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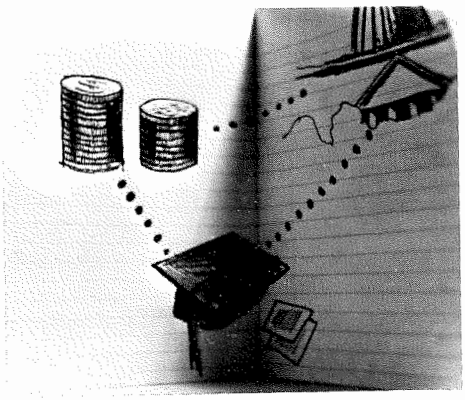

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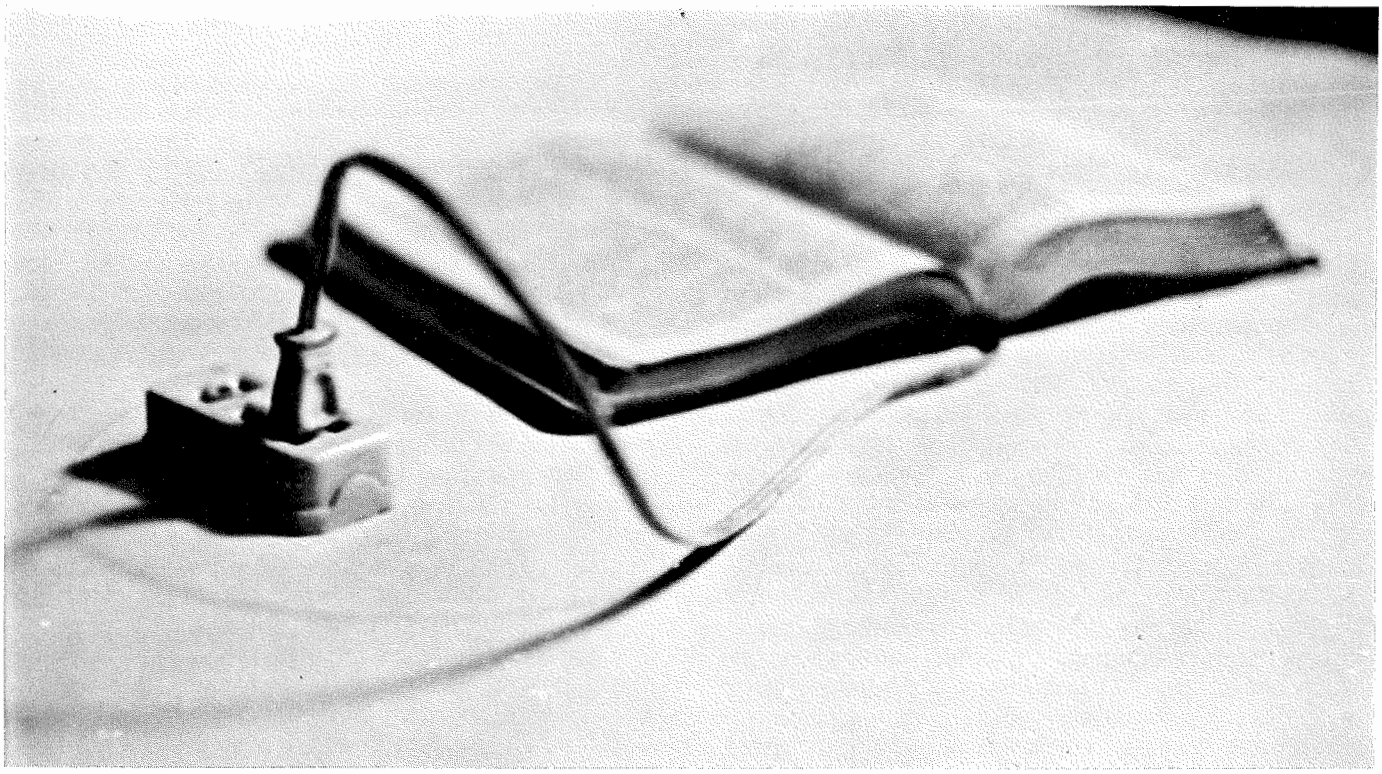
Educational Technology:

Economics, Management and Public Policy



Ronald Randall and Charles Blaschke

Part I: Economics and Management

To the extent that the new educational technology calls for fundamental changes in the instructional process itself, it demands a concomitant overhaul of traditional patterns of educational management.

