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ABSTRACT

Methods of assessing the actual and potential efficiency of alternative instructional strategies, including those which depend heavily upon mechanical and electronic instructional aids, are explored in this essay. The paper also compares the problem of evaluating educational outcomes with that of evaluating government outputs in general, and discusses the strengths and weaknesses of the systems analysis approach. Finally, an extended example is given which is designed to illustrate an analytical procedure for determining costs and to provide insights into the place of audiovisual materials in contemporary education. (SP)

ON THE ECONOMIC ANALYSIS OF EDUCATIONAL TECHNOLOGY

Herbert J. Kiesling*

Introduction

Economic historians have long held that one of the most important causes of all social change is technological change. On the heels of three decades of accelerated advance in the field of educational technology, and in the face of much more to come, American education finds itself in the midst of a searching self-appraisal concerning its traditional teaching methods.

While quick change is exciting, it is also hard for those functioning in its midst to adequately analyze it. This paper represents an attempt to build an analytical framework which would allow a semblance of orderly empirical investigation, using the professional expertise of the political economist. It is the appraisal of an "outsider," as the author has had little direct experience in audio-visual technology before embarking on this study. Hopefully the drawbacks coming from the author's lack of technical expertise in some of the concerns of the paper will be counterbalanced by the advantages of a fresh and objective viewpoint.

This essay will explore methods of assessing the actual and potential efficiency of alternative instructional strategies, including strategies which depend heavily upon mechanical and electronic instructional aids. It will compare the problem of evaluating educational outcomes with that of evaluating government outputs in general. The strengths and weaknesses of the systems analysis approach will be discussed. Finally, an extended

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example will be given which is meant to illustrate the analytical procedure suggested in the paper and at the same time give the reader some insights into the place of audio-visual materials in the contemporary education scene.

Education is itself a public product, of course, and the professional economist whose speciality is Public Finance is not unacquainted with problems such as that posed above. It should be instructive to discuss some of the special problems which the economist has in analyzing the efficiency of government services because these problems are directly relevant to the task of this paper. Our understanding will be aided if we start by discussing the task the economist faces in the private sector.

Consider for a moment how one would set about finding the most efficient method (the method with lowest average cost in terms of total resources used per unit of output) of ~~rolling~~ rolled sheet steel. Finding the most efficient method presupposes we know all the possible alternative production methods and that we then compare the per unit cost of each method. There is nothing in this procedure which is impossible. Engineers can provide us with alternative technologies for producing steel sheets and if we impute a cost to each we have the answer.

The political economist who would find the most efficient method of providing a public service is not so fortunate however. This is because public sector outputs, by their very nature*, are to some extent

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*The private property system owes its fundamental justification to the desirability of having those who benefit society reap a corresponding return and those who impose costs should pay a corresponding price. When goods can easily be priced to individual recipients, the market system accomplishes this task well. But when benefits or costs of activities cannot be priced to individuals, i.e., when many of the costs or benefits are intangible in nature, it then becomes necessary for collective intervention.

intangible and therefore cannot be quantified into meaningful output units such as tons of sheet steel. To appreciate this one merely needs to ponder the problem of measuring the units of "national security" or "law and order." But without a meaningful measure of output it is impossible to evaluate the efficiency of government programs.

Faced with this situation the economist has two choices. First, he can give up. If he does not wish to do that, he must compromise somehow and accept the fact that his analysis will not be as precise as that of his counterpart in the private sector. The concept of "systems analysis" which seems quite stylish just now in the audio-visual literature is one method he has for compromising. The principle of sub-optimization is another. Each of these concepts is discussed in turn.

Systems Analysis and Public Outputs

After a rather concentrated reading of some of the audio-visual literature, I am surprized at the amount of attention that the concept of systems analysis has been receiving and am somewhat sympathetic toward Professor Oettinger's position that systems analysis is currently being oversubscribed. On the other hand, Oettinger's reaction to this also seems extreme.

Systems analysis is little more and little less than another name for economic analysis. Considering again the steel mill discussed above, the rolling mill constitutes a "system," or indeed, the entire steel company might comprise a system. Our inquiry into the most efficient production method was systems analysis pure and simple. As Kershaw and McKean put it,

> ...systems analysis is the comparison of alternative means of carrying out some function, when those means are rather complicated and comprise a number of interrelated elements. Such analysis could often be called "economic analysis,"

> Such analysis could often be called "economic analysis," since the aim is to find the best use of one's resources, but the word "systems" is useful in calling attention to the complex nature of the alternatives being compared.*

Kershaw and McKean go on to explain the rudiments of systems analysis very succinctly:

> The purpose of comparing one system with another is to show which is better. Or, more frequently, since quantitative analysis can rarely embrace all considerations, the purpose is to compare systems in a way that is relevant to a choice between them and helps one to decide which is better. Only one of the systems compared will ordinarily be an existing one, for the object is to "try out" innovations and new proposals in the comparisons -- to compare a system as it exists with what it might be after one or more proposed changes are introduced. Indeed one of the main products of making such comparisons is the devising of new and better variants -- the designing of new systems. ... It is characteristic of analytically interesting systems that there are many, many ways of varying the inputs. In education, for instance, not only can there be different pupil-teacher ratios, but different salary schedules and levels, different teacher training, building configurations, uses of television, degrees of emphasis on athletics, and so on almost to infinity.**

The most important criterion for meaningful systems analysis (economic analysis) is that there exist a meaningful measure of output. It is on this that all else depends. As we saw, analyzing a steel mill is no trick because we know precisely what a ton of rolled sheet steel with a certain chemical composition is. On the other hand, a systems analysis of the entire United States defense establishment is impossible since no one has the slimmest notion of what one unit of national security is. The problem of educational outputs is somewhat more manageable, however, and it may be possible to analyze a school or school district

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*J.A. Kershaw and R.N. McKean, Systems Analysis and Education, The RAND Corporation RM-2473-FF (Santa Monica, California, 1959), 1.
This important work, to my astonishment, has been completely overlooked in discussions of systems analysis I have seen in the educational literature, including one complete book on the subject by Pfeiffer. (33).

**Ibid., 1-2, 2-3.

as one system, using achievement scores in basic subjects as the output measure as Kershaw and McKean suggest. Several economists have done work along these lines, indluding the author. After spending several years with this type of analysis, I am not sure that using achievement performance for a complete school or school district is not overaggregating. If it is not, however, the systems analysis approach for evaluating alternative instructional strategies would be sinple if only achievement score performance is accepted as a meaningful measure. The researcher merely needs to experiment to see which instructional strategy yields the best results within the budget constraint of the school district.

The Concept of Sub-optimization

Let us return to the problem of analyzing public outputs whose benefits are mostly intangible. Defense is always the obvious example although it is easily possible to argue that there are too many dimensions in the public education product to be able to analyze them with one set of test scores. The compromise which the economist must make in this case is that he has to find a lower level of production such that a useful measure of output becomes available. This technique is called "sub-optimizing," and it is a very important one for the analysis of public outputs. Thus, while it is impossible to measure units of national security, it is possible to measure the number of days it would take to deliver a fully equipped paratroop division to some spot in the world. In education, examples of sub-optimization outputs might include science achievement in grades 4, 5, and 6 of pupils who come from middle-class socio-economic homes. Another output might be the same achievement for pupils from disadvantaged socio-economic backgrounds; another the amount of French vocabulary taught in high school, etc. In my judgment it is often true that these different outputs should be treated separately.

