DOCUMENT RESUME

ED 028 513 EA 002 110

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Prerequisites for Systems Analysts: Analytic and Management Demands of a New Approach to Educational Administration.

Upper Midwest Regional Educational Lab., Inc., St. Paul.
Pub Date Feb 69
Note-16p.; Paper presented at the Annual Meeting of the Amer. Educ. Res. Assn. (Los Angeles, Calif., Feb. 5-8, 1969).
EDRS Price MF-$0.25 HC-$0.90
Descriptors-Administrator Role, *Educational Administration, *Educational Research, *Educational Researchers, Linear Programing, Organization, Resource Allocations, Statistical Analysis, *Systems Analysis, *Systems Analysts

There is much to be gained by using systems analysis in educational administration. Most administrators, presently relying on classical statistical techniques restricted to problems having few variables, should be trained to use more sophisticated tools such as systems analysis. The systems analyst, interested in the basic processes of a group or organization, attempts to use available resources to maximize goal attainment. Linear programing provides a valuable tool for the analyst by considering dynamic relationshiips among many variables. Systems management and systems design represent two different levels of activity, the former concerned with day-to-day operation and the latter with organizational patterns. Systems management requires two types of personnel--the system manager and the system researcher. The manager replaces administrative roles such as the superintendent and principal; the researcher is analogous to the business analyst. The key to the effective performance of these roles--and hence to the benefits of systems analysis--lies in the degree to which suitable training can be provided for role incumbents. (HW)

PREREQUISITES FOR SYSTEMS ANALYSTS

Analytic and Management Demands of a New Approach To Educational Administration

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Presented at Annual Meeting
American Educational Research Association
Los Angeles, California
February, 1969

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February, 1969

Like other applied behavioral sciences, educational administration is beginning to make considerable use of the terminology of general systems theory. The school is seen as a sub-system of a larger community social system, political actions affecting the school are carried out in a political system and internal management of the school centers on an organizational system. At this time productive results are largely emotional in nature; schoolmen and their professors seem to feel more comfortable in the language of general systems theory -- productive output notwithstanding. All this is not to say that the perspectives of systems analysis are of little use to educational administration. Quite the contrary. The assumption underlying this paper is that much is to be gained through such a systematic approach to educational organizations. Systems analysis offers a fresh point of view which may well identify educational factors which, in turn, can be managed for the mutual benefit of children and educational administrators. The thesis of this paper is that such a desirable state can be reached only by addressing the question, "What are the conceptual and analytic tools needed for effective implementation of general systems theory in education?". The several roles generated for administrators by the systems approach each have need of special tools which must be provided by those who carry out basic training and research. The following discussion outlines several research and training needs as related to the analysis and management of educational systems.

Problems in Current Analytic Methods

The study or analysis of human systems has two major goals. These are, first, more effective and efficient control of operating systems and, secondly, the design of new systems which can attain desired ends more ex-

(This paper is prepared especially for the conference noted on its title page. The author acknowledges the criticism and support of Mr. Marvin Daley, Program Director, Upper Midwest Regional Educational Laboratory.)

peditiously with less expenditure of human and financial resources. Each of these goals, in turn, relies on the reduction of uncertainty regarding the consequences of action. The decision maker - or system manager - wishes to know the likely outcomes of his decisions and the probabilities associated with each outcome. The system designer also desires a quantitative estimate of the impact a new system will have on human activity.

At this level of discussion, systems analysis does not seem to be generically different from other approaches to knowledge about human affairs. All attempts to develop a science of human behavior are judged by their ability to predict the consequences of action. Most have, at least implicit in their conception, the dual goals of effective management and new and better designs for human activity. Where systems analysis is set apart is in the methodology used by the analyst and in the forms of evidence and relationships sought. These are, of course, intimately interdependent and make it necessary to develop special techniques for those who manage and design systems. Some examples will illustrate this point.

In contemporary activity in educational administration, in both research and management, much reliance is placed on classical statistical techniques. It is a rare practitioner who has studied more than two-variable problems in statistics. The researcher who has a good grasp of multivariate analysis or might be able to operate independent of the control-experimental group research design is similarly rare. The net result is a body of research and writing -- and practice -- which has a fairly narrow view of the problems of educational organizations.

