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Systems Techniques in Education

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Educational planners can use systems analysis techniques to deal with the problems of finances, unlimited demands for limited services, inventories, and planning facilities through simulation.

systems techniques in education

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Today's school administrators often face financial and other crises. If the basic problem of public schools is to maximize the flow of educational services from the limited resources allocated for this function, then the system-analysis approach can be particularly remunerative.

Systems techniques have been employed with great success in many areas; medicine, space technology, defense, transportation, and communications. A logical extension for these techniques is careful application in an educational system. In 1968, a group from the National Security Industrial Association (Task Group IV, 1968) examined military and space technology for application in the field of education. The group formulated eight basic points which they felt characterized the typical application of systems analysis to training problems. This group further suggested that the extension of this approach to education could help significantly in improving public education.

In a very simple analysis one can consider that an educational system has two inputs—finances and students. Obviously, little can be done to change the kinds of students; but something can be done, via the systems approach, to optimize allocation of dollars and maximize returns for dollars expended.

Thorough systems analysis can identify general problem areas, such as finance and organization. Once such problematic areas are identified, solutions can be devised through more specialized operations research (OR) techniques, such as linear programming, queuing theory, inventory theory, simulation, various network analysis models, and statistical and probability theory. At present these powerful OR techniques have only limited application in the educative process, because of the inherent multiplicity of objectives and goals. However, they can be used to reduce costs or maximize services in such supportive processes as maintenance, transportation, and food services. Definitions and possible application for systems analysis and some of the OR techniques are presented in the following paragraphs.

Systems Analysis

A diagram in one report (Introduction to Systems Analysis, 1968) illustrates the dynamic way in which systems analysis typically operates. This diagram (Figure 1) reveals that systems analysis involves continual examination of each step, feedback to previous steps, and consideration of various capabilities and limitations which influence the decisions made at each point.

