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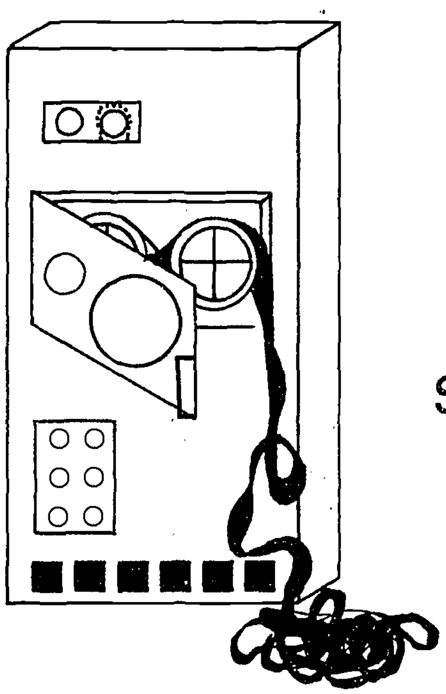
ABSTRACT

Higher education faces continuing cost pressures from a multitude of new demands. The consequence is a new emphasis upon resource allocation that is only possible if the required data about program costs, program outputs, and program income are readily available. The task of the new management in higher education is to gather the needed information for intelligent, persuasive resource allocation. This paper is a summary of a conference of cost simulation models, how to end the confusion surrounding them, and how to promote the need for serious long-range planning in higher education. The contents include definitions, case studies, problems, evaluation, and applications of cost simulation models. Presented are individual experiences with cost simulation models at Colorado University with CAMPUS: RRPM at Portland State University; PLANTRAN at the University of Denver; SEARCH at Eight Colleges; and Computerized Financial Planning at the University of Maine. The appendix includes the American Council on Education's program of studies to improve the resources for planning in postsecondary education. (Author/PG)

Society for College and University Planning
1973 Spring Conference 2



LET'S END THE CONFUSION ABOUT SIMULATION MODELS!

MANAGEMENT DIVISION
ACADEMY FOR EDUCATIONAL DEVELOPMENT

SEPTEMBER, 1973

The Society for College and University Planning held its "Spring Conference 2" on March 28-30, 1973, at the Mayflower Hotel in Washington, D.C. The theme was cost simulation models; the purpose: to end the confusion surrounding them and to promote the need for serious long-range planning in higher education.

Vice Chancellor of the City University of New York, and Mid-Atlantic representative of the Society, Frank J. Schultz introduced the conference with the following message:

> I am enthused that the Society has broadened its mission into comprehensive planning. Higher education has gone through change and it has changed dramatically. The danger is that it will change fundamentally without design or purpose.
>
> We can no longer be casual about our futures. With the constant acceleration of change in our society the future is upon us faster than ever before.
>
> The Society has accepted this challenge and the swelling ranks of its membership attest to the need. As a society, we are dealing with planning on at least two levels: (1) the processes and techniques of planning (that is, the art and science of planning), and (2) the major issues confronting higher education today and in the future. This particular conference, of course, deals with the process.
>
> My main message: be cautious about using simulation and other mathematical techniques. Don't be enamoured, but also don't reject these.

This paper is a summary of that conference, and, hopefully, it will capture the spirit of all that which was said during those two days.

LET'S END THE CONFUSION ABOUT SIMULATION MODELS!

A Summary of a Candid Discussion of Their Place in Higher Education

Society for College and University Planning
1973 Spring Conference 2

Management Division
Academy for Educational Development
September, 1973

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INTRODUCTION: RESOURCE REALLOCATION

INFORMATION NEEDS AND LIMITATIONS

If the "new depression" in higher education finance is one of the realities of our day, as I believe it is, then the "new management" established to cope with the new depression is equally with us. This new management calls for an extensive and intensive array of information not previously collected or analyzed on most college and university campuses.

In the response of many different colleges and universities to the exigencies of the new depression, two circumstances seem to have prevailed. One has been the necessity of carefully devising an internal structure and process for resource reallocation; that is, an in-depth analysis of the objectives, costs, and income attached to the various programs of a particular institution. Upon this basis, decisions have to be made about what goals and what technologies to adopt consistent with the available income of the institution. Secondly, resource reallocation has placed immense new demands upon data collection and data analysis. Resource reallocation is not possible without extensive information to guide decision-making.

The information needs of higher education management today are far more extensive and far more exacting than at any other time in our history. The most important single kind of information indispensable to college or university resource reallocation is program cost and income data. There are two phases to this need: the program phase and the cost-income phase. The two are closely related and become almost inseparable in analysis. I wish to emphasize in particular the cost-income phase.

The nature of the higher education enterprise is such that a college or university spends what it receives. Cost is a function of income. Indeed, income determines the cost of a higher education program. The very phrase, "resource reallocation," testifies to this relationship; it is an exercise determining what costs to support with what income.

It is very important, of course, to recognize that most higher education income is earmarked. Where the use of income is not restricted by the specific terms of a grant, a gift, a contract, or an appropriation, there may well be an implied restriction. For example, income from ticket sales for admission to intercollegiate athletic games should be applied to the costs of the intercollegiate athletic program.

I am convinced that any analytical procedure which does not clearly relate the costs of programs to the income available for the support of programs will be highly defective. Indeed, I would go a step farther and say that in the whole process of resource reallocation, a major criterion of judgment about the desirability of programs will be the relationship of income to cost.

The cost-income relationship of college and university programs can only be determined, however, when there is an appropriate and useful arrray of program entities identified for a college or university. Apparently, most colleges and universities are still a long way from having an acceptable and useable program classification structure. Yet, resource reallocation in a college or university can only be undertaken in terms of program units. Obviously, it is not sufficient to say that a college or university as a whole constitutes a budget unit. If higher education is going to look carefully and critically at its current allocation of resources and then is going to consider a possible reordering of resource utilization, it must do so in terms of clearly defined program units.

The word "program" is another one of those concepts of management which has acquired widespread use in recent years without any corresponding widely accepted definition. Of course, the very extensive Program Classification Structure prepared by Warren Gulko and published by the National Center for Higher Education Management Systems (NCHEMS), first as a preliminary document in 1970 and then as a technical report in January, 1972, emphasized that, for effective management, a program classification structure must be utilized in the budget process of a college or university, with a designation of the cost centers of the institution. And a program classification structure is meaningless if it is not also utilized for accounting purposes. Thus, program classification is not just an exercise in the orderly and precise identification of programs which an institution performs. The structure becomes meaningful in management terms only when it is an integral part of the budget and accounting process.

Costs of instructional programs, are, of course, expressed in dollars. But these costs mean very little for analytical purposes except in terms of some units of output. Here the complication is a familiar one. There is only one readily available unit of enumeration for instructional output, the student credit hour or its derivative, the full-time equivalent student, on an academic or calendar year basis. Most higher education enthusiasts object to the full-time equivalent student as the unit of educational output because they insist this unit ignores other equally important outputs which cannot be quantified, such as research outputs, public service, cultural outputs. The criticism is certainly justified. Yet, at present, there is no other alternative.

There have been many studies of higher education costs over the years. I am amazed when I encounter criticisms that managers do not know what their costs are. All of us know our costs only too well, but we have not been very forthright in presenting them.

There are two very good reasons why so much data on the subject of higher education costs are confusing. One reason is our failure to analyze costs in terms of various program categories. The other is our failure to make clear the fact that costs vary from program to program and from institution to institution, simply because the inputs to those costs vary. As already pointed out, colleges and universities spend what they receive. And no two institutions with the same program mix and the same enrollment will necessarily have the same inputs. If instructional costs are separated from research costs, public service costs, auxiliary service costs, and student aid costs—a separation which is not always easy to achieve and in some instances may not even be attempted—we will still find considerable variation among institutions with comparable programs.

The most important source or cause of varied costs is faculty compensation. Obviously, the college or university with the highest faculty compensation will have the highest instructional costs.

The second most important source of varied costs is the faculty workload standard. These standards vary from institution to institution, and often from one instructional program to another, and they are expressed in a number of ways. One component, perhaps, is the class size variable, which may cause major variance among the newer forms of program cost. I think the most common measure, however, is student credit hours of instruction, as it gives some flexibility to departments in arranging the instructional procedures which they deem most appropriate to their subject matter and their available resources.

The costs of an instructional program are affected also by the extent of instructional support services: secretarial assistance, laboratory, instructional, or library assistance, and equipment and facilities provided to the faculty. These inputs tend to vary considerably, and they necessarily have their impact upon instructional costs. Then there is the whole matter of indirect or overhead costs for instructional programs. In general, the larger the enrollment of an institution, the less is the overhead cost per student, simply because these costs are relatively fixed or increase per student only marginally.

Colleges and universities always contend that they could usefully spend more money. If classes were smaller and faculty members were responsible for fewer student credit hours, they would be more productive and better able to advance their professional competence. These are all familiar arguments, difficult to demonstrate and complicated to quantify. The arguments are really articles of faith within the academic enterprise, and there has been just enough demonstration of the power of this faith to lend some credence to it.

Higher educational institutions tend to believe that higher costs are associated with higher quality, that faculty members with reduced instructional loads make a substantial contribution to society through research and creative activity, that faculty members engaged in public service are better instructors. The whole matter of costs cannot be separated from these beliefs. Indeed, we really do not know very much about costs until we are able to answer the qualitative questions.

Thus far, my comments have been directed chiefly to the primary program areas of higher education activity: instruction, research, and public service. Certain other cost concerns, such as auxiliary services, can also be troublesome. But I want to consider particularly the cost of student aid, an aspect that deserves much greater concern than it often receives.

Student aid is not a support program of higher education; rather, it is a primary program, one of the major objectives of our colleges and universities. Almost without exception, institutions of higher education have dedicated themselves to equal access. No matter how selective or nonselective a particular admission process is, I have yet to find a catalogue which says that students are admitted only upon the basis of family income.

On the contrary, colleges and universities generally assert that they are interested in enrolling students of given academic abilities regardless of their socio-economic status. Moreover, this is more than an assertion; it is backed by an expenditure of funds, a commitment of their own general funds as well as those from outside sources.

General funds are also often used to recruit the students which an institution wants. The motives are not purely altruistic or egalitarian; often student aid is used to encourage particular students to enroll. Sometimes there is a fear that if a college or university does not spend more for student aid, it will lose enrollment or will lose a particular kind of enrollment.

Nonetheless, higher education does deserve credit for the effort and resources which it expends in order to assist students in meeting their costs of college or university enrollment. Few persons realize how much money is spent for this purpose, money which otherwise might be used for faculty compensation, faculty support, research, public service, or overhead.

And, again, reporting practices vary. Some administrations report all disbursements for student aid as part of a distinct program of the institution. Others record the expense of student aid as a part of instructional cost, some even as a "reduction of income," although this practice seems to be disappearing. (While I question this practice, I sympathize with it.) The inclusion or exclusion of student aid expenditures is another factor in producing variations in the way colleges and universities determine their costs of instruction.

As higher education has sought to provide access for disadvantaged students, it has become involved in another program, another cost, that of remedial instruction. With an open-door policy, two obligations follow. The first is to decide what minimum standards of cognitive performance to enforce and how these standards may be applied in a curriculum open to students of diverse cognitive abilities. The second obligation is to afford some assistance to students whose pre-college education may have been deficient. The first obligation is an exercise in curriculum development; the second, in individual development. Both involve cost; thus, there is another demand upon resource reallocation.

There is also a cost demand in the area of personnel management. If faculty collective bargaining becomes widely adopted, there will be negotiation costs. Federal compensation programs have already added to costs. The major recent impact upon personnel costs, however, arises from the equal employment opportunity act and related executive orders for affirmative action programs. Although it may be argued that these costs are a small part of a multi-million dollar budget and that they are the price to be paid for past lip-service to but limited performance in equal employment opportunity, the point is that personnel management is going to cost more. Moreover, informational needs will be much greater.

Higher education faces continuing cost pressures from a multitude of new demands. The consequence is a new emphasis upon resource reallocation, a possibility only if the required data about program costs, program outputs, and program income are readily available. The task of the new management in higher education is to gather the needed information for intelligent, persuasive resource reallocation.

There is one final and obvious observation to make about resource reallocation. Information is not a substitute for action. It can assist the decision-making process; it cannot and does not replace decision-makers. There are some who wish it were otherwise, but the buck still stops at some point in the decision-making process.

John D. Millett
Vice President and Director
Management Division

THE MOTHER OF INVENTION

The financial support of higher education is one of the major political issues of the day. While there is little disagreement concerning the fact that higher education is facing a financial crisis, there is considerable disagreement as to the approaches to meeting this crisis. Traditionally, university administrators have turned primarily to the receipt of additional funds as the solution to their financial problems. And, traditionally, they have received those funds.

