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ABSTRACT

The technical, social, and procedural phenomena that facilitate the effective utilization of analytic models in decision-making are examined. Attention is focused on the theoretical issues associated with: (1) selection and fit of the model to the needs of the decision setting; (2) human factors such as cognitive style and the political climate surrounding the decision participants; and (3) the role of the model on the decision process. Theoretical concepts are illustrated by examples from three applications of a single health science curriculum cost construction model. A central thesis is that models must be adapted to the conditions of the decision setting and the characteristics of the problem to ensure utilization. Model technology must be appropriate to the decision, feasible in terms of practicalities, and of demonstrated validity. Issues relating to individual attitudes and organizational norms are best addressed through building the client/consultant relationship and through the careful early diagnosis of the setting. Since a model can assume a variety of roles in the decision process, client/consultant expectations must be clarified on the stage at which the model will be used, how it will be used, and by whom. The development in the late 1970s of a curriculum cost construction model is described. It was developed by consultants for the University of Michigan School of Pharmacy, and then university staff developed similar models for the School of Nursing and the Program in Physical Therapy. Attention is directed to factors in the utilization of mathematical models and model characteristics required by various decision types. (Author/SW)

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EFFECTIVE USE OF MODELS IN THE DECISION PROCESS: THEORY GROUNDED IN THREE CASE STUDIES

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This paper was presented at the Twenty-Second Annual Forum of the Association for Institutional Research held at the Denver Hilton Hotel in Denver, Colorado, May 16-19, 1982. This paper was reviewed by the AIR Forum Publications Committee and was judged to be of high quality and of interest to others concerned with the research of higher education. It has therefore been selected to be included in the ERIC Collection of Forum papers.

D. R. Coleman, Chairman
Forum Publication
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ABSTRACT

This paper examines the technical, social, and procedural phenomena that facilitate the effective utilization of models in decision making. The paper focuses on the theoretical issues associated with (1) selection and fit of the model to the needs of the decision setting, (2) human factors such as cognitive style and the political climate surrounding the decision participants, and (3) the role of the model in the decision process. Theoretical concepts are illustrated by examples from three applications of a single health science curriculum cost construction model.

A central thesis is that models must be adapted to the conditions of the decision setting and the characteristics of the problem to ensure utilization. Model technology must be appropriate to the decision, feasible in terms of practicalities, and of demonstrated validity. Issues relating to individual attitudes and organizational norms are best addressed through building the client/consultant relationship and through the careful early diagnosis of the setting. Since a model can assume a variety of roles in the decision process, client/consultant expectations must be clarified on the stage at which the model will be used, how it will be used, and by whom.

Mathematical models have gained wide acceptance in higher education administration over the past decade. These years have seen a shift in emphasis from the large, comprehensive models such as the Resource Requirements Prediction Model to flexible, modeling software and smaller, problem oriented models of the sort described by Hopkins and Massey in their recent book Planning Models for Colleges and Universities. The years have also seen a shift in interest from the technological structure and mathematical validity of models to factors which facilitate their utilization.

Instances of failed or ignored modeling efforts have been documented by Plourde (1976), Weathersby (1976), and Dresch (1975). Many administrators, while recognizing the hypothetical relevance of operations research techniques to higher education, resisted them out of concern that they might force quantification on unquantifiable issues or foster efficiency at the price of longer term effectiveness (Kirschling, 1976).

The linkage between the models and their utilization in a decision setting is complex. As a type of policy analysis typically performed by staff analysts who are not in the mainstream of decision making, mathematical models and simulations share many of the problems encountered by all institutional researchers in preparing data and analytic reports. However, there are also problems that relate specifically to the technical nature of this particular type of management tool.

This paper will explore the problems of facilitating the use of analytic models in decision making. Based on the authors' experience with a small, curriculum costing model in three different health science settings and on a review of relevant literature, the paper will develop a conceptual framework that can be used by model developers to analyze the surrounding conditions which will influence the effectiveness of their models in providing decison support. The focus of the framework is on utilization and factors that improve it, not on explicitly technical or mathematical questions. The intent is to propose and to illustrate a general agenda of questions for the internal staff consultant or institutional researcher to think about at the outset of a consulting relationship in which a small scale mathematical model is used. Examples of specific points under each agenda heading are based on the particular experiences of the authors and can be readily supplemented by the modeling experiences of others.

