practical experience in business or systems-related fields. By comparison, an AASA survey in 1970 found only one percent of school superintendents who rated such skill areas as useful to their functioning. The reasons for this change of attitude can be attributed to several factors, including the decline in student enrollment which, in "business cycle" terms, has created a depression for the education market, forcing school administrators to face serious budget decisions with no growth data to justify budget increases. Indeed, with falling enrollments, reductions in budget are frequently the demand put forward by the local taxpayers. In many districts the "management team" must now face the problem of managing scarce resources. Within this framework the opportunities for educational technology are increasingly becoming a reality; the degree to which the benefits will be realized, however, is still another matter, as illustrated below.

For instance, a 1968 study (Blaschke and Randall, 1968) compared a simulated application of computer-assisted instruction (CAI) in electronics training conducted by the Defense Department with a similar type of CAI in secondary education in New York City Public Schools. Simulating the hypothetical use of the 1500 IBM CAI Series in electronics training at Fort Monmouth (New Jersey), it was found that a reduction in student time of approximately 10 percent justified the over-all expenditure and conversion to CAI in a large portion of the existing curriculum. This justification was mainly based on the fact that 60-80 percent of electronic trainee enlistees left the service after their term of duty, reducing the time available for realizing the more than $5,000 training investment per trainee. Hence, a shorter training time made possible through CAI would allow an earlier direct duty assignment, resulting in a justifiable return on investment. In New York City, however, the potential time savings on the part of students were constrained by the compulsory school attendance requirement (e.g., 180 days per year). Moreover, where other time savings resulting from CAI allowed a reduction in teacher effort, in New York City these particular functions were provided for the most part at home by the teacher (e.g., planning, test recording, prescribing, etc.). Therefore, such reductions did not result in any real dollar savings.

To further illustrate the above point, a study by Curry and Sweeney (1972) compared the operation of a number of schools in Prince William County, Virginia, which were operating under a 45-15 year-round school plan to their simulated operation under a traditional school calendar. Using a budget simulator, TURNKEY's COST-ED

Model, the study identified the specific areas where cost savings would accrue. At the middle school level, a savings of 9.6 percent was found in over-all cost per pupil. However, as was carefully pointed out in this study, these savings were entirely dependent upon management actions. For example, the move to 45-15 with its reduced and level student loadings on district facilities over an entire calendar year would create some slack in the use of these facilities. If this slack were temporary and increases in student loadings due to future enrollment increases were allowed to occur until the facilities were used to capacity, then the savings would indeed be realized. However, an active management approach would be required, since a passive "administrative" tack would undoubtedly allow this slack to become institutionalized.

These studies serve to quantify the potential of adopting a management approach within public schools. They also serve, however, to illustrate the impact of lockstep traditions in constraining such a management oriented approach. As this management approach becomes more widespread, the opportunities for the application of educational technology become similarly more widespread, since the cost-effective application of such technology is inhibited by many of these traditions. And, conversely, the application of such technology in the presence of these constraints will be less than optimally cost-effective; and, being so, will not attract widespread support from the critics of its use.



Dysfunctional Incentive Structure

The incentives structure which exists at all levels in education, and particularly at the local level, tends to create additional barriers impeding the application of technology in a cost-effective manner. A study by Pincus (1974) compared the behavior of a school district to that of a competitive firm. According to Pincus, a district would:

1. Be more likely than the competitive firm to adopt cost-raising innovations, since there is no marketplace to test the value of the innovation (e.g., smaller class size) in relation to its cost. Therefore, any cost-raising innovation that is congenial to the public school authorities and acceptable to local taxpayers or state and federal funding sources will be adopted.
2. Be less likely than the competitive firm to adopt cost-reducing innovations, unless the funds so saved become available for other purposes within the district.
3. Be less likely than the competitive firm to adopt innovations that significantly change the resource mix (e.g., a higher ratio of teacher aides to teachers, sharply increased use of capital-intensive technologies), because any consequent productivity increases are not necessarily matched by greater "profits" to the district, and because any replacement of labor by capital may threaten the guild structure of the schools.
4. Be more likely than the competitive firm to adopt new instructional processes or new wrinkles in administrative management that do not significantly change institutional structure, because such innovations help to satisfy the demands of the public, of state and federal government, and of teachers and principals themselves for change and progress without exacting heavy costs to the district in the form of organizational stress.
5. Be less likely than the competitive firm to adopt innovations that change the accustomed authority roles and established ways of doing business, because changes in these relations represent the heaviest kind of real cost to bureaucracies.

In addition to, and partially as a result of this dysfunctional structure, there exist other elements which tend to constrain the effective use of educational technology and the application of cost-effectiveness techniques. These include federal, state and even local funding patterns for education.