Recently, however, colleges and universities have found that they are confronting a demand for more efficient allocation of *currently available* resources to meet this crisis. People are talking about "accountability." It is asked, "Can we get the same product for less money?"

In answering these demands, unpopular decisions have to be made and explained. Mythology, folklore, and even common sense are no longer acceptable bases for making decisions. College and university administrators need a technique that can provide the comprehensive data, at the time they are needed, to help them to choose among alternatives.

As a result of this need, several organizations have developed computerized planning models that are designed especially for use by administrators of higher education. These planning models are generally associated with one or another of a plethora of acronyms. CAMPUS, RRPM, PLANTRAN, SEARCH, and a host of others are all somehow concerned with improving the flow of information to administrators. These systems represent the most advanced state of the art of computerized planning systems.

The literature of higher education affirms over and over again that the fundamental processes of quality education are fragile, mysterious, and unmeasurable. Perhaps, however, it is possible to describe these processes to some extent by statistical means.

SYSTEMS DEFINED

Systems can be understood as experimental mathematical models which have the capability of "simulating" the college or university environment. Computer simulations study the dynamic behavior of physical or social systems and their responses to input variables and to their environment. The administrator then has an opportunity to test the consequences and implications of complex policy decisions before making them in real life. Furthermore, each of these systems has the capability of projecting resource requirements in a variety of modes into the future.

The majority of the systems have a common basic approach. They build a "model" of the university in terms of characteristics that the administrator wishes to have included (i.e., enrollment figures, fiscal figures, space, personnel, etc.). Next, series of assumptions concerning the model are identified (i.e., enrollment will rise, fall; manpower requirements of society in certain professions and job categories will change, etc.). Third, the model is "moved" into the future, thereby "simulating" expected university activities in terms of initial modeling characteristics and assumptions. By varying parameters, the experimenter can fit the model to known situations. Component by component, the model is tested by holding certain variables constant; after behavior is validated, components are combined and tested again until the entire model performance matches, as closely as possible, the real system behavior. The ultimate goal of simulated planning models is to enable colleges and universities to make more rational decisions about the use of their own resources and the direction of their development. The extent to which this expectation has been fulfilled in higher education is as yet far from clear.

In many cases, however, the model is proving successful—doing what a model is supposed to do. It is forcing decision-makers to examine relevant variables and their interrelationships before decisions are made. Modeling can cultivate the art of management by forcing explicit and analytical consideration of important internal institutional relations and alternative policies, as well as strengths and weaknesses of institutional data bases and management information systems. Given traditional university administration by consensus among large numbers of competing, equal and vocal interests, the educative attributes of modeling are even more appropriate than in many business situations where management decisions are made by relatively smaller numbers of people who are full-time managers. Further, modeling is one of the tools of the systems approach to university management.

A model may be viewed as an evolutionary component in the overall information systems development of an institution. A large model is a superstructure, based on the operating data systems, but at the same time functioning to guide and to integrate the development of those systems.

Potential

There is another meaning to the term, "model", other than simulating an organization. Webster suggests that the word "model" means "to make or conform to a standard of excellence." Thus, one may ask what a model should be or do for an institution.

Use of a model can encourage administrators to conduct planning and budgeting by starting with educational program objectives rather than simple extrapolations from past operations. In addition, a computer simulation model can free planners from extensive calculations, permit evaluation of effects and interrelationships with a great variety of factors, and allow tentative consideration of many alternative patterns in order to make decisions that provide optimum use of resources for achieving the objectives of the program.

A model can be an important part of a management information system, and its function is to improve management. It must provide information in sufficient depth, breadth, and flexibility not only to satisfy the institution's managers, but to increase their effectiveness. It must modify their behavior so that they push more of their decisions downward in the hierarchy, so that they explore all options open to them in a given situation rather than evaluate single proposals. They must make their decisions on a smooth annual cycle, rather than when stimulated by major and minor crises, and at the appropriate time of the year after careful deliberation for all but the most unexpected problems. Most important, it should happen that basing all decisions upon full information becomes such an ingrained habit that all who decide policies or procedures refuse to act without adequate information.

To bring about the appropriate changes in management behavior, the model must be, on a continuing basis, believable; that is, it must be capable of validation. Secondly, it must be relevant. If the elements in the model that are selected to represent reality do not bear on the decision problem faced by the user, if they do not reach the proper level of data aggregation, the outputs produced by the model obviously will have little use. The model builder will find that he or she has produced what Paul Jedamus of the University of Colorado has described as "an irrigation system for a mirage." In addition, the model must also be flexible; if it is to retain its usefulness over time, it must be capable of being easily redefined or restructured to fit changing requirements of the user in a fickle world of changing issues and values. It should be adaptable to the development of managerial techniques which fit the needs of individuals at the institution. The thousands of dollars that may be invested in the design of a sophisticated analytical model are wasted if the model can represent only a transient crisis. Finally, its content must be communicable. If the users cannot participate directly in the manipulation of the model, at least through an effective interpreter or translator, they are less likely to believe it, to see its relevance to their problems, or to participate in its adaptation to changing needs.

Limitations

While the literature reveals many articles referring to the use of computer simulation as something of a panacea, other writers continue to doubt the suitability of its application at a level of complexity comparable to that of administering a university. Unfortunately, many potential users expect that a model instantly will produce a management information system; when instant results are not forthcoming, disenchantment leads to premature abandonment. Any large-scale analytical model requires fertile soil, time, nourishment, and the help of many green-thumbed developers working cooperatively before the model can bear fruit in the policy formation and management processes of an institution.

An institution is not required to have modeling. Once it is there, however, it is relatively easy to implement any one of a number of simulation models to help anticipate and plan for the future. Through modeling, administrators can envision the future impact of decisions—sometimes subtle, sometimes drastic—ranging from varying general requirements to establishment or elimination of an entire program. Models are a "handle" and only that, however; they are not a substitute for informed judgment. Often intuitive modeling may be more accurate than the computer print-out. The administrator can use simulation/forecasting models but must avoid being used by these tools.

The output of the educational enterprise is difficult to conceptualize and is nonmeasurable. What one calls outputs and inputs are usually only proxy variables for the real thing. Also, many important parameters such as average section size, course level, or instruction type are used in ways which attribute to them pedagogical characteristics which they may have, but which have never been measured. Thus, to avoid the insinuation that an analytical model quantifies a process which is essentially not quantifiable, it is necessary to observe that any analogy between an analytical model and an institution is an oversimplification. The model then embodies two sets of limitations: those associated with the builder's conceptualization of the educational processes within the institution, and those associated with the translation of the conceptual model into a computer simulation. These limitations must never be ignored and the model output must not be granted status or meaning beyond the limitations of the model in the context of each application.

It should be emphasized, then, that simulation is for analysis and prediction; it is not to be used as a process of synthesis. Thus, while a simulation may lead to more informed decisions, the precision of the model or the accuracy by which it represents the real world situation in *all* respects is not critical. Administrators may use simulation as an aid to building a new plan; modeling is principally a tool for them to test their theories and to gain greater understanding of the processes with which they are concerned. Increased understanding of relationships and processes leads to informed planning decisions even in the absence of comprehensive and precise data.

DECISION TO IMPLEMENT

A specific need for and a high-level commitment to planning should be generally evident in the institution before a computer-based system is implemented. What happens on campus prior to implementation is just as important in terms of successful utilization as what happens later. The most difficult stage in the process may indeed be that one taking place before the system is actually implemented. The college or university must first make the decision to utilize a model and then determine which one to purchase or borrow, or whether or not to build one's own.

One person found that the easiest way to sell something new, something better, something to improve one's institution, was to show that this new idea or procedure was functioning well at another institution, preferably one which was comparable to his own. Often, this is just the spark needed to implement some new system. If an institution is ready for a simulation modeling experience, it may prove beneficial to point out that Institution X has been successfully conducting the modeling experience for the past several years and that the experience has proven helpful.

The experience of implementing a model will probably be most rewarding if a formalized planning process is already in existence. Not many institutions have a well structured planning process. Many may not require one. Instead, they seem involved only with year-to-year budgetary planning, and the implementation of a simulation model might confuse the situation more than it would help. The objectives of the modeling experience will not be clear to the average decision-maker on campus and will probably be seen as some more meaningless administrative "busy work." Ideally, for the simulation experience to offer the maximum benefit, the planning processes of an institution should have progressed to the point that administrators can realistically decide among alternatives. If alternatives cannot be realistically considered, the modeling experience may become an exercise in futility.

In discussing the benefits of simulation modeling, it is also easy to oversell some people who have had little practical experience with administrative data processing. This oversell may generate excessive expectations which, in turn, will cause disappointments and hinder any further implementation attempts. As previously noted, some people believe the computer to be a wonder-worker—that it can make decisions and solve many problems. What they fail to realize is that any decent simulation model, used in conjunction with an acceptable management information system, makes decisions more difficult because of the greater variety of relevant information available. Decisions are no longer "cut and dried."

If an institution decides to build its own system, the obvious advantage is that it can respond to institutional needs in a very specific way. The most obvious disadvantage is that building a new model can be expensive, particularly in the amount of staff and administrative time it consumes. In buying a simulation model, there are also preliminary considerations to be made:

1. Make certain that it will be used. Remember that it is a long-term investment.

2. Review the available models and determine which ones produce reports at the level of aggregation needed.
3. Make certain that those selling the model take the responsibility for its full implementation on the campus.
4. Be certain that the seller also has experience in teaching those who make decisions on the campus how to use the model.
5. Determine what technical facilities are needed for the model.
6. Be certain that the vendor can provide prompt, continuous service in revising the model to fit changing needs.
7. If the chosen model is limited to a high level of aggregation, be certain that it can move to a detailed level with ease and that it can meet external reporting requirements.
8. Finally, consider the system to be experimental during the first year of its operation. It is certain to require extensive changes which cannot be foreseen during the implementation phase.

The purchase of a system that has already been tested should provide several advantages: most operating problems should have been eliminated; the experience of several previous users should have resulted in functional improvements; and, most important, the seller should be experienced in overcoming the problems encountered in persuading administrative officers and faculty members on the campus to make good use of the system.

CASE STUDY

The problem of assessing the use and the impact of computerized planning models was approached by one researcher, Jerome F. Wartgow, through an examination of the experiences of other colleges and universities that had implemented and were using one or another of these models.[1] He interviewed appropriate personnel at eight selected institutions from across the nation. The findings were then reported in case study format for the purpose of identifying the extent of utilization of simulation, determining the problems involved, and presenting the findings in the context of the local situation. The case studies represent a variety of institutional types and structures and reflect experiences with three of the more widely used simulation systems, CAMPUS, HELP/PLANTRAN, and SEARCH.

[1] Jerome F. Wartgow. "An Assessment of the Utilization of Computer Simulation Models in the Administration of Higher Education." Doctoral Dissertation, University of Denver, 1972. (Available from University Microfilms, P.O. Box 1346, Ann Arbor, Michigan 48106.)

Findings

The study identified two primary factors which influence the decision to purchase and implement a computerized planning model: (1) the effort of an individual on the university staff who has a personal interest in new techniques of management, and (2) a recognized need by university personnel for a tool to assist in answering "what if" types of questions. Once purchased, however, the system was used more extensively in those institutions which purchased it to meet a recognized need than in those institutions which purchased it primarily because of the recommendation of an educational innovator.

It may thus be confirmed that the relevance of these systems to administering higher education will not be generally recognized until the planning process on the campus has progressed to a point where administrators are forced to decide among alternatives and are aware of the need for information concerning the implications of choosing one alternative rather than another. Then, a computer-based planning model becomes a useful tool.

No discernible pattern was evident concerning the decision to purchase one of the models in preference to another, although it was clear that much of the discussion focused on choosing a model of appropriate complexity.

The confusion over the desired complexity or simplicity for a given model reinforced a general limitation that can be identified in the literature. In order to represent the system accurately, there is a tendency to develop more complicated models. As models become more complicated, they become less easy to understand and thereby defeat the very purpose of constructing a model: for simplification of the real system to facilitate understanding.

Recommendations

Because the study indicated that systems were most extensively utilized when a formal planning process was already in operation at the university, implementation of a system prior to proper preparation may tend to complicate rather than clarify its role in the overall planning process. In this regard, the computer model is not a substitute for planning, but, rather, a tool to be used to supplement the planning process.

