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There are basically four dimensions to a systems analysis that we find in current educational research: (1) Collecting information, (2) analyzing input-output relationships, (3) deriving models built upon these relationships to evaluate alternatives and to derive feasible solutions, and (4) attempting to derive the best solution consistent with the constraints. Three studies presently under way may help to provide insights into the range of educational research problems which might be beneficially examined from the systems analytic viewpoint. The first study deals with collecting information for building an evaluation system for elementary schools. The second is an attempt to develop a series of regression models for simulating the characteristics of secondary schools. The last deals with optimization of salary schemes. (DE)

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# Systems Analysis Applications in Educational Research

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"Systems" is an amorphous word; its meaning depends a great deal upon who uses it. Some speak of philosophical systems while others are concerned with control systems, and still others with political systems, social systems or weapons systems. Some use systems to identify a physical construct while others use it to describe a conceptual approach. Many use the term to indicate their concern with complicated organizations made up of many interrelated parts. Each has equal claim to the word. We define a system as a set of interrelated factors (inputs) that are used together to produce at least one output.

Systems are often in whole or in part enveloped by larger systems. For example, a classroom, a school, a district, a state's or nation's educational facilities can be legitimately defined as systems. The delineation of a specific system depends upon the decisions one wishes to make and the related questions the analyst wishes to answer. The generic question the systems analyst attempts to answer is how can the systems output be maximized in the direction of the desired objectives, utilizing available resources. To this end he must evaluate the resource cost and the corresponding outputs associated with combinations of

inputs. In essence, systems analysis is the comparison of alternative processes for achieving an objective when these processes are fairly complex and there are a number of interrelated elements.

The paper presented by Robert Morgan has discussed one application of systems analysis. In that instance, systems analytic techniques were utilized in planning an educational program. There are a number of other examples of systems analysis applications to education that might be cited. Many of these are referred to in the book, New Look at Education, sponsored by E.T.S. and written by John Pfeiffer. It seems hardly necessary to repeat a description of the applications discussed in this extensive report.

In addressing ourselves to the topic of this paper we found considerable difficulty in distinguishing between systems analysis application to education as exemplified by the E.S. 70 project and systems analysis application in educational research.

In some respects the discussion of a topic such as this implies a lack of such applications in educational research. That is not the case; there are a number of applications of systems analysis to educational research and most are worthy of and would require considerable time to discuss in detail. Moreover, many research, data gathering, and educational decision making situations presently taking place are, in effect, systems analyses.

Since it is not possible to consider all of these applications, we will limit our discussion to several studies presently being

performed at UCLA, and more specifically at the Center for the Study of Evaluation at that institution. One of the major research thrusts of the Center is concerned with evaluating educational systems. In these activities the Center has maintained that there is a necessity for considering a broad range of criterion, contextual, and instructional variables, for understanding the nature of the complex interactions between these variables, and for performing such evaluation research within naturalistic school settings in order to have it be of real value to education. This systems analytic viewpoint of the Center provides the framework for several studies which will be discussed briefly here.

There are basically four dimensions to a systems analysis that we find in current educational research. These might be classified as (1) collecting information; (2) analyzing input-output relationships; (3) deriving models built upon these relationships in order to evaluate alternatives and to derive feasible solutions, and finally, (4) optimization where the research attempts to derive the best solution consistent with the constraints.

Three studies presently underway at UCLA fall into these categories. The first study we will discuss deals with the collecting of information which eventually would be used for educational decision making. The second project encompasses two of the functions previously defined. Present efforts within that study entail the analysis of relationships between inputs and outputs, with future stages being concerned with the evaluation of alternatives and the selection of

feasible solutions. The third study to be discussed is an optimization problem. It has as its concern the selection of a single best solution from a host of feasible solutions.