That great improvements must be made is now commonly recognized. What we would like to know is just what kind of changes will be needed, and we need answers more informative than the slogans so often bandied about.

Ronald Randall, a graduate of M.I.T. and Harvard Business School, is an instructional management and cost analyst who has been developing models for determining the feasibility and application of CAI and other technology in military and public education and training programs. Charles Blaschke is contributing editor of ET.

Useful in finding these answers is the device of separating issues of "school management" from those of overall "educational administration."

Management of the schools deals directly with teachers, facilities, students, and the ways in which they interact; administrative issues, on the other hand, involve the control of school management through higher-level organization, policy and funding.

Figure 1 shows a conceptualization of how management and administration mix at various levels of the national educational system; it shows also how the administrative structure rests upon the underlying management foundation.

In the first part of this article the impact of educational technology upon management of the schools is investigated. The second part, "Implications for Public Policy," will discuss the ramifications of changes at this level upon higher administrative bodies.

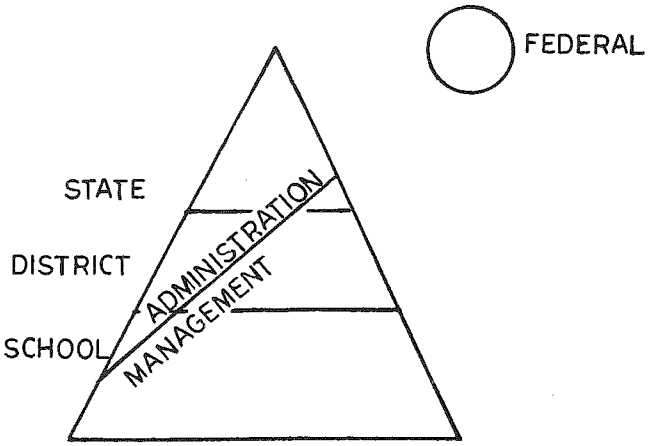


FIGURE 1: SCHOOL MANAGEMENT AND EDUCATIONAL ADMINISTRATION

The role of economics

Economics is only one of several sources of pressure which influence our educational institutions; other important ones lie in the spheres of politics and sociology. While the three are inextricably related, the political and social forces are felt most strongly in curriculum content and administration, and it is the economic pressures which are dominant in facilities planning and immediate school management.

At the same time, one of the most striking differences in the new educational technology lies in its economic character. Of prime interest is the much heavier weight placed upon capital investment in equipment, facilities and recorded curriculum materials by the new instructional tools, in contrast with the proportionately greater emphasis placed on labor (i.e., teachers) in conventional instruction. This changed balance toward more capital-intensive instruction is easily seen in such examples of educational technology as computer assisted and computer managed instruction, multi-media instruction and individually prescribed instruction.

Since economic considerations are both important characteristics of the new instructional tools and key determinants of patterns of school management, it is natural to turn to economics for insight into how educational management will change.

Economics and the process of change

No matter how effective they may be, new tools of instruction will not progress from the try-out stage to widespread adoption until they have proven themselves in the competition for budget allocations.

Since it is generally too costly to be affordable as a straight addition to current expenditure levels, the new technology may well have to rely on its ability to produce offsetting savings elsewhere to win it a place on the budget. Where the savings may come from is determined by the economics of the instructional technique and the existing pattern of cost incurrence (the "cost structure") of the school system. To what extent potential savings can in fact, be realized, however, depends squarely upon how well educational managers adapt their operations to the economic nature of the new technology. Justification of the costs for instructional television, for instance, is greatly aided by reducing the need for classroom teachers during its use.

In schools where the new technology can be afforded only if used in patterns different from those prevailing, either the patterns must change or the benefits of the new technology must be foregone. When the benefits themselves are established, this situation creates its own pressure for change; the effectiveness of this pressure, however, hinges upon recognition and acceptance of the specific changes needed. And both recognition and acceptance depend upon full understanding of the pertinent economic factors.

It is unfortunate that most school systems today are unable to conduct the type of economic analysis required to assess the impact on their budgets of markedly different educational technologies and methods of instruction. Largely responsible is the account structure maintained by most educational institutions. Since they are not profit-making organizations but governmental entities, their accounts are generally designed to serve two prime functions: funds control and simple requirements projections based on assumptions of basic continuity in current practices. This last observation is the critical one, since budgeting and accounting systems based on assumptions of continuity are remarkably ill-suited for the evaluation of major changes.