Other factors were also found to be significant:

1. *Participation.* The amount of user confidence in the accuracy of model-generated reports was found to be a function of broad participation in the development of the model and of confidence in the individual conducting the simulation. Greater confidence among the users of planning reports was noted when there was wide and active participation in the development of the assumptions and formulas used in the model. In addition, confidence held by university personnel in the ability of the admin-

istrator responsible for the model was found to be correlated to confidence in the system itself. Generally speaking, it appeared that the personal and political influence of the individual having responsibility for the system was a more significant factor in successful utilization of the model than the position which he or she occupied.

2. *Data Base.* The accuracy of the base data in the initial use of the model tended to influence the extent of future utilization as well as the degree of user confidence in future uses. University personnel often view the initial use of the system with cautious skepticism. The careful collection of accurate base data will enhance the potential for successful utilization and consequently help overcome skepticism.

PROBLEMS OF IMPLEMENTATION

The case study suggests that there are various important factors which must be recognized and considered in the implementation of a computer simulation model. Without an examination of these elements and an understanding of the concomitant problems, the experience of utilization may be not unlike an afternoon at the madhatter's tea party.

Appropriateness

An institution should carefully select a model or system that is best suited to its unique needs. Care must be taken to ensure that the model is not too simple to represent the institution adequately or too complicated to be easily understood. Here is a real dilemma: if the model is too detailed, the user may not be able to cope with all of the judgmental demands which are made; if the model is too highly aggregated, simplified, or generalized, it may be impossible to relate its functional relationships to experiences and concerns at the real-world level. The precise relationship between the level of detail and sophistication of computer simulation and the effectiveness of decision-making in higher education is still largely unknown. An institution, however, should be able to determine in what areas modeling may be more appropriate than other techniques. If any major technical or conceptual modifications are to be made, it may be possible that the model is not appropriate for the institution or that the problem being approached is not appropriate for the model. This ability to determine when this tool is and is not appropriate is the primary determinant of its value to the institution.

Those who are considering various simulation systems should also explore the systems' capacities to meet external reporting requirements. State legislatures and coordinating commissions are requiring increasingly detailed information from state colleges and universities under the rationale of "accountability," and it is likely that federal agencies will require submission of increasingly detailed reports. Institutions should anticipate the possible modes of external reporting requirements and evaluate the available simulation systems as instruments to satisfy reporting procedures. This issue, however, creates a special dilemma for the private institution, which is not bound by the same number of constraints as the public institution. Is it worth the time and effort necessary to develop a system compatible with state and other agency systems?

It is most undesirable to select a model on the basis of the computer facility on the campus. With the flexibility available from remote terminals, the model should be selected to fit the institution's management needs; the necessary data processing arrangements can be made on the basis of the requirements of the model. To fit the level of aggregation particularly to the type of computer on the campus may be self-defeating.

Moreover, a certain amount of give and take between an individual and a model is permissible, but the needs of individuals must never be compromised to fit the requirements of a particular model. When one uses a computer in the development of management information, its principal benefit should be to speed the transition of the data from the form in which they are obtained to the form in which each manager needs them; it should provide rapid answers to questions. In the interests of "efficiency," it may be possible to persuade a few people that they can use data in the same form, although their needs differ slightly; *persuade* is the correct word to use in this case. If a manager objects to the form in which data are provided, or, even worse, if he or she has to rework the given data, the model must be modified. Otherwise, the manager will stop using the data and the investment in the model will be wasted.

Is the use of analytical methods compatible with the management style of the institution? Does the management information generated have application to problems of sufficient significance so that the associated costs are justified? The determination of whether modeling will be a useful tool presupposes considerable familiarity with and understanding of the institutional management style, including an appreciation of how that management style will change, with or without modeling.

There are a number of trade-offs: models for long-range planning generally make fewer demands on the data base than those used for short-range purposes; the greater the disaggregation of model capabilities, the more expensive the data base; on-line models imply competent data base management systems, integrated university management systems, and higher costs. Other trade-offs such as accuracy, flexibility, upkeep, design problems, costs, and convenience can be summarized as follows: the model must be simple enough to be understood and manipulated by users, representative enough to cover a significant range of applications, yet complex enough precisely to mirror the institution.

One can implement the most effective, efficient model in the world, but unless there is the proper environment in which to operate the model, together with the proper information needed to drive the model, the experience could prove to be of little benefit or could even be detrimental.

Time

In discussing the implementation of the model, it is often easy to get in over one's head with promises about what the model will do and when the model will be operational. Few systems groups have been able to meet their estimated time of implementation. This is a complex task, and a large number of people may have to be involved. It may be advisable to double any time estimate received from a systems group. In fact, a common misunderstanding of what the term "implementation" implies contributes to this discrepancy between actual and estimated implementation times. Quite possibly, implementation has a different meaning for the firms installing a system than it does for the institutions that are utilizing it.

Should an institution decide to borrow rather than purchase a model, there are special conversion problems involved. If the institution from which the model is to be borrowed has a different kind of hardware (that is, computer), or if it has the same manufacturer but a different model, or if it has the same model but works under a different operating system, extensive adaptation may be required. Therefore, when examining a model's feasibility, an institution should take into account how much added time and effort will be initially required if the model is to be borrowed. In some cases, if there are not well experienced systems people at the borrowing institution, it may be better to build a model from scratch, using the logic developed at another institution, rather than attempt a conversion.

The Wartgow case study found that the time needed to make a system operational was significantly underestimated in each implementation. Several problems were identified as contributing to this condition. The first and most significant was that considerable modification was required in several of the models prior to utilization. This factor may have far-reaching implications for the use of these systems in higher education. It might be inferred that "system packages" specifically designed for one institution are not readily adaptable to other institutions. This inference would support arguments advanced by some administrators concerning the "uniqueness" of higher education and the resultant inapplicability of scientific management techniques.

More verifiable, however, might be the fact that a necessity of immediate modification in models usually arises because the sophistication of the users has not developed to a point where they can identify appropriate and inappropriate uses of the model. Extensive modification in the system might imply that the model was being applied to a problem for which it was not appropriate.

An institution must provide adequate time for the administrator who is responsible for utilizing the model to perform this function. Purchasing a system to give it to an administrator as a "spare-time" activity is a poor investment. A certain time factor may also be necessary to work out problems, gain the confidence of the staff, and overcome resistance to change.

Definitions and Institutional Policy

As indicated in the time problem, the various terms such as "installation," "implementation," and "operational" must be clearly defined and understood. These terms have a number of different meanings.

Also to be defined are terms related to the data themselves. The borrowed model is a case in point. A basic data base which *seems* to drive the model may be developed, but precise definitions for each data element probably are not available to the borrower and may not have ever been formally developed in the first place. Credit hour, contact hour, faculty workload, and many other terms vary in meaning from institution to institution. If, moreover, the model is undocumented, then, chances are, many hours will be needlessly consumed by systems people trying to understand undocumented data.

An analytical model is typically structured by a set of categorical definitions, hierarchically ordered, by which masses of data are aggregated and reduced to a limited set of generalized indicators about the state of the systems being modeled and to a set of functional relationships (planning factors, coefficients, estimating equations, etc.) which connect the inputs to the model with its outputs.

The definitional structure of the model is the means by which complex and often chaotic data impinging on the decision-maker are brought into an ordered and simplified representation of reality. Unless these structural definitions can be clearly related by the user to the reality which they reflect, the difficulties of communication are likely to be insurmountable.

The functional relationships designed into the model are by far the most critical elements for achieving useful interaction between the model and the decision-making processes. The planning factors, estimating equations, and so forth are the representations of policy in the model, whether they are functioning to describe actual relationships or desired future conditions. The definition of functional relationships in the model must represent two kinds of policy: those functions which are within the control of the institution (control variables such as faculty workload), and those which are exogenous to the policy makers, at least in the short run. Obviously, the definition of these functional relationships in the model requires a sophisticated experience with the realities of institutional decision-making. One of the most common mistakes of the earlier analytical model building efforts was the tendency to "hard-wire" these policy factors into a model. The newer versions of most models provide more flexibility for the user to define and experiment with different functional relationships representing both exogenous policy factors and control variables.

Here, again, to the extent that the vocabulary of the potential user can be incorporated into the model interfaces, the more effectively and rapidly will communication with the model occur. The language of the sophisticated statistician or operations researcher, although increasingly familiar, obstructs communication with the typical user unless a skillful translator is available. It is far more practical to incorporate the translation into the design of the model rather than to have to interpret the meaning of an incomprehensible statistic. This is not to advocate the abandonment of sophisticated analytical techniques in the interest of continuing the misuse of the simple average, but rather to advocate the necessity for trustworthy translation as an essential part of model design.

A review of all policies which will determine how data will be projected by the model is of great importance. These policies must be verified both with the administrative officers (or committees) who determine them and with the individuals at lower levels who enforce them. On most campuses, there are an amazing number of misunderstandings and discrepancies in the way these two groups perceive institutional policy. The uncovering of these differences at this stage is a side benefit derived from the structuring of the model. Once the data have been organized and the policies have been built into the model, the computer can be programmed for the operation of the model.

Data Base

The development of a proper data base is probably the most important step in implementing a simulation model. A system must be designed which allows data to flow smoothly from the offices which collect them so that they will be incorporated into the model with the least amount of effort.

The process of institutional modeling is both simple and difficult. The functions performed are not difficult, but the implementation is. Specifically, most institutions have not collected comprehensive data about themselves, and, when they have, the data have not been rigorously edited and validated, nor maintained in an up-to-date data base. The use of much of these data for planning purposes is politically sensitive and leads to additional problems in planning. Thus, the mechanical problem of data collection and maintenance, although it is not central to the simulation process itself, may be one of the most important reasons for attempting implementation, which may then serve as a catalyst for the integration and perhaps redesign of an institution's information system.

Collecting the data, of course, is not enough; the various items must be integrated before they can reach the computer. Information typically collected for specific purposes in an institutional operating department must be meaningful when it is used with information from other sources. For example, information from the student file, academic personnel file, and the institutional timetable must be comparable for analytical purposes. Thus, the method of data collection, the data element definitions, the systems maintenance procedures, or procedures for access to files for both reading and writing must be appropriately and carefully coordinated so that information fed into the model is unambiguous, is generated by compatible systems, and meets the model's specifications for input data and parameter values.

The model's need to be supported by an integrated data base, or integratable data, may lead to additional costs, changes in procedures, and, perhaps, even organizational and personnel changes in the institution, changes which may not be required if a model is not used. These costs may be difficult to justify in an institution which is functioning adequately without manifest weakness in the information required by the operating departments and others in the performance of their duties. The costs must be weighed against the benefits derived from the availability of data from all sources, useable and understandable to more people for more applications—especially institution-wide management and planning applications.

Equally essential is confidence on the part of the users in the relative validity of the model as representing reality. The model must be capable of being applied to an audited and verified history so that its predictive functions can be compared with known and accepted conditions. Most non-technical users have a low tolerance for statistical error variance measures. The reason does not stem just from statistical illiteracy; in a controversial policy-making environment, especially when a modeling system may result in deprivation or penalties for some actors, even a minor range of error will be used to deny the validity of the analysis.

The more highly aggregated and broadly generalized models present a special problem. In general, the more highly aggregated a model is in terms of input data, the fewer are the policy variables that must be handled. These policy variables, however, must be aggregated to the same level as the input data. They frequently are weighted averages of the detail being aggregated, and, as with all averages, they usually obscure significant differences in operations below the level of aggregation.

For example, faculty teaching loads may be expressed in a model as "average student credit hours per FTE teaching staff" for "lower division" courses in the "social sciences" division. This average load factor (SCH/FTE) compounds the sums of the products of credit hour teaching loads and class sizes for all courses and sections offered, all types of instructional methods, in all of the several social science fields. A user at the institutional operating level, such as a department chairman, has difficulty relating to the aggregate value of SCH/FTE in terms of the real world: students enrolling in courses, faculty teaching assignments, and so on.

At higher levels of administration—users farther removed from specific activities—aggregated indices are essential. But as soon as a significant difference in a load or cost index is observed, as between two disciplines, between two levels of instruction, or among the same fields at different campuses, the question is: "Why the difference?"

Since, by its very nature, a model is supposed to provide approximations of reality under conditions of uncertainty, the contrary urge to make a model over into an accounting system, no matter how beautifully integrated the data may be, will destroy its fundamental purpose and utility. Yet those who seek the certainty of the past require and, perhaps, deserve a sense of comfort that the model is capable of replicating a past history before they can trust it as a simulator of the future.

When the phenomenon being modeled is subject to a wide range of error due to uncertain futures or inadequate information about the present, and the policy issues are sufficiently threatening that some users will refuse to accept the outcomes, gaining acceptance from the constituency of users becomes very difficult. So far, there is no solution to this problem.

