DOCUMENT RESUME

ED 029 380 EA 002 219

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Pub Date Feb 69

Note-15p.; Preliminary draft of paper prepared for Annual Meeting of the Amer. Educ. Res. Assn. (Los Angeles, Calif., Feb. 1969)

EDRS Price MF-$0.25 HC-$0.85

Descriptors-Administrator Role, *Cost Effectiveness, *Educational Economics, *Input Output Analysis, Mathematical Models, Productivity, Resource Allocations, Statistical Analysis, *Systems Analysis, Teacher Role

The interests of economists in educational systems have taken two directions: (1) Concern for the interchange of resources between educational systems and the national economy, and (2) an interest in the production of education. In expressing the resource interchange, economists rely on the language of productivity. Of concern is the global contribution of educational systems to national economic efficiency. This type of analysis is relevant to such decisions as whether more or less money should be spent for education and how money should be allocated within educational systems. Model building is essential to systems analysis, and the models used for this type of study are cost-benefit models. Economic systems analysis is now being directed to an examination of the internal efficiency of education, which involves analysis of the way in which education is produced. This focus requires schools to be thought of as productive systems with interrelationships among people, units of space, and equipment determining the efficiency of the process. An administrator's production function is developed and input-output studies, based on large-scale cross-sectional statistical analysis, are used to provide empirical guidelines for the improvement of allocation within educational units. (TT)

An Economic Approach to Systems Analysis

Paper prepared for 1969
Annual AERA Convention
in Los Angeles, California

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Preliminary: Not for quotation

Introduction

Educators have often been accused of indecent haste in adopting new slogans, climbing aboard bandwagons, and generally using new words to clothe old phenomena. It is therefore appropriate that we view with skepticism the onrush of the systems analysis enthusiasts, who claim to have developed technologies which will revolutionize education without, apparently, altering the interpersonal behavior which underlies organizational life. On the other hand, in order that we may intelligently evaluate these new technologies, we must obtain an understanding of their essential characteristics and of the theories which provide their underpinning.

The meta-theory of systems has had considerable utility in providing insights into the nature of organizations. Powerful analogies, such as those involved in applying concepts like homeostasis, entropy, and ultrastability to the physical, biological, and social sciences threw new light on each of these disciplinary areas. The ubiquitous concept of feedback is particularly valuable; while its utility in electrical engineering is well known,its potential for improving the operation of educational systems has not yet been adequately explored.[1]

A system may be defined as a set of inter-related parts designed to accomplish a given purpose. The notion of inter-relatedness suggests that systems analysis is concerned with the interactions among the elements of a system, and the manner in which the operations of the various elements are coordinated. Furthermore, since all elements are important, systems analysis focusses on a comprehensiveness of viewpoint which renders simple bivariate analysis obsolete. The concept of purposiveness is also essential. Systems analysis is concerned with the degree to which an organization is successful in reaching a given set of goals or objectives.

Despite the apparent value of general systems theory as a method of clarifying the nature of phenomena, the manner in which it is applied varies among the physical, biological, and social sciences. Within the latter, the assumptions used and the purpose of the analysis, as well as the conclusions which are reached differ according to whether the analyst is a sociologist, an anthropologist, a social psychologist, a political scientist, or an economist. To be sure, Talcott Parsons has been partially successful in synthesizing these approaches, however, economic analysis, at least, remains largely outside Parsons' framework.[2] Since economics is the discipline within which some of the newer systems applications such as PPBS have been developed, it is necessary that its assumptions and methods of attack be recognized, and also that the limitations of these procedures be made explicit.[3]

<u>The Economist's Approach to Systems Analysis in Education</u>

Thus far, economists' interests in educational systems have taken two directions. The first is toward a concern for the interchange of resources between educational systems and the national economy. The second direction, only recently coming into its own, is an interest in the production of education. With respect to its methodology, systems analysis in economics is characterized by a reliance on mathematical models, and an insistance on empirical testing.