One project within the Center is concerned with building an evaluation system for elementary schools. The project has been planned as a 5-year development program encompassing systems analysis procedures. During this period the major stages of systems analysis will have been applied including the definition of objectives of the system, analysis of requirements and formulation of system specifications, identification of major subsystems including analysis of interfaces or interrelations among subsystems, a comprehensive design phase, a thorough and intensive test phase including both simulated and actual tests and a final modification phase to provide an effective system for operational use with review and feedback continuing through the early operational use period.

To elaborate further on this application, some of these major stages relative to the development of an elementary school evaluation system may be described in somewhat more detail. Of major importance in system analysis is the clear definition of the system's objectives and insuring that these objectives are ever-present and considered throughout all subsequent stages. The general objective for the ESES program was stated as a dual objective as follows:

1. To develop a complete evaluation system that is accurate, sensitive, reliable and cost-effective. This will include a management information system that contains information

necessary for decisions relative to a single school and its programs and emphases. Included also will be individual school diagnostic information for improving performance of its grade levels, classes or other groups of individuals.

2. To provide data leading to new information and concepts relative to evaluation of a school program, including the identification of important variables and their interrelationships and the exploration of cause-effect relationships.

With respect to the definition of subsystems and the design phase, categories of variables consistent with the elements of the Center's model of evaluation may be thought of as subsystems. Thus, a major task here is the identification of important variables within each category, development or adaptation of appropriate measures, identification of relationships among these variables and working out procedures for overcoming technological or methodological problems including sampling problems, multiple criterion problems, and mulit-variate analysis techniques. In addition, there are some of the more practical problems involving development of procedures for collecting data and data processing, preparation of computer programs, etc.

With respect to testing of the system and the model, it is contemplated that both simulation testing and real-world testing will be required. Simulation testing may be useful in resolving sampling problems, technological problems, and procedural problems. Real-world testing is necessary for determining relationships among variables, practical problems of data collection, applicability of models,

and the like.

A second project deals with the development of a series of mathematical regression models. The development of these models constitutes an exploratory study to define relationships between inputs and outputs. Once these relationships have been defined and understood, a mathematical model will be derived for simulating the characteristics of secondary schools and explaining the effects of the school's characteristics upon its performance outputs.

The study deals with an examination of approximately 400 California 4-year high schools that have undergone the accreditation process through the Western Association of schools and colleges in the last several years. Data were obtained from this source and supplemented in small part by other readily available data items. From these data, 103 study variables were generated for use in the analysis. These were categorized into the elements of the conceptual model that we have used to guide our efforts.

In terms of this model all of the data items were classified as either being fixed inputs to the system, process characteristics of the system which are administratively controllable, or outcome measures. By fixed inputs, we referred to measures of the student entering the system as well as financial resources being provided to the system. (Measures of external systems, i.e., community characteristics both in terms of social, political and economic characteristics, were also considered as a part of the fixed inputs to the system.)

By process characteristics of the system we referred to the alternatives for the utilization of the financial and human resources. In this category were included variables which dealt with line item budget allocations within the system, teacher-student ratios, teacher salary ranges, listings of traditional course sequences normally taken by selected groups of students, and other such variables which were expressions of the educational policy of the school. The alternative processes that we worked with in this stage are not discrete processes, but are instead highly interrelated characteristics which, in aggregate, may be thought of as sets of alternative processes. Lack of a program budgeting system in the schools and the data on specific educational programs that might be provided by such a system, makes it infeasible at this time to talk about program alternatives for this system in terms other than that indicated.

The output measures that were used in the study were fairly standard kinds of variables which might have easily been improved upon. In the first iteration of this study we have assumed that the criterion dimensions included in the accreditation report are the measures of effectiveness for the implied system objectives, and are attempting to build a model based on these system objectives. The variables included which fell into this category were measures of student achievement on standardized tests of reading and mathematics ($Q_1$, median, $Q_3$), percentage of senior students entering junior college, state colleges, state universities, or private institutions, and college grade point average of the student groups at each of the first three types of institutions. In addition, there were measures of the drop-out rate. Also, there were various measures designed to

show changes in student career aspirations over the course of the high school period as well as changes in student plans toward entering college. In all, 103 study variables were generated from the data.