Fortunately, most reasonable people do understand the uncertainties of the future, and they will accept good, honest interpretation of the potential for model error. In fact, there is a contrary danger that the "hard numbers" that seem to be displayed in the computer-printed outputs of a model will be taken too seriously, without adequate understanding of the relativeness of their predictive validity.

Modeling is useful in isolating some of the technical problems of generating normative and comparable interinstitutional data. Yet, the cost of developing these data through the systems model may be greater than the ensuing benefits. Each college or university must answer the following questions before taking on what could be a formidable task:

1. Are the data bases and associated information systems capable of supporting a model which will provide management information beyond that which is available within the institution now?
2. Is the cost of maintaining the data base included in cost estimates of using the model?
3. Is the cost of improving the data base included in cost estimates of model implementation? If the model program classification structure and data element definitions do not match the university structure or administrative practices, what are the "costs"?
4. Can the cost of improving and maintaining the data base be charged to other benefits which accrue beyond model use? In this regard, costs and benefits may be subtle. For example, an improved data base may promote more efficient practices in operating departments, while, on the other hand, attempts to improve the data base may be

seen as a threat by some and thus reduce overall efficiency by producing friction between individuals and departments.

These remarks are not intended to diminish the importance and usefulness of institutional models but rather to suggest that the use and understanding of these models should not be insurmountable hurdles for any administrator. While the future may be open for much more sophisticated modeling at the institutional level, until these basic functions are performed accurately, until the data bases have been built and tested, and until administrators become familiar with the methods of experimentation and analysis of models, the currently available simulation tools are more than adequate. The process of observing how program costs change with change in input variables and certain institutional parameters is a learning process in itself. The output variables produced by the model may never be used in any planning document, but if college presidents come to learn more about the relationship of output and input variables, institutional simulation will have earned its keep. A second major benefit will have been gained if use of simulation has led to the desire to maintain accurate data bases of institutional information so that "when we think we are deciding on the basis of facts they *are* facts and not mere myths and prejudices."

Staff Support

In making judgments about whether or not to invest in a simulation model, which specific model to adopt, and whether to build, buy, or borrow one, naturally, the technical characteristics of the model and the state of the data base are important. The behavioral characteristics of the people in the institution, however, are even more important. In fact, the technical characteristics of the model are important only in the way in which they affect these behavioral characteristics.

When selecting a model, the institution should consider where the burden for implementation will fall. If the institution decides to build a model, the burden of effort falls entirely upon the planning staff: the systems staff and whoever else can be found to offer assistance. With this responsibility comes complete control. When an institution buys a model, however, the burden will usually fall on the seller to varying degrees, depending upon the nature of the model. In borrowing a model, the burden is upon both the institution and the lender.

An institution may establish confidence in the results of the system by placing the model in the office of an administrator whose judgment is respected and who has an appropriate level of personal and political influence and prestige within the institution. Although this may cause problems if the individual leaves the institution, confidence that university personnel have in future simulations is positively correlated to the confidence obtained as a result of the initial utilization.

It is clear, then, that someone must organize the activities of those who will provide the data for the model, train those who will use it, and make the necessary adaptations of the program to meet the general and individual needs found on the campus. On a large campus, it is likely that the budgeting office or institutional research office will include individuals with these capabilities. If someone from one of these offices develops a cost simulation model, it is essential that the line officers and not the staff officers of the institution determine the requirements and specifications of the reports to be provided by the system. Systems analysts can design the model only within the specifications set by the institution's provost, deans, department heads, or business officers.

These various relationships suggest, perhaps, that the analytical model, large or small, can be made purposeful and useable only if a systematic two-way communication (user to model, model to user) can be organized. This communication may develop into a recognition of specific roles attached to the model. Although there are different names for the same roles, a description of what the roles entail may be important to an understanding of the use of models in a college or university.

It should be obvious, first, that if analytical models do not have any users, they have no purpose. The potential user of an analytical model is anyone who seeks better understanding of the possible consequences of alternative courses of action within a decision-making or policy-forming environment. The model must serve the chief academic officer, the faculty committees, the chief business officer, and the president, *in that order*. To reverse this listing of the priorities of individuals on the campus is to ensure that the model will have little, possibly no effect. All of these individuals or groups must be trained to explore all options available in each case before them and the consequences of each of their options. The support of the chief academic officer, who is in the best position to persuade the most reluctant group to adopt cost simulation, is especially important.

The user, however, does not necessarily make decisions directly with the output from the computer. Someone (or a group of people) may be responsible for interpreting that output. Thus, new roles are necessitated.

One role is that of the data provider. The data provider has two primary perspectives of models. One is from the data base which supports the model (and other aspects of the management process), and another is from the interface between the model and the decision-maker. The data provider sees the model as part of an integrated university management information system. This person is aware of the weaknesses of the data base and the limitations of the model and modeling; he or she is experienced in operating this and perhaps other models. By assisting in the formulation of the decision-maker's questions and by responding in accordance with this formulation, the data provider provides information the manager needs in a timely, useful format. Thus, the data provider may not be one person or even one department. Often, offices of institutional research or analytical studies provide this service.

The interface perspective arises out of the mismatch between the busy executive and analytical models provided by the present state of the art. Limits to the range of problems, the use of technical language, and a lack of adaptability in models, as well as the fact that most managers do not have the time to formulate their questions analytically mean that the data provider must serve as the interface between the executive and the model.

The data provider helps the administrator formulate his or her own problem, so that it falls within the limitations of the model and the ancillary support ability of the data provider and can be input for the computer. The technical details of making the problem machine-readable are important, and there are costs associated with them. The more important and prior issue, however, is the conceptual one, the formulation of the decision-maker's query into the problem-solving framework of the model, as well as the translation of the generated solution. The data provider and the model may be seen by the executive as a "black box". Often, the output from the computer run is merely data; it must be integrated manually with other information, structured and ordered so that it is in a form (even a medium) which makes it understandable.

Thus, the data provider must understand the full ramifications of the executive's questions and be able to relate to these in terms of the limitations of analytical modeling and the assumptions inherent in the given model design. Further, the data provider must make the consequences of these limitations known so that they can be taken into account by the executive in making a decision on the basis of the data provided.

In a complex system, the role of the data provider may be further refined. More than the translation of questions and answers, the task may require another position between those of the data provider and the decision-maker, for further integration of data or for assistance with the planning aspect of a computer simulation model. This may be the task of the policy analyst.

The importance of planning factors, as the links between the model and its users, has already been stressed. The functional relationships by which resource requirements or costs are estimated from projected program loads reflect actual or potential institutional policies, sometimes explicit, more often implicit. The policy analyst must make all policy implications of the model structure clearly explicit to the users, gain their direct participation in modifying or establishing future planning factor assumptions, engage them in experimentation with alternatives, and organize their evaluation of the outcomes.

The primary function, then, of policy analysis is to bring the operations of the model into a close fit with the decision-making processes for which they are intended. It is essential that at least one actor in the system be assigned full responsibility for ensuring that the role of the policy analyst is performed and sustained. Otherwise, the communications flow is likely to be episodic and narrow rather than cumulative and comprehensive. The sustained role of the policy analyst is to create and maintain a continuous feedback between the policy-making processes and the information generated in the model. This difficult role requires participation in decision-making processes and, at the same time, deep involvement in the design and operation of the model itself.

Over time, with the attentive care of those persons performing the policy analysis role, the planning factors of the model can become the keys to more rational and deliberate governance. Whether or not decisions on key policies are made by the squeaking-wheel method, by collective bargaining, by negotiated compromise, by an as yet unborn PPBS approach, or by edict, the search for better information will continue. Analytical models will not be useful in this search unless they are built directly into the day-to-day processes of planning, budgeting, and policy development—through the role of the policy analyst.

If a college or university does not have experienced personnel to implement a systems model, there is also the very workable alternative of using professionals outside the institution to provide this service. Experience has shown some colleges and universities that this approach may be less costly than attempting the task solely with college or university personnel.

Indeed, one factor that has been identified as contributing to the length of time involved in implementation is the inexperience of the personnel responsible for using the system. The assumption that a person with no prior experience with computers can operate a simulation system would appear to be invalid. Inexperienced persons may implement the models eventually, but if the system is to be used efficiently, the user must have had some prior experience in the use of simulation models or computers, or both.

The Wartgow study found that institutions that relied primarily on university personnel during implementation experienced more difficulty than institutions that utilized the services of the firms that had developed the models. The least difficulties during implementation were reported by those institutions that contracted the entire implementation to outside personnel. Generally, the problems encountered during implementation were in the areas of data collection and computer technology.

In-service sessions and in-service materials also influence the extent of utilization of the systems. Consideration and discussion of the "human element" as it is related to the use of the model may be as important to successful implementation as technical considerations. An institution should be prepared to evaluate these in-service sessions and materials to be certain that the content as well as the number of sessions are adequate to meet the needs of the institution.

An immediate benefit of the initial experience with models will be the knowledge that those involved will gain about their own institution. Modeling is a structured method of introducing support analysts and others to the value and use of analytical management tools and of providing for the maturation and integration of data bases.

Participation

In most complex organizations—including colleges and universities—the executive officers, governing boards, operating managers, and policy committees are the ultimate users of analytical models. They are the principal actors in the policy-formation processes, both internally and at the interface with external agencies that provide resources and therefore greatly influence policy. In a large and pluralistic organization, these participants in decision-making may number several hundreds of individuals, at least on the crucial policy problems such as the budget-making process. Obviously, the problem of organizing their effective participation in the use of an analytical model in order to achieve validity, relevance, flexibility, and meaning is overwhelming at times.

A simulation model cannot be a good management tool if its use is limited to those who make high level policy decisions. One of the most effective uses of cost simulation is to have those who are proposing new projects determine the consequences of their projects. Ideally, each department should be free to use the model to consider each curriculum change. When departments are able to predict results, it is amazing how frequently changes which might otherwise have been proposed are never submitted. This kind of departmental evaluation saves time and raises morale.

A well formulated model can prove useful to all levels of administration, from the departmental level to the presidential level. Meetings of departmental heads, deans, and central administrators should take place from the beginning, so that all feel and are, in fact, involved. It is important to recognize that academic department heads are key administrators, since it is at their level that the principal purposes of the institution are carried out. An institution must continuously, from the outset, encourage wide and active participation and involvement with the model. Lack of participation by the institution's personnel in the development of assumptions and formulas to be used in the model is a strong predictor of unsuccessful utilization.

It may be inferred that participation leads to a fuller understanding and eventual acceptance of the model. This would support the argument that resistance to the utilization of "scientific management techniques" stems mostly from people who misunderstand the nature of modern administration. Further, when participation in the development of the model has been limited, and use has also been limited, one might infer that the model was comparatively unsuccessful as a result of misunderstanding on the part of those who were not involved.

What resistance by what sectors of the institution will be manifested by the introduction of an analytical model and associated data base and information system improvements? Passive indifference, especially on the part of key senior people, can be at least as counterproductive as overt reasoned opposition. Also, it must be remembered that almost everyone is for "progress." Thus, verbal approval and encouragement are no substitutes for clearly established priorities backed up by specific budget allocations for the introduction of modeling.

From another point of view, the process can also promote cooperation and coordination among different offices. There is now a reason for meeting and working together. In fact, it may be the first time that all of the officers responsible for data collection and maintenance have been brought together under a project leader to work on data systems improvement without a predominant feeling of loss of power.

The simulation model may also be of benefit if the output reports are well organized and comprehensive. These reports may generate a desire for a decent, current management information system. Administrators at all levels often do not realize what information could be available to help with their decisions. They do not know what they are missing. In other words, they do not know what they do not know. In institutional research, it is often necessary to generate a need by providing administrators with unsolicited information which has been generated after an analysis of decision-making processes. If this information is not available, the institution will still continue as it always has but it probably will not make the best use of its resources.

EVALUATION BEFORE IMPLEMENTATION

Generally speaking, experts suggest that institutions planning to proceed with implementation of a computerized planning model should evaluate the prospective systems in terms of four basic criteria:

1. Performance. How effective is the system in providing needed answers? How appropriate is it to stated needs? How well does it reflect institutional policy?
2. Utility. How useful is the system? How often will it be used and how many people will participate in its application? Is it flexible enough to accept major changes in organizational structure?
3. Time. What is the time required for installation? How much time is required for collecting base data necessary to operate the system? What is the time required to retrieve information?
4. Cost. Is the value of the information worth the cost of implementation? Will it save money in terms of time and personnel? Is a model really needed at current costs?

As these conditions are met and proper preparations made, computer planning models have the potential of becoming valuable administrative aids. With the passing of time and the satisfaction of certain other stipulations which have been identified previously, that potential should be achieved. At that time, the use of computerized institutional planning models in the administration of higher education will provide valuable assistance in the task of more efficiently allocating institutional resources.