The educational manager, trained in classical statistical decision making, generally casts a particular problem in terms of alternate and null hypotheses. Having done so, much of the variation of interest to the problem

is eliminated; because the fund of knowledge from which these hypotheses were derived is limited, the choice of particular null and alternative hypotheses may be merely fortuitious. In his studies of decision making, the practitioner has been exposed to statistical tests of difference between means and proportions and therefore further limits his problem to the comparison of two factors or measures. If these factors do not conform to his experience with measurement, he is at a loss as to where to turn for estimates of the conditions which will determine the success or failure of his action.[1]

The researcher in educational administration is little better off. Generally, his is a more intensive training along the lines of that given the practitioner. He may be more highly skilled in sampling techniques and may have some knowledge of tactics to be used in dealing with multivariate problems. However, he is quite tightly bound to classical research design and to hypothesis testing as the logical technique for advancement of knowledge.

The point to be made from the above examples is that the analytical tools and experiences of practitioners and researchers constitute ways of looking at problems. By choosing modes of analysis from other research traditions, without critical examination of their applicability to problems

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[1] The training referred to is that most often provided as a service by departments of educational psychology. Educational administration accepts these research and decision making models without taking into account gross differences in purpose in the two traditions. Where the educational psychologist may be interested in a two variable problem -- because he is able to control extraneous sources of variation -- the administrator must deal with many variables -- because he cannot so control his world. The significance of this difference is felt more keenly by the researcher in administration. He feels bound to designs for research whose conditions he cannot hope to approximate.

in educational administration, those who train administrators have created many generations of persons poorly adapted for solving problems they face. Because systems analysis constitutes another -- and quite different -- way of looking at educational problems it may contribute to more fruitful solutions, but only if suitable tools of analysis are made available to practitioners and researchers.[2]

Systems Analysis: Methods and Perspectives

How does systems analysis provide alternatives to traditional methodology in educational administration? The answer to this question is found in the focus of attention of the systems analyst and in the methods of study he employs to meet the joint goals of improved system design and control. Let us review several of these areas of interest and their associated analytical models.

First of all, the systems analyst is interested in the basic processes under way in a group or organization. The filling of grain barges by the miller, maintenance of parts inventory for auto repair and acquisition of behaviors by children in schools all constitute processes of interest to the systems analyst. By noting regularities in such processes the analyst may be able to offer guidelines to management which will result in more effective utilization of resources and in control over organizational activity. Process analysis is largely the area of application of operations research.[3]

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2 The limitation imposed by methodology has been a continuing concern in the social sciences. In sociology see, Walter Buckley, Sociology and Modern Systems Theory (Englewood Cliffs, N.J., Prentice Hall, 1967), in psychology see, Murray Sidman, Tactics of Scientific Research (New York; Basic Books, 1960), for examples.

3 Operations research techniques are outlined in numerous texts, among them, C.W. Churchman, et. al., Introduction to Operations Research (New York, J. Wiley, 1957).

The analyst makes use of mathematical and computational techniques which simulate the process understudy, making it possible to examine directions of process change and effects of changes in process on variables of interest to the organization.

In education the analyst might focus on elementary school classrooms to determine optimal patterns of teacher behavior needed to attain learning goals. In the general stimulus-response learning paradigm, the acquisition of a particular behavior by a child is functionally related to conditions of environment and reinforcement controlled by the teacher.[4] By examining several classrooms the analyst may be able to determine values for conditional probabilities of response acquisition as related to probability and timing of reinforcement. These findings can then be used by administrators and teachers to design more effective educational activities for children.

Secondly, systems analysis attempts to arrive at some optimal use of resources available to the organization to maximize goal attainment. Here the systems analyst recognizes the constraints and possibilities which set limits on organizational action.[5] Generally, the goals of the organization are approached through some combination of efforts and resources. These combinations make varying contributions to desired ends and have associated costs and profits which must be considered in optimal organization of the system. Where such constraints have been established over time, the techniques of linear programming can be employed by the analyst to seek the desired

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4 For a good summary of research in controlled acquisition of behavior see, Leonard Krasner and Leonard Ullman, Research in Behavior Modification (New York, Holt, Rinehart & Winston, 1965).