Curriculum Cost Model at the U of M

In the late 1970's the University of Michigan invited an external consultant to develop a curriculum cost construction model for the School of Pharmacy. The authors of this paper provided staff assistance to the consultant, and then were directly responsible for developing similar models for two other health science units, the School of Nursing and the Program in Physical Therapy. In each case, the conditions surrounding the initiation and development of the model influenced the shape of the final product and its use in the decision.

In the School of Pharmacy the dean and his faculty were interested in determining the cost implications of phasing out the undergraduate Bachelor of Science program while expanding the Doctor of Pharmacy program. Various combinations of curriculum and enrollment options were explored. Administrators in the School of Nursing wanted to deal with several major cost-related issues at once. These included: 1) decreasing the enrollment at the undergraduate level and increasing graduate enrollment; 2) changing the mix of faculty and related workload expectations by moving toward a greater proportion of research-oriented, Ph.D. trained faculty; 3) restructuring the undergraduate curriculum.

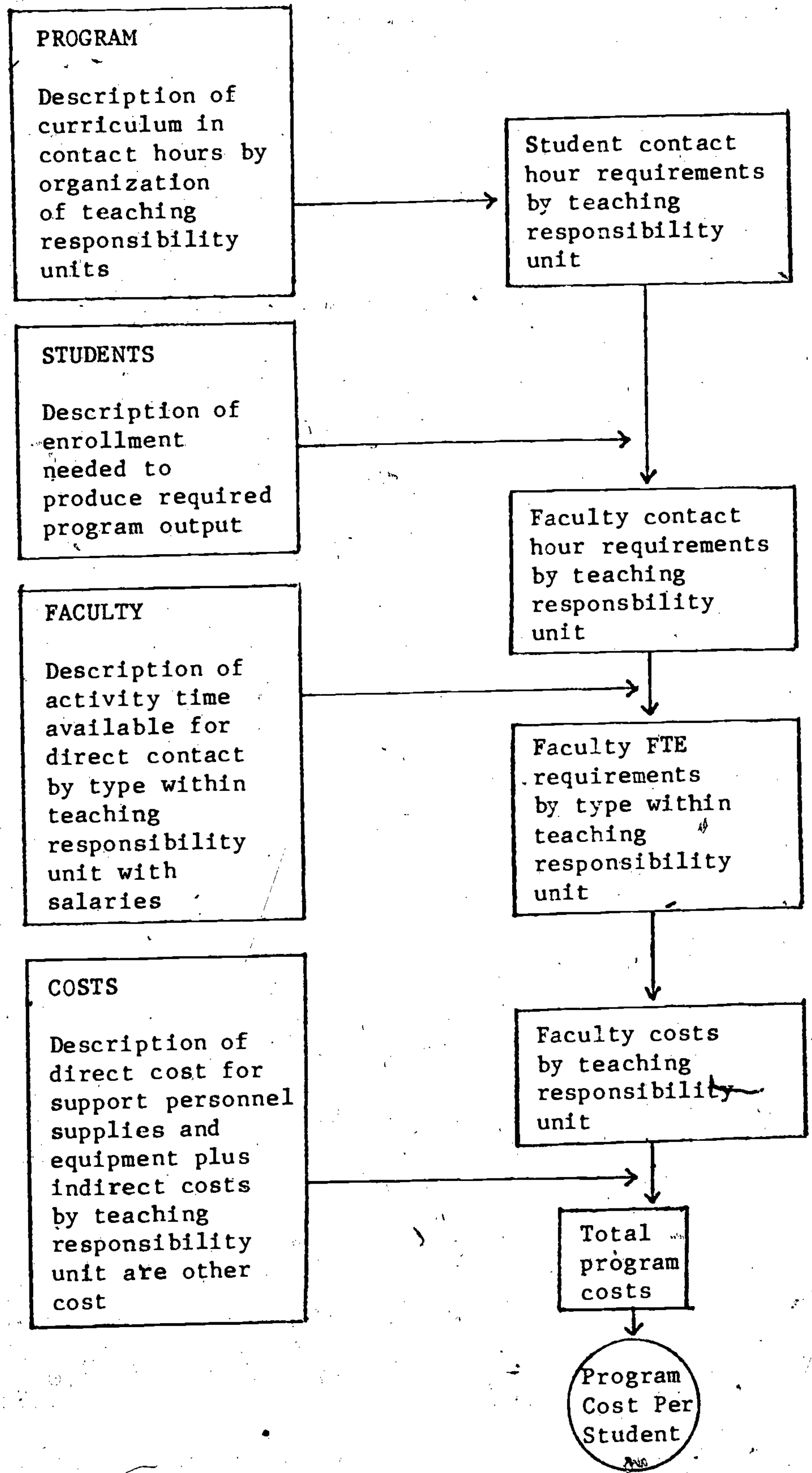
In the third case, the Physical Therapy Program was faced with an unsatisfactory budget arrangement and a sudden shift in the curriculum requirements imposed by the state licensing agency for physical therapists. The Program needed an estimate of the cost for instruction that was provided to physical therapy students by various Medical School departments and it needed to estimate the cost of several new courses required by the shift in expectations for licensing. The Pharmacy and Nursing modeling efforts were initiated by the mutual agreement of the Vice President for Academic Affairs and the respective deans. The Physical Therapy effort, on the other hand, was initiated at the request of the Medical School dean's office and the program's director. In all three cases technical assistance was provided by staff from the central office of institutional research.