The Wartgow study concluded that, in general, experiences to date have indicated that the time and expense involved with computerized planning models have *not* been justified in terms of the extent of their utilization. This conclusion, however, must be considered in the context of the following qualifications: (1) an important benefit of the utilization of these models is that attention is focused on long-range planning; (2) a model has the greatest potential of becoming a valuable and appropriate tool in institutions which are in a process of change; and (3) the value of computer planning models in higher education is dependent upon the ability of the user to recognize situations in which this tool is needed and appropriate.

APPLICATIONS

The ordinary use of an analytical model is to simulate an institution under prescribed conditions and/or inputs of interest and to perceive certain consequences, usually resource requirements. The first extension of this mode is to answer "what-if" questions. The usual what-if merely changes the operating point of the model with respect to various parameters. What-if questions are asked because someone has an idea that the proposed operating point is "better" in some sense or because there is an interest in determining the sensitivity of some output to a prescribed change in the input. Thus, the purpose of the what-if question is to ascertain information helpful in optimizing the enterprise against some criterion. This use of models raises a point: why not use an optimum seeking model which answers the what-ought-to-be question? Unfortunately, few existing models have such a capability.

What are the kinds of problems to which modeling is applied? Most models, like the institutions they imitate, are student-enrollment driven. Historical and anticipated student flow patterns in institutions or even in the total postsecondary educational sector are important determinants in most institutional management and planning decisions. In addition, models can assist the institution in gathering data needed or required by the state, federal, or local government or government agency to determine funding activity. Another use of the model is for academic planning and curriculum design. Models can contribute to the planning process by showing the relations between institutional goals and objectives and resources required by academic and other programs designed to achieve them. Since many aspects of space and facilities are relatively easy to quantify and measure, these resources usually can be proportioned among the university or college programs to which they contribute. Also, models form a component of the information systems used for space and facilities planning, inventory and control. Academic and support staff requirements of an institution depend upon its academic plan, and the detailed determination of these resource needs is an additional application of modeling. Finally, for financial planning and budgeting purposes, models are useful in translating resource requirements and revenue calculations into cost projections and budget allocations.

Some of these applications bear further explanation.

Enrollment Demands

Planners must be able to predict demand, both the enrollment demands of students and the employment requirements of society. They must also understand the higher education system well enough to be able to relate policies to social priorities. Higher education systems have long-time constants; they are slow to respond to change. Policies should anticipate changes in demands, environment, and social priorities. If many of these factors could be adequately described by a computer model, higher education planners would benefit from the opportunity and experience of experimenting with a multi-variable dynamic computer model.

Enrollment demands are a function of many factors: birth rate, economic levels, dropout and stopout rates, and financial aid funding levels. Demands vary for different types of educational opportunities: commuter versus residential campuses, geographic location, and various instructional offerings. Job and career opportunities vary by program and degree category; they also vary geographically and with time. Any of these factors may fluctuate with the help of the economy and of federal policies. The comprehensive computer model could assist planners in interpreting these demands as functions of time and in analyzing existing resources such as physical facilities or faculty concentration in various disciplines. Simulations could help to evaluate strategies to fit future demands with potential resources.

Curriculum Demands: The Induced Course Load Matrix

In all cost simulation models in higher education, the relationships among students in various programs and courses taken by these students may be expressed in the form of a matrix of participations, to determine the participation rates. This matrix is the basis for estimating the course loads induced by a given number and mix of students; hence the term Induced Course Load Matrix, or ICLM.

Two major problems arise in the use of the ICLM. The first problem is that the ICLM has been shown to have instabilities through time. There are several reasons for this instability; changes in student preferences, prerequisites, degree requirements, quality of courses, content of courses, and the schedule of courses all contribute to periodic change in participation rates. Also, many of the participation rates are zero, representing a situation where there is no interaction between a program and an activity.

The second problem that is often brought out (usually by those who have never done much work in the area) is that of size. The problem may be illustrated by the situation at the University of Colorado in Boulder, as it is described by Gary M. Andrew. There are approximately two million participation rates to be estimated. The question is then asked how all these data elements are derived. First, the matrix has *many* zero elements (a very sparse matrix) that are ignored. In the university's experience, less than ten percent of the participation rates are positive; if only the participation rates over .05 are considered, the density reduces to less than five percent. The remaining elements come directly from the student data base.

The ICLM based on historic data provides an effective statement of "what is" that can be used by curriculum planning committees and various other academic planning activities in the institution. Furthermore, the structure of the ICLM provides a system for communication between and among departments.

In terms of the ICLM, academic planning may be defined as the process which leads to adding, deleting or combining rows and columns for the ICLM. Most of the latter changes will result in changes in the participation rates in the ICLM.

For example, one faculty member active in curriculum planning examined the ICLM for some programs he had developed. He found that the actual student behavior was considerably different from what he and his committee had imagined, and the net result was a very different student profile. It was then necessary to institute some new requirements and prerequisites to implement the academic plan which the curriculum committee originally had in mind.

In another case, the student profiles and the course profiles in two departments, as indicated by the ICLM participation rates, appeared to be interchangeable. When a course by course comparison was made between the departments (using course syllabus, text books, and assignments for comparison purposes), it was found that there was an eighty percent overlap between them.

After proposed changes are described and the appropriate modifications made to the ICLM, the effects of these changes on resource requirements can be simulated by using the new ICLM in the cost simulation model. If the resource requirements needed to implement these academic program changes are greater than the faculty and other resources available, programs can be modified and rerun. This will prevent the institution from making overcommitments and running mediocre programs which do not serve the students.

Academic Planning

Every enterprise has a plan, whether or not it is articulated and whether or not it is written or simply perceived. Some general direction exists, with overall goals and both general and specific objectives. Planning for an existing enterprise is, therefore, a process: not one of creation, but of identifying and articulating that which exists and then molding those dimensions into a well understood and directed whole.

Planning is, moreover, a continuous process. No matter how clearly goals and objectives are set forth at a point in time, they are continually affected by operational decisions, resource availability, and the number of persons served, as well as by a changing external environment. Continued modification is therefore required if any model is to deal effectively with reality. Thus, a plan is never really completed. Rather, it must be updated through a feedback mechanism consisting of information relating to its major objectives and the components designed to accomplish them.

Aggregate planning models in higher education can be very useful in planning a new institution or planning for expansion of existing institutions. Few people, however, are going to have the pleasure of working in such institutions in the next fifteen to twenty years. A first principle in higher education planning is that mature, stable institutions have more constraints than young and/or growing institutions. Planning in mature institutions must fully recognize these constraints. Hence, total enrollment, one of the biggest variables driving aggregate planning models, is a constant; only change in mix within the given total enrollment is variable. In such a situation, more detailed information is necessary. (It is also generally true that any decision-making under constraints requires more data than that without constraints.)

A result of these constraints is that change in a mature institution occurs much more slowly than change in a growing institution. Therefore, a second planning principle is that it is extremely important to understand the time transformations that can take place and to convert a constraint at one point in time into a control in a longer time horizon. For example, while in one year there may be little or no flexibility in the faculty complement, five years later, turnover and retirements may allow new choices of personnel and new directions for the department. The total operation of the system must be therefore understood as it *is*, and those constraints in the current system that can be changed through a longer time (planning) horizon must be identified.

A third principle of higher education planning is that it should be a continuum from the most disaggregate organizational unit (the department or division) all the way through central administration and proceeding to whatever state coordination takes place. This continuum must have a two-way communication channel and decision process.

Given these three principles, it is important that any planning system in a mature institution should provide sufficient detail so that the intricacies of constraints, control variables and time are understood and so that the system can provide information along the continuum from the most disaggregate unit to the most aggregate level of planning. This philosophy dictates that the planning function must be intimately familiar with the operations of the institution and that the operations must be involved in planning.

Data concerning higher education operations have tended to center on the organizational unit. It should be remembered that an organizational structure is not a "given" (or even a direct result of the enterprise's plan) but is a management convenience primarily related to resource accountability. This focus on the organizational unit is understandable, since the unit manager and the organizational hierarchy are the primary users of data, and they are normally held fiscally accountable. Also, this information is usually input-oriented and deals with whole elements—personnel, equipment, courses, sections, etc. The organizational focus of this information is often undergirded by an institutionalization of the interests of the faculty, wherein preservation of position, privilege, priority, and power becomes as important, or more important, than the reasons for which the organization was established. In this environment there is a tendency to consider organizational data to be program information.

In and of itself, however, organizational data is of limited use in program-oriented planning. This traditional organizational focus must be modified for use in program planning and evaluation. For example, history course offerings within a multi-purpose institution are not related directly to any well defined subset of the overall plan. Therefore, only when the information concerning history offerings is consistently organized and compared to similar information for other offerings, within the context of an outcome-producing program, is it relevant to the program planning process, or to the degree program planning process. The same argument applies to each discipline offered by the institution and all activities which serve multiple program objectives.

Much of these data, on the other hand, should consist of the same basic components, at least whenever possible. Data which are useful for multiple purposes are the highest priority elements for collection, storage, and reporting.

Top management actively and consistently should attempt to relate the organizationally focused data to the needs of program-oriented planning. Regrettably, the frenetic pace of enrollment growth in the late 1950's and 1960's, followed by sudden enrollment stability or decline and severe economic problems, has forced higher education management into a reactive mode, concerned more with dealing with a never-ending series of crises than with a thoughtful review of objectives and programs. This observation is not intended as an indictment of institutional management. Collective bargaining, student cries for "relevance" and a voice in governance, fund raising, lay-off decisions, and the allocation of increasingly scarce resources do create crises.

What is involved in this reconstruction and what does it imply for the institution, especially for modeling? First, it is necessary to analyze and categorize the relevant information—expenses and related data—into a common format. This may not always be an easy task, but it is essential if reports are to be meaningful.

Next, the demand placed by the programs of service on institutional support needs to be analyzed and recorded. This is necessary if the organizationally-oriented data are to be related to the programs. Where they are not related, it is probable that their impact is random. The institution should examine whether or not a program really exists or if it is merely a broad title or category.

In both of the above steps, the meaningfully related information elements must also be "crossed over" and distributed. A faculty workload analysis and other distributional studies are necessary to ensure that the manpower and other resources used are well understood and linked to the proper discipline, level of study, program, and level of student.

Outcomes—what is meaningful to the institution and the jurisdiction within which it operates—must also be determined and related to those individuals completing programs (or those not completing but who in some measure benefit). The task is not easy; it requires the development of indices either not now maintained or which may only exist in partial form in one office or another. This link to the evaluation process tests the program against the institutional goals and objectives and the purposes for which it was established.

The term "academic planning" can have many meanings. At the state coordinating level, academic planning usually means what programs of student education are offered in the state and where the programs will be offered. At the institutional level, academic planning is composed of a host of departmental activities, from the development of curriculum for new student programs to the renovation of existing courses.

Academic planning may be defined as a multi-stage process made up of three components:

1. Obtaining a firm understanding of *what is* the current state of the academic programs. This includes the courses offered by each department and the courses taken by the students in various student programs.

2. Deciding *what ought* to be the state of academic programs in terms of deleting, combining, expanding, and/or renovating both courses and degree programs.

3. Implementing the changes necessary to go from *what is* to *what ought to be.*

It may then be seen that implementation of these changes can be the result of a two-way interaction of systems models with the disaggregate academic planning process in higher education. In this interaction, the information developed for the cost simulation model can provide structured data for review and decisions for academic planning, and the cost simulation model itself can be used to estimate the resource implications of proposed academic plans.

State-wide Planning

Can computer models also aid state-wide planning for higher education? The elements comprising state-wide planning are similar to those for an individual institution but are on a larger scale: analysis of interrelationships, extrapolation of alternatives, and assessment of the probable consequences of new directions. Thus, a modeling or simulation process is clearly suggested. Little, if anything, seems to have been done, however, by way of building a computer model of this magnitude for a state-wide system.

The availability in the past of state-wide computer simulation models for higher education would probably not have helped to predict recent shifts in student attitudes towards education and modes of living; it seems likely, however, that it would have led to more enlightened analyses of the supply of Ph.D.'s, the falling demands for new teachers, and, perhaps, the increased demands for allied health professionals. It is not suggested that a computer simulation, without years of experience and research, could with any accuracy represent all the demographic, economic, and social factors influencing enrollment and employment pressures within a specific state; nevertheless, even without good validated data, planners can gain great insight from careful analysis and experimentation with systems models. Although planning horizons in higher education extend over five, ten, and even fifteen years, the lead times necessary to establish colleges, to build buildings, to develop new departments and degree programs, or to evolve new disciplines are so very long that planning decisions are always needed as early as possible; and, hence, the time available for planning is less than one would desire. Analysis and experience gained by experimentation with computer models could save planners many months or even years. Even approximate models employing uncertain data should strengthen the planners' confidence in their projections, for planning is, at best, based more upon intuition than a fully rational synthesis.