For evaluating such changes as are likely to be required for the efficient utilization of educational technology, a very different type of accounting is needed — "functional accounting." In this framework, costs are aggregated not in terms of funding sources or expense types, but in terms of the operating factors or management decisions which affect them and the functions they support. This is very similar to the basis of the "program budgeting" concept, discussed in the second part of this article.

Only when educational costs are recast in this fashion can the economic pressures accompanying instructional innovations be clearly recognized and dealt with.

The COST-ED Model

To analyze the economic factors related to use of computer assisted instruction (CAI), we were recently compelled to devise just such a framework.

The result was a "cost model," which may roughly be viewed as a high-level, managerially-oriented accounting structure for organizations whose prime function is instruction. Dubbed the COST-ED Model (for **CO**sts of **S**chools, **T**raining, and **Ed**ucation), it highlights the critical cost factors and variables and simplifies investigation of the interactions among them.

The analytical concept upon which the model is based appears in **Figure 2.** Important aspects of the design scheme are:

- Use of "cost per unit student achievement" as the final summary statistic.
- Relation of all costs to one of a set of "functions" chosen on the basis of usefulness for each application.
- Division of resources consumed into "enabling" and "operating" categories.
- Provisions for the charging of costs on time-dependent and unit bases.
- Identification of "opportunity costs."

The model is designed primarily for use in analyzing the projected economic characteristics of a new instructional system being proposed; through translation of available budget and accounting statistics into the model framework, however, it may also be employed to discover the underlying economic relationships in an existing instructional system.

Although a full description of the model would be too lengthy for this writing, a summary of its structure is given in **Figure 3.** Shown there are the basic modules which comprise the model, each of which may or may not be used in a particular application, depending upon the organizational environment, the objectives of the analysis, and the level of detail desired.

The facility for sensitivity and trade-off analysis provided by the model has been of great use in identifying important economic considerations relevant to the new educational technology. Three of these are discussed below.

Savings in learning time

The possibility for economic self-justification of technology-based instructional systems can be promoted through several byproducts of their proper use. In the case of CAI, for instance, the following claims are sometimes made:

- Reduction in learning time.
- Reduction in administrative paperwork.
- Lowering of requisite teacher qualifications.
- Increasing overall student:teacher ratio.

The validity of these claims is open to issue; and it is precisely for this reason that school systems contemplating use of CAI should be aware of the relative importance to them of each of the claims made. Also of interest are the sensitivities of savings produced by each claim to shortfalls of various amounts between the prior projection and the realized result. Recognition of which area has the most potential for absolute dollar savings and which is most sensitive to shortfalls in obtainable results is critical to proper focusing of management attention and the development of willingness to make changes.

Using cost data from the New York City high schools,* **Figure 4** shows the relative efficacy of changes in each of the four above-mentioned factors in producing savings usable towards offsetting investment in a CAI system. Interpretation of this figure leads immediately to the conclusion that **savings in average time to learn through CAI will be by a significant margin its most fruitful source of economic justification.**

A conclusion such as this has far-reaching ramifications. It shows that **use of CAI without provisions for the acceleration of faster students through the school system is very costly,** hence CAI exerts a pressure favoring more rapid advancement of the better student.

This, in turn, fosters many other implications. Some of these lie in the social and political areas and will not be discussed here. Another, however, impacts directly on school management: provisions for the acceleration of the faster student demand individualization of instruction and the virtual abolishment of those classroom patterns which can hinder the progress of the fast student. Not **all** classrooms need be abolished, but new and intricate scheduling patterns must be devised if the advantages of group instruction in certain areas are to be combined with the advantages of individually-paced CAI in others, without escaping from the realm of economic feasibility.

This is just one of the many chains of implications which may be drawn from the interpretation of such analyses as that depicted in **Figure 4.** Another is the danger that sellers of instructional software for CAI systems will bias their materials toward reduction of learning time at the sacrifice of certainty in the level of real mastery attained by the student. Still other implications can be drawn from this figure.

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*Data obtained from Board of Education, City School District of New York: **Annual Financial and Statistical Report, 1965-1966;** and, **Budget Estimate for 1968-1969,** dated December 11, 1967.