How would systems analysis be applied in a framework of sub-optimization? Again, what we have is merely economic analysis of an exactly specified "activity." But to illustrate, let us take an example from education. The output chosen is reading skill of grade school children from disadvantaged homes as measured by the Iowa Test of Basic Skills. A number of instructional strategies are chosen to accomplish the goal. Careful accounting procedures are instituted such that the amount and cost of all resources going into teaching reading to these children is known (program budgeting). An over-all long-range plan is made for spending resources on this program (planning). Each technique or "activity" is carefully evaluated and the strategy is selected which optimizes pupil performance within the constraint of the funds available for the task. Finally, if there are any costs or benefits of an intangible nature which, while important, do not show up in terms of money cost or in terms of the output measure chosen, these are carefully "noted in the margin" such that the proper decision maker is conscious of them when he makes his decisions.

An important drawback to the sub-optimization approach is the fact that some decision-maker must in the final analysis decide the relative importance of increasing the outputs of the various "sub-systems." But this is often no more of a problem with sub-optimization than it is with higher level systems analysis. Thus, even though we can relate all school inputs to achievement performance, some decision-maker must still compare the value to society of achievement performance with additional police protection or the installation of sidewalks. It is only when all outputs can be quantified in <u>dollar</u> terms that an over-all comparison is possible. When this is done (somewhat imperfectly) in the public sector it is termed "cost-benefit analysis." Cost-benefit analysis would only be possible for the education sector if all increases in achievement performance and other performance could be related to dollar rewards to society. While economists have done some crude studies of this kind, they are not important for our purposes here.

Let us summarize this discussion by listing the steps which need to be taken for a meaningful systems analysis in the school.

1. Define meaningful and concrete objectives. It must be kept in mind that it will not be possible to include every nuance of educational output in such a set of objectives. This is more true the more aggregated the level of analysis is. However, it must be kept in mind that some intangible objectives may be automatically satisfied at the same time as major quantifiable objectives are satisfied.

2. An output measure which is at least semi-cardinal must be found for each objective. A cardinal measure is one that has intervals which have interpretable units of width, such as number of test questions answered correctly, etc. An example where such units do not obtain is when one program is thought to be "better than" another.

3. Accounting techniques must be instituted where the inputs are costed carefully according to each objective.

4. Ingenuity must be exercised in constructing meaningful alternative ways in which the objective may be reached.

5. Each method for realizing the objective is tested and the experimental results analyzed. The cost of each alternative is carefully computed and this is also analyzed. Even if it is impossible to test differences in effectiveness, the cost analysis would still be quite valuable to the decision-maker.

6. The relative benefits from each approach are compared to the costs of their inputs and a cost effectiveness summary of the system made.

In the opinion of the author, this is the framework in which a proper analysis in education can proceed. It is an approach very similar to that given by Briggs and others in their study of instructional media which is published by the American Institutes for Research (8). An extended example of its working is given in the next part of this paper.

Some Suggestions for Implementation of the Analysis

There are a few more points about this approach which are germane to our discussion. First, it should seem obvious to the reader that the approach would require careful experimental control, as well as much patience and hard work. Because of this need for high quality control, I would suggest that research funds be channeled into a few extremely high quality experimental situations as opposed to a great many lower quality experiments. I would envision, for example, somewhere in the neighborhood of four to six experimental schools (or school districts) in the entire country wherein continuous research is conducted concerning the effectiveness of alternative instructional strategies with respect to the teaching of pupils from varying types of socio-economic backgrounds and with varying levels of ability.

The use of a few experimental schools instead of widespread experimenting would accomplish two other desirable results. First, it would be anticipated that if techniques become widespread which use objective test scores as the measure of performance, there becomes the danger that school teachers and administrations will begin to explicitly "teach for the tests," with the probable consequence that other, less tangible, but not unimportant, educational goals would be neglected. This would not occur if there were only a few experimental schools. Secondly, this scheme would control the effects of "experiment enthusiasm," the factor which makes much published research suspect concerning educational experiments which have been conducted in the past. In the experimental school, participating personnel would come to accept varying instructional strategies as a matter of course. Finally, experimental schools should be similar to "typical" American schools in as many respects as possible.

Sub-optimization and School Organization

With the expanded possibility for using mechanical and electronic instructional devices, and adopting a systems approach by program, it appears to me that a fundamental change in the organizational structure in most American schools would create an institutional framework wherein there is a natural tendency for the most efficient instructional strategies to be adopted for each task. Briefly stated, the idea would be to have an independent decision-maker with his own budget responsible for each lower-level educational objective in the school district. There can be no doubt that the new instructional devices are causing change to move in this direction. Consider the following observation concerning the use of a grammar program in Manhasset:

> The introduction of English 2600 led the teachers to question previously unexamined assumptions about teaching, to consider prerequisites to the study of the subject, to examine the value of teaching certain material, and to analyze the needs of students. At the same time they found themselves organizing for instruction in new ways, using large group teaching of a rather unusual kind, individual conferences once or twice a week for each child, a lay reader who also held student conferences, a class in remedial grammar, and a system of grouping homogenously by accuracy and speed in English grammar.
>
> The teachers also found themselves using a substantial portion of their two free periods each week for joint planning and evaluation of their program. The team, at first under the leadership of the teacher who had started the program, developed an associate relationship involving joint planning, teaching and evaluating of the program. When the need arose, one teacher could take over any one of the eighth-grade groups, and pupils could be transferred from group to group whenever

necessary. Yet no formal team-teaching structure was developed, and unlike teachers in many schools experimenting formally with team teaching, the teachers believe that their work load has not really increased. Rather, the work of planning has been transferred from home to school, and work time at school has become more concentrated.*

As I see it, this organization will be one in which the department chairman becomes a responsible decision-maker as he is in many universities.** One department for example, might be "History" in a small high school or "Eleventh and Twelfth Grade History" in a large school. The chairman has his own budget and participates along with the principal in hiring decisions for persons in his department. He is a master teacher and has a good knowledge of the strengths and weaknesses of the various audio-visual media. He has a hand in the planning of the curriculum and in daily lesson plans such that he can step in on short notice and perform <u>any teaching task</u> in his department without loss of continuity. He is free to substitute audio-visual media for teacher time and vice-versa at will as long as he stays within his budget and satisfies his superiors that the instruction is effective.

There will be ongoing evaluation of the educational "product" of his department both by the chairman and by the office of the assistant principal for evaluation. Finally, each school has an audio-visual media center which supports the department chairman's requests for equipment use and which coordinates the demands of the various departments.

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*John Herbert and Arthur W. Foshay, "Programed Instruction in the Manhasset Junior High School," <u>Four Case Studies of Programed Instruction</u>, Fund for the Advancement of Education, New York, n.d., 24, (22 .

