BIBLIOGRAPHIC DATA SHEET	1. CONTROL NUMBER PN-AAH-655	2. SUBJECT CLASSIFICATION (695) JD10-0000-0000

3. TITLE AND SUBTITLE (240)
Development and use of systems models for educational planning

4. PERSONAL AUTHORS (100)
Davis, Russell

5. CORPORATE AUTHORS (101)
Harvard Univ. Ctr. for Studies in Education and Development

6. DOCUMENT DATE (110)	7. NUMBER OF PAGES (120)	8. ARC NUMBER (170)
1979	59p.	379.1.D263a

9. REFERENCE ORGANIZATION (130)
Harvard

10. SUPPLEMENTARY NOTES (500)
(In Harvard Institute for International Development, development discussion paper no. 68)

11. ABSTRACT (950)

12. DESCRIPTORS (920)

Models
Systems
Planning
Program planning
Educational planning

13. PROJECT NUMBER (150)
931008900

14. CONTRACT NO.(140)
AID/ta-C-1336

15. CONTRACT TYPE (140)

16. TYPE OF DOCUMENT (160)

Development Discussion Papers

Harvard Institute
for International Development

HARVARD UNIVERSITY

DEVELOPMENT AND USE OF SYSTEMS MODELS FOR EDUCATIONAL PLANNING

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DEVELOPMENT DISCUSSION PAPER No. 68

June 1979

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0-1

Development Discussion Papers 59 through 73 were originally prepared for the United States Agency for International Development under a research contract with the Center for Studies in Education and Development of the Harvard Graduate School of Education. The Harvard Institute for International Development collaborated with the Center in this project and the papers included in this series are a sample of the contributions by participants affiliated with HIID.

An analytic paper which describes in reasonably, non-technical language what systems planning models are, describes some of the major types of models and the applications of some of these models to the planning of education at the national level, discusses the limitations of national planning models, and makes the point that there are still unrealized potential for further application of models to actual planning, as opposed to academic proposals for using a model in planning and policy analysis.

CONTENTS

Section		Page
1.0	The Context of Planning Education in Developing Countries	1
1.1	Planning in Theory and Practice	2
1.2	Limitations of Rational Planning	3
1.3	Other Planning Approaches	4
1.4	Planning Defined and Described	5
2.0	Models and Systems Planning	6
2.1	Types of Rational Models for Educational Planning	7
3.0	The State of Practice in Model Development and its Use in Planning	9
3.1	The Schiefelbein Model Applied in Chile	9
3.2	Model Development and Limits of Black Box Analysis	10
4.0	A Note on the Black Box Approach to Modeling and Social Analysis	11
5.0	Models Applied in Systems Planning in Education	14
	5.1.0 Black Box Features of Models and Analysis Methods	14
	5.1.1 Models for Target Setting and Forecasting in Planning	19
	5.1.2 Social or Demographic Target Setting	20
	5.1.3 Social Demand and Outreach	21
	5.2.1 Micro Level Manpower Requirements Forecasts	25
	5.2.2 Improving General Forecasts of Manpower Requirements	27
	5.2.3 Compound Models	27
	5.2.4 Summary Comment on Manpower Models	29
	5.3.0 Models for Tracing Systems Flow and Supply Forecasting	29
	5.4.0 Allocations Models in Mathematical Programming Form	30
	5.4.1 Optimizing in Allocations Models, and Goal Programming Possibilities	31

Section		Page
5.5.0	Instructional and Learning Models	32
5.5.1	Mathematical Models of Learning	32
5.5.2	Models of Instructional Outcomes	33
5.6.0	Models for Administration and Organizational Analysis	34
5.6.1	Modeling Educational Systems Structures	34
5.6.2	Scheduling	35
5.6.3	Modeling the Decision Process	35
5.6.4	Bounded Rationality and Transactional Analysis	37
5.7.0	Satisficing Through Goal Programming Models	38
6.0	An End Note on Heuristic Modeling	40
	Bibliography	

(Thematic Paper)

THE DEVELOPMENT AND USE OF SYSTEMS MODELS FOR EDUCATIONAL PLANNING

1.0 The Context of Planning Education in Developing Countries

The aim is to review both the theory and method of educational systems planning as it affects the practice of policy formulation, program development and decision making in the national learning systems of developing countries. The term national learning system signifies that the coverage in this work extends to planning and policy formulation for programs outside the formal school system, to include education and training in that amorphous area called, "non-formal education."

This review deals largely, though not exclusively, with educational planning in low income countries of Africa, Latin America and Asia, where the prime preoccupation is economic and social development, as this is evidenced by economic growth and more equitable distribution of income and services. The driving dynamic is change, social and economic, planned and unplanned, for the better or for the worse. In some instances countries choose and develop strategies and plans for managing change in pursuance of development, and these strategies and plans may overstress growth rather than distribution, investment in urban areas at the expense of rural areas, concentration on industry rather than on agriculture, and investment in capital intensive enterprise and technologies rather than efforts to promote labor intensive enterprises and employment generation.

Human resources are developed through education and training in response to economic and social goals, and educational plans and policies will, or should, differ according to strategies chosen. In many cases the countries, rather than freely choosing, seem instead to be chosen by the strategies of other more powerful countries, and planners may have to work within a framework of national dependency, presumably toward a reduction of this dependency. In all cases, however, the dynamic of change is pervasive, and the only option is to deal with it, through planning, or to suffer it. Planning in this sense may be no more than "the exercise of foresight" as C. E. Beeby (1965) described it. Here we will examine more systematic, or "rational" approaches to analysis and planning, but the point should be made that a resource poor country cannot manage change without some form of planning.

1.1 Planning in Theory and Practice

The aim of this paper is to describe and analyze the state of development of educational systems models for planning, and this task presents the dilemma of whether to constrain consideration to actual practice, with all its limitations and imperfections, or to range beyond this to include what planners could or should do if planning theory and practice were in perfect agreement. Although the main focus is on planning as it is done, and not as it should be done, the discussion goes beyond this into theories, models and methods that have potential for application, but as yet limited use in the planning of educational systems of developing countries. This is apparent in the section which treats the development and use of comprehensive planning models.

In the world of plans, policies and decisions, rationality is limited by reality, and no form of analysis or model yields unambiguous resolution of complex problems. There are limits on all rational approaches to planning, and yet the practice of planning has not yet approached these limits, even in those cases where systematic analysis and rationality have been attempted. Hence, this commentary may have a curious duality, in that the limitations of rational approaches and models are identified at the same time that the possible applicability of improved models and methods is advocated. The dilemma is easy to describe in words, difficult to apply in practice, and three propositions state the case:

(a) rational planning and systematic models are necessary in many situations to clarify complex systematic relationships and competing issues;

(b) in practice, rational planning and systematic models have not been used as widely as their potential usefulness merits;

(c) rational planning and systematic models have limits on their applicability; some limits are technical and data-bound and these can be identified and resolved; another problem is that a benign environment for decision making is wrongly assumed.

1.2 Limitations of Rational Planning

This paper goes beyond the state of the art to consider further development of rational models and methods, but it also goes beyond this to state the limits of applicability of these models and methods, and, in fact, identifies the limitations of reliance on rational planning to the exclusion of other approaches. Those who work in planning in developing countries, who think and write about their work and, collectively the writers of papers in this series are representative of this group, realize that there are merits and blemishes on all approaches to planning; for each approach there is a season -- a time and a place--- and where the disagreement comes is in the range of applicability of rational planning as opposed to alternative approaches. The writers who have contributed to this series of materials on planning differ as to the span of usefulness of rational planning. In this paper rational planning is accorded pride of place; in later papers it is handled less respectfully and other options are advocated. This difference of opinion in itself reflects the state of the art and the practice of planning.

1.3 Other Planning Approaches

To move beyond the limits of systematic, or "rational"[1] planning, other approaches to planning have been proposed, in some few cases developed and elaborated, and in rarer instances applied. These alternatives have been discussed under the rubrics of "participatory" planning, "democratic" planning, "advocacy" planning, "incremental" planning, "transactive" planning, "creative" planning and "radical" planning, approaches which are valuable as antidotes to the rigidity and formality of systems planning and rational planning. These planning approaches focus more explicitly on underlying social dynamics and human concerns, and also serve to orient the planner to the importance of dealing with individual attitudes and values and the subtleties of social

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[1]The qualifiers "rational", as in rational planning, and "creative" as in creative planning are ameliorative in the sense that they seem to imply that this form of planning has a corner on the quality signified by the modifier. Rational planning is clearly not the only approach in which analysts and planners attempt to proceed rationally. Conversely, rational planners are not necessarily devoid of social or political sensitivity or unskilled in bureaucratic survival, and may be as democratic as democratic planners, as creative as creative planners, as participative as participatory planners and as radical as radical planners. For a quick working definition of rational planning we adopt that of Allison (1969): rationality refers to consistent, value maximizing choice within specific constraints.

dynamics and cultural value influences. Rational planning also has limitations in dealing with educational process and outcomes that are lumped under the catchall term "quality". Dealing with quality issues is difficult in all planning approaches, because quality is hard to define.