THE SYSTEMS APPROACH

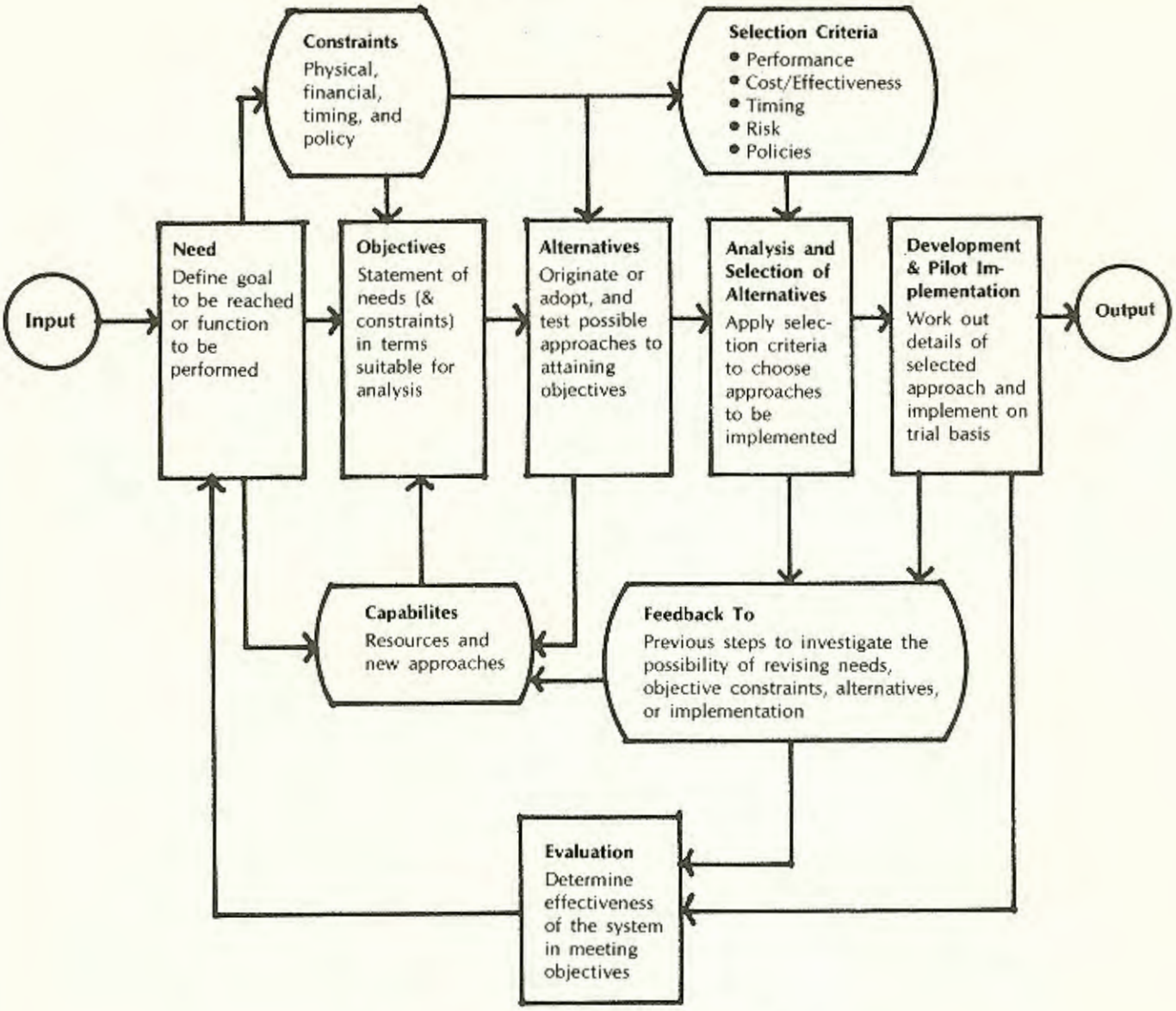

Figure 1: A flow chart of a typical systems approach.

For some purposes the systems analysis approach outlined here is too general. When this situation occurs the more specific OR techniques may be incorporated within the framework of a systems analysis.

Linear Programming

Linear Programming involves the planning of activities in order to obtain an "optimal" result. Stated another way it is a mathematical technique of allocating limited resources among competing activities in an optimal manner. Allocation problems occur whenever selection must be made among certain activities competing for certain scarce resources necessary to their performance.

The current trend of limited monies and the desire to maintain a high standard in education make linear programming's optimal allocation of limited resources increasingly valuable to educational managers. The technique is very versatile and adaptable to many situations. For instance, it can help maximize the amount of educational service for a fixed number of dollars or minimize costs while keeping the level of service constant. Already the technique had been used experimentally on a rather limited scale in the supportive areas of education, such as business administration, transportation, and maintenance.

Bruno (1970) presented an interesting paper using linear

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programming to allocate monies in a school district's salary schedule. One possible application of this mathematical model was to design a salary schedule so as to maximize the highest teacher salary. This model could be used to build a salary schedule that would act as an incentive for experienced teachers to remain in the district. Another possible linear programming function is determination of the optimal number of machines or people to keep available in a maintenance system.

Queuing Theory

Queuing theory involves the mathematical study of waiting lines. Queues, or waiting lines, occur when the demand for service exceeds the servicing agent's capacity to provide that service. Providing too much service results in excessive costs; not providing enough servicing capacity results in queues of excessive length. A servicing agent wants to achieve an economic balance between the cost of supplying a service and the cost associated with waiting for a service. The latter may result from various causes, such as, loss of customers who refuse to wait in a long line or loss of time resulting from a long wait. In education there may be a need to redefine these costs.

If the formation of waiting lines creates a problem in a school, then queuing theory would be an appropriate choice to help find a solution. It can help determine an optimal solution for school cafeterias where costs are too high or lines too long, for instance. The queuing technique requires the collection of data to determine the cost of students and teachers waiting in line, the cost of service, the distribution of service times, and the distribution of arrival times. From the financial point of view it should be noted that a trade-off develops: the gathering of data for the queue approach necessitates added expense, but the statistics yielded by this method allow administrators to make very accurate decisions which minimize expenses incurred by queue formation.

Another area where queue formation often presents a problem is in the paper flow of the system. Processing increased numbers of requisitions at certain times of the year is a common phenomenon which often leads to unwieldy paper queues. Queuing models can be used to analyze this phenomenon and determine the optimal number of personnel to process the paper flow.