**This is not to say that university departments are themselves efficient. The reason, again, is that the chairman is responsible for too many sub-functions. But that is another story.

A Detailed Analysis: Instructional Strategies for Elementary Education

Not the least of the virtues of looking at public services in the manner outlined above is that is provides a convenient framework for thinking about the problem in systematic fashion. As a way both of illustrating the technique and at the same time examining the potential of alternative instructional approaches in elementary education, this part of the paper will deal with the costs and outcomes of alternative instructional strategies for the teaching of science, reading, and arithmetic to elementary school pupils. Time did not permit the author to be as exhaustive as he should have in the treatment of the literature and many of the numbers in the analysis are not obtained in scientific enough fashion for them to be trusted. This is especially true on the effectiveness side. Cost investigations were somewhat more thorough.

There are four basic steps to the analysis. First, a specific output measure needs to be isolated. This is relatively easy at the elementary level since performance in basic subjects form a large percentage of elementary education. In the example here we have used reading, science, and arithmetic studies, with "science" being interpreted quite broadly in one instance (learning how to dial the telephone.)

The second step is to carefully isolate in detailed form a number of major strategies for teaching this information of which the traditional reliance of a single teacher in a classroom is one. The purpose of these strategies would be different according to the aims of the individual researcher. If the evaluation is to be one of the experiments that have already been performed--such as that in this paper--then the researcher need pay attention only to strategies that have been used and perhaps also, for instructive purposes, some extrapolation of strategies close to those already performed. The drawback to this approach of course is the fact that many of the studies in literature are not strictly comparable. As Briggs points out:

> Many experiments were designed to compare the overall effects of one medium with another, or with a combination of media, over an entire course. While such experiments are of value for the practical purpose of choosing among existing packages of instruction on particular topics, they do not represent a basis for designing an analytic procedure for planning new instructional courses, When a lengthy course or sequence, representing several kinds of learning, is prepared in two different media and the results analyzed, the most frequent result is a failure to demonstrate a significant difference. One reason for such a finding could be that each of the media compared was more effective for some elements of instruction and less effective for other elements, so that the differences in effectiveness among media were canceled out in the overall analysis.

Briggs goes on to succinctly state an even more frustrating problem:

> Another problem in employing the classroom literature for the present purposes was the failure to describe the content of instruction in sufficient detail that the type of learning involved could be identified. When it is suspected that the materials used in an experiment did involve several types of learning, it would be necessary, for the present purpose, to be able to identify specific criterion test items which correspond to the separate types of learning presented during the experiment. Almost no investigators report data which make this kind of analysis possible.*

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*Leslie J. Briggs, Instructional Media: A Procedure for the Design of Multi-media Instruction, A Critical Review of Research, and Suggestions for Future Research, American Institutes of Research (Pittsburgh, Pennsylvania, 1967), 24.

This excellent discussion is the best I have been able to find on the analysis of multi-media instruction and is the one that incorporates the best understanding of the approach outlined here.

Briggs' remarks illustrate a great problem that exists in the educational literature which has to do with the shameful quality of the reporting of educational experiments.

A very tangible virtue of the procedure outlined herein is that it would impel investigators to report findings in a more scientific manner.

Despite these problems, the approach can have a great deal of value and is probably the best one for putting existing empirical work into a meaningfully ordered analytical framework.

The second approach is to design and conduct experiments according to the various proposed strategies. This of course requires the professional expertise of the trained educational psychologist who keeps in mind the relative theoretical effectiveness of different instructional techniques for teaching different tasks--perhaps using the Gagné 8-fold classification of subject matter or concepts of the like.

Based upon the 21 experiments outlined in Chart 1 , my own knowledge of educational practice, and some imagination, I have constructed a set of twelve possible teaching strategies for basic elementary-school subjects. Each strategy is different in some major respect from all the others. Depending upon the patience and resources of the researcher, a great many more strategies could be isolated although in most cases the additional effort would not be worth the candle. Thus, the major inputs varied in the twelve strategies are seven: Administrators, para-professional personnel, secretaries, TV instruction, teachers, films, and programmed learning, this last to include computer assisted instruction. An analysis where more detail is introduced would include such things as filmstrips, overhead projectors, etc., as variables, not to mention strategies which utilize school buildings 12 months per year. In this paper it is assumed that the use of such devices is usually <u>in addition to</u> the resource inputs of the twelve major strategies and, moreover, that the incidence of their use is relatively stabile between strategies and therefore, they are not considered in the analysis. This does not imply they are unimportant.

Each of the strategies is now discussed in more detail. There are two major variations with respect to administration--traditional and with departmental organization. The first six are traditional; the last six departmental.

Strategy 1. Traditional Single Teacher Instruction

This is the strategy which has proved durable over many decades. Some audiovisual aids are used but the teacher carries the main burden of all the instruction and course organization. There is little supervision of curriculum detail by higher administrators and therefore, there are only about three to six principals and supervisors for every forty teachers. No TV is used; nor is there programmed learning of any type, although some films are used. Our strategy assumes three principals and supervisors per 1000 pupils (a figure based on a New York study by the author)*, no para-professional people, two secretaries for each principal and supervisor, a full-time teacher, no TV, no programmed instruction, and two 15-minute films shown per week.

Strategy 2. Traditional Single Teacher with Additional Use of Televised Instruction

This strategy is essentially the same as Strategy 1 except that the teacher depends on audio-visual aids more heavily and it is therefore somewhat more expensive. The teacher uses some combination of five 60-minute, ten 30-minute, or twenty 15-minute televised periods per week.

Strategy 3. Traditional Single Teacher with One Period (60 minutes) per Day of Instructional Television in Large Classes of 150 Pupils.

This strategy is identical to the previous one except for the fact that the children attend the ITV lectures in large groups. The

*Kiesling (27).

assumption made is that one teacher gives the lecture while another monitors the large lecture section. Since we assume one teacher per 25 pupils otherwise, this strategy releases four teachers during the TV instructional period.

Strategy 4. Traditional Single Teacher with Programmed Instruction

This strategy is the same as Strategy 1 except that it adds 300 minutes of programmed instruction per week. There are two variants: Variant A uses computer-assisted instruction for drill and practice programs while Variant B uses teaching machines. These same two variants are used whenever there is programmed instruction.

Strategy 5. Traditional Single Teacher with Programmed Instruction with Pupils in Large Groups

This strategy is identical to Strategy 4 except that pupils receive programmed instruction and view films in groups of 100. During programmed instruction one teacher answers questions and another either answers questions or assigns work to the pupils who finish the program.

Strategy 6. Traditional Single Teacher Except That Films Are Shown to the Pupils 60 Minutes Per Day in Groups of 150.

It is assumed that only one teacher is present during the time the film is shown thus releasing five teachers for one hour. The sixth teacher could of course easily be replaced by a para-professional person at some savings.