The particular model used for these costing efforts comes out of the work of Gonyea, Harper, and others who have focused on the problems of describing health professions education programs in terms of resource requirements and cost. A more detailed discussion of some of these problems and suggested approaches for dealing with them can be found in Gonyea (1978). One of the approaches described there, is the program cost construction model which is designed to deal with the complex structure of health science programs.

The basic components of the model are illustrated in Figure 1 and can be summarized as follows: 1) a course by course desciption of the curriculum in terms of the required student contact hours, 2) conversion of student contact hours to required faculty contact hours based on given enrollment levels and section size constraints, 3) conversion of faculty contact hours to faculty FTE given workload assumptions, 4) estimation of faculty costs and total program costs, and 5) calculation of the program cost per student.

Some of the advantages of this model are its simplicity and

Figure 1. Program Cost Construction



From Gonyea (1978, p. 85)

flexibility. Programs can be described uniquely or aggregated to a general pattern, depending on need. The model can be used for predicting faculty staffing requirements, for estimating the impact of various enrollment levels on affected units, or for exploring new instructional modes, in addition to determining per-student curriculum costs. It can properly be described as a curriculum planning tool as well as a costing method.

Factors in the Utilization of Mathematical Models

Model developers know that the process of describing a problem in mathematical terms often results in a different perception of the problem. This, in turn, is reflected in alterations to ~~the~~ model. Model creation is therefore an interactive process in which the model is gradually adapted to fit the reality being described, just as the vision of reality shifts with new insights gained from the model

A central thesis of this paper is that models and model builders must respond to the conditions of the decision setting and the characteristics of the problem to ensure utilization. Adaptation is needed to accomodate technological constraints, the needs and norms of the people who receive the model, and the demands of the decision process for which the model is developed. In these three areas - technology, human factors, and decision process role - there is a mutual impact between the model and its setting.

Model Technology

In determining the technology of a model the objective is to achieve an appropriate fit to the constraints of the setting in which the model is being used. Models are flexible tools, whose structure can be controlled and adapted by the model builder in several ways. The consultant must ask several questions.

The first question is: will the model's output fit the information needs of the decision makers? The information needs of decision makers depend on the type of decision to be made. Keen and Scott Morton have suggested an analytic framework for categorizing decisions in their book, <u>Decision Support Systems</u> (1978, p. 79). Borrowing from Anthony (1965) and Simon (1960), these authors propose a two-dimensional matrix which divides problems by organizational level and by problem nature. The organizational level categories are strategic (i.e., fundamental goals and directions), management control (i.e., specific plans for realizing the goals), and operations (i.e., day to day execution of the plans). The problem nature categories are structured (i.e., problems in which the factors are separable, definable, and predictable), semi-structured (i.e., problems only partially definable) and unstructured (i.e., problems with interdependent factors where the governing rules are unclear, unknown, or dependent on the values of decision makers).