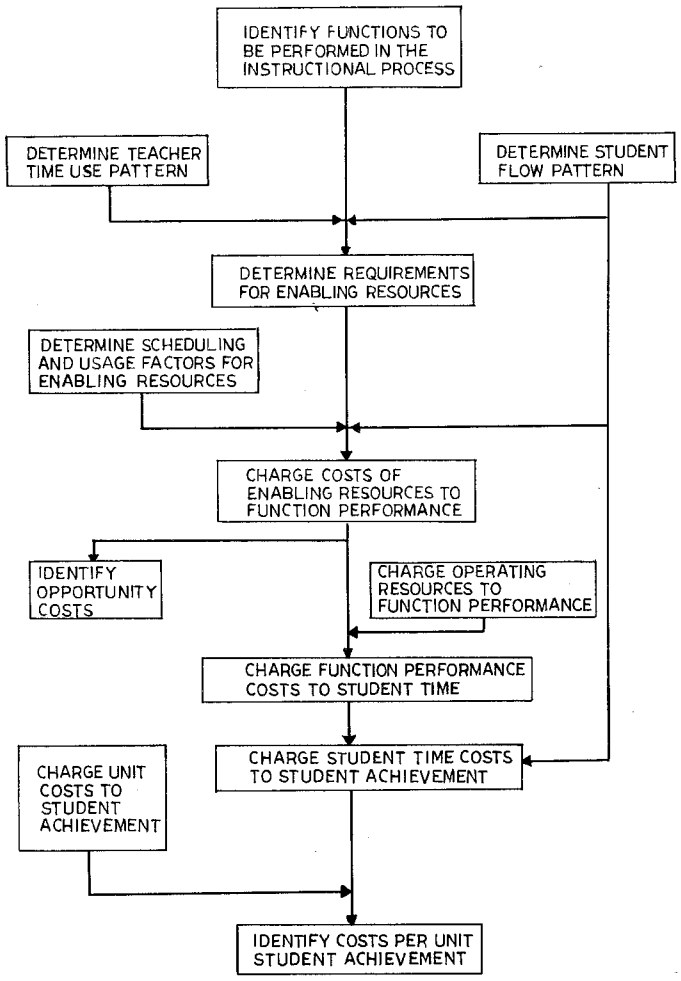

FIGURE 2: DESIGN SCHEME FOR COST-ED MODEL. The model relates over 50 isolated cost factors to each other according to the scheme here depicted so that the impact of each on the ultimate "cost per unit student achievement" may easily be identified.

