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ABSTRACT

This review analyzes current research trends in the application of planning models to broad educational systems. Planning models reviewed include systems approach models, simulation models, operational gaming, linear programming, Markov chain analysis, dynamic programming, and queuing techniques. A 77-item bibliography of recent literature is included. (RA)

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# Models for Planning

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**MODELS FOR PLANNING**

**Analysis of Literature  
and  
Selected Bibliography**

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## FOREWORD

In mid-June 1970 the Clearinghouse received an urgent request from Central ERIC in the U.S. Office of Education to prepare selected bibliographies and brief analyses of literature on eleven critical topics related to school organization and administration.

The bibliographies and analyses were required by USOE's National Center for Educational Research and Development (formerly the Bureau of Research) in planning its new program of directed research and development. School organization and administration is one of four areas of education chosen by the center to receive concentrated research and development assistance. The others are reading, early childhood, and vocational education.

Through a joint effort the Clearinghouse staff completed the bibliographies and analyses for shipment to USOE by July 2, the deadline date.

The analysis and bibliography combined here focus on (1) the kinds of planning techniques, strategies, etc., that now exist in education or are under development, (2) the evidence of effectiveness of such planning systems, and (3) promising planning models and strategies in other fields not yet applied to education.

The literature cited in the bibliography and analyzed in the paper was drawn from a search of the two ERIC index catalogs, Research in Education and Current Index to Journals in Education, and from the following non-ERIC sources: Books in Print, Cumulative Book Index, Education Index, Public Affairs Information Service, Sociological Abstracts, Social Sciences and Humanities Index, and Book Review Digest. Although the urgency of the request precluded a full and comprehensive search and analysis of the literature, the reviews and bibliographies are intended to assess accurately some of the current developments and emerging trends on the topic.

Many of the documents cited in the bibliography can be ordered from the ERIC Document Reproduction Service. Instructions for ordering these documents are given at the end of the bibliography.

Philip K. Piele  
Director

Analysis of Literature on  
MODELS FOR PLANNING

A variety of planning models--including linear programming, dynamic programming, Markov chain analysis, computer simulation models, operational gaming, program evaluation review technique, critical path method, and queuing techniques--have been analyzed in the literature and applied to broad educational systems.

Linear Programming

Problems of assignment and distribution are two of the most important applications of linear programming models. Educational planners can use the technique to assign personnel or equipment to various activities. Shapley and others (1966) used an assignment model in a problem of bus routing and assignment of students. Clarke and Surkis (1968) devised a linear programming model to achieve a desired ethnic composition of students at each school, set a maximum travel time for any given student, and minimize total daily student travel time. Similar assignment models are provided by Lefkowitz and D'Epsopo (1967) and O'Brien (1967a).

Bush and Mosteller (1955), Cogswell and others (1965), and Oakford and others (1967) have developed sophisticated linear programming models capable of generating master schedules of classes and assigning students. Models to determine optimum strategies for allocating state resources, to determine

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Note: This paper was adapted largely from "Systems Approaches to Educational Planning," by Marvin C. Alkin and James E. Bruno, part 4 of Social and Technological Change: Implications for Education, a monograph containing five papers commissioned by the Clearinghouse.

logical and consistent salary schedules at minimum district cost, and to consider various patterns of subsidies for college students are provided by Bruno (1968) and Hoenock (1969). A study by Bowles (1967) concerned the problem of allocating resources to education within the context of a whole economy. Both costs and benefits of various educational programs were explicitly considered.

Stone (1966) created a model that depicted the flow of students through an educational system by means of an input-output matrix. Each level of education was considered as the input for the next level.

### Dynamic Programming

Linear programming and input-output analysis are used in static models. Dynamic programming is a more useful mathematical technique for solving problems with many interrelated stages, often measured in time intervals. It takes into account the effect that changes in previous stages have on present and future stages. Presently, applications of dynamic programming are mostly potential. Among the problems potentially solvable by this method are the timing of equipment replacement and the smoothing of production levels to meet variable demands (Lindsay 1963). In education, decisions concerning the location and size of future schools and the repair and replacement of school equipment might be amenable to this analysis.

### Markov Chain Analysis

A Markov chain is a procedure used to describe and predict the behavior or state of a system at some future time based on the system's present status

and on some transition probability figures or probable flow rates. The DYNAMOD model developed by the U. S. Office of Education is a Markovian, demographic-flow model used to predict increases in students and teachers for the nation as a whole in the next decade (Zabrowski and others 1967). Merck (1965) has a similar model for projecting movements of personnel through a system, and Durstine (1969) has a model dealing with numbers of students in each level of an educational system.

### Computer Simulation Models

Many computer-simulation models have been used to explain expenditures for education at the macroscopic level (Alkin 1966, Hirsch and Marcus 1966, James and others 1963, and Miner 1963). At the individual school level, the greatest advances have been at the university level. Wilson (1969) provided a conceptual framework for the consideration of computer-simulation techniques in higher education planning. The University of California has employed such models for its planning purposes (Keller 1967). Two other models that describe the workings of a university are Judy (1968) and Koenig and Keeney (1969).

In elementary and secondary education, Sisson (1969) has a model for determining the required number of teachers and other employees for each year of a planning period. Another model, intended to relate resource allocation to achievement, was described by Sisson in 1967 as under development.

Other models have been developed for projecting school enrollment (Griffin and Schmitt 1967), locating sites (O'Brien 1967a and Uxer 1967),

and recruiting and using substitute teachers (Hausman and Rath 1965 and Bruno 1969a).

### Operational Gaming

One variation of simulations is operational gaming. Goodman (1969) is developing a game dealing with a problem of school integration and geared primarily to the school board member as a participant. By allowing participants to play roles as representatives of various community interest groups, the game enables them to better understand the political implications of potential decisions. Adelson and others (1967) used inputs provided by several rounds of expert judgment as the basis for an educational-planning game. Although geared to the national level, the technique might be appropriate at the school district level as well.

### PERT and CPM

Two of the least mathematical of all the systems techniques for educational planning are program evaluation review technique (PERT) and the critical path method (CPM). Although CPM and PERT are alike because both are essentially network types of analysis, CPM originally differed from PERT by including cost factors as well as time and by employing some mathematical procedures for finding lowest cost. Now, however, aspects of cost are also being related to and used in PERT.

The leading advocate of the application of PERT to education is Desmond Cook. A monograph prepared by Cook (1966b) describes the technique and its pertinent applications to education. Gold (1968) reported on its use in

scheduling the construction of at least three other junior colleges. Kapfer (1968) has developed an institutional strategy based on PERT to assist teachers in establishing a sequence of activities leading to greater individualization of instruction.

### Queuing Techniques

Many segments of education seem appropriate for analysis by queuing techniques. Queuing theory is concerned with the waiting-line problem. Queues or waiting lines often form where people or things require some specialized service whose facilities are limited. The time factor is always involved. Application of queuing theory requires information concerning the rate of arrivals at the servicing stations, the time required to perform the service, and the method of selecting whom to be served. In general, the problems take one of two forms: Either the facilities to meet certain specified needs must be determined, or the facilities are fixed and the problem is one of scheduling the arriving units. The ultimate goal in such problems is to achieve an economic balance between the cost of service and the cost of waiting.

School business applications might include the scheduling of secretarial or telephone answering time. Perhaps it could be applied to the scheduling of books or student registration. Gold (1968) employed the technique to determine how many counselors should be made available by a city college. Although such applications appear pedestrian, they point out clearly that relatively simple applications offer the greatest benefits at this time.

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