Table 1 presents the Keen-Scott Morton matrix with examples in each decision category drawn from the higher education context. The strategic/management control/operational categories are found at all levels of an organization. A strategic decision for one level may be a management decision for another. Thus, the strategic decision of a university to shrink in size becomes a management control decision when some colleges are favored and others cut, if seen from the perspective of the central administration. However, when the Literary College decides to discontinue Geography, it is a strategic decision for the College.

Problems at the strategic level are future oriented and broad in scope. They involve the values and judgment of the decision makers, usually the chief officers of the organizational unit. Problems at the operational level typically involve predefined activities requiring little judgment. These are usually handled by clerks or administrators.

Table 1

DECISION ANALYSIS FRAMEWORK WITH
EXAMPLES FROM HIGHER EDUCATION

Organization Level / Type of Decision	Strategic Planning	Management Control	Operational Control
Unstructured	Major Resource Reallocations	Faculty Promotion Decisions	Determining Graduation Requirements
Semi-Structured	Long Range Budget Planning	Curriculum Cost Projections for Alternative Curricula	Admissions Recruiting Strategies
Structured	Faculty Flow Analysis	Annual Resource Allocation Cycle	Schedules for Assigning Faculty to Classes

The information needs at these different levels vary in the degree of accuracy and detail that is required. The nature of the problems also varies; some problems yield more easily to modeling than others. How the level of control and the nature of a decision can impact on model characteristics such as accuracy, level of detail and scope of parameters is illustrated in Table 2. Since the boundaries between categories are in reality indistinct and often overlapping, the characteristics in Table 2 are intended to be generalizations.

The second question: is the model a valid representation of reality? Models typically consist of a set of parameters that remain constant and a set that change. The first represent the "givens" in a problem setting and the second the "variables," or factors to be examined. In the design stage, the model builder identifies the factors that seem fixed and those that are subject to changes in policy (or reality) and constructs the model accordingly. However, models must be adaptable to changes in the relationship between fixed and variable parameters, since fixed factors may later be recognized as subject to policy.

In a faculty flow model the percentage of tenured faculty who resign is often treated as a given, yet this parameter is subject to changes in policy and needs to remain flexible. While this example is obvious, the parameter in the curriculum cost model which relates the ratio of faculty salary to total overhead costs for a department or school is less so. The ratio depends on many exogenous factors and cannot be treated as a given although it often is.

The model's validity must be tested both for the accuracy of predictions under a set of assumptions, and also for the accuracy of assumptions about the nature of parameters. Testing the model's validity based on data with a known outcome allows both model builder and client to assess the

Table 2

MODEL CHARACTERISTICS REQUIRED BY
VARIOUS DECISION TYPES

Organization Level / Type of Decision	Strategic Planning	Management Control	Operational Control
Unstructured	Wide range of variables Aggregation high Low accuracy	decreases -------> decreases -------> increases ------->	Medium range of variables Aggregation medium Medium accuracy
Semi-Structured			
Structured	Medium accuracy Aggregation medium Medium range of variables	increases -------> decreases -------> decreases ------->	High accuracy Very detailed Narrow range of variables

model's parameters and to adjust them where necessary. Even when relationships seem obvious, models sometimes yield surprising results and it is necessary to determine whether these results reflect reality or some peculiarity in the model's structure.

The third question: is the model practically feasible in its data requirements, schedule, and method of operation? The availability and flexibility of computer systems and scheduling considerations will determine whether a model should be computerized or whether a quick pencil and paper product would be more useful. More important than the method of operation is the question of data. The model builder must be sure the chosen model does not require data that are either not available or not collectible within the timeframe. The difficulties in obtaining data for the large simulations like RRPM have been amply aired (Plourde 1976), but similar problems can complicate the use of small, problem centered models such as the faculty flow models using a Markov chain.

Three points have been listed in relation to model technology. The first is the level of detail and scope of the model's parameters in relation to the type of decision to be made. The second is the need to test the validity of the model's parameters against real data, both with respect to the numerical value used and with respect to its function as a fixed or changeable factor. The third is the mundane question of data collection and scheduling. Considerations in all three areas will influence the shape of the model which ultimately emerges.