1.4 Planning Defined and Described

"Planning" can be defined as foresight exercised to stimulate and guide social action toward articulated objectives. "Foresight", "action", and "objectives" can be treated with varying mixes of unquestioned assumptions, focused calculation, informed judgment, systematic doubt, or programmatic research, depending on the planner's biases, methodological tool kit, available data, sponsorship, and local circumstances which control how plans can be put into effect.

When applied to teaching/learning activity that is organized into programs, institutions, and education and training systems, comprehensive and systematic educational planning covers the development and statement of goals; determination of policy and program alternatives; assessment of costs and resources with evaluation of outcomes or effects; and the monitoring of allocations' decisions and implementation activity. Results of this last step are fed back into what is a continuous process. This is the rationalistic view of educational planning. There are other planning traditions, including transactive planning, advocacy planning, radical planning, and disjointed incrementalism. These rely more on building up and outward from small-scale experiments.

Whereas rational planning builds on codified knowledge, and comprehensive,sequential analysis, with goals and program alternatives specified and evaluated; by contrast, the other less conventional versions of planning emphasize intuitions, skills, and continual adjustment within specific social contexts. This review mainly deals with the more conventional "rationalistic" tradition of educational planning.

More fundamental to the rational approach to planning than the kind of codified information, often expressed in quantitative form, and the kind of analysis that is applied to the data, is the fact that rational planning relies much more heavily on formal models which frame the epistemological approach of the planner and guide his analysis of reality. It is around this topic of systems models that the discussion of rational planning will be built.

2.0 Models and Systems Planning

In developing a model a planner singles out elements from reality, symbolizes them, defines and portrays them as a system of variables, and analyzes relationships among variables in the system as an aid to description, explanation and forecasting. Of late, planners talk of projecting and forecasting, rather than predicting, but as long as planners have to deal with the future, an important class of models, sometimes called normative, attempt to portray the future as it is planned to be. In the planning context a model may clarify relationships among variables, or trace relationships between desired objectives and outcomes which are indicated by changes in variable values. Variables may be exogenous, set by policy or on the basis of information derived outside the model, or endogenous, derived by operating within the model.

Planners also distinguish between variables which are under policy control and those which are not, and between goal or target variables and those that are within the model but irrelevant to the outcome of interest. In the Schiefelbein (1974) planning model applied in Chile, manpower targets were set into the model as exogenously derived, and the educational activities, i.e. enrollments at various levels of the system were endogenously derived in the running of the model toward a stated objective of minimizing cost under resource constraints. The model was designed to satisfy the educational requirements of manpower targets, within the resource constraints imposed by budgetary limits on expanding stocks of teachers, classrooms and materials. The objective was to do this at minimal cost. The equations of the model, and an explanation,are shown in Appendix A of paper 30 in this series. ("Policy and Program Issues Raised by the Application of Compound Models).

2.1 Types of Rational Models for Educational Planning

Educational planning models can be categorized in various ways; according to whether they are designed to describe, explain, or forecast, although these are not always clearly different; according to the form of the expressions, graphic, verbal, symbolic; and according to use in the field of educational planning for allocation, target setting, assessment and costing. There are models for analyzing organizations and the decision and learning process. Comprehensive or multi-purpose models may combine many forms and uses to analyze changes in an entire educational system over time. Schiefelbein and Davis (1974) review these classifications and note that one of the shortcomings of educational planning models is the lack of linkage between comprehensive-systems models and the teaching-learning which goes on at the heart of the educational process.

Fox (1972) divides models generally into two broad classes -- algorithms and heuristic aids. Algorithms are constructed in mathematical form so as to yield a computable solution, and are termed "computable models" by Schiefelbein and Davis (1974). Mathematical programming models, linear program, quadratic programming, integer programming, dynamic programming and goal programming, offer algorithms for computation, as in the simplex method. Heuristic models clarify and help explain, and the simplest example would be graphic portrayal of the dynamics of an educational system or organization. Heuristic models may depict logical relations that help in exploration of possible solutions, rather than being developed into a form that yields a computable result, or a single optimal result. Gaming and simulation may yield families of interesting possible outcomes.[1]

More clearly heuristic are goal-achievement and cross-impact matrices, and pattern arrays which clarify logical relationships and effects; decision trees which sketch out chains of decisions along alternative paths and sometimes have probability estimates of paths to final states; and block designs which show systems relationships. The methods of the futurists, namely Delphi which attempts to reach consensus estimates by polling panels of experts on future events, and scenario writing which depicts alternatively structured futures, are more purely heuristic; and long-range technological forecasting with its quasi mathematical divination should lay claim to no more than heuristic value.

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[1] Some planners, Schiefelbein for example, see no practical distinction between simulation and optimizing in practice, and view the results of one run of an optimizing model as simply a trial to be varied through sensitivity analysis and other changes in the parameters and even the structure of the model. The object is to inform policy makers and not to determine policy by single-shot model runs. (See Development Discussion Paper No. 69, HIID, June 1979 on policy issues raised by system models).

3.0 The State of Practice in Model Development and Use in Planning

There was a vigorous development of comprehensive or systems-wide models in the period 1962-1973. (Correa and Tinbergen, 1962; Adelman, 1965; Bowles, 1969; Stone, 1965; Moser and Redfern, 1965; Schiefelbein and Davis, 1974 are a representative selection.) Of these models only the Correa-Tinbergen, the Bowles, and the Schiefelbein model were taken to the computation stage; and only Correa-Tinbergen, used in the OECD Mediterranean planning project, and the Schiefelbein model, used in the planning accompanying the Chilean educational reform, were run as part of a planning exercise. Finally, only the Schiefelbein model was used by planners within the educational system to affect educational policies and programs.

3.1 The Schiefelbein Model Applied in Chile

The Schiefebein application marked a high point in model development and application of that period. The experience revealed the limitations on the use of tightly structured comprehensive models. Run as a linear program model with the objective of planning the output of formal schooling and on-job training at minimal current and capital cost, the model indicated,in broad terms,possible expansion possibilities for the education and training system, indicated possible bottle-necks to growth goal attainment over time, and suggested a number of problems which had to be studied with more detailed analysis and research, e.g. options for training teachers, and alternative ways of improving the quality of instruction to increase flow through the system.

There were three major limitations on the usefulness of the model. One was imposed by the rigidity of the mathematical programming structure and the algorithms for computing the result. In the linear programming model it was impossible to include feedback relationships. Feedback relationships can be included in a dynamic or multiple loop feedback model, but this requires a different model structure. Chilean planners had to use fixed coefficients over time, although approximations could be introduced at the beginning of each time period.

A second major problem arose in applying the model to an actual policy analysis and decision making context. A single goal was chosen, that of minimizing cost, and this was unrealistic in the circumstances. Goal programming offers a way to avoid this, but has the same limitations imposed by the first kind of difficulty.

A third set of limits came in applying the model to learning processes. The model could not deal with essential qualitative relationships which are at the heart of the education process. The model fell short in providing indications of what planners, policy makers and program developers could do about changing basic programs for influencing the quality of education. A more elaborate model was developed to accommodate effects of instructional quality, but it was difficult to get this model into computable form. The promise and problems of such programming and optimizing models in actual planning are reviewed by Schiefelbein and Davis (1974), but in general the model was too rigid and too general to serve many practical ends of planning. More flexible models were required.

3.2 Model Development and Limits of Black Box Analysis

Since the Chilean model application in 1970, there has been further development of models for education planning, but no marked increase in real world use. The problem of linking systems changes with the central core of teaching-learning has not been solved, or approached, and may lie beyond remedy in the foreseeable future. Comprehensive models yield useful information at a systems-wide level, but treat the central activity of education as something that goes on inside a black box. They yield few guidelines for shaping instructional or learning strategies.

4.0 A Note on the Black Box Approach to Modeling and Social Analysis

Before reviewing the various types of systems models used in educational planning, a note on black box models and analysis is appropriate. In a black box model, the inputs and outputs of a system[1] are clearly portrayed for analysis, but the central process of the system is not. The workings of the process can sometimes be inferred and described with sufficient accuracy to enable the analysts to design, re-design, and, in general, to manage and control the system and its performance. Classic systems modeling has been borrowed from science, engineering and technology, and applied to social systems analysis and planning. Some of the classic designs are shown in Figure 1 graphs.

These are conventional systems designs, applicable to the design and study of a variety of physical systems. The black box nature of the analysis is clearly understood by analysts when they apply them. Hare (1967) provides a readable introduction to the subject.

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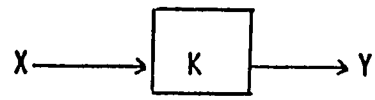
[1]R. Chin (1961) defines a system as "a collection of interrelated parts which receives inputs, acts upon them in a planned way and thereby produces certain outputs." Silvern (1972) emphasizes that a system is the structure or organization of an orderly whole. Churchman (1968) stresses that a system is made up of a set of components that work together for the overall objective of that whole; and Mesarovic (1972) stresses the point that a system is a relationship among objects specified or defined in terms of information processing and decision-making. Systems models show the structure within the bounded system and the components or subsystems and their relationships, and define the inputs and outputs to the system and the goals of a system.