Modeling may have a long way to go, however, before it can be of much benefit to state higher education planners. A university might have RRPM models, for instance, for each of several college campuses and, upon occasion, might combine them into one model for the university as a whole. A state planner, on the other hand, would not find it easy or productive to combine several RRPM models of different institutions into one system-wide model. Data, parameters, and variables would not be compatible, and assumptions about outputs and environmental factors would differ widely. System models must be built as a system. Moreover, such a composite model would contain far too much detail for any practical purpose. Suggestions have been made about functions that might be included by state planners in computer simulations of education systems, but, unfortunately, there exist no complete, prepackaged simulation programs for this purpose (with the possible exception of the NCHEMS Student Flow Model). There are, however, several general purpose software systems, such as HELP/PLANTRAN, that permit the writing of one's own planning equations for the simplest or the most complex systems.

Comparison and aggregation of data from many institutions require standardization and controls which are difficult to establish. Moreover, it is often difficult to be sure that all institutions actually have the desired data. It is this point that leads to the conclusion that a major benefit to state agencies resulting from the use of institutional simulation models is that through the use of these models at college level there develops an appreciation for the importance of collecting and maintaining data bases on critical institutional variables. In time, such data may become available for state-wide planning.

Short-term planning at the state level, for one or two years in advance, is a more quantifiable process. Like that for an individual college or university, it is a resource allocation problem, involving enrollments, staffing levels, salary policy, budget formulas, and annual budgets. Costs are projected into the future based upon enrollments, adjustments for inflation, and perhaps special new program costs. Computer programs may prove useful in the analysis of detailed institutional data and as an aid to the aggregation of this data. It is not clear that the process can be properly labeled a simulation, however. A so-called budget model is based upon history, politics, goals, objectives, and expectations and is not built upon a careful analysis of the fundamental processes taking place in an institution. Some evaluation of alternative strategies may take place, but detailed experimentation and analysis for optimization of alternatives are not usually parts of this budgetary exercise. On the other hand, the exercise is a necessary and important one and would be impossible to perform without accurate institutional data.

Although some institutions have been able to engage in effective program planning, legislatures, governors, and Congress have increasingly come to look beyond the institution for the locus of the planning activity. In response to the pressures of growth in the 1960's and with the encouragement of the Higher Education Facilities Act of 1963, an increasing number of states have established higher education coordinating agencies. By 1971, all but two states had either a coordinating or governing board charged with the responsibility for comprehensive statewide planning for higher education. The Education Amendments of 1972 completed this transition with the requirement under Section 1202 that states establish or designate a "commission" to engage in planning for all of postsecondary education.

In order to perform its planning functions effectively, the state agency must identify, articulate, and modify the existing plans within the context of postsecondary objectives and outcome-oriented programs. There must be a feedback mechanism to ensure the flow of information relevant to the program components of the overall plan.

Models can also be helpful in the negotiation process if the state agency makes proper use of the information it has at hand and attempts to forecast the impact of its decisions. If the agency is able to "look down the road," the institution should also be able to do so if it wishes to remain an active participant in the planning process.

The state agency must have program-related information in order to initiate and update the planning process. This necessity imposes demands on the institutions for a new perspective in gathering institutional data. The agency will in all likelihood use the data to assess the long-range impact of its decisions or recommendations. The institution will then look to modeling either to improve its own management or to negotiate effectively with the state. The net results are the same: an improved understanding of who does what—for whom—why—and with what results. All parties—the institution, the state and the participant—should be better off as a result of this effort.

Federal Planning and Data Requirements

Planning and evaluation in the U.S. Office of Education are supported by a series of research activities which are intended to provide a critical and up-to-date examination of current operational and administrative procedures, a review of program impact and alternative strategies, and an understanding of the needs of the participants in the educational process.

In support of the planning activities, a series of enrollment and cost projection models for student aid grants, student loans, and facilities is under development, as is an equal educational opportunity cost simulation model. In support of these planning activities, the Office of Education requires input information from postsecondary institutions.

The OE enrollment-student aid projection model, developed in 1970, is capable of projecting college enrollment by sex for each income-ability quartile to the year 1990 for all students and all full-time college level students. Student aid needs can be estimated by using a separate model which considers student resources and the cost of attendance. With the passage of the Education Amendments of 1972, the student aid model is undergoing revision to reflect the new federal student aid programs. In this regard, a new thrust, the Basic Opportunity Grant Program may well have a major impact on the college attendance rates of all students and on the distribution of these students among institutions. Thus, it will be necessary not only to have the capability to project expected enrollment by income level and control of school, but the model must also have a sensitivity analysis capability. By changing any one of a number of the assumptions, such as equalizing college going rates in different years, the component of the needs analysis system, or the rate of growth of tuition and living costs, it should be possible to estimate the expected enrollment, total funding, mean award, distribution of students and funds by family income level and control of institution.

In addition to these efforts, the Office of Education is working with the National Center for Higher Education Management Systems at WICHE to develop a broader simulation model which will not only allow an analysis of the impact of a given student assistance program on student enrollments, but also the institutional response. A related but separate effort, in terms of resources and staffing, currently under development, is an estimation model to project the overall demand for federally guaranteed student loans, along with the interest subsidy and the default payments required for each cohort of loans. Finally, the Office of Education is studying national physical facilities utilization in order to develop a set of planning factors which can be used with the enrollment-student aid cost simulation model and the NCHEMS model to provide estimates of future space needs, given alternative levels of student enrollment. The study includes determination of space needs and utilization rates, condition of plant, and the expected depreciation of current facilities, again, by type and control of institution.

USOE evaluation activities, as contrasted to planning, focus primarily upon the present existing federal programs administered by the agency. Most of the current programs are student-oriented. Even the two major institutional grant programs, Special Services for Disadvantaged Students and the Developing Institutions Program, are intended to provide students with a more meaningful educational experience.

Institutions participating in federal grant programs are expected to provide the government with periodic fiscal operations reports. In addition, they are expected to supply, when requested, program and participant information in varying levels of detail. Of particular interest to the Office of Education, as noted above, is the impact of the Federal Student Assistance program upon students and institutions alike. The types and amount of information needed from institutions may seem formidable but are not unreasonable. College and university planners should be able to estimate the number of students who can be expected to attend the institution during the next planning period. They should have some knowledge of student family resources and the kinds of programs and services students will demand. They also must be able to anticipate how the needs of students will interface with the institution's resource base and program structure. If, in fact, an institution has this capability, then it probably will have little difficulty supplying the kind of information federal planners and evaluators will request. In planning for a new thrust for the Developing Institutions Program, the components of such a system were outlined.

The system should consist of a series of simulation capabilities to assist colleges and universities in the analysis of alternative programs and policies as part of the development of comprehensive multi-year program and financial plans. The components suggested include:

1. A student flow capability to assist colleges in the forecasting of future freshmen enrollments on the basis of participation rates from colleges and area high schools, as well as from other parts of the state and country, and to assist in the forecasting of the rate at which students pass through the institution.
2. An academic activity capability to calculate the instructional and noninstructional workloads at each department of the institution.
3. A faculty activity capability to calculate the number and cost of faculty required in future years.
4. A facilities requirements capability to calculate the future requirements of teaching and non-teaching space.
5. An operating cost capability to calculate total revenues and expenditures for each of the years covered by the planning period, to allocate direct and indirect costs to courses and degree and discipline programs, and to calculate the cost of graduating for a typical student as well as the total institutional cost of producing one degree.
6. A capital cost capability to calculate capital revenues and expenditures for each of the years covered by the planning period.

Federal reporting and evaluation information could easily be derived from such a system.

The task is then left to the individual institutions to achieve a standard of excellence in their planning and evaluation activities. They must ask if their present or proposed planning and management system provides the right kind of information at the time it is needed and at the right price for their needs. If the reply is affirmative, a school should not have much difficulty in meeting its federal reporting and evaluation requirements.

INDIVIDUAL EXPERIENCES: CAMPUS AT COLORADO

(as reported by Gary M. Andrew)

In February of 1972, the University of Colorado decided to implement the CAMPUS system. It was determined that a disaggregate approach to planning was appropriate, and CAMPUS satisfied this criterion; other reasons followed.

The university felt that the abilities of the model to carry inventories of staff and space and to make projections with these constraints at hand would be valuable. Another major advantage of the CAMPUS system was the interrelations it sets up among various institutional data systems. Other planning models do this, but much of the value is lost in aggregation.

A third reason for the need for more disaggregate data was in answer to constant requests by the state for detailed data in ever-changing formats. Both operating and planning data had to be available in disaggregate, easily accessible form; otherwise, the entire analytic capability of the institution would be spent "grubbing data".

The system also had to speak NCHEMS/PCS. By taking advantage of the disaggregate nature of CAMPUS and setting congruent structural definitions, each participant in the planning process could understand at least one set of reports. With this communication base, the other methods of reporting the same data could be explained (translated).

Finally, the disaggregate approach to planning was the best possible way to link academic planning sectors. Academic planners could provide inputs to the resource planning process in a form which they understood and which the planning model could use directly.

Organization for Implementation

Since the project has begun, there has been some reorganization which will greatly increase the probability of success. The university had initially contracted the Systems Research Group to redesign and rewrite, jointly, CAMPUS VI. The result was SRG's CAMPUS VIII for IBM equipment and the University of Colorado's CAMPUS/COLORADO for CDC 6000 series equipment. Concurrent with development at the university, the Colorado Commission on Higher Education contracted the Systems Research Group to implement the system at three other Colorado institutions. A considerable amount of the university's technical staff time was spent in assisting these institutions.

Because of the large number of interfaces necessary and the shortage of staff (only two full-time personnel), the primary effort has been to get the software and the data base operational before beginning interaction. (This is dangerous, as indicated below.)

Progress, Problems, and the Future

Because of the magnitude of the data at the Boulder Campus, the current emphasis is on running the contact hours, the staff, and the space portions of the model. The details of supply and expense and other dollar resources will follow. This approach has already proved to be useful in some departmental planning.

Another benefit becoming apparent is the information from "intermediate" reports. These reports, such as space inventory reports, are generated as the data from the operating systems (such as student files, course files, and personnel rosters) are processed and prepared for entrance into CAMPUS.

The university, moreover, is about to undertake a massive reconstruction of the major operating data systems. This will include student record systems, payroll personnel systems, and financial accounting. The CAMPUS model will be helpful in the design by producing data for planning "automatically".

Thus far at Boulder there has been little interaction with faculty, committees, and department heads. Although this may present problems, it was presumed necessary to have the computer software and the existing data base in fair condition before starting discussions. The plan is to work with three departments in detail during the next six months, interacting with various faculty committees; a training program in general university management is being developed for deans and department heads. The model will be useful for illustration and training. At the same time, the model is to provide information to the budget cycles. This will probably be one of the most difficult tasks, because the budgeting process may be undergoing considerable change in the future.

Finally, the academic planning process will be developed in conjunction with the model. This will include development of procedures for data flow so that the information from an approved plan can go directly into the operating systems.

Conclusions

The planning and management process at the University of Colorado, with the aid of CAMPUS, is designed to extend from the most disaggregate unit (the department) through the central administration to the state coordinating commission. Such a process requires communications among the various components, detailed data and methods of aggregation, and a considerable amount of time for development, two to five years. Thus far, the implementation of the CAMPUS model has placed tremendous demands upon the data systems: the simulation model itself is a large and sensitive program, requiring almost constant attention of a competent systems programmer. Still, the CAMPUS system is proving even more beneficial than originally projected in the area of academic program planning.

Extensive experimentation would be prohibitively expensive. The system, however, is designed in a modular fashion which allows certain questions to be answered by rerunning only selected portions. Furthermore, the data are arrayed in such clear and convenient formats that most minor changes can be evaluated very quickly "by hand".

The energy and intellectual levels of staff necessary to implement such a model are very high. It requires dedication on the part of all involved in the implementation. Is it worth the effort? At this point, the university would have made the same choice were the whole thing to be done over again.

INDIVIDUAL EXPERIENCES: RRPM AT PORTLAND STATE UNIVERSITY

(as reported by W. Keith Evans)

The use of RRPM at Portland State University in Portland, Oregon, as well as at seven RRPM pilot test institutions, has made clearly evident to its users the good and bad points of the system, to serve as selling points or warnings to other institutions.