Inventory Theory

Inventory theory is a relatively new quantitative technique that has been applied to the problem of determining inventory policies. An inventory in an educational system can be defined as a stock of goods held for future distribution. Since inventories constitute an alternative to future production or purchase expenditure the choice among policies depends upon the total cost incurred for each. Each total cost includes: (a) the costs of ordering or manufacturing, (b) holding or storage costs, (c) unsatisfied demand or shortage penalty costs, (d) salvage costs, and (e) discount rate.

The area of materials and supplies provides for a natural application of inventory theory. Some school districts purchase a full year's complement of materials and supplies at the beginning of the year and then distribute most of it to their schools shortly after its arrival. Advantages of this procedure are the discount rate allowed for large orders and savings due to inflation. Saving might possibly be increased, however, by ordering half the complement at the beginning of the year and investing the remainder of the funds until they are needed to purchase the remainder of the year's supplies. Inventory theory could compare these two procedures as well as other alternative models to determine the optimal policy.

Wynn (1968) used an application of inventory theory with the food services of a school system. Obviously, a cafeteria director would be interested in discovering the optimal amount of hamburger to be purchased, as well as the optimal length of time between purchases. Inventory theory can determine these values.

Simulation

The technique of simulation, with the advent of the high-speed digital computer, has become increasingly important to operation researchers. Simulation is nothing more than the technique of performing sampling experiments on a model of the system to be examined. The experiments are performed on the model rather than on the real system when the latter would be too inconvenient, expensive, or time-consuming. Simulation is often applied to problems that are too complex for analytical solutions using queuing and inventory theory. However, because of the expense involved in simulation, the analytical approach is generally preferred whenever possible.

Today's educational system offers many areas where application of simulation can be valuable to administrators. It can be useful in designing new schools, choosing new personnel, developing financial budgets, and designing new curriculum. In designing new schools, for example, simulating the traffic flow or the assignment of classrooms can determine which design yields optimal conditions. Dusseldorf (1970) reported on a project which involved the simulation of a school building, the staff, curriculum, and students. The object of the project was to determine the building facilities needed for 200 junior high students under a flexible schedule. Reportedly, the rooms needed in the building—number, size, and type—were accurately determined.

Simulation games can be developed to help train personnel officers to choose qualified personnel. One such game was developed by Gunnell (1970) as an instrument for training university and college department chairmen to make more realistic and effective decisions regarding the recruitment of faculty members. In this development variables important in recruitment decisions were identified, weighted, and programmed into the game. An administrator playing this game manipulates certain variables pertaining to environment, compensation, and other job-related factors. Upon completion he receives a department chairman recruitment score and comments relative to his score.

Simulation may become increasingly important in the areas of budgeting, as management attempts to get the optimal curriculum for the available funds. In 1970, the Western Interstate Commission on Higher Education (1970) developed a budgeting game for a university setting based upon PPBS principles. The numbers of departments, full professors, and associate professors, as well as salaries for each academic level, and monies for materials and library expenses within each department are some of the parameters that may be altered. The output of the game is broken into

eight reports which include such analyses as the total budget, the budget of each department, and the monies associated with each degree program.

Network Analysis

Network analysis is one of the more widely used of the OR techniques in educational systems. The planning and control of research and development projects is a problem which has been attacked by a network analysis technique known as PERT (Program Evaluation and Review Technique). Educational managers can utilize PERT to plan and develop projects in the educative process and its supportive functions. PERT can, for example, facilitate planning a summer maintenance project, a bond issue strategy, or a curriculum development project (Handy & Hussain, 1969). Teachers might use PERT to plan the long-range organization of a course into basic units to be covered.

Another educational system problem for which network theory is applicable is choosing a set of connections that provides a route between any two points of a network so as to minimize the total length of these connections. Such application can be useful in transportation, where the object would be to minimize the total distance required in the busing procedure.

Statistics and Probability Theory

Statistical models are widely used and well-known in the educational environment. They will only be mentioned as the most widely used OR technique in education.

Summary

Systems techniques have been employed with great success in many areas and can be applied successfully in educational systems. In the conventional systems approach, systems analysis is utilized to determine general problem areas; then the more specialized operations research (OR) techniques subserve efforts to discover rational solutions. To increase the effective utilization of systems power in educational systems, educators must be informed of not only the existence of these techniques, but also of the scope of their applicability and their immensely pragmatic and valuable potential.

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