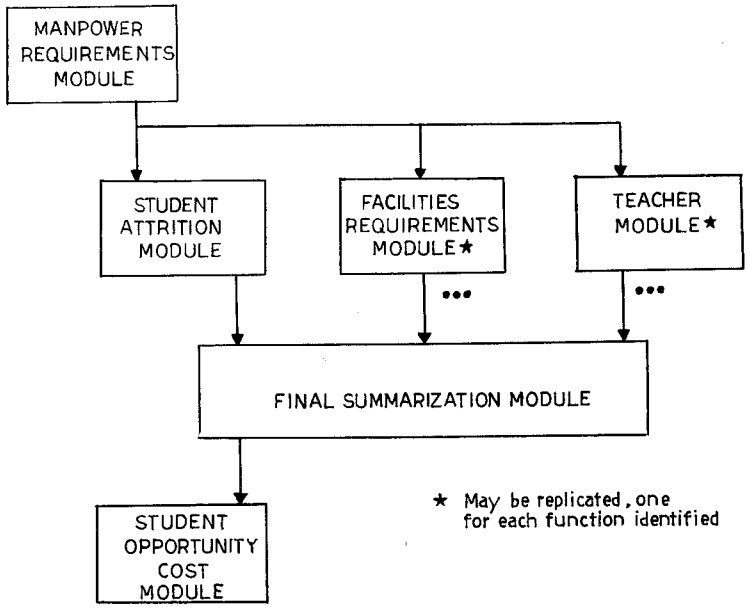

FIGURE 3: THE SIX MODULES OF THE COST-ED MODEL

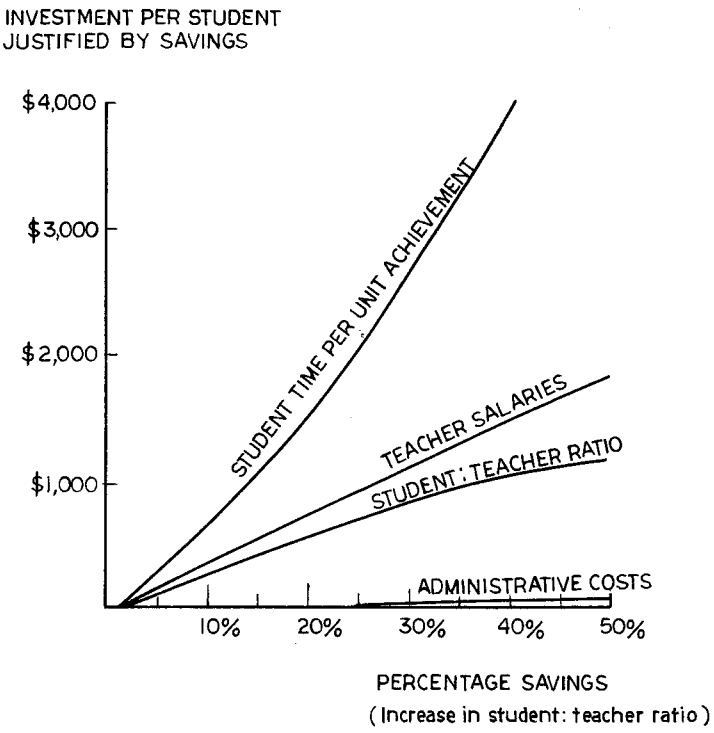

FIGURE 4: TRADE-OFFS TO JUSTIFY INVESTMENT IN CAI. These plots are based on the assumptions that the ratios of amortization and operating costs to investment in a CAI system are approximately double those of current plant and equipment in use in New York City High Schools, and are based on the current cost structure of the New York City school system.

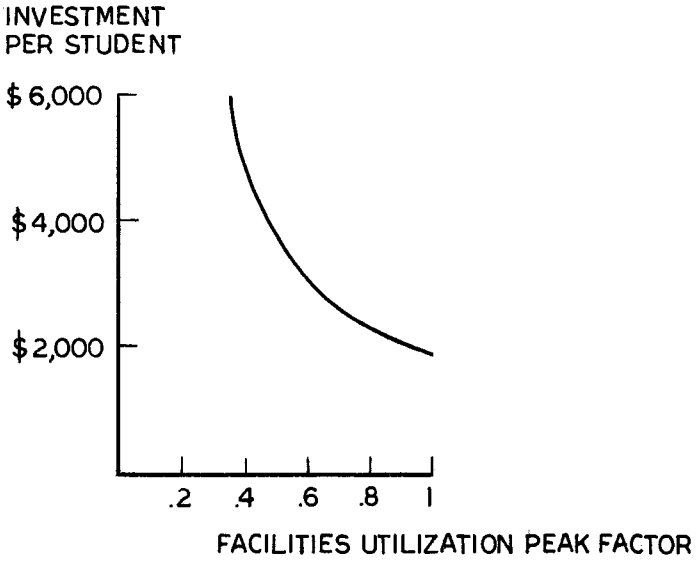

FIGURE 5: IMPACT OF SCHEDULING FOR FULL UTILIZATION OF CAPITAL INVESTMENT. This chart shows how investment per student in educational facilities may be increased without increasing total cost per unit student achievement through scheduling techniques which reduce the facilities utilization peak factor. The scales are based on the 1965-66 New York City investment of about $1900 per student with a peak factor of approximately 1.0.

Full utilization of facilities

As the mix of resources employed in the instructional process changes from being labor-intensive to being much more capital-intensive, the complexion of economic pressures acting upon the patterns used for the conduct of instruction changes dramatically.

Teaching labor, for instance, is compensated largely on the basis of the time during which it is actively employed; such capital costs as amortization and debt service, on the other hand, are incurred regardless of whether the investment they support is actively in use or idle. Teachers perform classroom duties only for three to five hours a day, five days a week (and, traditionally, only about 35 weeks a year); by comparison, such capital equipment as a computer system can support operations 24 hours a day, every day of the year (less allowance for maintenance). While the limited availability and usage-based compensation of teachers creates pressures for rigid schedules and maximum class size, the unlimited availability and usage-independent cost structure of capital equipment creates equally strong economic pressures for full-day, year-round, capacity utilization.