This paper turns first to the concept of resource interchange, based on open systems theory applied to education. Systems may be classified in several ways. They range from simple to very complex. A pair of scissors is a simple system; an electronic computer is more complex, while the nation's economy is an exceedingly complex system. They also vary along a continuum from deterministic systems such as simple machines to probabilistic systems such as biological organisms or social organizations.[4] Educational organizations are probabilistic and exceedingly complex, falling in the category of cybernetic systems.

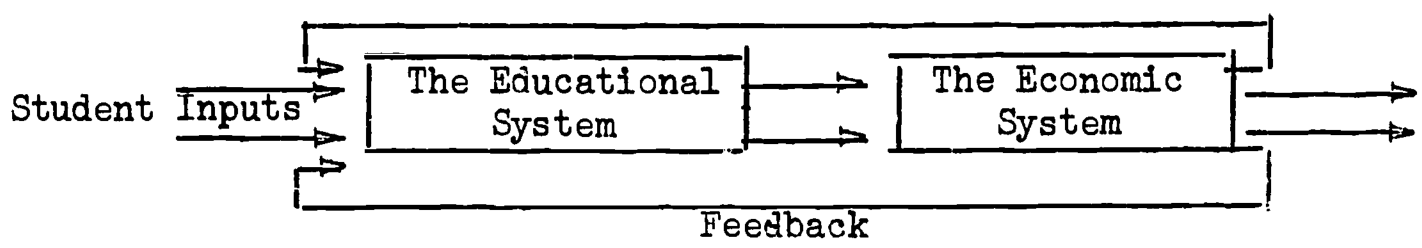
Systems may also be classified according to the degree to which interaction with their environment is an essential aspect of their nature. The old-fashioned watch which needed energy inputs in the form of frequent winding were partially open, while the newer models with their self-contained power cells are so closed that they will respond to few inputs, except perhaps a blow from a sledge hammer. Among social organizations, the medieval monastery attempted, for historical reasons, to remain apart from its environment, while the modern Democratic party, by way of contrast, is embarrassingly open. Some school systems, especially those whose administrative staff members have had such long tenure that they interact mostly with each other are relatively closed. The community school, which takes the school into the community and the community into the school is, at the other extreme, an open system.

(1) Educational organizations as open systems.

Open systems are engaged in a constant process of interchanging energy with their environment.[5] They absorb energy inputs, process it according to their central purposes, and return the processed inputs as outputs to their environment. Educational systems use such inputs as teachers and other hired personnel students, space, and various kinds of goods. They process the student input and provide their environment with outputs in the form of "educated" people who can help the larger society perform its basic functions.

The economist expresses this resource interchange in the language of <u>productivity</u>. A revival of the classical economists' interest in the quality of labor as a factor in the production of wealth resulted largely from curiosity about the unexplained residual factor which remained when labor and physical capital were used in the Cobb Douglas production function to determine the causes of economic growth.[6] More recently, the relationship between years of schooling and income have been used in attempts to estimate education's contribution to the productivity of its economy.[7] In these studies, educational systems were regarded as black boxes, and systems analysis involved the construction of mathematical models depicting the relationship between inputs and outputs of educational systems.

Figure 1



In these studies, the concern is with <u>external productivity</u>, or the contribution of educational systems to the national economy. This type of analysis is relevant to such global decisions as whether more or less money should be spent for education, and how money should be allocated within the educational systems, for example, between secondary, elementary, and higher education.

The rhetoric of the economist's systems approach is that of cost-benefit analysis. The importance of costs permeates the systems analysis literature. Costs are best defined in terms of what is given up by taking a certain course of action.[8] Costs are both monetary and non-monetary; the cost of attending a theatrical performance includes both the monetary outlay for ticket and transportation and the sacrifice entailed in giving up activities in which a person might otherwise be engaged. Gary Becker has pointed out that all consumer goods have two cost elements--goods and time. In the case of education, time is an important cost, on both a macro and micro level. At the global level, costs include the foregone earnings of students, while within schools, costs include the time componant of a given educational activity.

To the economist, model building, is essential to systems analysis. The inputs and outputs which he examines are amenable to mathematical treatment. Furthermore, because of his background, the economist, like the engineer, is readily able to utilize the mathematical procedures which systems analysts and operations research personnel prefer. The mathematics of cost-benefit analysis have, furthermore, been developed through the analysis of durable physical capital, such as hydroelectric projects, and the analogy to human capital is readily made.