Human Factors

The objective in developing a model is for the information produced to be used in a decision process. While the validity of the information depends on technical factors based in the model's structure, its utilization depends on the willingness of the participants to accept and consider it.

In most higher education settings where models are used, modeling is not the usual form of researching decisions. The model represents an innovation and intervention in a familiar and known pattern of making decisions. The model does not typically come into a setting where there is no information; it comes as a competitor into a setting where information already exists and routines are there to use it. Two kinds of problem may arise. The first has to do with the attitudes and behavior of the individual decision makers who are party to the decision. The second has to do with characteristics of the organizational group.

With respect to individuals, Ungson, Braunstein, and Hall (1981) have reviewed the considerable research which has been conducted on the role of cognitive style in the gathering and processing of management information. At the cutting edge the research is still too undefined to provide useful guidelines to the practitioner. Although there are varying conceptual approaches and definitions, two central factors appear to influence most of the measurement instruments that have been developed. These are the manner in which people gather information and the manner in which they process or interpret it (Bariff and Lusk, 1977, p. 822). McKenny and Keen (1974) propose a matrix along these two dimensions, defining the information gathering categories as "perceptive" and "receptive" and the processing categories as "systematic" and "intuitive." The resulting four cell matrix identifies distinct cognitive styles which are significant for the modeling consultant. The authors suggest that a systematic manager aims at a model with predictive power and carefully defined constraints while the intuitive manager tends to use models to understand problems better and is less concerned with margins of error and detail.

In the academic arena the consultant is confronted with a broad array of thinking styles that are rooted in disciplinary norms. Explaining a model to a nurse or an English professor is quite different from explaining one to an engineer or an economist. The consultant needs to be sensitive to these differences among his clients in order to adjust appropriately the presentation of the technique and results as well as the model design itself. While there is some disagreement in the literature regarding the degree to which the decision maker must understand a model before utilizing it (Massy, 1981; Schroeder, 1973; McKenney and Keen, 1974), it does appear that there must be a minimum level of understanding prior to acceptance. The consultant must therefore tailor presentations to bridge the gap between understanding the model and trusting in it on the part of the client.

A second consideration with respect to individuals that the consultant must address has to do with resistance. In their book about organizational change and innovation Zaltman, Duncan, and Holbek offer an extensive list of the many forms in which individual resistance is seen (1973, pp. 94-104). The resistance may derive from anxiety about understanding the model or from fear that the model will take away decision making power. It may also be based on the perception that, while interesting, the model is not relevant to the problems at hand. This attitude leads to perfunctory participation in the model development and can yield inaccuracies in the model's data and structure.

On the organizational level the decision making traditions or social climate may interfere with utilization of the information. Organizational groups have distinctive styles of decision making varying from the data oriented and systematic to the political, intuitive, or consultative. Introducing a model to a group of the first type is less difficult than to a group of the second type. Even the data using organization, however, may distrust the output of a model because the information is in an uncustomary form and no behavioral routines exist for making use of it. If the information produced by a model is to be used by a group, a process must exist through which the results can be reviewed, debated, and related to the decisions. The consultant may have to help the group design such a routine.

The social climate of a group may affect the manner in which models are used in that, like any information, the results of a modeling effort are subject to abuse. They can be taken to the political advantage of a faction, or discredited and ignored if key people do not endorse the effort. The model may uncover hitherto unknown or unrecognized inequities, or may require the negotiation of conflicting and politically charged data sources. The curriculum costing model, for example, requires both an average salary figure and a workload parameter. These are often sensitive issues on a campus.

How can the consultant avoid individual or group resistance and motivate the client's interest in the modeling effort? Careful attention to building the client/consultant relationship is recommended by Kolb and Frohman (1970) who describe an organizational development approach to technical consulting. Organizational development consulting typically addresses problems and methods of intervention in the personnel interactions of an organization (French, Bell, and Zawacki, 1978). Kolb and Frohman, for instance, stress the entry phases of the consulting relationship before model development begins. During these phases of scouting, diagnosis, and planning the consultant must sense how the people will react to the model and how the model will fit into decision routines, in addition to thinking about more technical issues. The consultant must also establish credentials and credibility, since these help build the client's trust in the utility of the model building exercise.