Figure 1

Classic Systems Diagrams

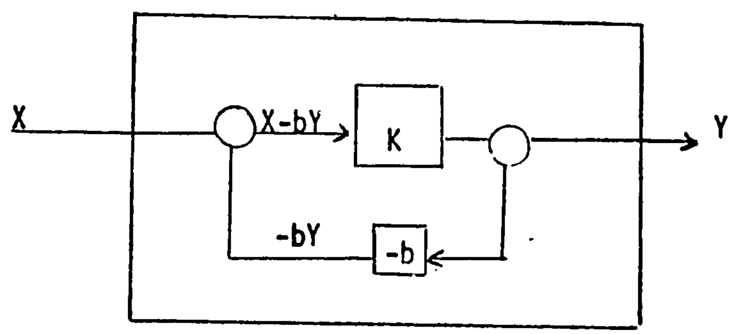
a) Single input, transformation and single output



The transfer function is the ratio of the output to the input:

$$T = \frac{Y}{X} = K$$

b) Transfer function for a feedback loop

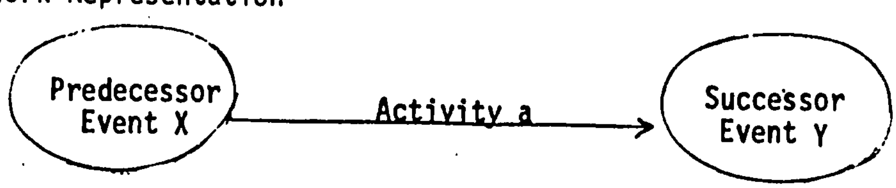


$$Y = K\,(x - by)$$

$$T = \frac{Y}{X} = \frac{K}{1 + bK}$$

c) Flow Graphs

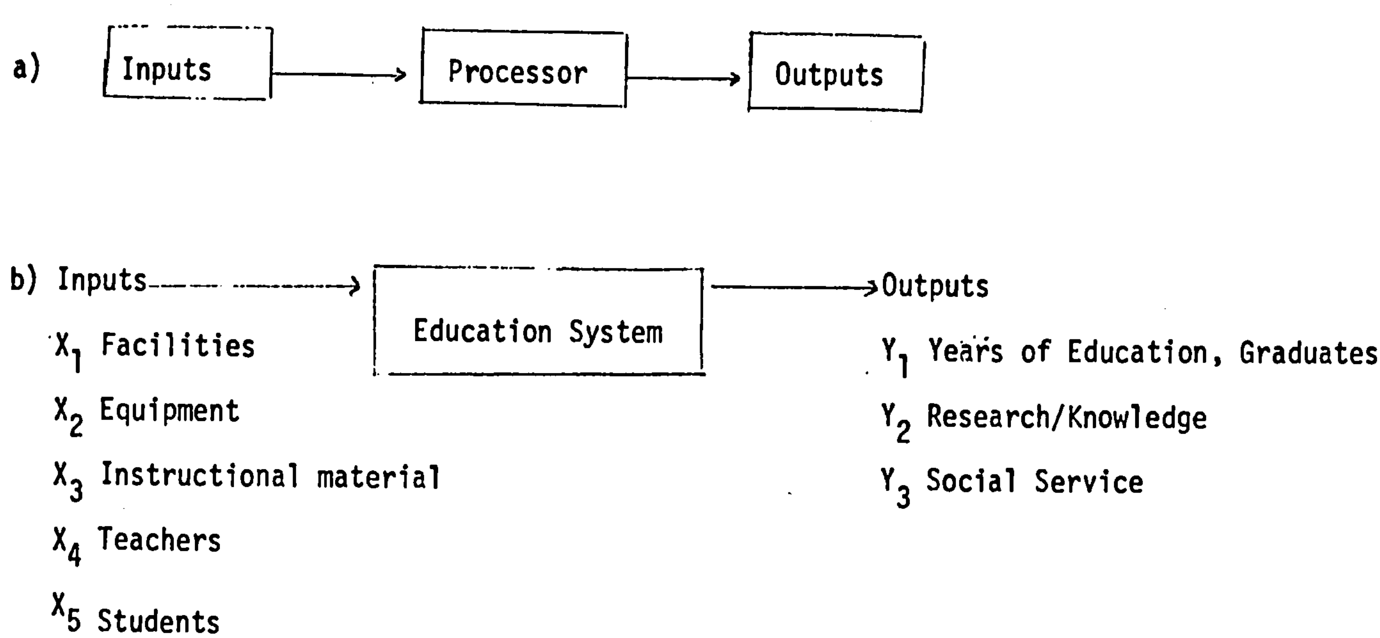
d) Network Representation



Systems models are also applied to the analysis of more open social systems, and in education, as in Hussain (1973). The models are used by social analysts and planners, but sometimes, as the designs and analysis become more complex, the black box basis of the analysis is not always so clearly recognized. A simple schematic of the application to educational planning might be:

Figure 2

Black Box Models Applied to Educational Systems and Process



Systems models and analysis methods fit certain of the tasks of analysis and planning in social systems reasonably well, despite a basic difficulty in bounding open systems. For example, Block Diagrams and their alternate expression in flow diagrams can be used to schematize school system structures and the flows through different levels of a graded school system if numbers flowing through the system are all that is of interest to the analyst. Network representation can be appropriately applied to scheduling project activities, as the training material on Critical Paths and PERT (Programmed Evaluation and Review Techniques). illustrates. The black box nature of the analysis is usually perfectly clear to the analyst and planner, and more importantly, it is clear to the person who reads or uses his work. The nature and limitations of black box modeling and analysis will not always be clear when applied in some of the systems models applications that follow.

5.0 Models Applied in Systems Planning in Education

The models and analysis methods that will be listed and discussed are useful and essential for performing various tasks central to systematic planning. Almost all of the models and procedures are black box representations of some aspect of social reality. In reviewing the models, these black box features will be noted. This does not destroy the usefulness of the models.

5.1.0 Black Box Features of Models and Analysis Methods

In pointing out the black box features we offer a cautionary sign to those who use the results of analysis performed with the model:

A) Models for Target Setting, which include:

a. Models used in the social or demographic approach to planning;

b. Models, perhaps more accurately, systematic procedures, to serve the manpower requirements approach to planning;

c. Models for incorporating rate-of-return analysis in planning.

All of these models have important black box features. Population projection models and methods are based on assumptions about the way the essential components of fertility, mortality and migration will change over time. The full social dynamics which affect fertility are not analyzed in detail, but certain evidence is appraised (live births, age-specific fertility patterns, birth expectations) as a basis for setting the assumptions or hypotheses that underlie fertility projections. The full range of social and economic dynamics which affect these component rates are not analyzed.

Manpower requirements forecasting is assuredly a black box procedure. The factors affecting increase in product and productivity and hence employment are not analyzed in depth, nor are the relationships of productivity to occupation or educational attainment fully studied. Rate-of-return analysis is applied to aggregated earnings data to construct earnings profiles over time and to relate these to educational attainment levels, but without direct analysis of the effects of educational attainment on job performance and productivity.

B) Models for Tracing Flows in Systems. These are usually subparts of comprehensive models, or allocations models, used for projecting enrollments and graduates after demographic projections of entrants are made, or for projecting "supply" in response to manpower "demand" forecasts.

Enrollment flow models deal with students as so many heads; the flow rates of promotion, repetition and drop out are generally constructed on the basis of aggregate estimates based on groups or cohorts, without analysis of individual performance.

C) Allocations Models. These model the attainment of objectives with fixed resource limits and input coefficients. Resource allocations models usually lump resources without qualitative distinctions; a teacher body is a teacher body although sometimes training levels and experience are differentiated. Unit costs and unit allocations are derived from averages, i.e., so many students per teacher and so much salary paid to the average teacher.

D) Models for Analyzing Input-Output Relationships in a School System. These models can be traced to the classic studies of educational antecedents and outcomes which have "enriched" the professional literature in the field of education over the past thirty years. More recently economists have used the approach in production function analysis and sociologists in analyzing the data of "natural experiments." The lines of development are quite similar, resting on application of least square models to regression analysis of variables "measured" in the cross-section. Multivariate statistics, burgeoning in application over the past fifteen years, has made the black box models less simple for the layman to detect.

A typical production function analysis might be based on a model of this kind:

$$A = f(X_1 \ldots X_i, X_j \ldots X_q, X_r \ldots X_z)$$

Dependent Variable

Some measure of school output, e.g., school achievement

Independent Variables

$X_1 \ldots X_i$ Educational Inputs

$X_j \ldots X_q$ School or Community Environment, SES status

$X_r \ldots X_z$ Prior Education or Intelligence of Student

The function is fitted through least squares and in the resulting regression analysis there is an attempt to assess the relationship of the independent variables to the dependent variable A, which might be some measure of achievement.[1] There is no direct analysis of the process of education or its effect on learning outcomes, as these might be analyzed in control-experimental research and evaluation models, which will be dealt with in other sections of the instructional materials of this series. (See reference papers by Picker and Kline, Harvard Graduate School of Education, Center for Studies in Education and Development).