The Bad Points of RRPM

The data create, perhaps, the most fundamental problem. RRPM requires that input data be organized generally by the NCHEMS Program Classification Structure formats. This requirement usually means that an institution must reorganize its record-keeping system. And, the more complex the institution is, particularly in terms of deviation from instruction as the primary activity, the more difficult will be that reorganization. The output of the model is also displayed in this format, which will require either adjustment and orientation to it or else translation back to the customary frame of reference.

Also, the model is inflexible. Structural changes are difficult, if not impossible, to make; one must adhere to the designer's conception of how internal interactions take place. This is much less true of a model such as PLANTRAN, which gives the users a great deal of opportunity to define the model's internal structure.

Another problem arises from a feature integrated with the model which generates average unit costs per student major, a feature referred to by its users as an "automatic paranoia" generator. Such costs can perhaps be valuable for internal management, but some evidence has been produced to show an instability and unacceptable variance in the figures. There is also potential damage from the misunderstanding of these figures. It may be difficult to explain their meaning, in its proper context, to all users, when the unit cost data are so conveniently spewed forth. The data are much more likely to be called forth in splendid isolation. It is an ever necessary task to remind people of the non-precision of RRPM results, and the false precision of the output makes the task harder.

Although enrollment is a key factor in academic planning, another problem arises because the model is unrealistically sensitive to enrollment fluctuations. For example, an increase in student credit hours automatically and relentlessly produces in the model an increase in the number of required faculty, without regard for other less expensive alternatives. Further, if the model is used to estimate noninstructional program costs (such as library), all estimated increases or decreases in dollars are derived from fluctuations in enrollment.

In tandem with the centrality of enrollments to the model's function is the ICLM. Besides the vast potential for error when dealing with so many averages (the average major on the average distributes his or her course activity on the average term), there is the additional question of reliability and stability of majors. There may be no homogeneity within majors in terms of course activity, and homogeneity within categories is the essential key to the ICLM. Therefore, the second foundation stone of RRPM begins to crumble. It is only fair, though, to point out that RRPM does not require the use of majors as a prime category, but it is generally used.

Also important is the fact that RRPM concentrates most of its analytic power on the instructional program. Therefore, a complex multi-versity with a large portion of activity and budget in research and public service will not find the model to be nearly as effective as it is for the less complex institution. In addition, RRPM may not be effective as a cost allocation or budget model. Because of the "average of averages" phenomenon, it best serves as a trend indicator for futures which are longer range than two years.

Moreover, RRPM provides no picture of income. An increase in students will reflect an increase in the gross cost, but RRPM does not portray the net increase which could be lower than the gross cost as a result of the offset from additional tuition income. Enrollment estimates are also excluded. RRPM cost estimation comes after an institution has decided how many students it will have. The model has no student enrollment or student flow estimator; the institution must accurately predict enrollment for best use of the model.

The RRPM concept is quite simple, but the various levels at which it does its simple tasks are extensive. It is difficult to comprehend the expanse of the model at any one glimpse. It takes a knowledgeable person to interpret the answers and to ask the right questions in the right way. Therefore, it is essential to employ an interface person who can operate at high levels where the hard decisions are contemplated and who also can live with the model, to prevent unproductive use.

Related to the need for an interface person is the fact that there are questions which cannot be answered very well or at all by the model, and there are a number of questions which can be answered better in other ways (on the back of an envelope, by guessing, or by detailed analysis with real data). For instance, looking for a specific cost reduction for either the next year or the next ten years is conceptually backward to the manner in which the model operates because the model is not designed to start with a specific cost answer. Further, looking for a model-produced answer for next year's budget stretches to the breaking point the trend-only virtue of the model.

In addition, there are other kinds of questions that, while conceptually acceptable to the model, are physically difficult to ask the model to answer. For example, changing the mix of faculty rank in the institution requires a computer input card for each department. On the other hand, the model does provide for some frequently used changes through a blanket parameter card; in limited cases, changes are easy.

Validation of the model can be vexing and difficult, since it accepts, uses, and arrays data in a manner usually foreign to most record-keeping systems. There is a great deal of analytic legwork involved in tracing and tracking model validation output from institutional records and then bringing the model closer to reality. In some cases, validation is the major segment of work in the technical implementation task.

There are questions which an analyst can and should calculate precisely by hand. For example, the effect of a salary increase in a particular department is micro enough that the model's macro approach will not specify detail sufficiently, nor should computer time be wasted. An important prerequisite for effective use of the model is an operational, medium- to long-range planning structure. Because of its expansive planning orientation, the model may be a round peg in a square institutional hole. Finally, RRPM does in no way indicate the benefits from any cost alternative. The machine provides only the cost; the user, the benefits. Sensitive people, not a machine, must provide the key ingredient to any decision for which RRPM has provided some analytic service.

The Good Points of RRPM

Those same factors that render RRPM a disadvantage also provide its beneficial aspects.

First, as was stated earlier, to gather RRPM data for purposes of building the model, an institution usually has to do some restructuring of current data records and files. Therefore, RRPM often provides both motivation for building an organized, effective institutional data base and an organized structure by which to define the data base. Institutional needs and RRPM needs can coexist. In this renovation process, other benefits also usually emerge. Quite often, new by-products, such as reports not required explicitly for RRPM, but with important management information embedded in them, emerge from the data organization process. Also, it encourages and, perhaps, forces a program approach to planning.

Even if an institutional data base is in reasonable shape and does not require reorganization or updating, all institutions must face the inevitability of reporting requirements—by local, state, and federal agencies—which will insist on the use of the NCHEMS data elements and program structures. That RRPM can thus conveniently prepare the institution in advance for an inevitable information need is one of the strong arguments for RRPM over other models.

In much the same vein, the output of RRPM, structured as it is after the soon-to-become ubiquitous NCHEMS Program Classification Structure, has virtue in acquainting the institutional users with that structure. There is also benefit in looking at institutional budgets or costs in a format that differs from the traditional ways costs are arrayed; in this manner, it is possible to eliminate bad habits or faulty assumptions.

Inflexibility may also have merits for those who need some direction and structure. As one becomes familiar with RRPM and, hopefully, with institutional management needs at the same time, RRPM may become increasingly useful. It has provided the learning experience and the motivation to move in a better direction with more suitable models or techniques.

The ICLM has its benefits, too. Even with all its real or potential weakness, it is a powerful model and reporting tool unto itself. In one case, the ICLM has been used in predicting course loads in advance of registration, and, at Portland State, it is helping to define an experimental program of lower division education. It can also be used as a discussion document in budget situations of all kinds,particularly where a severe action such as phasing out or establishing a department is contemplated.

Finally, if an institution is not engaged in planning, a sensitive administrator might find it a very powerful tool to awaken and motivate one's colleagues toward it. RRPM is structured, reasonably coherent, and focused toward the future. It therefore can provide a kind of conceptual programmed learning. In addition, the model can be an excellent communication device; the variety of constituents in a modern institution (faculty, administrators, governing bodies, students) can enjoy a common frame of reference. Perhaps, for the first time, people may be talking about the same things at the same time. Moreover, the model, particularly because of the ICLM, is a good tool for showing the high degree of interdependence and interrelation among departments, a fact which is often little understood or is forgotten.

Miscellaneous Good Points of RRPM

- *It is cheap.* NCHEMS will provide the software, documentation, and test data for $50.
- *It is clean;* that is, the computer programs are correct and will execute with a minimum of fuss, and they can be physically run on as small a machine as a 360/30.
- *It has test data,* helpful for debugging one's own data and useful for educational game-playing among people in the institution.
- Finally, *it is going to get widespread use.* There will be much opportunity to learn from the successes and failures of others in implementation. Innovators will probably modify and improve the model as well, and future users will benefit.
- *One might even use it to exchange and compare information* with other institutions.

INDIVIDUAL EXPERIENCES: PLANTRAN AT THE UNIVERSITY OF DENVER

(as reported by William B. Adrian)

The University of Denver is a private university of approximately 9,000 students and typical, perhaps, in its loose organization and in the independence of its individual units. The operational data systems have grown unevenly, in response to particular institutional needs as they have arisen. Thus, there is no institutional information system which is responsive to the needs of decision-makers for analyzing policy and long-range direction of the institution or for conforming to external reporting requirements.

In the past, long-range planning efforts have taken place infrequently, generally aided by an outside consultant firm, to culminate usually in a master plan which does not resemble the actual development of the university. In early 1970, however, the university discovered and acquired the HELP (Higher Education Long-Range Planning) system developed by the Midwest Research Institute for the Kansas City Regional Council for Higher Education. The current version is known as PLANTRAN II. With the assistance of a competent graduate student, the university initiated the system on a Burroughs 5500 computer within two to three working days. The new PLANTRAN II system will be put on a Burroughs 6700. Getting the system on the computer, however, is a minor problem, distinct from the *use* of the system.

Characteristics of the PLANTRAN System

The PLANTRAN system is *not* a model, but a computer "language" or a series of simple arithmetical calculation and projection techniques; it does not require a planning process or a sophisticated information system. Selection of the variables to be included in a model, the relationships among the variables, and the projections which are to be made for specific variables for a six or twelve-year planning horizon are all under the control of the model builder. Since the PLANTRAN system is essentially a calculation tool, it is different in concept from CAMPUS, RRPM, and SEARCH, which are models of higher education environments.

Potential users should be aware of several important factors. First, it is possible for the planner to begin construction of a model or models immediately, without revising any of the existing data systems. The obvious advantage is that the current data base, no matter what the status or format, can be utilized as input information for the system. The major disadvantage is that the system is totally dependent upon the quality of data which are built into the models; inaccuracies, gaps, and other flaws can compound an already inadequate situation. Secondly, the system is very flexible; it is easily adaptable to any peculiar characteristics. All is entirely dependent on the planners; thus, the system will be ineffective if the planners are unaware of the types of analyses which need to be conducted and the procedures necessary to build models. As nontraditional educational patterns continue to emerge, however, this flexibility provided by the system may become increasingly significant. Third, mini-models can be constructed to isolate and analyze specific problems or planning areas, and many interactions of the model can be included in one computer run. This is probably the system's strongest characteristic. As many as 4,000 variables are possible. It is also possible to build models at the lowest level of disaggregation and then aggregate the results. The time and effort necessary to build an adequate large-scale model, however, may be better spent implementing one of the existing institutional models, such as CAMPUS or RRPM. Next, models constructed with the PLANTRAN system are easy to understand and interpret, although there is always the danger of oversimplifying a model or omitting significant variables or relationships. Computer output can make even poor models appear authoritative. Finally, the level of complexity and sophistication of the system is limited and not easily adapted to the complex mathematical calculations generally associated with sophisticated modeling and simulation techniques.

Uses of the PLANTRAN System

Identified below are a few types of models which have been used at the University of Denver, primarily developed for cost estimation and comparison purposes.

Income-expenditure models: budget line items, including enrollments, tuition levels, and other estimated income variables and their impact on anticipated expenditures.

Departmental models: variations in faculty load, credit hour organization, and average class size at the departmental level, as well as lower division, upper division, and graduate levels.

Humanities model: faculty staffing, average section size, and planning costs for an experiment in a new required humanities curriculum structure, to be compared with the costs of the traditional humanities requirements. This mini-model also has allowed an assessment of the potential impact of the new program on the traditional program.

Other uses: instruction devices, budgeted research, and a variety of other uses.

Major Problems and Issues

The effects of PLANTRAN on the decision-making process at the University of Denver have been primarily indirect and are thus difficult to measure. The models have not provided much new information, but they have confirmed and clarified some of the suspected problems. The university has not developed a large-scale simulation model. In fact, no model has been built with more than four hundred variables. Thus, the system can be described as operational for *ad hoc* and special purpos· ~odels. The development of mini-models for specific purposes will prob continue to be compatible with the style of planning at the university.

Perhaps the most important effect has been the awakening of an awareness of the need for more detailed and long-range policy analysis. In addition, the system has focused attention on the need to integrate the various operational data systems which currently exist. The personnel system has been improved and expanded and some weaknesses in other operating systems have been identified and corrected, partially as a result of work with the PLANTRAN models. These effects have made the time spent on the development of the models worthwhile.

It should be noted that, in relation to large-scale models, the PLANTRAN system requires much less of a commitment to planning and to the development of an adequate information system. The requirements of the other models force individuals on the campuses to develop information and assumptions which must be included in the models before they are operative. Because of this necessity, along with the time and effort involved in operation and maintenance, it is likely that there will be a stronger commitment to incorporate the model into the planning process of an institution. From this standpoint, it is possible that a more flexible and simplified system such as PLANTRAN may be viewed as a toy to be played with from time to time, rather than as a significant tool in the planning process.

