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ABSTRACT

Most college administrators are anxious to make use of management science techniques to assist them in operating their organizations. Despite their positive attitude, however, these administrators seem to lack a systematic method of approaching their specific organizations to decide which areas of application and what techniques should be introduced. This is due to a lack of understanding as to what is available, as well as the inability to assess what benefits and costs will be derived from the various efforts and what interaction exists between different applications. Also, there is the question of how the responsibility for analysis effort should be placed within the organization. Faced with these deficiencies, administrators in education have shied away from endorsing applications of management science in their organizations. This paper provides academic administrators with (1) a critical review of available tools, (2) a structure for considering possible analytical projects to be undertaken, and (3) the steps that should be taken by administration to ensure proper organization, planning, and control of management science efforts. (Author)

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Abstract

The authors have found that most college administrators are anxious to make use of management science techniques to assist them in operating their organizations. In this context, we are using the term management science to embrace a variety of techniques and disciplines including Operations Research, Systems Analysis and Management Information Systems. Despite their positive attitude, however, these administrators seem to lack a systematic method of approaching their specific organizations to decide which areas of application and what techniques should be introduced. Part of this lack of approach is due to a lack of understanding as to what is available. Another factor is the inability to assess what benefits and costs will be derived from the various efforts and what interaction exists between different applications. Moreover, there is the question of how the responsibility for analysis effort should be placed within the organization. Faced with these deficiencies, administrators in education have shied away from endorsing applications of management science in their organizations. We believe that a better perspective will lead to a much better implementation record in this area.

Our objective for this paper, then, is to provide academic administrators with (1) a critical review of available tools, (2) a structure for considering possible analytical projects to be undertaken, and (3) the steps that should be taken by administration to ensure proper organization, planning and control of management science efforts.

INTRODUCTION

It has been said that higher education is entering an era of crises; an economic crisis due to dwindling enrollments and rising costs, a crisis of public confidence and a crisis of student disenchantment [1]. These crises are making our institutions more difficult to manage and they call for improved management methods and procedures. A number of improved management methods come under the heading of management science. Unfortunately, the use of management science methods has not reached its full potential and there is a striking lack of understanding of the use of these techniques among university administrators [4]. This paper discusses how management science should be used and what it can do to improve university administration.

We are using the term management science (MS) in a broad sense to include such other terms as Quantitative Analysis, Operations Research, Systems Analysis and Management Information Systems. For our purposes the main characteristic of management science methods is the use and interpretation of quantitative data to assist in solving management problems. The key is quantitative data. In addition, MS may involve the use of a model or statistical analysis to provide, for example, a forecast or a prediction of outcomes. Our main topic then, is how can MS be used to help improve the academic management process?

In Section 1 the currently available techniques are reviewed. These techniques are discussed in terms of four major categories of management

science effort: (1) Planning, Programming and Budgeting Systems, (2) Management Information Systems, (3) Cost Simulation Models and (4) Mathematical Models. Some of the relevant experience that has been gained using these techniques is also noted. Section 2 lists the specific types of projects that could be adopted by an academic administrator. These are discussed under four major areas of administration: (1) faculty, (2) finance, (3) students, and (4) facilities. In Section 3 guidance for approaching the problem of using management science to assist academic administration is provided. This section includes prescriptions regarding the priorities of various studies, comments on organizational responsibility and review procedures.

Section 1: Reveiw of Management Science Techniques and Experience in Academic Administration

This review is a nontechnical survey of the MS methods which are available for university management. It is a broad survey intended to establish a point of common departure for the discussion later in this paper. More detailed surveys are contained in [20], [22] and [23]. For purposes of discussion, it is useful to identify four categories of MS effort: (1) Planning, Programming and Budgeting Systems, (2) Management Information Systems, (3) Cost Simulation Models, and (4) Mathematical Models.