A recent study (Peat, Marwick, Mitchell and Co., 1976) found that late funding and funding

uncertainty, which reached their heights during the period 1970-74, had a dramatic impact on local educational decision-making. With local units receiving funds during the middle of the operational and fiscal year, many decided to purchase materials and hardware rather than running the risk of having to return unobligated funds such as those under ESEA Title I. Such items may be purchased with little lead time; but, unfortunately, this same lack of lead time also means "with little systematic planning for their use." Ironically, even though the concept of "forward funding" came into existence toward the end of that time period, local educational agency administrative behavior still reflects a great deal of suspicion due to late funding experiences of the early 1970s. At this writing, somewhere between 30 percent to 40 percent of the total national current allocation for ESEA Title I still remains uncommitted locally as a safety valve to be used by the localities should appropriations be passed late. Such uncertainty tends to preclude serious planning for the effective application of educational technology, which in many cases requires a rather substantial initial investment.

Even though attempts have been made to consolidate federal and state funding for districts, there do exist a large number of categorical programs which by their nature again force a piecemeal approach to the application of educational technology in public schools. For example, in conducting several national studies over the past year, we have observed a large number of individualized instructional programs being used in elementary reading and math instruction. These programs encompass both compensatory education and the locally sponsored districtwide offerings in these subject areas. Due to comparability and supplanting provisions in the rules and regulations of ESEA Title I, however, the compensatory and non-compensatory components differ methodologically and conceptually. For example, in states such as Michigan and Florida, where the state legislatures have mandated either individualized instruction for all students or the use of diagnostic and prescriptive techniques for all students, in some localities the Title I components are less individualized than the local regular components, even though the Congress specifies that Title I children should have "an individual plan of instruction." In many other localities and states, where the regular instruction is relatively less individualized and the Title I component is relatively individualized, there exists little coordination between the regular teacher and the Title I teacher, again leading to dysfunctional instructional practices. Local agencies' concerns about possible program audits have a direct impact upon the program configuration of ESEA Title I programs. In fact, it could be argued that the audit mentality of districts who maintain separate, pull-out type programs for compensatory education students simply to satisfy auditors is an extension of the passive or reactive administrative mentality already discussed. This is especially clear when the actions are analyzed of those districts which make educational rather than audit rationales their top concern in planning or designing their compensatory education programs. It seems that passive acceptance of dysfunctional elements of federal policy never requires the justification that active pursuit of educational quality sometimes does.

There do exist, however, a number of "light-house" states which have recognized the problem and have attempted to provide funds for compensatory education programs, at least in such a way that the cost-effective application of technology is encouraged. Over the last four years in Michigan, the "Chapter 3 Program" districts have been allocated a specific amount of dollars per low-achieving child. Subsequent funding to these districts has been based upon the degree to which participating children achieve a set of objectives assigned them. Each district is given total discretion in terms of the use of the monies, and specific provisions preclude a funds-use audit. The net result during the early 1970s was the procurement by localities of a large number of technology-based instructional systems. For example, during the first year of the program approximately 35 percent of the total $23 million allocation was spent on the purchase of learning systems, materials and equipment. Subsequent allocations were used for most part to train teachers in the effective implementation of these items and the expansion of certain packages to include a greater variety of materials. Until this "management by exception" philosophy—with its emphasis on *output* rather than *input*—expands, there will always exist forces to perpetuate a piecemeal application of instructional technology.

Teacher Unionization

During the 1960s and early 1970s one of the major barriers to increased use of educational technology generally was the opposition of organized teacher groups. Observations during the conduct of the OEO Performance Contract Experiment of 1970-71, for example, indeed indicated that these groups were not only opposed to performance contractors and incentive-based remuneration but also were opposed to the use of teaching machines and other instructional technologies. Undoubtedly, some teachers were concerned that machines would replace them. Evi-

dence from a Dade County, Florida performance contract project, which was very successful, showed that a technology-based program which allowed class size to increase from 25 to 40 students per teacher could be implemented. Not surprisingly, it was only through close cooperation between the teaching staff and the private corporation whose program was being adopted in two demonstration schools that this implementation was possible. Student achievement during the first year of the project was greatly improved, and participating teachers received bonuses of up to $4,000 related to these improvements. The cost of purchasing and implementing the instructional program was more than offset by the large increase in class size. In fact, the cost per pupil was actually lower than the prior year. It was clear throughout, though, that the removal of the teachers' cooperation would have doomed this project. Clearly, the usual experience outside of this project, and perhaps somewhat because of this project, was that such a reduction in staffing would have been bitterly opposed by organized teacher groups.

The nature of organized teacher groups, however, has changed in the very recent past. Job security for those employed—as opposed to more jobs or more sizeable pay increases—has become a major focus; and, for the most part, school boards have been willing to agree to security demands as a trade-off against salary increases, for instance. Hence, fear of being replaced by machines or for other reasons has significantly declined and, concomitantly, the ability to replace existing staff with teaching devices has also declined. However, other demands have affected both the nature of instructional technologies which have been selected and how they are used in the classroom.