Figure 5 shows how the New York City school system may increase the effective investment per student through scheduling for fuller utilization of its facilities' capacity. The particular scheduling variable shown is the facilities utilization peak factor, the ratio of maximum simultaneous users to total users served. Isolation of this as the critical factor is based on the following observations:

- The capital investment required varies with the capacity of the facilities, and the capacity is measured by the maximum number of simultaneous users.
- Pro-ration of the resultant capital costs, however, depends solely on the total number of users served.

The message of this figure is a simple one: doubly expensive school facilities could be supported if each were used by two full shifts of students, without increasing total costs per student. Of course, split sessions aren't the only answer; alternatives with the same effect are various forms of staggering the school day, week, or year and plans for securing year-round utilization of school facilities.

There are many reasons to explain why the economic pressures to adopt fuller scheduling are not effective. Of these, the two most important are the counter-vailing pressure of custom and the fact that capital costs represent only about 20% of total costs. If application of educational technology has its expected impact in increasing this last statistic, however, the economic pressures for change may produce dramatic results.

There are basically two ways of scheduling for fuller utilization of capital equipment to help justify its cost. One, just noted, is to level the peaks in the daily cycle of facilities utilization through staggering of current users. Another is to fill the valleys in the daily (or weekly, or yearly) cycles through attraction of new users. Of particular interest would be those for whom use of the facilities is of sufficient value as to command a high and collectible price. In the case of a CAI system installed in a public school, for instance, this might mean making the system available with different software packages of instructional material during the evenings, weekends, or summers for professional-level self-study courses or welfare-recipient job training. There are enormous possibilities for using the device of shared facilities to increase significantly the value of equipment available for use in public education.

While labor-intensive education emphasizes the management variable of class groupings, capital intensive education emphasizes the variable of facilities scheduling. It also produces, as noted above, a demand for individualized and very intricate patterns of student scheduling. Given the economic importance and the complexities of coordinating all the schedules involved, the need for a computerized system to manage the scheduling task becomes apparent. This is one of the elements of the argument that **computer managed instruction is virtually required to control any of the really powerful techniques of educational technology.**

Free resources

Each week, the average teacher spends about ten hours doing "homework" after school. Basically, this is time spent preparing lesson plans, drawing up and marking tests and the like. If an automated instructional system such as CAI virtually eliminates these functions for the teacher, can she be asked to spend the ten hours so freed back in the classroom? We may rest assured that teachers unions would tolerate no such action.

Since this time is not reclaimable by the school system, the teacher's salary must be considered, for all practical purposes to cover only her time spent physically at school. As a result, the customary time now spent at home actually represents a "free" resource contributed by tradition by the teacher to the school system.

Some very interesting deductions may be made from recognition of this as a characteristic of the cost structure of teachers' salaries. One is that the costs of preparing recorded or programmed instructional material for presentation through technology-based systems cannot be justified by offsetting savings of teacher's time, since the specific time saved is a "free" resource.

A second is that ways of profitably employing the teachers' free resources within the new educational technology must be found if the benefits obtainable from them are not to be lost forever. How this might best be done is a question for the educational systems designer, and one which will, in the best of textbook tradition, be left as a problem for the reader.

Which comes first?

It is one thing for industry to create new educational technology, and quite something else for the new creations to find a home for themselves in the nation's schools. Looking at the schools themselves, we may ask, which must come first, the change in management (the chicken?) or the change in technology (the egg?)?

A little reflection shows that **it is the management changes, not the technological ones, which must lead the way.** The reason is a simple one. In a management system which accepts the performer-teacher, the thirty-man classroom, and lock-step progression through the grades as the unquestioned norm, the new educational technology stands no chance at all of being deemed economically feasible for other than token use. Only with the dissolution of old customs and taboos and their replacement by "efficiency thinking" and the capability for effective economic analysis will the new instructional systems have a chance of passing the budget test.

Part II: Implications for Public Policy

Leaving little room for the "doubting Thomas" application of the COST-ED Model illustrates a major problem deserving increasing concern in public education today — inadequate management and lack of "efficiency thinking." Only when these gaps begin to be spanned will there be an opportunity to utilize and realize the savings from capital-intensive educational technology such as CAI when it is fully developed. The implications for public policy in education are apparent: a) greater emphasis to improve education management techniques and capabilities, especially on state and local levels; and b) the creation of an environment which is conducive to innovation, and rewards efficiency, in public education.