The same basic models and methods are applied by sociologists and economists in studies of the broader relationships of demographic, social and economic variables on education and earning. Figure 3 shows the application of path model and analysis to the study of the effects of social and educational variables on earnings and living standard. Path analysis attempts to get behind the cruder aspects of black box social analysis by setting up explanatory models of effects beforehand and analyzing causal relationships somewhat more explicitly, but the results also sometimes disguise the underlying black box features of the analysis of the process.

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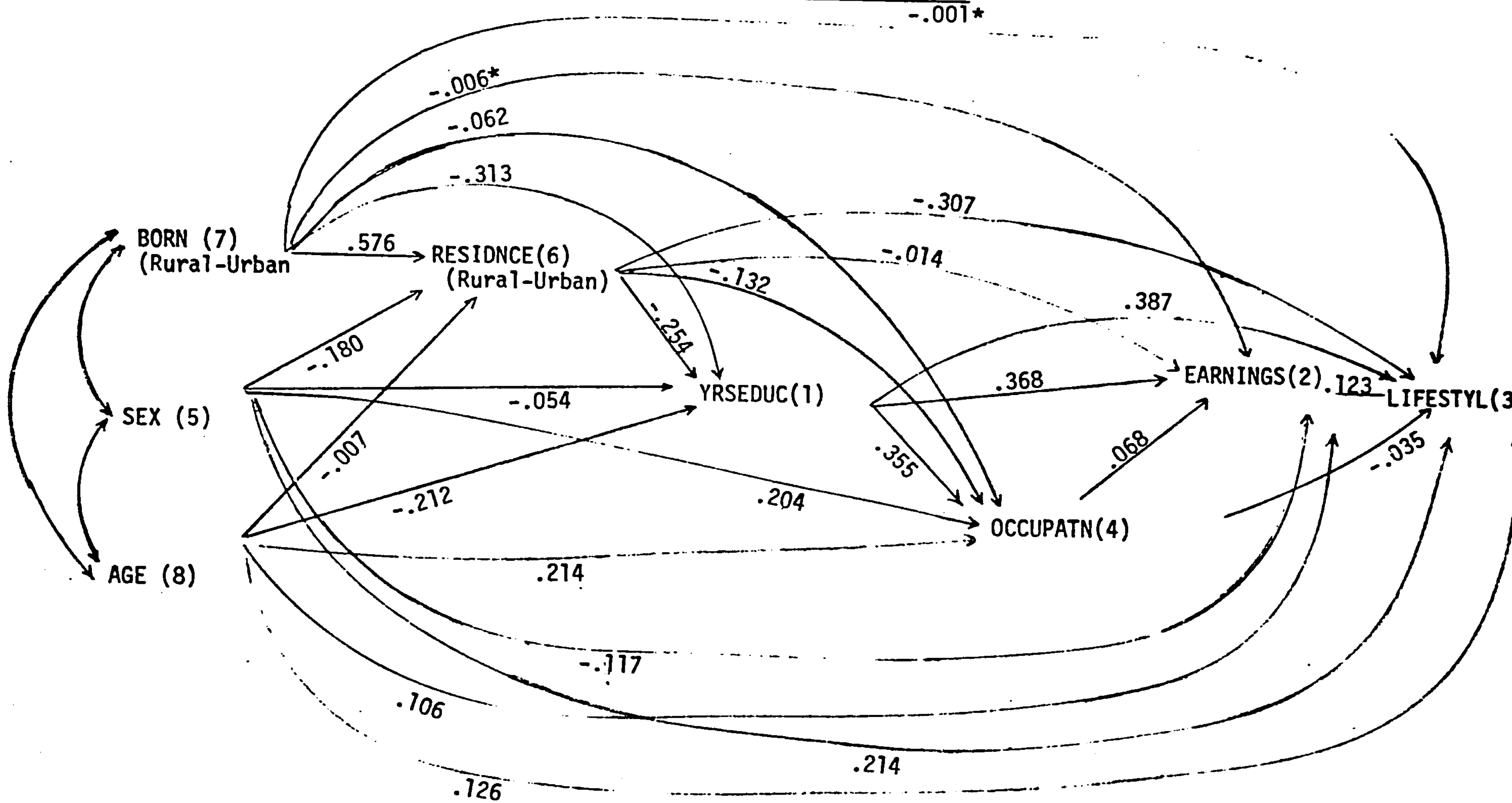
[1] A practical question to address might be how different amounts and kinds of educational inputs affect school achievement, or output as defined here. See paper by Lewis, Harvard Graduate School of Education, Center for Studies in Education and Development.

Figure 3

Path Model of Relevance of Education to Economic Social Outcomes, For Economically Active Population



Source: Harvard-AID Project Analysis of Data on Relevance of Education in El Salvador

E) Mathematical Modeling of the Learning Process. These models will be reviewed briefly. The more easily and precisely they fit into a mathematical form, the less they have been applied in educational planning. Here the learning process is simplified to a limited number of outcomes so that it scarcely resembles any learning process of relevance.

F) Organizational Models. This segment covers organizational structures and processes in graphics; organizational scheduling, as in PERT and Critical Paths; and decision models and gaming. Organizational graphics and scheduling formats are merely sets of descriptive (modeling) techniques useful for planners and administrators. These methods are more fitted to the systems models and analysis procedures which are black box explicitly and formally. Again, the fact that a model and analysis method treat the world or some relevant aspect of it as a black box process does not destroy the usefulness of the model or the analysis. The point is simply to keep the black box nature of the model and the analysis in mind when interpreting results.

5.1.1 Models for Target Setting and Forecasting in Planning

Planners still require a set of models and techniques for setting planning targets and forecasting the development of social and economic systems over time. Though in recent years there have been no impressive developments in the state-of-the-art there is a fairly well developed set of techniques which are being constantly improved by demographers and statisticians, economists, sociologists and planners. Only a brief description of these models and methods will be offered here, because most of them are familiar to planners, and even informed readers of plans and planning literature, and a more detailed presentation of these models, supplemented by computer codes and program documentation, will be given in other papers of this series.

5.1.2 Social or Demographic Target Setting

Population projections, or demographic forecasts, provide the basis for most comprehensive planning. Social and economic systems change as the size and structural characteristics of the basic population change. Demographic forecasts provide future estimates of school entrants, and hence provide the basis for enrollment forecasting. Population projections underlie many economic projections. The economically active population, or work force, can be derived from participation rates applied to the adult population. Economic growth forecasts may be related to population growth estimates in sectors where demand for goods and services by households can be related to population increase.

The basic components model for a population forecast is still a simple one. A population forecast for a future year derives from a base year population structured by sex and age; the age cohorts are multiplied by survival rates; females surviving into child bearing years are multiplied by fertility rates to get births; births are"survived"; migration is netted in, and the process goes forward iteratively year by year. Mortality and fertility rates and net migration are the components which determine the forecast. Demographers have improved their methods, but not through developing new or more sophisticated models. Improvement in the art of projection usually comes through better research and analysis of mortality and fertility rates.

In the poorest of the developing countries, and among certain groups of poor within more prosperous countries, the effects of improvement in health and nutrition are beginning to show up in lower morbidity and mortality rates. Demographers can use changes in these rates to monitor health programs,and in the process improve their estimates of the mortality component in projections.

Since 1960, school enrollments in the United States have been mainly influenced by the decline in births; and fertility estimates are the main concern of U.S. forecasters. Davis and Lewis (1978) discuss the fertility assumptions underlying the Series I, II, and III population forecasts of the U.S. Census Bureau, and trace some of the consequences of population change for educational planners in the U.S. Estimates of future births come from assumed changes in fertility rates which are based on analysis of other social and economic indicators and surveys of birth expectations. There are black box features in this analysis. Hence, improvement in the forecasts will come from improved social research, rather than from more highly developed forecasting models.

5.1.3 Social Demand and Outreach

Planners, in recent years, have carried out more detailed analysis of the social and economic structures of populations, in order to determine sub-groups served, or not served, by social and economic development programs. As plans, if not programs, focus more on the distribution of social and economic benefits, there has been an increasing attempt to trace differences in service and benefits to rural, as well as urban groups, to ethnic groups and regional groups, to members of groups isolated by geography, deprived by poverty, or ignored because of class bias.

In U.S. AID assisted programs a special concern is the response to the Congressional Mandate which singles out "the poor majority" for special attention and services. For planners the task is not so much to develop new general models as it is to specify in plan targets the relevant groups to be served,based on assessments of the special needs of these groups through survey and research studies. In the best of worlds planners assist these groups to identify and articulate their own needs.

An immediate task at national level is to develop more socially sensitive indicators based on improved analysis and measurement of distribution and equity. One paper in this series applies the Gini Coefficient to measure the distortion between proportions of the population in different economic and social classes and proportionate education and earnings received.[1] The coefficient has limited value as a measure of the dynamics of social processes, but it serves as a starting point for analysis. An increasing number of analysts and social scientists would hold that improvement will come not so much through improving modeling and analysis as through a reorientation of planning approaches so that they are more sensitive to local needs and more open to local participation.