5 As Ashby points out, the very essence of organization lies in such constraints and possibilities. Thus, systems analysis directs attention at basic environmental conditions rather than limiting study to current organizational conditions. W. Ross Ashby, "Principles of the Self-Organizing System," in H. Von Foerster and G.W. Zopf (eds), Principles of Self-Organization (New York: Pergamon Press, 1962) pp. 255-278.

conditions of operation.[6] Constraints and possibilities, expressed as a system of linear equations, can be solved to indicate alternate modes of operation and to isolate those modes which correspond to best use of organizational resources.

As applied to education, the search for an organizational optimum may occur in problems related to the combining of teacher and machine time in carrying out a course of instruction. Linear estimates of the productivity of teachers and machines -- possibly derived through regression analysis -- can be cast into a linear programming problem along with unit costs of the two instructional methods and other restrictions such as total available budget and space. In cases where linear approximations to the relations among variables seems inappropriate, the analyst can turn to step-functions and computer simulations to seek the desired solution.

The above example of search for optimum use of educational resources is a particularly good illustration of the difference between the conceptual approach of systems analysis and widely used tactics of educational problem solving. Where classical educational methodology might compare two methods of teaching as to their effect on a criterion variable, linear programming considers dynamic relationships among variables and can separate costs and benefits of a large set of organizational alternatives. In this way the organizational decision makers can more systematically select patterns of operation adapted to local needs and conditions.

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6 See, A. Charnes and W.W. Cooper, Management Models and Industrial Applications of Linear Programming (New York: J. Wiley, 1961), 2 vols., for detailed discussion of optimization in industrial systems.

In addition to concerns relative to process and optimization the systems analyst also addresses organizational structure and its effect on flows of information and activity. By viewing structure as an arrangement for making decisions to control organizational action, the analyst notes alternative possibilities and their impact on speed and accuracy of decision making.[7] Studies in this aspect of systems analysis derive generally from information and communication theory and build upon the algebra of flow diagrams and graphs.[8] Through these techniques, the analyst can address such problems as decentralization of administrative responsibility and its effect on speed and accuracy of communication.

The study of educational structures by systems analysts may be especially germane to current urban problems of decentralization of school authority. One of the major criticisms of existing structures for decision making is that action is delayed and accurate description of problems is difficult. By studying the channels of communication and potentials for error, the analyst may be able to make some quantitative estimate of the responsiveness of alternate designs to the needs for action in the local school. Such treatment of alternate approaches to school structure would be at best difficult in the framework of current thought in educational administration where perception and arguments by design abound.

As a final -- and possibly most important -- characteristic, system analysis does not bind human action to a single solution. General systems theory holds that any system open to its environment evolves some structure

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7 For an analysis of structural arrangements for decision making see, Rocco Carzo and John Yanouzas, Formal Organization (Homewood, Illinois, Richard Irwin, 1967), pp. 274-286.

8 Claude Flament, Applications of Graph Theory to Group Structure (Englewood Cliffs, N.J., Prentice Hall, 1963).

which is unique to its conditions. That structure may resemble its genotypic counterparts only in that it follows similar rules for development.[9] No two plants are identical in form, although they may have similar capabilities and may adhere to similar developmental processes. The same is true of human systems. No particular organizational structure is necessary for industrial production -- although certain processes may be needed and specific developmental rules followed. The organizational analyst is interested in discovering the rules by which a system changes and indistinguishing the states of development. With this knowledge, the analyst can make some estimate of the probabilities of transition of a system from one state to another and can indicate relative stability of organizational states.[10]

As applied to educational administration, this attribute of systems analysis is of significant importance. Not only is the structure of the school open to adaptation to new conditions, but, depending on the ability of the analyst to identify unique organizational states, some indication of a stable structure can be determined. This means that the administrator can effectively plan for structures that are optimal for certain environments without having to base his reasoning on some long-standing beliefs concerning school design.

The above list of the characteristics of systems analysis, although not exhaustive, suggests that its methodological tactics may provide a new and productive way of looking at educational organizations. As these approaches

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9 See Esp. Kenneth E. Boulding, "General Systems Theory - The Skeleton of Science," Management Science, 2, 1956, pp. 197-208 for a discussion of "blueprinted" growth and the concept of equifinality.