Other contributors to the organization development literature stress the importance of establishing a clear and explicit contract before actual work begins (Lippitt and Lippitt, 1978). The contract limits expectations and specifies roles and responsibilities in order to prevent later disagreements on who will gather the data, who will have access to it, and the like. The contract does not require a legal format, but it should be explicit and written.

The modeling consultant is typically an outsider to the client unit. This person may be associated with the central administration in a university or college, and as a result, may be perceived by the client as biased. It is important to be clear about the consultant's role, since abuse of this role is possible on both sides. As an outsider the consultant must anticipate a certain amount of slow progress during the period when the consultant and the client are developing a communication base and learning to understand each other's way of thinking.

To ensure that the results of a modeling effort are used, the consultant must pay attention to the human factors relating to individual attitudes and organization-level norms and climate. Guidelines on how to deal with these issues are found in the applied consulting literature of organization development. Key elements include building a relationship with the client and careful diagnosis of the setting during the entry phase.

Roles of the Model in the Decision Process

The purpose of using a model is to support the process of making decisions. This support can be rendered in a variety of ways. Hopkins and Massey (1981, p. 18) refer to line and staff roles for a model, paralleling the terminology used for types of delegation to employees. The line role delegates decision responsibility to the model. An example of such delegation is the German system of <u>Numerus Clausus</u>, which assigns entering students to disciplines and universities based on Grade Point Average scores in high schools. Strictly applied resource allocation models are another example of line delegation. In the staff role, responsibility for the decision remains with the decision maker and the model's function is to illuminate the options.

The range of possible roles for models is broader than the two just mentioned. Models can provide a neutral, common language for describing the activities of different organizational units. They can be used to lend credibility to decisions after the fact. They can also be used to educate by bringing important issues to the attention of a large constituency. At the University of Michigan a Revenue and Expenditure model and an Enrollment Projection model were used in 1978 to convince deans and faculty of the need to reallocate within the General Fund. Both models were simple and highly aggregated in order to show main trends and future possibilities.

Up until this point, the use of models has been referred to primarily in the context of a single problem and related decision. The decision environment, however, may be one of multi-problems and multi-decisions, all of which affect each other. The interrelation of various decision processes is sometimes ignored, particularly in decentralized settings. Another potential role for a model is to connect separate but related decision processes at different levels of the organization.

The role a model assumes depends in part on the point in the decision process where the model is used. Many frameworks have been developed to describe the phases of decision making. One useful one was developed by Mintzberg, Raisinghani, and Theoret (1976, p. 252) as a renaming of three phases identified earlier by Simon (1965, p. 54). Mintzberg calls his phases identification, development, and choice, and identifies several subroutines within each phase. For our purposes, the simple trichotomy is sufficient.

The University of Michigan example just cited illustrates a use of models in the problem identification phase. Before the central administration used the models publicly to raise the awareness of the university community, institutional research staff had used the same models internally to explore the extent of financial difficulty that the university was facing and to convince the budget officer to take action. A similar use of models is reported at Stanford and motivated Stanford administrators to undertake the Budget Adjustment Program. In the development phase models can be used to set out various alternative courses of action and to test their implications. Finally, in the choice phase of decision making, models can be used to set bounds for decisions, or even to make the decisions, as reported in Germany.

Thus modeling support in decision making can assume a variety of roles, depending on how the information produced is used. The role assumed is influenced in part by the phase at which the model enters the decision process. The contract between the consultant and the client group must deal with the expected role of the model in the decision process. In order to avoid confusion later, the various possibilities need to be openly discussed.

Adapting the Model to the Decision Setting: Case Examples

1. Model Technology

Fitting the basic cost construction model to the decision settings in Pharmacy, Nursing, and Physical Therapy resulted in three models which differed in parameter definitions, level of detail, and degree of precision. In both Pharmacy and Nursing, the decisions to be made were semi-structured management control decisions. The schools needed to determine what configuration of degree programs and enrollments were academically desirable and feasible. They also needed to explore the faculty resource requirements, given constraints on budget and curriculum. These same decisions had strategic implications for the central administration, since major revisions in curriculum and enrollment required additional resources to fund them. These resources had to fit with long range budget plans and priorities for the institution as a whole. The cost construction model was able to meet both kinds of information needs and facilitated the discussion across organizational levels.