Direct teacher involvement in selecting materials and/or developing learning systems has heightened in the very recent past. The impact on technology has been immediate and direct. For example, while a large number of packaged individualized instructional systems were being marketed in the early 1970s, there has been a definite trend away from such packages most recently. Moreover, many of the firms selling total packages have found the greatest demand is for components of their packages. In addition, many districts have developed their own instructional learning systems, which include: specification of performance objectives in areas such as reading or math, the development and use of diagnostic tests and procedures, and taxonomies of objectives keyed to a variety of materials. Having recently surveyed the most widely used elementary individualized math and reading programs employed for compensatory education students, it is interesting to note that recent editions of many basal series have dropped their diagnostic and prescriptive components, realizing that these components have been developed locally—and that the materials and curricular supplements are essentially what the district wants to purchase, to be integrated into their home-grown learning system.

The net result of this trend has been the purchase/adoption of components which were originally designed as a total learning system. "Teacher-proof" packages advocated by certain publishers during the late 1960s are virtually out of use in public schools today. How much of this recent trend has been brought about by local and national pressure by organized teacher groups for increased self-governance for teachers is difficult to say. It is clear, though, that the result of this trend is an increased involvement of teachers in these key program decisions.

It is interesting to note that a number of recent studies indicate this general trend has had a very positive impact on program effectiveness. For example, in a study of compensatory education in Michigan conducted over several years (Blaschke, Sweeney and Luebke, 1975), several variables which were strongly associated with program success were: the fraction of materials selected directly by the teacher, the direct involvement of the teacher in developing performance objectives for his/her students, and the amount of time allocated by the teacher to planning or developing instructional programs. A recent Rand study also concluded that teacher involvement was critical to the success of the program. An Educational Testing Service study of Title I reading programs also concluded that one of the significant characteristics of "effective" programs was the existence of a variety of materials used in the classroom, where this variety possibly reflects application of teacher-level choices.

Policy at a Crossroads

From a policy perspective there appear to be two different approaches for encouraging the systematic application of educational technology

in public schools. Underlying these two approaches are several assumptions and value judgements.

The first alternative is rather revolutionary and radical, based upon some assumptions about the inevitability of educational technology as a major delivery system for public schools. Proponents of this alternative argue that the increase in the labor/capital ratio in education in this country over the last two decades cannot continue in a post-industrial economy, noting that the ratio is declining in other service areas, such as health care. Moreover, the rate of increase in the cost of education (e.g., the doubling of cost per pupil in public schools over the last decade) cannot continue far into the future. With teacher salaries as the major contributor to that cost, an alternative such as educational technology has to become economically feasible in the very near future, if not already feasible—though not recognized as such. Moreover, it is argued that urban public school systems will change radically in the near future, with many districts actually going bankrupt, forcing the creation of new legal entities where many of the present barriers to technology will be reduced or eliminated.

The other alternative assumes that the infusion of technology will be through an evolutionary process, with major attempts to systematize school management and technological components of the education program. Proponents here would argue that in process-oriented industries, such as education, innovation usually occurs during troughs in the economic cycle, which indeed is a situation facing public schools today, due to a decline in student enrollment. Moreover, they argue that the major use of technology will be to systematize the instructional process rather than to employ technology, particularly hardware systems, in the instructional process directly (e.g., computer-managed instruction as opposed to computer-assisted instruction). In this sense the major function of technology will be to support classroom instruction, used as an aid for the instructional manager or teacher, while allowing for a greater range of decision-making power and flexibility at the classroom level. Each of the above approaches has merits and advantages.

As Pincus (1974) concluded, there are factors which would cause innovations to be supported in a bureaucracy. These include:

1. *Bureaucratic Safety*. When the innovation is perceived as favorable with respect to the current status and organization of the bureaucracy (because in a self-perpetuating non-market system, these bureaucratic values become socialized and tend to dominate other criteria; or, in other words, the bureaucratic costs are the real costs of the system).
2. *Response to External Pressure*. When external pressures for innovation are perceived as irresistible (because school systems cannot be entirely unresponsive to external pressures and financial constraints).
3. *Approval of Peer Elites*. When key figures in the bureaucracy and their colleagues in other educational bureaucracies can agree about the acceptability of the innovation (because in the absence of clearly defined output criteria, consensus among the elite is often the primary decision making criterion).

A concern stated a decade ago still appears to be germane: "As a society adept in developing technology, we have been inept in devising the social and political innovations necessary for creating an environment conducive to the application of the technology" (Blaschke, 1968). That so few researchers have even addressed this issue and its relationship to educational technology is a concern worth raising once again.

The winds of change are felt within public schools. But it is an evolutionary change brought about by an effective management process—rather than a cyclone of change brought about by the technology itself—that will lead to increased and productive uses of technology in this setting. After all, the survivors of a cyclone are mainly responsible for rebuilding, and when rebuilt the structure tends to closely resemble what has gone before. □

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