10 The analysis of system states indicated here is essentially probabilistic and often conforms to Markov process models. See, for example, John G. Kemeny and J. Laurie Snell, Finite Markov Chains (Princeton, N.J., Van Nostrand Co., 1960).

are applied to several administrative roles some implications for training can be derived.

Analysis and Management of Educational Systems: Roles and Methods

Systems management and systems design represent two substantively different levels of activity. Systems management is more directly concerned with the day-to-day operation of a particular organization and with its development. Systems design, on the other hand, deals with a large number or class of organizations and attempts to develop new organizational patterns which will improve existing practices. As such, systems management and system design suggest some division of labor with respect to analysis and a corresponding differentiation in methodology. A tentative effort in this direction is made in the roles discussed below.

Systems management in a particular organization is mainly concerned with identifying alternate courses of action and in specifying the consequences of action taken. In terms of roles in the organization this activity may be divided into two parts. First the identification of system constraints and possibilities, location of problems or decision points in organizational activity and selection of courses of action. These activities are closely associated with current administrative practice, especially insofar as this class of activities also contains the decision making behavior of organization members. The second class of system management activity deals with determination of relationships among system variables. This activity feeds system decision makers and indicates to them the likely consequences of alternate actions and the quantitative directions of system development. For purposes of discussion, the persons whose behaviors fall in the first class will be called

system managers. Those who carry out activities of the second class will be termed system researchers.

In traditional school organization the systems manager replaces administrative roles such as superintendent and principal. The analytic skills he brings to his role are those of identification of constraints and variables, planning and flow analysis and decision making. These are skills which might be developed through a training program comprised of finite mathematics and elementary decision theory.[11] By beginning with finite mathematics, the systems manager can develop a logical, problem centered, approach to probability and can note its multiple uses. He is thereby made to see that the statistical uses of probability are only one of numerous applications possible. From this foundation, the systems manager can continue his study of decision making without running the risk of limiting his view of problems to the classical statistical decision model.

Along with basic studies as outlined above, it is desirable for the systems manager to have introductory experiences with data and planning systems. This can be attained through analysis of simple problems using computational aides and in planning complex activities using PERT or similar techniques. Where possible, the systems manager ought to follow some elementary work in operations research to better enable him to communicate with his supporting research operation.[12]

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11 Footnotes11, 12 & 13 suggest training materials which may be suitable for each set of skills noted. For finite mathematics, John G. Kemeny et. al., Finite Mathematics (Englewood Cliffs, N.J., Prentice Hall, 1962) or Seymour Lipschutz, Theory and Problems of Finite Mathematics (New York, Schaum, 1966). For basic decision theory, Robert Schlaifer, Probability & Statistics for Business Decisions, (New York, McGraw Hill, 1959).

12 Operations research:
elementary level, Carzo & Yanouzas, Ibid. Also Richard Lewin and C.A. Kirkpatrick, Quantitative Approaches to Management (New York, McGraw Hill, 1965).
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As suggested in the above paragraph, the systems researcher is primarily concerned with process analysis through the techniques of operations research. He may, therefore, be much like those persons now being trained in many universities in Federally supported programs in educational research. In basic skills, the system researcher should possess those held by the systems manager. Upon these the systems researcher builds his knowledge of multivariate analysis and operations research.

This implies that the systems researcher is more like the business analyst than he is like the classical educational statistician. For many researchers, the most practical source of needed training may be in operations research courses in schools of business. However, such training is not an unmixed blessing. The techniques of operations research as used by business are generally not directly applicable to educational problems. If the systems researcher is to gain full benefit of his training in operations research some provision must be made to provide opportunities for translation of skills to educational settings.

The central thread of the above roles is that of probabilistic processes maintained in the third class of activities. These relate to the study of operating systems and processes to the end of new systems designs. Accordingly, the associated role is that of system designer. The activities of system design encompass those of system manager and researcher and draw upon them for inputs to new designs. As a result, the system designer can serve as a common link for the more practical roles and could, in many instances, serve as a trainer for researchers and managers.