Improving education management

1. Program planning and budgeting capabilities need to be developed on both state and local school district levels. Because of the capital intensity of CAI and related learning systems, capital budgeting and other planning techniques will be required. At the same time, with the increasing decentralization of **de facto** planning to the state education departments and the governors, and hence the emergence of politics of education on the local and state levels, justification of creative and effective programs is going to become more difficult. Program budgeting is probably the most effective method of justification both to local political forces and to the federal sources of funding.

Through the use of management tools such as "sensitivity" and "trade-off" analyses developed in the COST-ED Model, local school officials cannot only develop a basis for asking the right questions in order of priorities but also justify feasible alternatives and depict political implications of various choices of action. For example, in the New York City illustration, it was found that a 10% reduction in annual teacher costs plus a 20% reduction in learning time and a scheduling plan for peak usage of CAI facilities by no more than 50% of total students enrolled would justify an investment in CAI of about $3702 per student enrolled. However, as the COST-ED Model has shown above, if the 10% teacher costs savings comes from alleviating the need for grading, lesson planning and other roles teachers provide at home (and are therefore presently considered "free resources" by school administrators), what chance is there to realize this savings given the political ramifications of teachers' salary reduction? Hence, teacher unionization, negotiations, and personnel hiring practices become the issues of high priority in long-run planning.

Regarding public policy, the new Education Professionals Development Act provides the opportunity to develop program budgeting capabilities; however, the initial amount of non-earmarked funds available after support of traditional teacher training projects dampers optimism here. And attempting to force the development of these capabilities on local schools through federal or state guideline restrictions will only result in the changing of officials' and existing staff members' **titles.** Development of program budgeting capabilities and skills should be given higher priority and support by U.S.O.E. and state education departments.

2. At the federal level, and particularly at the U.S.O.E., which has accepted the major role for developing and testing capital-intensive learning systems, several actions need to be initiated or emphasized more heavily:

First, **"total package" granting or contracting procedures have to be not only developed but also used.** Those few local schools which have sought federal funding and have the capability to develop "program package" proposals have been discouraged by executive and legislative restrictions. Funds have been allocated according to various legislative

titles (e.g., ESEA) and evaluated atomistically by individuals, who in accordance with their responsibilities have tended to necessarily suboptimize; hence, why should a requesting potential grantee develop a "total package" only to have to dismember it for purposes of potential sponsor evaluation? A newly initiated ESEA "comprehensive program requests for proposals (RFP)" hopefully indicates a major change, last minute though it was, which will provide the opportunity for schools to attempt to develop "total package" proposals to be considered as such. Similarly, as Title III of ESEA is decentralized to the states, planning and evaluating staffs on the state levels must be made aware of the necessity for developing procedures which provide for total costs and benefits considerations.*

Second, regarding CAI and other capital-intensive learning systems development **per se, greater efforts should be made to direct large "critical mass" projects.** The Bureau of Research at U.S.O.E., the last federal bastion of funding leverage in public education, needs to ensure that: a) federal procurement and R&D contracting procedures foster rather than impede innovation in the area of computers in education; b) performance levels of achievement rather than design or physical "specs" are clearly determined and used in RFP's; and c) an agreed upon cost-sharing rationale is clearly articulated so that industry can guide its own internally-financed R&D efforts in this area in a manner which will tend to supplement existing federally-funded projects.

Third, with specific purposes in mind, computer managed instruction (CMI) needs greater emphasis. Official OE listings of R&D projects using computers in education indicate that CAI development has been emphasized by at least a factor of five greater than CMI over the last three or four years. Based on the results of the COST-ED Model, in order to lay the foundation for eventual effective use of CAI, at this stage of development greater emphasis must be made to develop, test, and evaluate CMI systems with the following research objectives in mind: a) to develop efficient administrative and scheduling systems which will provide the opportunities for realizing individuals' time savings through individualized, self-paced instruction; b) to develop and validate instructional strategies (instructional software) which will eventually be the bases for CAI systems to be used in the tutorial-socratic mode; and c) to anaylze the new role of the "teacher" as she becomes a "manager of the conditions of learning."