Departmental Organization Strategies

Above was discussed the author's idea of the departmental organization structure which would be required if there is to be efficient substitution back and forth between audio-visual materials and face-to-face teacher instruction. The chief difference is that more administrators, secretaries, and para-professional personnel would be used than are used in most schools presently. In most small elementary schools as they now operate little change in organization would be necessary. For a school with an enrollment of 500, say, required would be two additional assistant principals to head up phases of the curriculum. This represents perhaps a tripling of administrative personnel and the assumption used for the departmental organization strategies is that three times as many principals, supervisors, and secretaries would be required as are presently required. It is to be noticed that department heads have been classified as administrators and used full time for administrative tasks despite the fact that all of them would do some teaching.

Strategy 7. Departmental Organization with Pupils Instructed 1/5 by TV and 1/5 by Motion Pictures in Groups of 100

With this strategy a teacher is never used in the classroom to monitor TV and film instruction. This is done by para-professional people.

Strategy 8. Departmental Organization: Same as Strategy 7 with Programmed Instruction Substituted for Films

Unlike for films and TV, the assumption is that a teacher will always be present during programmed instruction.

Strategy 9. Departmental Organization: Heavy Dependence upon TV Instruction with Some Film Instruction

In this strategy, TV and film presentations are made in individual classrooms with teachers present in class 15 minutes out of the hour for discussion.

Strategy 10. Departmental Organization: Strategy 9 Except That the Pupils Are Instructed in Groups of 150

This is the most inexpensive of the twelve strategies.

Strategy 11. Departmental Organization: Half-time Single-Teacher Instruction and Half-time TV Instruction to Groups of 100 Pupils

Strategy 12. Departmental Organization: Heavy Use of ITV, Films, and Programmed Instruction, Groups of 100 Pupils; Single Teacher Otherwise

This is the most "capital-rich" strategy presented. Despite this, the average pupil sees a classroom teacher during 42% of his total instruction time.

Costs

Having constructed a meaningful set of alternative instructional strategies, the next step is to estimate the costs of each on a per pupil basis. This in turn requires estimates for the per-pupil costs for the relevant inputs. This was straightforward for the four labor inputs used, since it is relatively easy to assign salary levels which are approximately correct. The salary levels assumed for a 36-week school years are as follows:

Principals and Supervisors	$10,000
Teachers	$ 8,000
Secretaries	$ 4,000
Para-professional Personnel	$ 4,000

The costs of the three "capital" inputs are much more difficult to obtain, however. The next three sections include detailed discussions of per-pupil costs for closed circuit TV, films, and programmed instruction (computer or teaching machine). As the reader will see, the estimates obtained are merely approximate, although I feel they are reasonable interpolations of what I have found in the available literature on costs. The two most important single sources used were the detailed study by the General Learning Corporation (GLC) (18) for all the major audio-visual media and the Booz-Allen-Hamilton estimates of the cost of instructional television and computer assisted instruction which were prepared for the Committee on Economic Development (11). Cost estimates on computer technology also appear in Oettinger's coming book, and in work by Jamison and Suppes. I have also spoken at length with a number of people in the excellent audio-visual department at Indiana University (especially concerning film and teaching machine costs) and also at the National Center for School and College Television. Finally, I have found the discussions of costs of instructional television in Hagerstown, Maryland (6) most valuable. Throughout I adhere to the convention of making estimates in terms of ten percent blocks of instructional time. Unless otherwise stated, a school district of 20,000 pupils is assumed.

Cost Estimates for Closed Circuit Television

Three basic sources were used for CCTV cost estimation--Hagerstown, General Learning Corporation, and Booz-Allen-Hamilton.

The GLC estimate for ITV costs for 10% instructional time in a 15,000 pupil school district is approximately $33.00 per pupil per year. This includes some "in-house" production costs of "minimal Quality" (teacher lecture--some visual training aids). With greater reliance upon a national programming source the cost would be a few dollars less. The GLC estimate for a city with 150,000 pupils is only $11.00 per pupil per year.

Cost estimates in the Booz-Allen-Hamilton study vary greatly depending upon the software utilized. For a school district with 100,000 pupils B-A-H estimates ITV (for 1/6 time) would cost $800,000 for $50.00 per hour software and $3,200,000 for the exclusive use of the most sophisticated software produced in house. Their cost estimate for various combinations of software is $2,400,000. Few school districts would employ highly expensive software and many would undoubtedly concentrate upon the same type of software as that used in Hagerstown, which is relatively inexpensive. Thus, I have selected a compromise figure of $1,600,000, which is half-way between the two lower figures. This comes to $16.00 per pupil per year for 16.7% time or $9.60 per pupil per year for 10% time for 100,000 pupils.

The Hagerstown estimates are the only ones here coming from direct experience. I averaged required-TV usage for grades 3-6 in Hagerstown which comes to 13% of intructional time. There are some optional TV courses also and,adding two percentage points for that, we have a 15% elementary school program of ITV. For this 15%, Hagerstown spends about $300,000 in operating costs. They claim buildings for the TV cost about $225,000 although this seems low. With debt service and a forty-year write-off this comes to about $11,000 per year. I assume $20,000. Dividing $320,000 by 20,000 yields the very low cost of $16 per pupil per year for 15% of total instructional time. There is no provision for rented program material in this although Hagerstown does in fact produce most of their own programs, using their own teachers with large TV viewing audiences.

To summarize the foregoing, we have the following estimates for 10% time by size:

	Size			
Study	15,000	20,000	100,000	150,000
General Learning Corporation	$33.77			$10.81
Booz-Allen-Hamilton			$9.60	
Hagerstown		$10.67		

The GLC and B-A-H figures seem reasonably consistent while that for Hagerstown seems low. If the Hagerstown figure is reasonably close, the GLC figure is undoubtedly too high.

What cost figures to use for a school district of 20,000? It is difficult to reconcile the different size, but let us assume that the relative cost differences by size are correct as given by GLC. Using that relationship, the figures reduce to the following for a district with 20,000 pupils, 10% time.

Hagerstown	$10.67
GLC	32.92
B-A-H	16.36

The arithmetic mean of these three estimates is $20.00, which is the figure I will use in this paper.

But this is merely for the first 10%. How much would additional blocks of 10% time cost? There is little in the literature to serve as a guide on this point. Certainly there must be some economies of scale in closed circuit television. General Learning Corporation at one point estimates that the cost per pupil of closed circuit TV going from 10% to 20% for a metropolitan area goes from $10.00 to about $13.00, or approximately 30%. Using this information, my guestimate is that cost would increase 50% for each additional 10% and therefore, the figure assumed here is additional 10% blocks of closed TV instruction cost $10.00 per pupil per year. Further, and having nothing to go on (except some economic theory perhaps) I would think that after some point it becomes relatively expensive to provide TV again. Thus, I assume that after the percentage of instruction becomes 40%, the cost per hour per pupil again becomes $20.00.