INDIVIDUAL EXPERIENCES: SEARCH AT EIGHT COLLEGES

(as reported by Robert Hopmann)

The Computer-Assisted Planning for Small Colleges project (which came to be known as CAP:SC) brought together several necessary ingredients for success. A knowledgeable consultant with experience in simulation modeling for higher education provided a high level of technical expertise and competence to move the project without undue difficulty. The eight participating colleges[2] were self-selected and therefore, presumably, highly motivated to undertake the project.

As a result of a seminar in 1968, run by Peat, Marwick, Mitchell, and Company, eight colleges decided to commit manpower and money to proceed with CAP:SC. The first phase involved the formation of planning committees at each college to develop an organized approach to long-range planning and to design a common analytical framework to accommodate the planning information needs of the colleges. This phase lasted a year.

The participating colleges then agreed to proceed with Phase II, the design of the mathematical structure of the simulation model and the development of the computer program. From this point on, the project received considerable foundation support. In addition, time-sharing made cost an insignificant factor. Upon completing Phase II, each of the colleges decided to proceed to Phase III, the implementation in the local environment. The work of Phases II and III spread over another two years.

End Product

The end product of the project was the SEARCH model (System for Evaluating Alternative Resource Commitments in Higher Education). The model includes a data base characterizing the institution (detailed data on enrollment, faculty, facilities, etc.); environmental variables (expected applications for admission, income, investments, cost of construction, and other external factors) programmed as estimates for a given span of planning years; and, finally, explicit decisions (tuition, financial aid, hiring, etc.) which the college must make in order to project resource demands. The model then provides ten-year projections in a variety of formats.

The project was envisioned ultimately as the means of a total methodology for long-range planning. The two major objectives for reaching this goal were, first, to train key administrators and planning officers in the

[2] The eight colleges were Concordia Teachers College, River Forest, Illinois; Franklin College, Franklin, Indiana; Loyola College, Baltimore, Maryland; Macalester College, St. Paul, Minnesota; Mount Aloysius Junior College, Cresson, Pennsylvania; Park College, Kansas City, Missouri; St. Mary's College, Winona, Minnesota; and Samford University, Birmingham, Alabama.

concepts, techniques, and organization of overall institutional planning, and, secondly, to design and implement a mathematical simulation to make possible the exploration of a wide range of planning alternatives by enabling the planners to project expected resources, resource demands, and institutional characteristics quickly and easily.

Evaluation

The second objective was achieved much more successfully than was the first; the consultants were more successful than were the institutions.

When the project was first undertaken, the growth syndrome was still very much characteristic of college thinking, the idea that planning is planning for growth. The discovery that this is not true may have been one of the major factors in cooling enthusiasm for implementation of the planning project. Some administrators apparently had difficulty accepting the idea that college planning can, at least in part, be a science rather than an art. The model became a restricting force, giving too much weight to narrow fact, without enough free rein for reasoned speculation.

Certainly, in the small college, a prime prerequisite for successful planning is the enthusiasm and support of the president and the administrative staff. The problem is to maintain interest over a period of time. In the development of the SEARCH model, planning extended long enough that it already appeared to be a disappointment by the time implementation was possible.

Perhaps, on one hand the model was too complex, while, on the other hand, it was not complex enough. In terms of development and maintenance of information, the model was fairly demanding. Yet, it did not permit the fine tuned responses which some people expected.

The most significant problem was that of personnel turnover. Lack of continuity in the offices assigned responsibility for coordination of the planning effort as well as change in other administrative positions greatly complicated and, perhaps, were the primary deterrents of implementation. But the real difficulty was in the failure to train key personnel in institutional planning. Effective use of the model required that it take a significant place within the framework of planning activity. The planning activity generated in Phase I of the CAP:SC program, however, reverted quickly to day-to-day and short-range problem solving, often compartmentalized. The discipline of making explicit planning assumptions proved to be too taxing.

The CAP:SC project was not a failure. Utilization of what was learned and of the tool developed was largely a failure. It does not appear that the colleges have found a better solution for the planning problem; more likely, the planning problem is simply being avoided. It is much more fun to talk about planning than to do it.

INDIVIDUAL EXPERIENCES: COMPUTERIZED FINANCIAL PLANNING AT THE UNIVERSITY OF MAINE

(as reported by David R. Carter)

The University of Maine is a state-wide institution of public higher education, with seven campuses and almost 20,000 students. The present university was created by the Maine legislature in 1968, by merging the state university and five former state colleges. At the outset, the state colleges feared a loss of individual political advantage and representation in the legislature, a replacement of their local administration by an uninformed, unsympathetic and removed central administration, and a loss of campus autonomy. On the other hand, those who had successfully guided the single university concept through the legislature believed the new institution would enhance state-wide educational opportunity, would be more responsive to state needs, and would be less influenced by local political interests.

Decision to Implement a Computerized Budgeting System

The difficult task of relieving the concerns of those who opposed the single university and of achieving the hopes of those who supported it was the responsibility of the small office of the Chancellor. Establishing meaningful operational systems was the apparent answer, and it was in this milieu that the decision was made to build a computerized budgeting system (CBS).

The decision to build was based upon a number of factors. No budget systems were then known to exist that would fill the special needs and requirements set forth or to respond to the peculiar environment that existed in the university: the need of a central administration to understand various campuses. In addition, it was believed that the development of such a system might attract interest in and support of administrative efforts at the campus level.

The first task of CBS was to develop a means of answering the myriad questions of diverse interested parties. The annual financial plan was generated on four levels, distinct, but related: institution (campuses), major effort (educational and general programs, student aid, auxiliary enterprises), object class (salaries, supplies, maintenance, etc.), and programs (instruction, libraries, research, extension and public service).

Next, CBS had to provide certain basic analytical information. The campuses regularly submit detailed budgets via computer terminals to central transaction files. There the detailed budgets are reviewed and, when verified, transferred to a master file. Once the budgets of all campuses have entered the master file, CBS summarizes these budgets into a total university budget and produces evaluative data in a number of significant forms, such as distributions by campus; comparisons of past expenditures and present and future budgets; and evaluative matrices, including campus by object class, campus by program, and object class by program.

It was also recognized that the needs of accounting must be served. CBS accomplishes a number of accounting objectives. Verified accounting data from budget requests, for instance, are transferred automatically to the university's annual accounting records. Secondly, the categories used by CBS to describe the annual financial plan integrate directly with the ongoing financial reporting system. Finally, CBS categories parallel the university's end-of-year financial reports and thus contribute to their clarity and credibility.

The last output of CBS probably is the most controversial one. Despite enlightened knowledge that to derive next year's budget merely by adding some arbitrary percentage is budgeting at its worst, many governing bodies continue to require submission of budget requests on this basis. This type of projection capability was therefore built into the system, enabling the university to meet this requirement without imposing what is essentially a routine mathematical task on its twelve hundred individual account managers. This projection capability is also a simulation capability, by which the University of Maine is able to derive budgets based upon selected percentages applied to any combination of institutions, programs, object classes, or functions; it satisfies the "what if" questions.

It is envisioned that CBS also can be expanded to incorporate a broad program budgeting capability. In projecting the future, it is believed that the university's purposes can be served by the availability of financial information that is about sixty to seventy percent correct. Current efforts in program budgeting generally endeavor to achieve much greater accuracy, perhaps ninety to ninety-five percent. This increased accuracy is time-consuming and costly, and its justification is questionable. If, indeed, CBS can successfully sustain a broad program budgeting process within the University of Maine, this will equal if not outweigh its current contributions.

APPENDIX

The American Council on Education's Program of Studies to Improve the Resources for Planning in Postsecondary Education

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The American Council on Education's Office of Administrative Affairs is now planning a program of studies focusing upon two sets of interrelated problems: (a) the information needs of institutions of higher education, it would also include information concerning the non collegiate ning for postsecondary education; and (b) improvement cf the use of resources in higher education, including the benefits to be expected from innovations in management methodology.

More specifically, the proposed program would serve four major purposes:

1. Provide better planning and management information for use *in the near future* by education and government.
2. Generate procedures for systematic evaluation of developmental studies directed toward the improvement of planning and management and for making their results available.
3. Assist institutions and governmental agencies in the appraisal, selection, and utilization of study results.
4. Improve the effectiveness of the Council's liaison and other advisory relationships with federal agencies and with developmental programs in management methodology.

The studies, although subject to change, are being organized provisionally in terms of four projects. Most of the work would be done through consulting or contractual arrangements with individuals and research centers at universities, or with private, non-profit research organizations, under the general direction of the Council's Office of Administrative Affairs.

Project I. Improvement in the Utility of the Existing Information System of Postsecondary Education

Although the primary emphasis in this project will be upon higher education, it would also include information concerning the noncollegiate sector of postsecondary education. The interrelations between these two sectors have become increasingly important as a result of the Education Amendments of 1972 and of a growing interest on the part of college age youth in noncollegiate types of postsecondary education.

The principal task would be to develop a classified, annotated inventory of existing pools of statistical data on postsecondary education available in governmental agencies at all levels and from private organizations. There will be a critical review of the status of the various bodies of information, in terms of their utility for purposes of planning, resource allocation, and other management functions. This assessment would cover the scope, adequacy and availability of the data within each source, and coordination among the data sources.

The project will develop a classification of the principal types of users and a set of key questions or needs for each class, to serve as a testing device in appraising the adequacy of the existing information system. The Council would act initially as a clearinghouse for inquiries concerning the availability and location of the inventoried data banks, leading to the eventual establishment of a comprehensive computerized reference center.

Project II. Studies of the Long-Term National Need for Postsecondary Education, Under Varying Assumptions Concerning National Goals and Resources

A central objective of this project is to update a crucial core of the analyses and projections included in the volume by John K. Folger, Helen S. Astin, and Alan E. Bayer, *Human Resources in Higher Education* (Russell Sage Foundation, 1970), extending the coverage to the non-collegiate sector of postsecondary education. Further, the plans are to "institutionalize" such a program in order to provide continuing guidance concerning the long-term needs for educated manpower.

The estimates of "demand" reflecting ideals of self-fulfillment for individuals and optimization of societal benefits are likely to differ considerably from those based strictly upon economic assumptions concerning presently foreseeable supply-demand relationships in the manpower market. Thus, the choice of alternatives will tend toward creating a condition of "self-fulfilling prophecy," and what is assumed as the basis for public policy and institutional planning becomes highly important.

The proposed project would cover two types of studies: first, a set of long-term "supply-demand" projections for the major fields of postsecondary education, supported by contributing authorities, and, second, an evaluative commentary upon the technical analyses (and other related investigations).

Project III. Comparative Analysis of Resource Use by Different Types of Institutions

The manifold inadequacies of the existing higher education information systems and the virtual impossibility of instituting basic "structural" and substantive improvements rapidly enough to meet short-range planning and management needs justify a study to determine the utility of existing institutional data on resource use for appropriate comparative purposes. The principal objective will be to provide information on resource utilization to administrative officers in relatively homogeneous classes of institutions, for guidance in evaluating the comparative effectiveness or productivity of their respective educational programs and supporting operations.

The primary task will be to assemble from groups of comparable institutions the following types of data: resource inputs, including personnel, physical capital, and financial resources; students and other clienteles; and outputs or other services. This information would serve as the basis for calculating indices of instructional "productivity" such as student-faculty ratios, teaching loads, space utilization values, and unit costs of outputs.

A range of expenditure figures for research and public service would be developed, also, as well as comparative data for the major types of supporting services.

Project IV. A Study of the Cost-Benefit Relations Involved in Applications of Management Technology in Different Types of Colleges and Universities

In the past, little attention has been given to the cost-benefit relations involved in management technology, although, ironically, a fundamental precept for management decisions is that they rest primarily on cost-benefit determinations. The question of what procedures should be adopted by particular types of institutions—and what the cost-benefit results would be—cannot now be answered on the basis of criteria derived from systematic investigation.

The main purpose of this project is to develop, apply, and evaluate a methodological approach and a set of procedures designed to answer such questions. In this effort, attention will be given to a number of problems, such as: (a) the existing status of the institution's "operational" data systems and its data processing capabilities; (b) the nature and extent of utilization of the "management information" currently generated; (c) the changes required to enable the primary data systems to meet operational needs adequately; (d) the procedures and resources necessary to determine the effectiveness of resource use; and (e) the generation of the information required for reports for external agencies.

Wherever possible, the American Council on Education plans to cooperate with other organizations in conducting this study. It is expected that several different types of institutions will be involved, in order to extend applicability of the results and to enhance the sensitivity of the entire higher education community to the need for evaluation of the cost-benefit implications of proposals to adopt particular types of management systems.

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