Two procedures are commonly used.[9] The first is to reduce the stream of costs and the stream of benefits associated with an increment of schooling to a present value, using discounting procedures, and then to compare the present values of costs and benefits. Assuming that a rate of discount has been agreed upon, an investment is worth making if the present value of its benefits exceeds the present value of its costs. The second procedure is to determine the rate of return which equates the stream of costs and benefits associated with a given increment of schooling. In this case, the investment should be undertaken if the internal rate of return exceeds a given externally determined per cent.

These methods are suitable for guiding decisions at a macro level, assuming that agreement has been made on the underlying assumptions. Economic systems analysis is now being directed to an examination of the internal efficiency of education. This involves an analysis of the way in which educ- is produced.

(2) The production of education

From the economist's point of view, education, like homes, automobiles, or haircuts is a produced good. However, economists have until recently given little attention to the production of education. This omission is recently being corrected.

This focus requires that schools be thought of as productive systems. The interrelationships among people and units of space and equipment determine, in part, the efficiency of the productive process. The feedback of information about outputs and the use of knowledge about inputs become important data for the operation of the system.

It is well known that schools interact with other systems, including students' families, and that out-of-school influences on learning must be reckoned with. Hence, a systems approach to the production of education must allow for both school effects and background effects. In this context, the task of the administrator is to maximize the desired learnings, given constraints on the resources within his control. This principle of constrained maximization is an essential ingredient in the economic concept of systems.

The Administrator's Pruduction Function

The task of the educational administrator is seen as the production of "learnings." Each of these learnings consists of a block of knowledge to be acquired or a set of skills to be mastered. Following Bloom, we define ability as the length of time it takes a student to obtain a given "learning."[10]

The factors going into a "learning," for a given child are therefore goods (defined as including teacher's efforts, as well as space, books, equipment, etc.), background factors (including the familiar social class factors and also home pressures to achieve) and, finally, time.[11]

The administrator's production function is therefore expressed as follows:

$$Z_{ij} = g\ (X_1, \ldots X_m, b_{1j}, \ldots b_{nj}, t_{ij})$$

$$(i = 1 \text{ through } r,\ j = 1 \text{ through } s)$$

Z_{ij} is the i^{th} "learning" for student j.

$X_1, \ldots, X_m$ are the m goods used in the learning.

$b_{1j} \ldots b_{nj}$ are the n background factors related to student j.

t_{ij} is the time required for student j to master learning i.

The learnings vary, in the amount of goods required in their "production," the importance of background factors and, especially in the student time element of cost.

The administrative task is to "produce" a large number of learnings for a large number of students.

$$Z = \Sigma_i \Sigma_j\ (d_{ij}\ Z_{ij}) \qquad (2)$$

$$Z = h\ (X_1, \ldots, X_m, b_{11}, \ldots b_{ns}, t_{11}, \ldots t_{rs}) \qquad (3)$$

The d's are societal weightings given to the various "learnings" on the basis of shared values.

The administrator's task is to maximize Z, subject to certain constraints.

(a) A total resource constraint.

$$p_1 X_1 + p_2 X_2 + \ldots . + p_n X_m \leq C$$

C

Where p_i is the price one unit of X_i, the i^{th} good and ~~c~~ is the total resources available;

(b) A number of partial resource constraints

e.g. $X_p \leq D$

Where X_p is the number of items of the p^{th} input, and D is the total availability of this input. (e.g. number of trained teachers of automobile mechanis)

(c) Time constraints for each student

$$t_{ij} + \ldots . t_{rj} \leq A_j$$

Where A_j is the number of hours available to student j for his studies.