Cost Estimates for Films

General Learning Corporation estimates that in a local school district (15,000 pupils) per pupil annual cost for using films 10% of the time would be $51.71, with $36.59 going for production (including acquisition of rented materials), $6.13 for distribution, and $8.99 for reception. The GLC estimate for acquisition costs seem high however. Rental fees at the Indiana University Audio-Visual Center for five days' use are approximately $4.00, $9.00, and $13.00 for 20-, 60-, and 90-minute films respectively for black and white, double this for color. Assuming half usage of 20-minute and half of 60-minute films, half in color and half in black and white, and also assuming the films are shown to two groups of fifty students each week, total rental fees per student per year comes to $14.58 per pupil per year. Further savings could be realized by using more long films (which are becoming increasingly available) or by using a larger room for each showing. It is not reasonable to assume school district production in most instances of film material, although there is no reason why film production costs could not be almost as low as TV program production costs in Hagerstown, for example. Therefore I have adopted the figure of $15.00 per pupil per year for production and acquisition costs. Using the GLC estimate of approximately another $15.00 for distribution and reception costs, this yields a figure of $30.00 per pupil per year for 10% instructional time which is the figure I use.

8mm Film

While 8mm film is not specifically considered in this paper, a note should be added concerning this interesting new media. Perfect for individual and small group instruction, it costs only $10.00 for the purchase of a four-minute cassette and $55.00 for an 11-minute cassette. Small rear-screen projectors cost from $100 (silent) to $350.00. While the resolution is not quite as good as for 16mm, the 8mm film can also be shown to larger groups with projectors which cost about $400. The technology of 8mm films seems most adaptable to classroom teaching, with the possibility of the teacher stopping the film at any point to show one frame, going over material a second time, etc.

Cost Estimates for Computer Assisted Instruction and Branched Programmed Learning Using Teaching Machines

There does not seem to be much agreement concerning the costs of computer assisted instruction. Part of the reason is that some writers look at present technology and others think in terms of what will be possible in the future. Also, there is some disagreement over what the computer would be asked to do. If it were a full-scale tutorial program, it would be much more expensive than a simple drill device.

Booz-Allen-Hamilton arrive at the conclusion that CAI cost per student for 1/6 of a day per year in a school district of 10,000 for drill and practice would be $340,000, while in a district with 100,000 pupils it would be $272.00. Oettinger, in his forthcoming book, presents figures which are fairly much in line with these estimates. On the other hand, Oettinger cites studies which state that equipment costs (not including software) would be 2% of a school's budget (Bright) and $50.00 per year per student (RCA). The 2% figure would run only $10.00, an unbelievably low figure. Oettinger cites another study which projects Philadelphia expenditure for CAI at 10% of their total budget, or about $50-$60 per pupil per year. Also, Suppes, in an unpublished comment on Oettinger's book claims that we "could aim at" $30.00 per student for a drill and practice program. Dean Jamison, finally, estimates a yearly equipment cost of $90.00 per student for an IBM 1500 computer with 32 terminals. Jamison also discusses a modified CAI system which does not have continuous access to computers, uses audio and other shortcuts, which would cost a total of only $45.00 per year.

The Booz-Allen-Hamilton estimate for production cost is $200.00 per year while Jamison's for the IBM 1500 computer is $90.00. Using Jamison's figure for production and leaving everything else unchanged, for a 10,000-pupil district this comes to $230.00 per pupil per year and for a 100,000-pupil district, $162.00 per pupil per year. This is for 1/6 time however. For 10% time and for a 20,000-pupil district, this figure comes to $133.50. On the other hand, the original B-A-H figures of $340.00 and $272.00 convert into a figure of $200.00 per pupil per year for 10% time.

The General Learning Corporation, while discussing computer assisted instruction in some detail, at the same time feels that it is premature to make cost effectiveness analysis simply because it is so difficult to measure effectiveness. They do give some trade-off figures, however, which help establish costs. Investment per student with top utilization rates is given at about $2,000, a figure which undoubtedly is well in excess of $200.00 per pupil per year, although this is undoubtedly for more than 10% pupil time.

Finally, Patrick Suppes gives a detailed breakdown of a system which has 1,000 terminals with 40 students using each terminal which only costs $30.00 per student per year. With some misgivings (because of Suppes' figures) I have adopted the figure of $200.00 per pupil per year for CAI for 10% time. It is probably too early in the game to make a decent estimate for this technology however.

There is probably no reason to assume that further 10% blocks of instructional time would be less expensive and therefore, I assume each additional 10% instructional time also costs $200.00.

Other Programmed Technology

Computer Assisted Instruction in its simpler applications is basically programmed instruction. Thus, there are other less expensive programmed instruction technologies which are available. One of these is outlined by Dean Jamison, and is a branching program which uses a minimum of computer time. The student follows the course (at his own level) with earphones and a workbook. Jamison estimates that costs of this scheme would vary between 15¢ and 25¢ per console per hour. Using 20¢, this comes to 60¢ per week, or about $22.00 per student per year for 10% time.

Finally, there is the alternative of using teaching machines. Some types of machines make it possible to use a fairly sophisticated branching program similar to the simpler tasks that can be performed by computers. One machine which can accomplish this is the Auto-tutor, which sells for about $1,250 and lasts almost indefinitely. Software costs $110.00 per program and a student uses perhaps one program per week on the average. With a 25-year amortization and a $5.00-per-year maintenance cost, yearly cost of hardware is $10.00, and if six pupils per day use the machine, this is $1.67 per pupil per year. The cost to be imputed to this technology is closely related to the useful life of the software, however. Many writers assume that programs become obsolete after three years, although this seems extreme for such things as grammar, arithmetic drill, etc., as are often used for this type of program. More realistic figures might be seven or even ten years. The seven-year figure is used here. Per pupil software cost per week is therefore 110/7 x 6 = $2.62 for 16.7%, or $1.57 for 10% time times 36 weeks. This is $52.52. Adding the $1.67 cost of hardware gives a figure of approximately $60 which is somewhat higher than that of Jamison's scheme. Since the Auto-tutor method is presently in use, I have adopted the $60 figure for branched program instruction using teachin machines. With mass-produced software this cost could go down significantly, however.

Relative Costs of Media

It is now easy to compare the relative costs of trading off one media for another which is a chief advantage of structuring the analysis in this way. The relevant information for doing this is as follows:

	Cost Per Pupil Per Year					
	Percent of Instructional Time					
	First	Second	Third	Fourth	Fifth	Sixth
Instructional Input	10%	10%	10%	10%	10%	10%
Teachers	$32	$32	$32	$32	$32	$32
Para-professionals	16	16	16	16	16	16
Television	20	10	10	10	20	20
Films	30	30	30	30	30	30
Computer Assisted Instruction	200	200	200	200	200	200
Teaching Machines	60	60	60	60	60	60

It should be remembered that in order to replace a teacher it is necessary to spend some funds upon para-professional personnel. But if one para-professional (teacher-aide) can monitor a classroom of 100 pupils while a one-hour film is being shown, this allows the administration to free four teachers for that hour, assuming as we do that it is necessary for there to be one classroom teacher for every 25 pupils. Thus, in this example, the cost would be that of the media plus of the equivalent of one fourth of a para-professional (since one such individual is monitoring four regular classes) while the savings would of course be the salaries of the four teachers for that hour, assuming they are being efficiently utilized elsewhere.

From the figures just given, it is obvious that computer assisted instruction is by far the most costly of these technologies. Even teaching machines, of the Auto-Tutor type, with branching programs, are relatively expensive when judged alongside the other technologies. Of all the media, closed circuit TV is the least expensive. The reason TV is less expensive than films can be found in the copyright laws which forbid films to be shown through the TV facilities of an entire school or school district.