While this early stage of exploring the data base does not ordinarily lead to any great system insights or provide opportunities, yet, for full scale systems analyses, there are some kinds of results that come out of this first stage of systems analysis. The preliminary analyses of interrelationships as well as the work of "muddying our hands" with the data have already led to feedback which is modifying the data source and which in future iterations will lead to the ability to perform more precise systems analyses. This has taken place in two ways: (1) through a modification of existing data items (such as making certain linear transformations of data, inspired by the results of single predictor non-linear regression analyses); and (2) through improved specification of objectives.

This first phase of analysis which is primarily concerned with the examination of "orienting" techniques has provided some insights into present data items which are simply not appropriate as indicators either by virtue of their high interrelationship to other system characteristics which seem considerably more powerful as variables or by virtue of methodological difficulties in utilizing the data item as it presently exists. Furthermore, knowledge of other empirical research as well as our own intuition leads us to believe that certain existing characteristics of the system, primarily fixed inputs, are not adequately represented by appropriate variables. That is,

intuitively one can recognize certain characteristics of student inputs which just simply have to be included into any systems study. In addition, it appears that certain process characteristics are not yet well defined. This would be analogous to talking about the precise description of the nature of the instructional treatment when the thing being evaluated is a specific instructional program. Here, we are talking about an entire school as the system and it is necessary to define precisely the nature of the administrative-teacher-student configuration that is the process for that school. This is no easy task, but the analysis of data and continuing iteration help to point out areas where the process characteristics are not yet well defined and perhaps to suggest manners in which this definition might be improved. Indeed, a systems study often leads to the selection or derivation of new processes.

A second way in which this early stage of the analysis has helped to modify the system is through the specification of implied objectives. The tentative specification of these objectives leads in turn to the reconsideration and more precise definition of systems objectives in conjunction with those in administrative positions within the system. Learning <u>about</u> outputs and their relationships to objectives are some of the chief outputs of system studies. We should look at our outputs and objectives as carefully as we look at our model and its inputs. If we begin with tentative objectives such as we did in this study, we should expect to replace and modify as we move along. It is unlikely that we will be able to define satisfactory objectives at the beginning of a study. Analysis of existing educational systems,

unlike less complex instructional programs, very frequently cannot start with specifically pre-stated behavioral objectives. In such educational systems the range of possible objectives and educational consequences simply is not known.

The third project to be discussed is of a somewhat different type. The first two discussed dealt with relatively complex systems, and outcomes dimensions that were quite broad. This project is much more limited in scope. One of our colleagues at UCLA has attempted to utilize systems analytic techniques to develop a salary scheme which effectively reflects the established priorities and objectives of educational systems and which overcomes some of the limitations of the commonly used fixed step salary schedule. The proposed scheme utilized linear programming techniques to develop a logical, internally consistent salary schedule for school district personnel. In this study a linear programming model for a school district salary structure was derived, then applied to an educational system. The ability of this approach to consider school district priorities in a logical and rational manner was demonstrated by solving the model for the maximization of beginning teacher salaries. This criterion of effectiveness would reflect a situation in which a school district established as a priority or objective, the attraction of new young teachers.

The model itself seeks to evaluate school district salaries according to nine dimensions. In addition to the amount of school district resources available, the salary structure is considered in the final determination of salaries. In short, the model selects a single, unique

salary structure which satisfies both the budgetary and hierarchial constraints which are imposed on a system. The flexibility of using this method can be demonstrated by solving the model under various objective functions, such as paying higher salaries to ghetto area school district personnel.

We hope that these three examples just presented help to provide insights into the range of educational research problems which might beneficially be examined from the systems analytic viewpoint.