In order to maximize Z, the administrator needs to have knowledge about the educational production function in order that he may wisely allocate the resources (including goods and time) which are at his disposal. Input-output studies, based on large scale cross-sectional statistical analysis, have procided some empirical guidelines in the improvement of allocation. These studies, based on multiple regression, have taken goods and background factors, but not students' time, into consideration. There has been some mild controversy over the correct way to deal with background variables.[12] Initial studies have attempted to control for the effect of the background variables by statistical procedures. Table 1 shows an example of the results of this kind of analysis. The background factors, if entered first into the regression equation, explain most of the variance, leaving little to be accounted by the school variables.[13]

Table 1

Per Cent of Variance of Test Scores
Explained by Three Categories of Inputs

Categories of Inputs	Test Score Variables					
	1	2	3	4	5	6
A. Background Variables	48.5	32.5	39.9	40.3	30.7	36.7
B. Per Pupil Expenditures	1.8	0.1	1.6	0.3	0.8	1.5
C. School Variables	11.6	14.7	12.2	9.8	11.4	6.5
Total	61.9	47.3	53.7	50.4	42.9	44.7

Note: In this table, outputs were: Columns 1-6, Information test total, grade 12 boys; English test total, grade 12; reading comprehension, grade 12; creativity, grade 12; mechanical reasoning, grade 12; mathematics Part II, grade 12. Background variables included: median family income; quality of housing in area served by school; median years of schooling, adults 25 years of age and older. School variables included: size of 12th grade class; median starting salary of male teachers; type of secondary school (comprehensive, technical, etc.); number of books in school library; age of school building.

Samuel S. Bowles and Henry M. Levin, in commenting on the Coleman Report, have suggested that this procedure of controlling for background variables is not appropriate, in view of the high degree of intercorrelation between the background variables and the school variables. They suggest that the regression coefficients and their standard errors are the appropriate statistics to use in determining the effect of the school variables in the presence of background variables. Hence, a more appropriate statistical analysis would be that reported in Table 2 or the regression equation reported by Levin and Bowles.[14]

Table 2

Regression Coefficients in Input-Output Equations

Var. No.	Description of Inputs	Beta Coefficient	Standard Error of Coefficient
2	Mean starting salary -- male teachers	.3498	.0100
28	Quality of housing in area served by the school (the negative correlation indicates that high test scores are related to good housing)	.1608	.0032
32	Percentage of boys in last year's graduating class who went to college	.2299	.0030
12	Age of school building	.1537	.0026
21	Median family income	.2008	.0053
29	Average daily percentage of absenteeism	-.1403	.0028
11	Number of books in school library	.1103	.0028
4	Type of secondary school (The positive relationship here indicates that higher test scores are obtained in comprehensive high schools)	.0962	.0026
16	Does the school have a guidance program?	.0903	.0028
17	Size of community (population)	-.1497	.0030
15	Experience of teaching staff	.1088	.0028
5	Grades included in the secondary school (The schools that include from Kindergarten to Grade 12 or Grade 1 to Grade 12 do more poorly than all other schools combines)	-.0645	.0028

Source: Same as for Table 1.

The results of this study and others suggest that the teacher input is one of the most important explanatory variables. Levin and Bowles also conclude that school facilities have an independent effect, while the Thomas study supports the importance of the school library as a factor contributing to students' performance in English.

In a recent study, Levin has carried the discussion one step further, and examined the relationship between cost and effectiveness in increasing student verbal achievement by (1) improving teachers' verbal score, and (2) increasing teacher experience. He finds the cost of the former to be considerably less than that of the latter investment.[15]

These studies are exploratory. Additional analysis, using a variety of output variables, would result in the development of regression equations over a time sequence, and for different sub groups of students. These in turn can add to the knowledge about the administrator's production function.

Summary and Implications

This summary has merely highlighted certain aspects of the economist's approach to the study of educational systems. The paper has ignored some highly relevant aspects of the problem, such as the relationship between financial systems and the production of education. This concluding section does highlight certain implications.

(1) Theoretical implications. One of the limitations of the economist's production function approach is the lack of a theory of learning which would provide a guide to the anticipated input output relationships.

Interestingly enough, there have already been some fruitful by-products in the area of economic theory from the study of human capital. The emphasis given by economists to the importance of foregone earning as a cost element in education has, apparently, stimulated Gary S. Becker to conduct his analysis of the economics of time allocation.