Cost Analysis of Alternative Instructional Strategies

Cost per pupil per year for each strategy is given at the bottom of Table 1. As the reader can see, the most economical strategies are those in which it is possible to take advantage of using groups of pupils which are at least 100 pupils in size. Thus, of the traditional single teacher strategies, the two most economical ones, numbers 3 and 6, both use groups of 150 pupils for media presentation. It is noteworthy that the traditional single teacher strategy is much more expensive than the two best strategies. Of course, when it is necessary to maintain a relatively full time teacher plus using audio-visual devices, the cost becomes greater, as with strategies 2 and 4. This is particularly true with computer assisted instruction.

As discussed above, when teachers are replaced and large classes are used for media presentation it is necessary to introduce more administrative planning using a departmental organization. Despite increased administration costs, the departmental scheme seems to yield economies, with all except strategy 9 being at least as inexpensive (using Teaching machines instead of programmed learning) as any single teacher scheme. The most inexpensive scheme of all, strategy 10, utilizes classes of 150 pupils for viewing films and television, with teachers providing 15 minute discussion periods after each film or TV presentation.

Effectiveness

Up to this point only the costs of alternative strategies have been considered. Nothing has yet been said about the effectiveness of each.

Chart 1 gives in summary form the effectiveness of 21 studies which are relevant to the teaching of grade school basic subjects and which represent, at second hand, reasonable approximations to at least some of the strategies given in Table 1. They are meant to illustrate in crude fashion a preliminary attempt at evaluation.

Most of the studies mentioned in Chart 1 are closest to our strategy 2, which merely adds television instruction to single teacher instruction. Counting the two racial groups in Study number 11, there were 12 of these experiments, of which three showed the TV treatment as significantly better, one inferior, and the others showing no difference. From these studies it would be difficult to conclude that strategy 2 is much better than strategy 1.

Five of the studies could be (with some awkwardness perhaps) construed as fitting into strategy 3 which uses large TV classes. Of these, four are significantly better, one shows no difference, and one is insignificantly worse. One of these experiments is the experience of Hagerstown, Maryland, which had positive results over a great many replications. There is a suggestion at least, therefore, that strategy 3 is more effective than strategies 1 and 2, as well as less expensive.

Strategy 4 employs single teacher relationships but with the addition of drill-and-practice type programs provided either through the medium of teaching machines or computer assisted instruction. There are three teaching-machine-programmed-learning studies listed in Chart 1 and one experiment using CAI. In two of the three teaching-machine-programmed-learning studies high ability pupils did significantly better than control groups and the third reports simply that good students had time left over to do other things. For average ability children two of the studies showed no difference while the third (Manhasset) showed experimental groups doing significantly better although there was some question raised about the testing procedure. One study reported specifically on low ability children and found poorer performance although not statistically significant. Many programmed learning studies complain that low ability pupils often fail to finish and therefore lose interest.

We have listed only one study for strategy 4A (or 5A), i.e., the one that uses computer assisted instruction. In that study, of which I have only a preliminary fragment, Suppes reports by class and therefore does not differentiate by ability level. In two experiments Suppes finds no difference in one and significantly better performance for the programmed learners in the other.

To summarize with respect to programmed learning, if I were a department head with the responsibility of dealing with higher ability children, I would look into programmed learning for rote skills very carefully. Otherwise the results do not as yet seem to warrant the additional expenditures required. There is no doubt that this technology will have a definite role in future instructional strategies.*

There is only one study which more or less fits strategy 6, which uses films one hour a day or so, shown to large groups. That study, by Slattery,(36), also does not use as large classes as called for by strategy 6 and filmstrips were used besides motion pictures for the teaching of fifth grade social studies. Slattery found both filmstrips and motion pictures improved performance with best performance coming with heavy use of filmstrips.

Since the departmental organization struture assumed in the last six strategies in Chart 1 does not correspond to many real-world school situations there are not many experiments which fit those six strategies, although most of these strategies have their single-teacher-organizational-structure counterparts. Thus, strategies 7 and 11 are similar to strategies 2 and 3 for example.

Roughly speaking, the Milwaukee experiments in elementary science (number 15 on Chart 1) look as if they could easily fit into strategies 10 and 11. Of the 12 strategies, number 12 relies the most on mechanical instructional aids. There have probably been no experiments where A-V materials are used this heavily. Of the experiments listed in Chart 1, number 19 is perhaps the only one which came close to using this technology.

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*The investigator cannot read into the literature on programmed learning very far without noticing the fact that it is an instructional technology which has very different impacts upon pupils with differing levels of ability. More specifically, the chief attraction of programmed learning technology is the speed in which it can teach some rote skill subjects such as grammar and arithmetic to high ability pupils. The technique should not properly be compared to the progress of <u>all</u> pupils therefore, but with pupils with high, average, and low ability levels, somehow defined. This is another example of the benefits to be gained from sub-optimizing the analysis to the point where the program and pupil population is homogeneous.

General Summary of Results

On the evaluation side of this analysis, there seems to be a great deal of evidence that many of these strategies are of equal effectiveness, at least insofar as average ability-level pupils are concerned. If I had to hazard a judgment, I would say that mixed-media schemes which use 10 to 20% instructional TV seemed to provide the best results. It seems most clear, also, that face-to-face teacher instruction, preferably in small classes, is the one input necessary to make all the other ones "go."

If we can believe the many findings in the literature of "no difference," then the task of comparing efficiency is simple; we merely need to compare the costs of each strategy. Thus, of the strategies using traditional organization, numbers 3 and 6 are best, while strategy 10 is far the most inexpensive overall. Of the strategies which use traditional single teacher organization, it is important to notice that the most inexpensive are those which utilize large groups of pupils for Audio-Visual Media presentation. My final over-all impression, considering both cost and effectiveness, is that the most efficient general teaching strategies for average ability elementary schoolers would be some combination of strategies 3 and 6.

If the outcomes are significantly different for the various strategies, however, and as the number of relevant strategies becomes larger, more sophisticated analysis is needed. This is available in the form of linear programming analysis and it would not be difficult for economists with a knowledge of managerial economies to set the problem up and solve it in a linear programming framework. Until more precise evaluation of alternative strategies is possible this will not be necessary, however. It will be enough for the administration to choose the strategy which yields the best pupil performance subject to the limitations of his budget.