Adjustment of the model to the decision began with the negotiation of parameter definitions. While "programs" were defined in the Pharmacy and Physical Therapy cases as "degree programs," this definition was expanded for Nursing to include a set of service courses offered by a research unit within the school. Differing definitions for the length of the academic year and for faculty FTE (e.g., 9-month versus 12-month FTEs) were also needed. All definitions were questioned in terms of their appropriateness to and consistency with the purpose of the model and its structure.

In general the Nursing model was the most complex and detailed of the three models, due in part to the number of degree programs within the School. Matching the level of detail to the decision setting resulted in a more aggregate approach in Pharmacy and a truncated approach in Physical Therapy where the primary interest was only in the direct instructional cost of the program and not in the overhead costs.

The relationship between fixed and variable parameters became important in adjusting the model to fit needs. For both Pharmacy and Physical Therapy the workload parameter was fixed after a reasonable figure had been derived from analysis of actual data. In Nursing, the workload parameter became a major policy variable. The School wanted to increase the research efforts of the faculty, but this implied decreasing the average instructional workload. Several alternatives were tested through the model. The policy implications of this were many including some that were unrelated to the model such as hiring and promotion practices, and some that were related directly to other model parameters such as average faculty salaries.

Fitting the model to the practicalities of data availability and time constraints did not pose any serious problems. The simplicity of the model structure meant that computerization was not necessary. The time required to develop the model in the three settings varied considerably, however. Physical Therapy required two months and Pharmacy required several weeks. Nursing, on the other hand, took almost a full year to complete because of the complexities of the issues and the need for extensive data gathering efforts involving several sources. The practicalities forced some compromises to be made along the way. For example, Nursing desired a greater level of detail about program structure than was feasible given existing data sources. It was necessary, therefore, to spend several hours with each program investigating, course by course, how much time was spent in each mode of instruction.

In all three cases the validity of the model was verified by describing the year just past and comparing the predicted faculty resource needs and total costs with the actual needs and expenditures. The process of verifying the model and exploring the discrepancies that emerged helped build the confidence of the faculty and the modeling consultants in the model's definitions and structure.

2. Human Factors

Cognitive style proved an important factor in the shape of model that was developed for Pharmacy and Nursing. The Pharmacy participants tended to take a perceptive/intuitive approach to the model. That is, they were concerned with looking at the broader relationships of the model components in order to get a better sense of the problem. Specifically, this meant a willingness to use a generalized graduate program description and to tolerate a certain margin of error because the focus was on the relationships of the data, not on the details.

In contrast to this, the Nursing participants tended to take a receptive/systematic approach which meant a focus on detail and a greater concern with accuracy. As a result, each of the seven graduate Nursing programs was described in a very structured and highly detailed manner. The role of the consultant in this setting was to shape the model to reflect the concerns about detail and accuracy and at the same time to help the Nursing faculty use the model as a tool for broadening their conceptualization of the problem.

The nature of the organizations being dealt with proved to be an important factor, especially in the case of the School of Nursing. When the authors began extensive data gathering efforts within the School, they encountered a highly charged political climate. The School was attempting to deal with several major issues at one time without a clear sense of overall direction. The result was that among the various factions and departments internal to the School, there was conflict over what the goals of the School ought to be in addition to a sense of competition for scarce school resources. It is not surprising that many of the departmental chairpersons initially viewed the model with suspicion. Fears of the model being used as a political tool rather than as an information tool were frequently expressed. The faculty also felt that the Vice President for Academic Affairs was intervening in an area of decision making that was not his domain. The fact that the modeling consultants came from the Vice President's office did not help.

The authors dealt with this by emphasizing three points in their contacts with the faculty. First of all, the neutrality of the model was stressed by making it clear that the model's only agenda was to reflect some alternative courses of action objectively and as accurately as possible. Second, the chairpersons were assured that their full approval was required for the final model description of their respective programs. Finally, the potential benefits of the model for planning purposes at the program level as well as at the school-wide level were emphasized. Central to building a level of trust was making sure that each of the participants fully understood the model and the basis for its main assumptions. This helped to reduce the concern of political abuse.