(2) Practical implications. It is still too early to know whether these theoretical and empirical studies will lead to improvements in the

internal efficiency of educational systems. It does seem that some of the newer technological systems, such as PBBS have advanced beyond the present state of empirical and theoretical knowledge. These studies provide the needed theoretical framework and, equally important, provide a basis for cost-effectiveness analyses upon which alternatives included in planning and budgeting systems can be evaluated, in terms of their respective costs and benefits.

(3) Research implications. There are many kinds of research studies which are needed to fill in the knowledge gaps revealed by input-output studies. For example, although there have been some recent studies in this area, little is yet known about the effect of scale upon the costs and outputs of educational systems.

Finally, the limitations of economic systems studies must be noted. Theories which see people and objects as parts of an education machine ignore the effect on learning outcomes of interpersonal relationships among students and between students and teachers. Just as analyses of business firms must, since the Hawthorne and pyjama factory studies, take the effect of the peer group into consideration, studies of educational systems cannot revert to a machine-like explanation of productivity. On the other hand, economic systems provide a benchmark against which aberrations due to socio-psychological effects may be estimated. Hence, economic systems analysis serves as a hypothesis generator while socio-psychological analysis serves as a means for explaining the difference between the effect predicted on the basis of the production function and the observed effect of educational procedures.

1 Stafford Beer, *Cybernetics and Management*. New York: Wiley, 1964, Chapter IV.

2 Talcott Parsons, *The Social System*. Glencoe, The Free Press, 1951.

3 PPBS stands for Program Planning and Budgeting Systems. For a discussion see Harry J. Hartley, *Educational Planning--Programming--Budgeting.* Englewood Cliffs: Prentice-Hall, 1968.

4 Beer, *op. cit.*, Chapter II.

5 Daniel Katz and Robert L. Kahn, *The Social Psychology of Organizations*. New York: Wiley, 1966, pp. 26-28.

6 Theodore W. Schultz, "Education and Economic Growth" in *Social Forces Influencing American Education*. Chicago: University of Chicago Press, 1961, pp. 46-88.

7 For example, Edward Denison, *The Determinants of Economic Growth in the United States*. New York: Committee for Economic Development, 1962.

8 Mary Jean Bowman, "The Costing of Human Resource Development" in *The Economics of Education*, edited by E.A. G. Robinson and J. E. Vaizey. New York: St. Martin's Press, 1966, pp. 421-450.

9 Gary Becker, *Human Capital*. New York: Columbia University Press, 1964.

10 Benjamin S. Bloom, "Learning for Mastery" reviewed by D. Gene Watson. *Administrator's Notebook,* XVI. No. 8 (April, 1968).

11 Gary Becker has developed a theory of time allocation, related to the consumer's behavior. This paper adopts Becker's theory to the decisions made by educational administraters. While college students may select courses as a housewife selects items in a supermarket, the time of elementary and secondary school students (while in school) is allocated by their teachers and principals. Gary Becker, "A Theory of the Allocation of Time." *Economic Journal* LXXV No. 299 (Sept., 1965), pp. 493-517.

12 James S. Coleman, *Equality of Educational Opportunity*. Washington: U.S. Office of Health, Education and Welfare, Office of Education, 1966. Bowles and Levin, "More on Multicollinearity and the Effectiveness of Schools." *The Journal of Human Resources* III, No. 3 (Summer, 1968) pp. 393-400. Samuel Bowles and Henry M. Levin. "The Determinants of Scholastic Achievement--An Appraisal of Some Recent Evidence." *The Journal of Human Resources* III, No. 1 (Winter, 1968), pp. 3-24.

[13] Source: Data re-computed from study by J.Alan Thomas "Efficiency in Education: A Study of the Relationship between Selected Inputs and Mean Test Scores in a Sample of Senior High Schools." Ph.D. Dissertation, School of Education, Stanford University, 1962.

[14] Op. cit., "More on Multicollinearity . . . . . "

[15] Henry M. Levin, Cost-Effectiveness Analysis and Educational Policy--Profession, Confusion, Promise. Research and Development Memorandum No. 41, Stanford School of Education, Stanford Center of Research and Development in Teaching, 1969.