Postscript: The Future of "Capital" in Education

While not germane to the discussion in the main body of this paper, I should like to venture some observations concerning the future of mechanical and electronic instructional techniques based upon some simple economic theory. Professor Baumol has capably demonstrated the plight of the labor intensive industry in a capital-rich economy both in his book written with Bowen (5), and more rigorously in a paper published in the American Economic Review (4). Briefly put, sectors which cannot increase their productivity by deepening of capital are at a serious long-run disadvantage relative to those sectors which increase productivity through improved capital equipment. The reason for this can be understood best from a consideration of the following chain of circumstances. Technological progress occurs in some sectors of the economy, for example, in steel production, automobile production, coal mining, etc. Such progress allows higher profits and for some reason or other--let us say it is because of union activity--wages rise to keep pace with the rise in productivity. With small exception this has happened throughout much of the past two centuries. Wages in these sectors are higher but because of the increased productivity, prices of the products do not go up--over time they may even decline. But since each national economy is a single labor market, wages do not go up in half of the economy without their being bid up in the other half as well. Over time wages tend to seek one level (and degree of unionization seems to have no effect on this) just as water tends to seek one level. Now, with wages having gone up in sectors where it is not possible to deepen capital and so raise productivity per worker (such as most government service, live symphony orchestra music, and barber services) the only resource for these sectors is to raise prices. There is no theoretical end to this process--if it continues long enough, prices in the labor intensive sectors will become infinitely high! With higher prices in these sectors, consumers substitute their purchases and buy more and more products where productivity has kept pace and less and less where it has not.

Until the 1960's, American Public Education, with a traditional resistance to change, has remained a highly labor-intensive sector with the result that prices of educational services have been rising rapidly. But the more prices increase, and the more the prices of the labor inputs--mostly teacher salaries--increase, the more economic pressure there is to substitute capital for labor. Thus, we should expect to see a much greater use of capital in American Education in the next fifty years.

This situation in the American Education Industry today (on all levels) is not unlike the situation in the American coal industry thirty years ago. It appeared at the time that American coal was being priced out of the world market and that any more increases in the wages of miners would kill the industry altogether. But John L. Lewis, an adamant man, led the union to seek and get much higher wages anyway. And what happened? Faced with higher wage costs, mine owners strained to introduce labor saving equipment, which they did so successfully that today American coal has a competive edge in world coal markets. Part of the reason for this is that the high paid miners are themselves happier and more efficient than otherwise!

With teacher salaries having gone up a great deal in the past several years, I feel that American Public Education in the 1970's will be in the same position as American coal in the 1940's. Let us hope that the end of the story is equally happy. If it is, much will have been gained, for American Public Education will have high quality teachers using sophisticated instructional materials.

TABLE 1

TWELVE INSTRUCTIONAL STRATEGIES, SEVEN SCHOOL INPUT

	INPUT			
STRATEGY	1 Teachers	2 Para-professional Personnel	3 Closed Circuit Television	4 Films
		% of	Total Instructional	Time
raditional Sin-gle Teacher	100			3.3 (two 30 minut films per wk)
raditional S-T ith one period er day Instruc-ional TV	100		16.7 (five 60 minute or ten 30 minute sessions per wk)	3.3 (as in Strateg 1)
raditional S-T ith one period er day ITV where upils are in arge classes of 50 pupils	88.9 (one teacher gives lecture; one teacher monitors the large lecture session)		2.8 (as in Strategy 2 and divided by 6 [150/25 = 6])	0.6 (as in Strateg 1 and dividec by 6)
raditional S-T ranched Pro-rammed Learning ith CAI or eaching Machines	100			3.3 (as in Strate 1)
raditional S-T ith CAI or Teach-ng Machines where upils are in arge groups of 00 pupils while aking Programmed earning	91.7 (during Programmed Learning sessions, one teacher answers questions and another teacher answers questions or assigns work to pupils who have finished the program)			0.9 (as in Strateg 1 and dividec by 4)

BLE 1

ATEGIES, SEVEN SCHOOL INPUTS

NPUT

3 ed Circuit levision	4 Films	5 A. Computer Assisted Instruction B. Programmed Instruction with Branching	6 Principals and Supervisors	7 Secretarial	Cost per Pupil per year
Instructional	Time				
	3.3 (two 30 minute films per wk)		1	1	$367
16.7 60 minute or 0 minute ons per wk)	3.3 (as in Strategy 1)		1	1	$394
2.8 Strategy 2 divided by 0 = 6/ 5 _/)	0.6 (as in Strategy 1 and divided by 6)		1	1	$330
	3.3 (as in Strategy 1)	16.7 (five 60 minute or ten 30 minute sessions per week)	1	1	A. $701 B. $467
	0.9 (as in Strategy 1 and divided by 4)	4.2 (as in Strategy 4 and divided by 4)	1	1	A. $343 B. $337

TABLE 1 (continued)

	INPUT			
STRATEGY	1 Teachers	2 Para-professional Personnel	3 Closed Circuit Television	4 Films
	% of Total Instructional Time			
Traditional S-T with one period per day of films shown to groups of 150 pupils	86.2 (only one teacher present when film shown)			2.8 (five 60 mi or ten 30 ute or fif 20 minute films or combinatic divided b,
Departmental Organization: 40% reliance on TV and Films shown in groups of 100 pupils	60	10 (one monitor for each TV or film session for 100 pupils)	5 (20% divided by 4)	5 (20% divid 4)
Departmental Organization: 20% ITV and 20% CAI or Programmed Instruction. TV and Programmed Instruction in groups of 100 pupils	67.5 (for TV, one teacher lectures; for Programmed Learning, one teacher answers questions and one teacher answers questions or assigns work to pupils who have finished the program)	5 (as in Strategy 7)	5 (as in Strategy 7)	
Departmental Organization: very high dependence on Film and TV: Teacher Discussion 15 minutes per class	25	76.7	66.7	10 (six 30 mi Films per

E 1 (continued)

INPUT

3 osed Circuit Television	4 Films	5 A. Computer Assisted Instruction B. Programmed Instruction with Branching	6 Principals and Supervisors	7 Secretarial	Cost pe Pupil per ye
Instructional	Time				
	2.8 (five 60 minute or ten 30 minute or fifteen 20 minute films or some combination & divided by 6)		1	1	$322
5 divided by 4)	5 (20% divided by 4)		3	3	$307
5 in Strategy 7)		5 (20% divided by 4)	3	3	A. $40 B. $33
66.7	10 (six 30 minute Films per wk)		3	3	$410

TABLE 1 (continued)

STRATEGY	INPUT 1 Teachers	 2 Para-professional Personnel	 3 Closed Circuit Television	 4 Films
		% of	Total Instructional	Time
As with Strategy 9 except Film and TV shown to classes of 150; Teacher discussion in classes of 25	25	12.8 (76.7 divided by 6)	11.2 (66.7 divided by 6)	1.7 (10 divider 6)
Departmental Organization: 50% Instructional TV to classes of 100; single teacher otherwise	50	12.5	12.5	
Departmental Organization: heavy use of ITV, Film, and Programmed Instruction, Groups ~~of 100~~ pupils; single teacher otherwise	41.8 (one teacher teaches the TV and two teachers are present for Programmed Instruction)	13.3	8.3 (33% divided by 4)	5.0 (20% divid 4)

TABLE 1 (continued)

INPUT

3 .osed Circuit Television	4 Films	5 A. Computer Assisted Instruction B. Programmed Instruction with Branching	6 Principals and Supervisors	7 Secretarial	Cost p Pupil per ye
.1 Instructional	Time				
11.2 divided by 6)	1.7 (10 divided by 6)		3	3	$20?
12.5			3	3	$277
8.3 divided by 4)	5.0 (20% divided by 4)	8.3 (33% divided by 4)	3	3	A. $428 B. $312