5.2.0 Economic Target Setting: Manpower Requirements and Rate of Return

Schema 1 sketches out the essential methods of the manpower requirements approach to the setting of plan targets. The first column depicts alternate approaches to the forecasting of manpower requirements. The first approach, called "the basic method" in the instructional manuals in this set of materials, could scarcely be called a model and simply represents a set of steps for tracing educational "demand" from manpower requirements. The <u>alternate</u> model shows growth in occupations deriving from three sources: (a) historical growth in employment in the sector; (b) historical growth in productivity in the sector; and (c) an elasticity coefficient (usually based on inter-country comparative data) relating growth in productivity in the sector to growth in the occupation. Growth in the occupation over time is projected to increase exponentially

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[1] Snodgrass, D. "The Distribution of Schooling [illegible] DDP No. 53, HIID, February 1979.

Schema I

Outline for Manpower Planning

I. AGGREGATE LEVEL FORECASTS

1. BASIC METHOD
   General Economy
   X sectors
   - a. Product forecast (plan targets) $P \rightarrow$
   - b. Productivity forecasts $P_{p.c.}$
   - c. $\frac{a}{b}$ = E:Employment by sectors
   - d. E distributed sectors by occupations
   - e. Occupation distributed by education (levels and programs)
   - f. Education demand aggregated

2. Alternate Method (Growth in occupation)
   X_{ij} = number in ocup.(i); sector (j)
   - a. $Prop^{X}ij = X_{ij}/L_j = K_j(Q_j/L_j)^{bij}$

     (K = constant)
     bij: Elasticity of X_{ij} to Productivity

     $= \frac{d_{lg}\ X_{ij}}{d_{lg}\ (Q_j/L_j)}$

     $D_{it} = \sum_{j=1}^{n} (X_{ij})_t\ e(b_{ij}r_{pj}+Y_{Lj})^t$

     D_{it} = Demand Occupation i, time t
     bij = International data on Elasticity
     Y_{pj} = National data historical Trend productivity
     Y_{Lj} = Growth in numbers of workers trend

   - b. Distribute by Education levels & Programs
   - c. Aggregate Education Demand

3. Apply aggregate level ratios as checks, e.g.,
   - a. Participation rates
   - b. Demographic rates

II. DISAGGREGATED (PIECEMEAL) REQUIREMENTS (TO SUPPLEMENT AGGREGATE FORECASTS)

1. Service Sector/Govt
   - A. Population based service norms/ratios
     - a) Education (link to supply)
       - i) Social Policy (coverage, demographic)
       - ii) Education policy
         Program staffing,
         e.g. t/p ratios
     - b) Health Services
       - i) Coverage needs, demand
       - ii) Delivery systems/norms/ staffing i.e. Beds/Doctors/ Nurses/Parameds
     - c) Other Government Services
       - i) Defense (numbers, organization, manning tables
       - ii) Police, fire sanitation (state, municipal)

2. Core Industry Arrays
   Input/Output, Foreward/Backward Linkages
   - a) Scale/Technology/manning tables (present and future)
   - b) Establishment surveys
     Employment (Present & Future Estimates
     Wages and Salaries)
     X occupation, given market share, prices, scale, technology

3. Small INdustries and Pvt. Services
   Linked to other industries & service needs
   Linked to population served ratios & technology
   Linked to income & effective market

4. Agriculture
   Crops/Acreage
   Land Tenure Patterns
   Cultivation Patterns
   Export, world Demand, Exp. Policies, prices
   Domestic, Numbers, Diet, Income

5. Fill details in cells and check with Aggregates from I. Final iteration deficit Phase I

   Demand - Base stock + wastage - supply
   = Deficit
   Interaction in subsequent ieration phases

III. DEMAND/SUPPLY EFFECTS ON FORECASTS

1. General Government Goals/ Policies Anal.
   - A. Growth Rates economy
     - a) Investment, monetary, fiscal
     - b) Employment plans, policies
   - B. National Education: Demographic/Social targets
     - a) access
     - b) flow
     - c) output, programs/issues
   - C. Education Sector Policies
     - a) input norms
     - b) costs
     - c) resource constraints
       revenue policies/finance
       H.R. lags (e.g. trained staff)
     - d) Admissions/scholarship policies, subventions, systems & institutions
       - i) influence access & flow
       - II) influence incentives choices

2. Demand/Supply/Price interactions Econ.
   - A. Labor Market Information
     - a) job opportunity
       - i) openings, promotion
       - ii) earnings (wages, salaries)*
       - iii) Other returns (psychic)
     - b) Guidance Information
       Voc/Career choice
       Educ/Career choice
   - B. Rate of Return Studies*
     - a) Earnings profiles
     - b) Employment probability

3. Social/Cultural Interaction
   - a) National
   - b) Community
   - c) Family
   - d) Individual

*Effects on Demand & Supply Choices (Elasticities if possible) according to these three parameters. Behind the algebraic facade of the model lie black box methods used to relate growth in occupations to growth in productivity, and to relate occupations to levels of educational attainment. Varying occupational structures could have produced the same productivity patterns, and varying educational attainments could be matched to the occupations.

The other columns of Schema 1 list information which must be incorporated into a manpower analysis to give it substance. This may include rate-of-return analysis which in simplest form estimates the net benefits of levels of educational attainment by subtracting direct and indirect costs from earnings differences between workers with successive levels of educational attainment. An interest rate is then applied to discount this to present value, or an internal rate is computed by comparing two net benefits levels. The basic methodology has not been improved much, but results have been made somewhat more valid and useful for planners by disaggregated analysis which computes different rates for different groups, for example, males and females, or for workers in modern sector jobs of primary labor markets as contrasted to workers in secondary labor segments. Analysis by Schiefelbein in the Dominican Republic in 1974[1] indicated that these returns are very different by region, and by sex, and an averaging across such classes gives a meaningless result in economic and social terms.

In the actual practice of manpower requirements forecasting, the use of aggregated models is only a first step to provide a framework for more detailed analysis. The final requirement estimates are refined by using an array of specific information on public and private sector industries.

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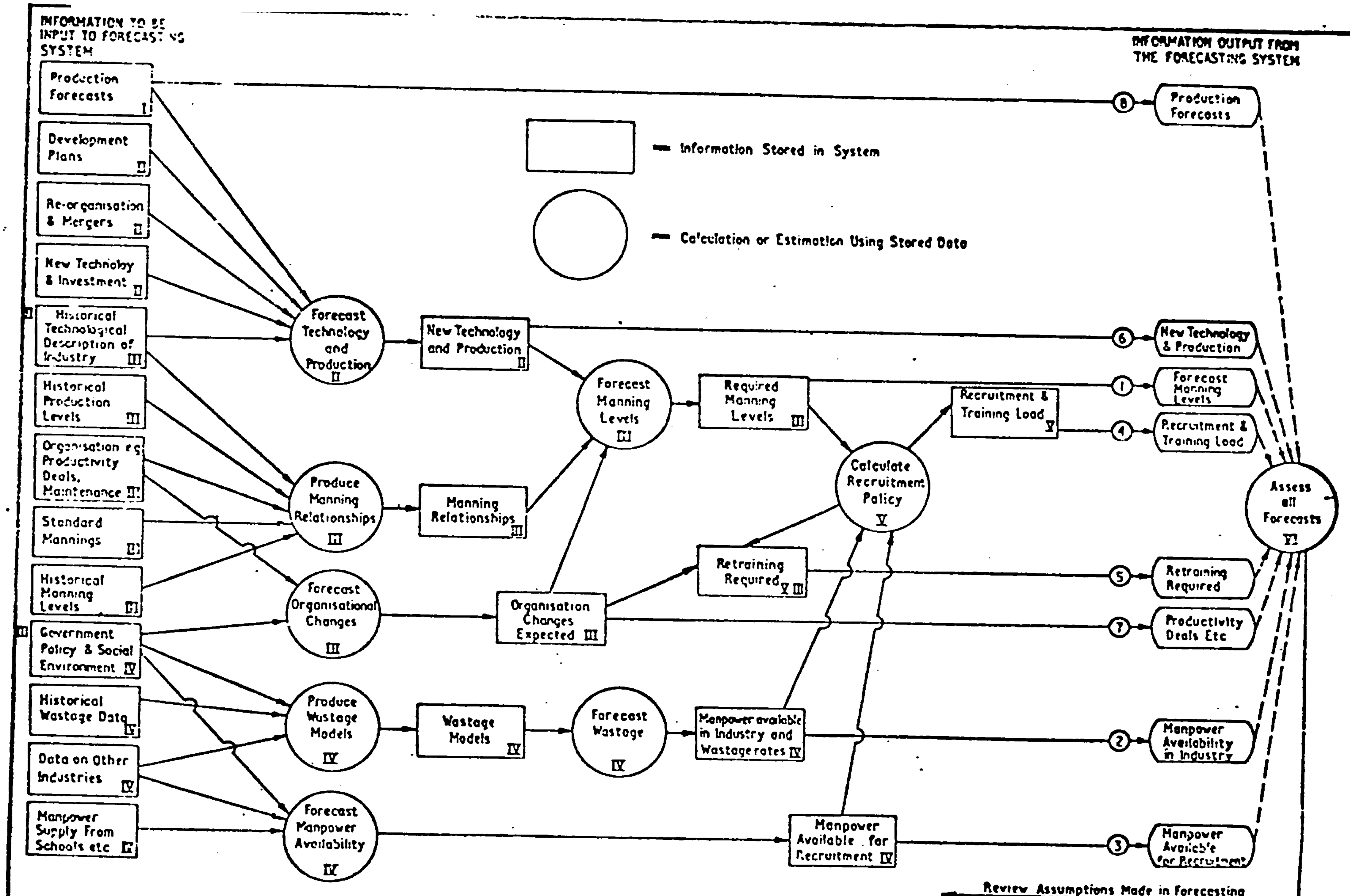
[1] Davis, R. "Dominican Republic Case", Paper 78, Harvard Graduate School of Education. Center for Studies in Education and Development.