***One of the major reasons why CAI-CMI systems are being used in the military more than in the public schools is the existence of systems procedures and "total package" concepts. See Charles Blaschke, "The Defense Department and the Future of Education Technology," Phi Dalta Kappan, January 1967.**

It is encouraging that the U.S.O.E. is considering a few endeavors in this area, such as the CUES (Computer Utilization in Education Systems) project to parallel large privately-financed projects like Project PLAN. Such projects have to be of sufficient size, managed and directed competently, and conducted in a real world classroom-type setting where serious experimentation can occur in the politically volatile world of urban education.

Creating an environment conducive to change

A pending report by the influential Committee for Economic Development relates directly the relationship between capital-intensive educational technology **innovations** and **efficient management.** The CED is the first responsible national vocal group to have faced the issue squarely; hopefully its recommendations will be taken seriously.

1. Public education is a 200-year-old monopoly and inefficient as a result.

Without competition it is folly to believe that public education will reform itself and improve its services. "Open schools" and competitive systems proposals advocated by Professor James Coleman, Christopher Jencks, Paul Goodman and others should be analyzed not to answer the questions "If," but rather "How?"

The California State Legislature recently approved a program of experimental schools under a newly-created and autonomous Education Research Council responsible to the Legislature. These schools will provide opportunities for contractor-operated experimental schools to teach reading and math and to conduct action research on early school instruction. Other proposals for community-owned Franchised Learning Centers have been made and are in the initial stages. At least one profit-making company presently teaches elementary curricula on a per student learning achievement basis through contractual arrangements with parents. The urgent question, therefore, is which one or combination of these and other alternatives is feasible for promoting creative change and efficiency in the fundamental manner which public schools allegedly educate children—a question of public policy needing priority attention!

2. Without the criteria and means for measuring achievement, it is premature to apply sophisticated systems analysis techniques to education programs.

This is especially true if costly CAI and similar systems are to be justified and learning time saved. It is interesting to note that after 12 years of support for the development of software and hardware associated with CAI, the Department of Defense recognized that the criteria for measuring effectiveness

did not exist. Under Project THEMAS and in its "advanced development program for education," it has supported those CAI projects whose end result would contribute to the solution of this specific problem.

It would appear that greater priority should be given by U.S.O.E. to the development of learning achievement criteria than we see in many of the small efforts presently under way. As state and local education agencies increasingly continue to determine the objectives of education programs (either through active prescription or inaction), availability and central dissemination of ways to measure achievement will become critical. Again, for the development of the necessarily large "hard" data base on instructional strategies and achievement criteria, it appears essential that large interfaced projects be initiated, probably using CMI systems as the technological bases for the action research.

3. To assume that innovation and efficiency thinking can be forced from the top down through layers of administrative bureaucracies to the classroom levels is rather tenuous in light of past experience.

A bottom-up to management efficiency approach needs testing. Such an approach would begin at the lowest management level, the classroom; be based on instructional management systems, which provide information so that decision-making could be based on increasing students' learning; and be implemented by an incentive system rewarding those better "managers of the conditions of learning." The crux of the matter is ensuring that rewards are based on learning performance. If this problem can be solved, then the traditional problems of teacher resistance to automated instruction, time wastage, etc., will become minimal. This small movement to efficiency thinking on the most decentralized level might become the seed of germination which would permeate the higher echelons of school systems administration.

4. Essential to the creation of an environment truly conducive to educational innovation will be the reduction of uncertainty related to questions about the political and social impact of capital-intensive instruction. For example:

- — the impact of individualization of instruction on the movement toward collectivism through organization and association and toward social democracy.
- — increased unionization in an ever increasing labor intensive "industry" which has never been part of an industrial revolution; new long-run approaches to the issues in teacher negotiations are needed.
- — the growth in education of the "cult of efficiency" without clear articulation of educational objectives in a continually growing affluent society.

Until the last decade, education had been considered as social custom detached from the political arena, especially at the local level. As education policy becomes increasingly decentralized, and attempts to define and direct educational policy increase, the local politics of education will become increasingly an ally or impediment to be reckoned with. This is particularly true for costly and controversial innovations such as CAI and CMI, which if used effectively will force administrators to change fundamentally the management and operation of their instructional programs.

Public policy which tends to enlighten rather than confuse vested interests groups will play a large role in the future of U.S. public education over the next critical decade. □

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Lawrence Lipsitz