CHART 1

A REPRESENTATIVE SAMPLE OF EXPERIMENTAL FINDINGS:

Author	General Description	Nature of Experiment	
Almstead and Graf (1)	Reading instruction, Grades 4 and 6, using talkback-equipped TV	Full reading instruction by TV where student could "talk-back" to TV teacher. Para-professionals as monitors possible	F I
Amirian (3)	TV Instruction, Science Information, Grade 5	In science, 30 half-hour classes on TV during academic year	
Carner (9)	TV instruction, fifth and sixth grade reading	Total time and half time instruction of reading by TV	
Curry (13)	TV instruction, seventh grade mathematics and sixth grade science	Mathematics: 20 minute periods plus face to face instruction Science: 30 minute TV periods plus face to face instruction	
Curry (12)	TV instruction, fifth grade science	20 minute TV lessons every other day with 10 minute teacher discussion. Also: TV instruction with high pupil involvement versus TV instruction with low pupil involvement	i w i

CHART 1

ˀ EXPERIMENTAL FINDINGS: AUDIO-VISUAL TECHNIQUES

Experiment	Control	Effectiveness (Experimental versus Control)	Scheme More or-Less Similar to Strategies in Table 1
-tion by TV where -back" to TV teacher. 's monitors	Face to Face Instruction (FF)	Grade 4: +3.6 months Grade 6: +2.8 months Iowa Test Basic Skills	2, 3, 7
hour classes on ear	FF	No difference	2
time instruction	FF	All TV: Superior students: significi-ly poorer Average students: no difference Below average students: significantly better Part Time TV: no difference	2
nute periods plus :ruction TV periods plus :ruction	FF	Above average students: no difference Average and below-average students: poorer	2
s every other day ner discussion. on with high pupil TV instruction lvement	FF TV instruction with low pupil involvement	No significant difference	2, 11

Author	General Description	Nature of Experiment
Dietmeier (15)	TV instruction, fifth grade science	90 classes total. In 24, TV instruction with teachers trained in TV. In 24, TV instruction with teachers not trained in TV. In 24, TV instruction with teachers not trained in science or TV
Enders (16)	TV instruction, sixth grade science	1. Twenty 15 minute TV programs during a 20 week period 2. Twelve 15 minute TV programs during a 20 week period
Gordon (19)	Speech Sound Instruction, TV, third grade	Two 15 minute instructional TV periods per week with 3 face to face periods
Hall (21)	Various standard subjects taught to elementary pupils	Large group TV instruction, some whole periods and some partial periods
Himmler (23)	TV instruction, fifth grade reading and arithmetic	Reading: 25 minutes of ITV and then 25 minutes of face to face instruction, 20 classes Arithmetic: 25 minutes of ITV and then 15 minutes of face to face instruction, 20 classes

CHART 1 (cont.)
page 2

'xperiment	Control	Effectiveness (Experimental versus Control)	Scheme More or-Less Similar tc Strategie: in Table]
ı 24, TV instruction ł in TV. In 24, TV chers not trained in uction with teachers ce or TV	18 classes FF	No significant difference in any group	2
TV programs during TV programs during	FF	The TV groups were significantly better; the 12 lesson group did best	2, 3, 7
ıctional TV periods ə to face periods	FF	No significant difference	2
:uction, some whole :tial periods	FF	Face to face instruction slightly better; not statistically significant	2, 3, 7
s of ITV and then 25 :o face instruction, ıtes of ITV and then e to face instruction,	FF 19 classes	No significant differences; instructional variety found most effective	2

Author	General Description	Nature of Experiment
Johnson (25)	TV instruction, fifth and sixth grade science	Large and small TV classes
Anderson (28)	Learning to use the telephone, grade 5	1. Film Strips 2. Motion Picture Film with manual 3. Film Strips, Motion Picture Films, manual
Romano (34)	Use of films and slides for teaching of science, grades 5, 6, 7	Experimental groups used films and slides
Slattery (36)	Fifth grade social studies instruction	Use of filmstrips and sound motion pictures
Suchy and Baumann (37)	Elementary science	First year: Instructional TV in large classes. Full period TV lessons Second year: Same as first year except 30 minute TV lessons

CHART 1 (cont.)
page 3

periment	Control	Effectiveness (Experimental versus Control)	Scheme More-or-Less Similar to Strategies in Table 1
sses	FF	White students: TV significantly better Negro students: No significant difference Students in large TV classes did as well as in small classes	2, 3, 7, 10
.m with manual ›n Picture Films,	FF	Multimedia instruction most effective. Face to face instruction only least effective	6 (except groups are small)
sed films and slides	No films and slides	Experimental groups better than control in all tests	6 (except groups are small)
sound motion	FF	Both filmstrips and sound movies improved performance; filmstrip presentation was the most effective	6
ional TV in large od TV lessons first year except s	FF	TV significantly better	3, 7, 10, 11

Author	General Description	Nature of Experiment	C
Herbert and Foshay (22)	Programmed Instruction: English 2600 Program, Grades 7 and 8	First year: grammar taught with program in three 30 minute sessions per week and at no other time Second year: Programmed grammar sessions for four classes at once in large room. When a pupil finished, he went to another room where he was assigned themes to write	a. th u st
Schramm (35)	Programmed Instruction: grammar written in house, grade 10	Program used to teach grammar	
elen and Ginter (39)	Programmed Instruction: fourth grade multiplication	Programmed instruction given in three 40 minute periods per week during the tenth through twentieth weeks of the term	
adetsky (41)	Multi-media usage for instruction: filmstrips, slides, projectors, teacher aides	Individual learning for pupils in carrels	

CHART 1 (cont.)
page 4

...periment	Control	Effectiveness (Experimental versus Control)	Scheme More-or-Less Similar to Strategies in Table 1
...aught with program ...essions per week ...ed grammar sessions ...nce in large room. ...d, he went to ...e was assigned	FF as before, as part of the 90 minute social studies period	Significantly better except for low ability pupils perhaps. During second year average score +6.0 months compared to prior years	4B, 5B
...grammar	FF	Above average students: significantly better Other students: no difference	4B
...given in three ...week during the ...h weeks of the	FF	No significant difference except good students had time left to do other things	4B
...r pupils in	FF	Faster learning, not statistically significant	none 12 ?

Author	General Description	Nature of Experiment
Suppes (38)	Programmed Instruction, Computer Assisted, Drill and Practice, Mathematics	Ten minute daily drills as a supplement to the regular teaching program, two experimental schools and two control
Hagerstown Schools (6)	Closed Circuit televised instruction, lectures by teachers. Music, art, mathematics, science, French	About 12% of total instruction in grades 3, 4, 5, 6 given over TV, mostly full hour periods

CHART 1 (cont.)
page 5

.periment	Control	Effectiveness (Experimental versus Control)	Scheme More-or-Less Similar to Strategies in Table 1
:s as a supplement ʒ program, two :nd two control	FF	Statistically significant better learning in one experimental school and no difference in the other	4A, 5A
truction in grades TV, mostly full	prior experience (FF)	Statistically significant and in most instances large increases in achievement performance in arithmetic, science, reading	3, 6, 10, 11