5.2.1 Micro Level Manpower Requirements Forecasts

A partial listing of key information is shown in the second column of Schema 1. This information can serve micro level, or special sector, manpower planning. Manpower requirements planning also may be done at detailed level for a single key sector, e.g. agriculture or industry; a key sub-sector, e.g. irrigated agriculture or export crops; a single industry or resource, e.g. non ferrous metals or petroleum; a central government service, e.g. education or health. Manpower planning at less aggregated levels may require different information, formated and analyzed differently.

Piskor (1976) reviews the models and methods applied to manpower requirements forecasting and planning at national, regional/industry, and at corporate levels within large firms. In the analysis of manpower requirements within firms a variety of static flow models, dynamic flow models, and mathematical programming models, including goal program models,Charnes (1968) and Price (1974), have been applied. The strength of the analysis depends more on the adequacy of a comprehensive and current management information system than on any model form. Piskor (1976) shows a schematic developed by Purkiss for manpower planning at the corporate level. The Purkiss "model", shown in Schema 2, should suggest the complexity of the variables and their relationships and the necessity of having an extraordinary source of quality management data.

Despite criticisms, the models applied at the level of the national economy are necessary for providing totals to check individual sectoral or industry forecasts. Information for the micro level analysis may come from "establishment surveys" which provide estimated future requirements for workers in specific industries. Detailed estimates by occupations may be derived from manning tables based on engineering or



Schema 2: **Purkiss Model of Manpower Planning**
Source: Purkiss, C.J., "Models for Examining and Optimising Manpower Deployment; International Research Systems, Ltd. (Surrey, UK)

technological requirements; other estimates may be based on the ratio of specialist to the client population to be served; from service or plan norms in the health service, or teacher-pupil ratios in education.

5.2.2 Improving General Forecasts of Manpower Requirements

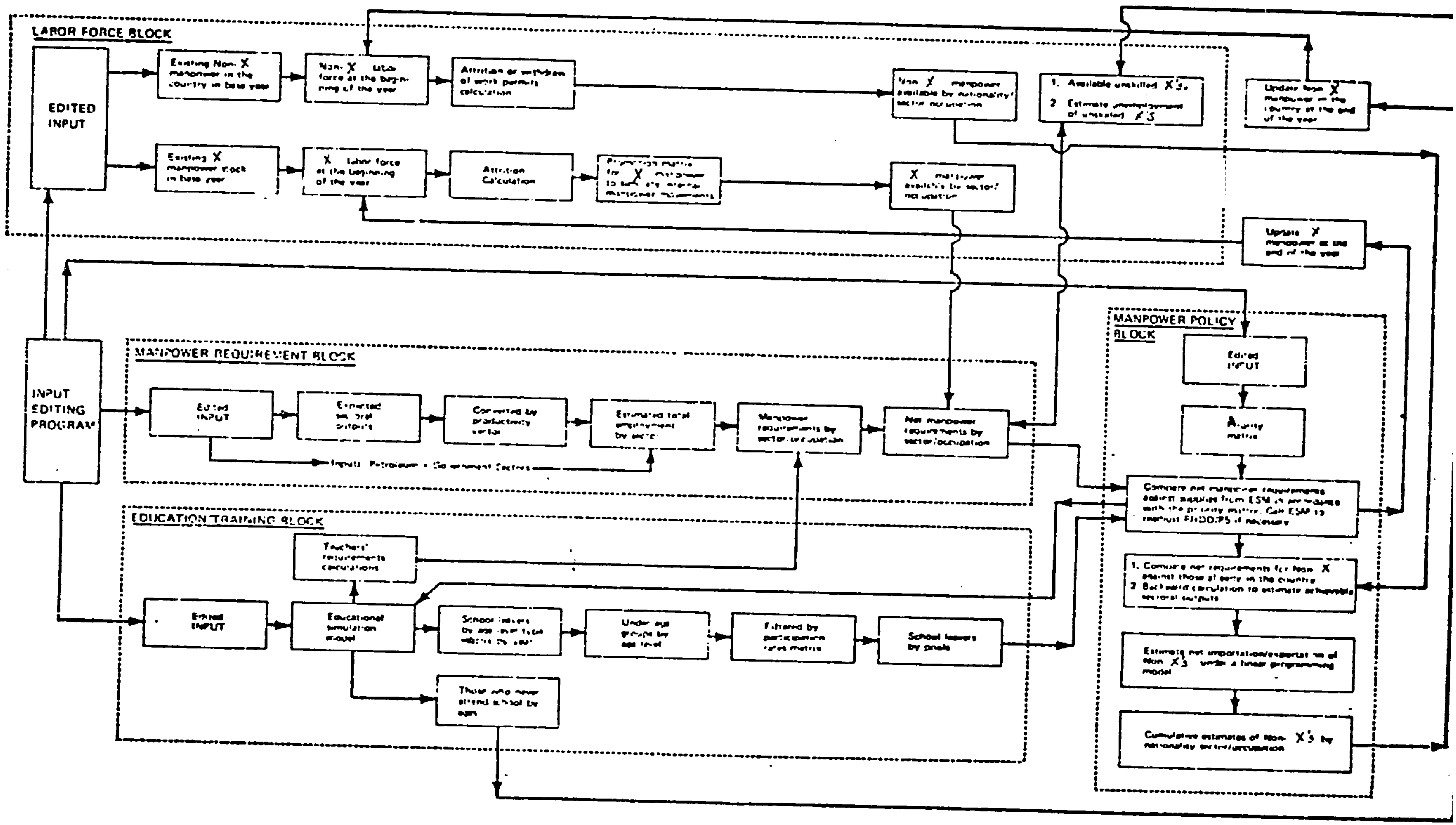
Manpower requirements forecasts can be improved by incorporating cost-benefits analysis into segments of the procedure, and by accounting for the effects of wage changes in the labor market on supply and demand. Freeman (1975) offers a set of analytic schemas for translating price changes in the labor market into elasticity coefficients to modify demand and supply forecasts in manpower requirements analysis and planning. Freeman also suggests incorporating a richer store of policy control information of the type sketched out in column three of Schema 1. In practice planners have always incorporated available information on government monetary and fiscal policies, educational sector policies and programs which affect supply, e.g. guidance programs, admission and scholarship policies; also included are labor market survey data on access to employment, promotion, earnings and other incentives. Systematizing data for comprehensive analysis has been difficult because of the lack of general models to structure the information.

5.2.3 Compound Models

The Compound Model developed by the World Bank for Saudi Arabia as schematized in Figure 4, is a comprehensive manpower requirements and educational planning model, with blocks that deal with current work force stocks, manpower requirements forecasts, and forecasts of educational and training supply. The requirements and forecasted supply, plus foreign labor imported, are compared, and the model has a block which allocates

Figure 4

MANPOWER PLANNINNG STUDY (II)
SKELETON OF THE COMPOUND MODEL



higher level manpower according to projected requirements. The manpower requirements forecasts are of the conventional kind, and the model does not encompass all the policy and program information which Schema 1 outlines.

5.2.4 Summary Comment on Manpower Models

The state-of-practice in the development and application of models for educational planning in accord with manpower requirements is that there are a few useful, albeit rudimentary models of the type shown in Schema 1. Forecasts based on general models must be supplemented by incorporating additional specific and general information, and sometimes by applying analysis to take into account price effects on labor markets and cost-benefits comparisons of alternative programs for meeting the requirements forecast.

5.3.0 Models for Tracing Systems Flow and Supply Forecasting

Planners, borrowing from state-space models, markovian process models and control theory models, have evolved a useful set of models for forecasting flows through an education and training system, and for estimating educational "supply" for comparison with the manpower requirements called educational "demand" forecasts. The instructional manuals in this set of materials describe the models and the computer programs for using them.[1]

In simplest form the methodology is similar to cohort survival methods used in demographic projections. An entering cohort of students is survived through the various levels of the system by multiplying the entrant numbers (which is usually the result of a demographic projection of children attaining school entrance age), by a survival or promotion

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[1] Paper 37, Davis, R. "Enrollment Projections in Educational Planning" Harvard Graduate School of Education, Center for Studies in Education and Development.

ratio which yields the numbers at the next level of the system in the next period. In graded school systems, flow through the levels is determined by three rates: promotion, repetition, and drop-out or desertion from the system. When arrayed into a markovian transitional matrix, the rates pre-multiply a vector of enrollments by levels, with new entrants added in, and the result is an estimate of enrollment for the following year. As in cohort survival methods the process is iterative year-by-year to whatever plan target date set.