The above example illustrates that the role of the consultant must be much more than that of a technical expert. The consultant may have to assume the role of persuasive communicator, neutral negotiator, or insightful policy analyst. Activities in the beginning phases, such as scouting and diagnosis as well as model development itself, depend on the consultant's ability to ask the right questions and the client's ability to provide relevant information. Some of the graduate program descriptions in the Nursing case, for example, were revised two or three times before they reached their final form. Throughout the revision process, the politically charged atmosphere and a long term feeling that the School had been unfairly treated at budget time necessitated more than usual attention to fostering trust and to establishing the credibility of the modelers.

3. Role in the Decision Process

The utility and effectiveness of a model is very much dependent on whether it is developed as an integral part rather than external to specific decision processes. The effectiveness of the cost construction model used in the three University of Michigan cases lies in the fact that it was tied directly to one of the most basic and key decision processes that occurs within the University - that is, the budget request and allocation process. In terms of its role in the decision process, the model was intended to function in a staff capacity as part of the problem development phase rather than in a line capacity. The cost construction model was not developed to make decisions, but rather to enhance the judgment of the decision-makers (the Vice Prsident, the deans, program chairpersons) by exploring alternatives and expanding their understanding of the problems at hand.

In addition to helping the units explore alternative curriculum and enrollment strategies, the model provided a common language for negotiating internally and externally the allocation of resources. For both Pharmacy and Nursing, the negotiation process took place between the deans of the Schools and the Vice President for Academic Affairs. The model not only helped to frame the negotiating issues, but also provided "hard" evidence that the changes would require increased funding and estimated the magnitude of that increase. Both of the parties involved in the negotiation process understood the model well enough to be able to challenge and question some of its assumptions and to suggest further alternatives to be tested by the model. For example, in the Pharmacy negotiations, the Vice President questioned whether an increase in clinical hours in order to meet accreditation standards was more than what was required. Further analysis showed this to be true and the model was revised to reflect a smaller increase. This change resulted in a significant decrease in the resource requirements projected by the model. Because of the effort put into educating participants about the model and involving them in its development, the basic validity of the model was not called into question at any point during the negotiation process.

The potential for a model to be misused either deliberately or inadvertently always exists. The cost construction model began to be used within the School of Nursing to decide some very specific staff assignments in the undergraduate program. This was an inappropriate use of the model since its structure, components, and accuracy were not designed to replace judgment in these kinds of decisions. This incident suggests that once a model is implemented and accepted, it can easily take on a validity and life of its own beyond the original intentions. Obviously the consultant cannot prevent such misuses once the client has assumed full ownership of the model. Attempts to use the model in ways it won't support can be diverted during the model development stage through careful consultant/client discussions on the role of the model and its strengths and weaknesses for that role.

Finally, it should be noted that most decisions require more information than the model itself can provide. Supplying supplemental information may be an additional responsibility of the consultant, particularly if he/she is an institutional researcher. In the case studies described here, for example, model results were supplemented by tuition revenue projections for various enrollment alternatives and by an enrollment study which analyzed the feasibility of the proposed alternatives based on historical, demographic, and professional supply/demand trends. The kind of supplemental information required will, of course, depend on a number of factors including the nature of the decision, the nature of the model, and the unique information needs of the decision-maker.

Summary

Analytic models can be an integral and effective component of the decision support systems of college and university administrators. To facilitate their use, three areas of concern need to be addressed by those persons sharing the responsibility of introducing, developing, and implementing a model in a particular setting. The model's technological aspects must be appropriate to the decision, feasible in terms of practical considerations, and of demonstrated validity. More difficult to deal with in the modeling process are the various human factors. Issues which need to be considered there include the cognitive style of the individuals receiving the model results, the political climate and managerial decision-making traditions of the organization, and the role of the consultant. Of final concern is the role of the model in the decision process: at what stage it will be used, how it will be used, and by whom. It is only in viewing models in a broader technological, social, or procedural context that greater effective use can hope to be achieved.

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