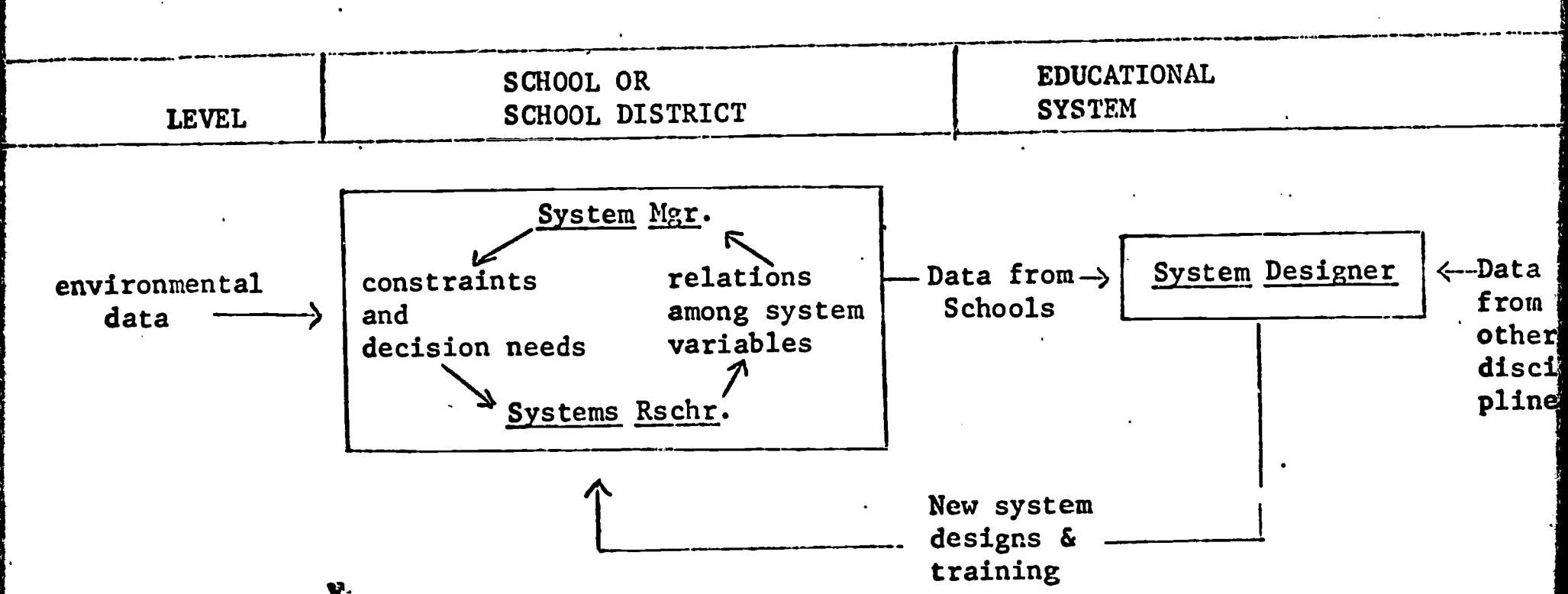
The systems designer needs to be aware of technological and social changes which might influence new system designs. In addition, he must be

current in the basic processes under way in systems with which he deals. This means that the designer of educational systems must be abreast of contemporary research on learning as basic system process. He must also be skilled in probability analysis and in information and communication theory.[13] With these skills he is likely to see the directions possible through changes in basic processes and not remain locked into one major form of system design.

As noted, the suggested roles for system analysis in education are closely related. The following diagram illustrates several major inter-dependencies:

Diagram I

Roles and Relationships in
Management & Design of
Educational Systems



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13 Probabilistic Processes
J.G. Kemeny, Finite Markov Chains
J.S. Coleman, Introduction to Mathematical Sociology (New York, Free Press)

The diagram suggests a close relationship between the systems researcher and systems manager. They are, in effect, a management team which deals with the realities of the particular organizational setting. However, because of similar systemic perspectives and modes of analysis they are in close communication with those who design new systems. They serve as a reality test of such designs and insure that effective designs will be implemented.

The key to the effective performance of these roles -- and hence to the benefits of systems analysis lies in the degree to which suitable training can be provided for role incumbents. Thus our discussion has come full circle. The productivity of any set of concepts is directly dependent upon the tools and methods available for putting those concepts into practice. In the case of systems analysis the analytic prerequisites are clear, as are the challenges which training programs must meet. To look at education as a systems analyst means that one must first acquire the means to analyze systems; only then can meaningful results accrue through the systems approach.