The markovian model, or format, has not been improved basically over the version which appears in Schiefelbein and Davis (1974) and earlier versions in Blot (1965). The flow model may be incorporated into a more comprehensive planning model or as a part of a manpower requirements forecast. A flow model is a component of both the Schiefelbein and the Compound Model. UNESCO has a computerized flow model called ESM. World Bank,and the General Electric Demos models developed for USAID, have versions of the same basic flow models. The accuracy of flow model forecasts depends on the basic demographic forecasts of entrants and on the parameter estimates or rates that govern flow. In most developing countries repetition rates have been badly underestimated. Schiefelbein has attempted to improve the estimates by simulating flows and checking the results against expected age group distributions.[1]

5.4.0 Allocations Models in Mathematical Programming Form

One standard form of an allocation model, Hopkins (1971), Schiefelbein/ Davis (1974), consists of: (a) A column vector of resources available for the educational process being planned, e.g. teachers of various categories, classroom and laboratory space, supplies... (these resource estimates, usually derived exogenously through analysis of the educational process, cannot be exceeded in the model, and the column is called

[1] See "Dominican Republic Case", Paper 78 , Harvard Graduate School of Education Center for Studies in Education and Development.

a vector of resource constraints); (b) a matrix of technological coefficients reflecting the unit amount of resources required for giving a unit amount of education, e.g. a year of education at a specified level; (c) a set of initial enrollments in various educational program types and levels. These are activity variables which can take on various values as the model is run. A set of feasible solutions, e.g. enrollments served, is produced within the resource constraints. (See Paper 30, Appendix A)

In the form described, the model is cast in a linear programming activity analysis format, and the repertoire of mathematical programming techniques are available to elaborate and improve on the model by setting an objective function in linear or quadratic form and optimizing among the set of feasible solutions, by casting the model into dynamic form, or by carrying out sensitivity analysis in which parameter values are varied and the results are studied as in a simulation of a real system. In the United States, Hopkins (1971) offers one of the simplest explanations of the the model as applied to allocation of resources in university planning. Weathersby and associates (1967) have developed and applied the model in university planning. Other applications of programming models have been reviewed by McNamara (1971). Bowles (1969) and Schiefelbein/ Davis (1974), among others, used the activity analysis format for allocating within a more comprehensive model designed for developing countries.

5.4.1 Optimizing in Allocations Models,and Goal Programming Possibilities

One major limitation has been that optimizing models are often set up as though the planner had a single goal or objective which could unambiguously be expressed in an objective function. (This is an expression which links an objective through an activity outcome to a performance criterion). In planning, generally, and educational planning specifically, this is not the case, and many educators would not accept a single objective of minimizing costs in the system over time, as in the Schiefelbeing/Davis model (1974).

Goal programming, which is a satisficing format rather than an optimizing one, offers more flexibility, in that the planner can establish priorities among several objectives and satisfy them to varying degrees within the same model. Goal programming also offers the simplex algorithm just as other forms of mathematical programming. Quantitatively expressed objectives for over and under achievement of prioritized goals can be assessed in a single run of a model.

Fuller discussion of goal programming belongs in the section on organizational models for decision making. Here we note in passing that goal programming has been used in allocations modeling. S. Lee (1972) applied goal programming to resource allocation in education, and C. Lee (1974) used illustrative data from two recent planning exercises in Korea to study the possible usefulness of goal programming models in the allocation of resources under different input policy options.

5.5.0 Instructional and Learning Models

There have been few major developments in instructional and learning models which have influenced practice profoundly in the years since Schiefelbein and Davis (1974) reviewed this work. There have been interesting attempts to model learning mathematically.

5.5.1 Mathematical Models of Learning

Development of stochastic or statistical models of learning, initiated by Bush and Mosteller (1955), and pushed forward by Atkinson (1964, 1965) still seems confined to studies of the molecular aspects of simplified learning tasks, which do not interest most researchers who work with planners and policy analysts in the full complexity of the school situation. More recent developments in mathematical modeling by Suppes (1968) and Offir (1971) attempt to deal with more heterogeneity or range in the response set than learning measured by all or none performance, more complexity in the stimulus set and more variability among subjects; although Laubsch (1969) indicates that coping with many varying parameters leads to intractability. The newer models are still highly simplified analogies of real world learning but a bit closer to instructional reality than more classic learning models.

There is still a big jump from learning models to the kinds of questions planners and policy makers are required to answer; but the problem may be that planners and policy makers are incapable of translating administrators' questions into meaningful terms for those who analyze learning.

5.5.2 Models of Instructional Outcomes

Some "instructional models" do attempt to link instruction to policy planning. Restle (1964) made an early and interesting attempt to apply structured learning models (probability of learning within a certain number of trials) to analysis of questions posed at the level of policy and decision making, e.g. determining optimal class size (the age-old question) on the basis of minimal costs, and determining optimal rates for introducing instructional materials. Schiefelbein and Davis (1974) made an attempt to link the Carroll (1963) model for "instructional efficiency" into a comprehensive systems planning model for Chile.

The Carroll model provides a quality of instruction and learning index number which is basically the ratio of the time-spent on a learning task to the time-needed to master it. Time needed is a function of the general intelligence, and specific task aptitude of the learner, and the clarity of instruction. The index, however, only fits instructional situations where there is a straightforward task,as in learning the sounds of a foreign language,and a highly precise criterion measure which can be expressed in units of time required to attain a given level of mastery. The index was used in the Schiefelbein planning model but in a form of the model that was never fully implemented in planning practice. This line of activity does not seem to have advanced much either in theory or practice since that time.

5.6.0 Models for Administration and Organizational Analysis

Under this heading many lines of model development, most of them heuristic, could be grouped, including decision models. One line of development is through organizational charts and graphics and yields the conventional kind of static models of organizational line and staff, a form much beloved by bureaucrats and early O&M experts. One form of the model is the classic illustration of the black box.

5.6.1 Modeling Educational Systems Structures

A parallel development of graphics is used to show systems structures,as in the education systems charts which almost inevitably preceed descriptions of school systems in the early work of UNESCO. The systems sketch,[1] showing levels and kinds of education in training programs and the legal age for each level, is of considerable use in the first step of a systems analysis and planning project, but if left in the usual idealized state it can be useless or even harmful to the practice of planning. The system sketches can be made dynamic by adding arrows and lines to reflect relationships among components of the system; but no system actually functions as the charts suggest.

[1]See "Exhibits" in Davis, R. "Enrollment Projections in Educational Planning." Paper 37

Planners must modify the idealized sketch by analyzing how a system actually functions. In the Guatemala educational sector assessment sponsored by AID, even a quick investigation of the system revealed that there were a half dozen different systems of primary level education functioning with different curricula, different patterns of supervision, administered under different auspices, supported differently and with vastly different unit costs. The simple description of primary level education in the Ministry of Education systems graph might tend to confuse (cf. paper on morphological mapping)

Starbuck (1965) has shown that formal mathematics can be applied to modeling organizational relationships, if certain simplifying assumptions about hierarchy can be made; but there has been little application of such analysis in planning.

5.6.2 Scheduling

A well developed set of techniques, if not models, can help the planner in systematic scheduling with graphics, PERT, Critical Paths, systems graphing. These methods are discussed and explained in the instructional unit which is part of this series of papers.[2]

5.6.3 Modeling the Decision Process

A third line of activity begins with the highly rationalized but verbalized formulations of organizational characteristics and administrative behavior, Barnard (1938), is reflected in more general social systems theory of Parsons (1956), and becomes more formalized around decision making as in Simon (1959) where specified functional relationships among variables are modeled. One part of this line goes toward abstract models that are founded on decision theory, decision under risk, decision under uncertainty and game theory. Examples are the work of Wald (1950), Churchman (1957), Chernoff and Moses (1959), and Luce and

[1] DeHasse, Jean and Thomas Welsh, "Morphological Mapping," Paper 22.
[2] Lewis, G. "Scheduling", Paper 63, Harvard Graduate School of Education, Center for Studies in Education and Development.

Raiffa (1957).

The structuring of organizational decisions in game and decision format and the casting of strategies in minimax loss, maximin utility and minimax risk forms yields a simplification of most decision making in the real world, although the decision tree analysis of Raiffa is useful. Decision models depart from social policy and planning situations in several important ways:

a. Systematic decision models do not deal with goals as administrators deal with them. Usually the number and complexity of goals must be cut down to frame the problem, and getting an objective function expression that is tractable often leads to simplistic measures of utility which are difficult to measure and relate to the real world form of goal statements. (Klitgaard, 1973)

b. Just as there may be too many goals, the analysis may yield too many alternatives to handle, and so the analyst has to combine different possibilities to yield limited numbers of alternatives. Though there are ways of ranking and ranging these, so that one set dominates another, the alternatives may either get too large in number or too aggregated and simplified to be related usefully to policies and actions. Bold planners like Constantine Doxiades may begin with eleven million alternatives in launching the planning of the future of Detroit, and boil these down to a manageable few hundred options, but most planners get baffled by such numbers.

c. There are rarely pure states of nature in the social policy situation, and consequences interact with decisions and choices of alternatives.

d. It is difficult to get decision rules articulated, sometimes because they are difficult to express, and sometimes because decision makers are unwilling or unable to express them.