One of the main purposes of a Planning, Programming and Budgeting System (PPBS) is to help relate the resource requirements of an organi-

zation to its goals [5] and [21]. It does this by presenting financial, budgeting and other resource information by programs which are defined according to the outputs of the organization. In higher education, primary programs usually are: Instruction, Research and Public Service. An output oriented budget (program budget) would display resource requirements by programs instead of the usual line-item categories of traditional budgets.

As noted above, this budget structure should allow an administrator to relate the various resources consumed to the outputs or benefits of each program and thus facilitate program tradeoffs and analysis. This differs considerably from the traditional budget purposes of control and measurement of the work-efficiency of operating units [21].

While considerable effort and publicity has surrounded PPBS in recent years, it is not clear that the advantages have been realized to date in actual practice. In the Federal Government, PPBS has had little impact, even though all federal agencies were directed to implement PPBS in 1966 [24]. In general, PPBS has never been integrated into the decision making process. The technical changes were accomplished but the managerial changes were not. In higher education, both the University of California [2] and Ohio State University have tried to implement comprehensive PPB Systems with disappointing results. Weathersby and Balderston [24] present a good review of experience through 1971.

It does not appear that the mediocre results noted above can be blamed on a lack of enthusiasm by top managers. At the University of California and especially at the Department of Defense, extremely active efforts were made by top management to make the PPBS work. The failures were apparently due, rather, to the enormity of the problems in reforming a bureaucratic system. It has just not been possible to force the use of the analytical information generated by a PPBS when the basis of decision making continues to be primarily political in nature. This leads us to question the basic utility of a PPBS approach except in a very sophisticated management system, and it emphasizes the need to explore other management science methods for improving management.

Another area of MS is the use of Management Information Systems (MIS) to improve university management. According to MIS designers, if management has better information then it will make better decisions. The MIS effort involves collecting, storing, and retrieving data not only on financial matters, but on such other management concerns as student admissions, registrations, space utilization and so on.

Much of the literature in the MIS area has been concerned with the conceptual and theoretical development of MIS. For example, [15] contains some excellent conceptual articles and a comprehensive survey of the MIS literature. In an article on actual MIS developments in universities, Kornfield [14] describes MIS projects at three universities: Utah, Ohio State, and Illinois. The article describes the systems, the costs, benefits and problems at each institution.

Our experience has indicated that information system issues are currently among the most important to academic administrators. The organizational nature of universities makes information system design both extremely important and very difficult. The current state of development is typically poor. Tremendous insights can be achieved by simply diagramming decision and information flows.

With respect to systems design a major issue is the total information system concept. This envisions a large centralized data base with very flexible report generating capability to "slice" and aggregate the data in a variety of ways. The University of Minnesota seems to have opted for a more decentralized view. They are emphasizing central administration assistance of individual units to develop their own information systems. We believe that two factors argue strongly in favor of this approach at large universities, at this time. One is the simple psychological factor that collected data is suspect unless it is your own. The other is that information must be integrated into the normal management system both for collection and dissemination.

Another issue is the one of common data element definition. NCHEMS[1] has developed a data element dictionary. The dictionary defines data terms in the areas of students, staff, courses, finance, and facilities. It serves as the basis of the NCHEMS program for common institutional data bases. The idea of common data definitions is a good one and should be adopted, to the extent that it is practical, in individual institutions.

[1]National Center for Higher Education Management Systems at WICHE.

The third category of management science effort is the recent development of large-scale computerized cost simulation models (CSM). The purpose of these models is to relate enrollment projections to the resources required in terms of faculty, staff, space and dollars. These models translate enrollment projections into costs by means of input factors such as student demand rates for courses and faculty-to-student ratios. They project or simulate the future costs of the institution for the given inputs.