5.6.4 Bounded Rationality and Transactional Analysis

The limitations on organizational analysis and decision models force analysts and planners along two practical lines of activity. One is to face the limitations of systematic models in reflecting human behavior in organizational decision making. The concept of bounded rationality in organizational decisions has been developed by March and Simon (1959); and Lindbloom (1965). Warwick, in a paper in this collection, studies the transactional context of organizations where rational planning is limited.[1] McGinn and Warwick in their paper,prepared as part of this set of materials, analyze the organization of educational planning in El Salvador.[2] Their methodology goes beyond formal models and assumptions of rationality to analyze the social context and human interactions which determine decisions. This transactional context often can best be presented in the form of case document. Rather than to attempt to portray the full richness and complexity of the organizational decision context with symbols and equations and graphics, the transactional context is described in full in a case study, and the process is analyzed to get at underlying influences on the social dynamics of decisions. This is not an alternative of despair, but simply a recognition of the limits of systems models and analytic techniques applied to the complexity of human motivations and behavior. The transactional approach attempts to avoid black box modeling of the social process of decision making.

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[1] Warwick, D. "Integrating Planning and Implementation: A Transactional Approach," Development Discussion Paper No. 63, HIID, June 1979.

[2] McGinn, Noel and D. Warwick, "The Evolution of Educational Planning in El Salvador: A Case Study," Development Discussion Paper No. 71, HIID, June 1979.

Dunn (1971) critiques the limitations of rational models and suggests that an evolutionary model from biology is more suited to the analysis of the development of human social institutions. There is increasing use of case and documentary studies applied to the analysis of the transactional context of planning, policy formulation and decision making in education and technical assistance in the developing countries. McGinn and Schiefelbein (1975) in a series of cases, study the relationship of planning to educational reform at the national level in Chile; Hudson (1976) uses cases to assess the social outreach of organizations in developing countries; Coombs and Ahmed (1974) develop case studies of non formal education and training; and Jamison, Klees and Wells (1975) study the costing and planning of instructional technology projects with project cases.

5.7.0 Satisficing through Goal Programming Models

The application of goal programming to allocations has been mentioned, but at the cost of some repetition it is worth including more on goal programming models in the context of organizational decision making. Charnes and Cooper (1961) laid the foundation for goal programming approaches and followed with subsequent applications (1968). Ijiri (1965) and S. Lee (1972) advanced the theory, method, and applications. A readable work which extended the possibilities and applications was provided by Ignizio (1976).

Lee (1972) describes goal programming as a mathematical model in which "the optimum attainment of goals is achieved within the given decision environment". The features are: multiple objectives may be incorporated into the model; the objective function may have non-homogeneous units of measure instead of a single, and often ersatz measure, expressed in utility or cost; goals can be ordered in a hierarchy of importance so that lower order goals are only considered after higher order ones are attained; and deviations between goals and what can be attained within "constraints" are minimized so as to come as close as possible to attaining the goals. The goal programming model minimizes over or under achievement of goals according to a statement of prioritized objectives. Hence the model loops back to earlier decision modeling of Simon, where the decision maker sought to satisfice rather than optimize. The model requires analysts to identify goals and express them operationally, to rank them pre-emptively (in terms of deviations to be minimized), and to assign weights between priorities at the same level of importance. In practice it forces planners into a more realistic dialogue with decision makers before a model is set up or run. It also helps planners and decision makers to spell out more goals, establish priorities among them, and derive a more realistic and satisfactory set of possible results. In reality, plans are almost always only partially fulfilled, and a model which drives toward an optimal is not wholly realistic.

Goal programming has not had many applications in planning in developing countries. C. Lee's study (1974) marks a pioneering effort to illustrate the possibilities with the data and plans of a developing country. The models can be applied to allocation of resource inputs in education as in S. Lee (1974), or academic management as in Geoffrion (1972), or in allocation of manpower as in Charnes (1968) and Price (1974). The major future application is in general improvement of policy analysis in support of planning. It is not limited, as C Lee (1974) suggests, to linear applications, for Ignizio has developed goal programming as a more general form of linear and non-linear programming (and dynamic and integer programming) in which multiple rather than single goals are programmed.

Goal programming can offer heuristic advantage by modeling decision structures within a more realistic policy context. The models are also backed by algorithms with which analysts can test out options for partial attainments of sets of multiple social goals. Though the model will not produce solutions to guide planners and decision makers to unique and pre-determined and infallible decisions, it will vastly clarify goals, technological relations, and resource possibilities within the operating context of a complex social system.

6.0 An End Note on Heuristic Modeling

It might be argued that heuristics is just an "easy way out" -- a way of dispensing with the rigor of more systematic, algorithmic models, and a way of avoiding political commitments to clearly specified targets. Heuristic modeling is useful where basic disagreement exists on the facts, causal relations, or values involved in planning decisions, so that analysis must be opened up to a greater degree of "informed judgment" based on techniques like Delphi, simulation, and dialectical scanning. Heuristics may be useful in planning to help clarify assumptions, enable planners to go beyond black box analysis to examine processes in education, and to understand, though not predict or control, broad forces which may affect the future.[1]

Heuristic approaches are especially useful in planning for long-range futures, which can easily be mis-represented by rigid models of projection from past trends: structural relationships change over time as social institutions evolve and adapt; inter-relationships are extremely complex, major events are disjointed, in contrast to the continuity of trends expressed in most mathematical models; and most important, the future is malleable -- a function of social commitment, and not just the outcome of

[1] Davis, R. "With a View to the Future: Tracing Broad Trends and Planning," Development Discussion Paper No. 61, HIID, June 1979.

forces empirically measured in the present and past, Dunn (1974).

Heuristic modeling serves mainly for assessing the broader social, political, economic and technological trends shaped by historical processes which are not easily portrayed in mathematical expression. The techniques for long-range scenario building have been evolving quite rapidly in recent years, becoming quite sophisticated and rigorous in terms of procedures. Two chapters in the OECD book (1973) are representative. In one, Froomkin describes four "heuristics" of long range planning, apart from the more traditional analysis of trend extrapolation: (a) "genius forecasting," (b) "scenario construction," (c) mathematical simulation, and (d) consensus planning (primarily Delphi). Another chapter in the OECD book is by Willis Harmon et al., titled "The Forecasting of Alternative Future Histories: Methods, Results and Educational Policy Implications." This work focuses on needs, values, and beliefs as the generators of alternative futures.

Typically the heuristic approach does not aim at a single prediction: it describes <u>alternative</u> futures, Henderson (1978), and the broad forces moving society toward one or the other alternative future possibilities. The intervention possibilities that are available to policy makers are shown in <u>lineament</u> (see Paper 7 in this set). In recent work, education is not seen as a leading sector or point of intervention for controlling the future. Instead, education is seen in the role of responding to conditions generated by "larger" social economic and political forces. This represents a change, or in some sense a disillusionment, with the thinking of the sixties, which often depicted educational investment as a major force in economic growth and social change, Denison (1962); Robinson and Vaizey, eds. (1966).

This brings home, once again, a point made earlier, that educational planning is closely tied in with prevailing theories of socio-economic processes in the larger context of development. This does not mean that strong links have been forged between educational planning and national development plans, or between planning and research on educational effectiveness. But it does mean that new models underlying educational planning seem to evolve in a way that is fairly responsive to general shifts in the conventional wisdom about the role of education in economic growth and social change, Cohen and Garet (1975). The seventies have learned at least something from the failures of the First Development Decade of the sixties: social goals are not fulfilled by economic processes alone; and economic growth does not follow mechanically from educational investments in the way depicted by planners a decade ago.

Newer approaches to modeling, in addressing alternative futures, raise the issue of what it would take, especially on a political level, to bring about the more preferred scenarios. Formal systems models focused on inputs and outputs and black boxed the process itself. Past relationships among variables were analyzed to provide precise estimates that were then extrapolated into the future, and the spurious precision sometimes suggested that the planner could foresee the future and deal with it through specific courses of action. In our view planning is both less omniscient and less omnipotent, but worth the effort if it provides only a glimpse of the future and improved understanding of the present.

Heuristic modeling, on the other hand, moves toward analysis of the process of change and less precise portrayal of the future. In part this reflects a sense of failure in past planning efforts, a realization that the old models not only did not solve the problems of the world, they did not always protray these problems in a way that made them easier to analyze and solve. There are a number of possible responses to this charge. The models were rarely ever used to shape plans and policies. In part this is a criticism of the models, and in part it is a criticism of the limitations of policy and decision makers; but mostly it is evidence of the complexity of the world and its problems. If a few decades of work on rational modeling did not make the world a happier and more prosperous place, neither did several thousand years of unplanned activity, before the advent of models, make for a pleasant world; but the search for improved forms for modeling the social process must still go on, if for no other reason than for want of an alternative.

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