Cost simulation models are usually quite large in terms of data requirements, they require a computer to perform the calculations and they are expensive to implement. There are three major CSM's currently in operational use, RRPM, CAMPUS and SEARCH. RRPM has been developed by NCHEMS and pilot tested at eight colleges or universities to date [6], [8] and [9]. This model is currently being actively promoted by NCHEMS. The CAMPUS model is similar in many respects to RRPM. It was developed at the University of Toronto and Systems Research Group, Inc. [11], [12]. It has also been implemented at several sites in the U.S. and Canada. Finally, SEARCH is a CSM which is available from the consulting firm of Peat, Marwick and Mitchell [13]. It has similar features to the other models.

Although CSM's have demonstrated some value in the improvement of institutional management, there has recently been concern expressed over the suitability of these models [7] and [18]. The concern centers around

the large amounts of data input required, the amount of detailed output generated, the fascination with computerization and the lack of analysis of key decision parameters. Large-scale CSM's will have difficulty gaining widespread acceptance until university administrators demonstrate a capacity and willingness to actually implement the outputs which are generated. We shall return to this point later.

Finally, there has been some significant work on the development and use of mathematical models. These models include prediction of faculty and student flows, enrollment projections, institutional cost analysis and optimal resource allocation models. This type of analysis tends to be much more technical than the preceding approaches and it is aimed at small scale operational problems, such as the effect of various enrollment ceilings on graduation rates. Each of these techniques can be considered for use in developing models to handle the needs of particular institutions. The main developments in this area have come from the Ford Foundation Program for Research in University Administration at the University of California, Berkeley. Some of the models developed under this program will be discussed below.

Mathematical models can be used for several purposes. First, they can predict student flows within a college or university based on historical or other data. A common type of model (Markov model) projects student enrollments by major and grade level for each of several periods in the future. These enrollments are based on historical (or other)

probabilities that a student in each particular major and grade level will continue in the same major, drop out or pick some other major. These probabilities are applied to current student profiles and projected inputs to predict student profiles for several periods into the future. Secondly, models can be used to predict faculty flows by rank and tenured or untenured status. Many of these models are Markovian in nature and they base projections on percentage type transitions in the same manner as the student flow models.

The remainder of the work done in the modeling area includes the development of production functions, optimization of resource allocation and analysis of topics such as year-around-education and retirement plans. A number of different such studies have been done. For details see [22] and [23].

Section 2: Potential Management Science Projects in Academic Administration

Based on a thorough review of all of the current analysis efforts, we believe that many academic institutions have common problems and could benefit from certain common types of analytical studies. These types of studies are outlined below to indicate the analyses that we believe should be considered in most institutions. The studies cover four areas of administration: faculty, finance, students and facilities.

1. Faculty Studies. There are two types of faculty studies which appear to have a potential for high payoff; (1) instruction outputs and

(2) tenure policy. With regard to instruction output, preliminary analysis at the University of Minnesota [10] indicates that there was a high degree of variance between academic departments. If output is measured in terms of student credit hours (SCH) per faculty member FTE, then it can be broken down into three factors:

$$\text{SCH per faculty} = \left(\begin{matrix}\text{Credits per} \\ \text{Section}\end{matrix}\right)\left(\begin{matrix}\text{Sections taught} \\ \text{per faculty}\end{matrix}\right)\left(\begin{matrix}\text{Students per} \\ \text{section}\end{matrix}\right)$$

Therefore, output of instruction could be considered the product of three policy control variables; average credits per section, average faculty workload in sections taught and the class size. Each of these three factors can contribute to observed variances in output between departments. These variances can then be analyzed to determine the causes and possible courses of corrective action.

A second area of potential faculty analysis is tenure policy. The specific problem here is the increasing number of tenured faculty resulting from declining or constant enrollments. Oliver [17] has shown from University of California data that with current promotion policies that almost all faculty will be tenured in the future. The problem is caused by high promotion rates to tenured positions relative to the loss rates of tenured faculty. When the inputs to tenure are higher than outputs from tenured ranks, the number who have tenure will increase. In the past, the number on tenure has increased, but the percentage of the faculty in tenured positions has not, due to expansion of enrollments

and the faculty as a whole. If the same policies are retained in periods of constant faculty size, then the result is a drastic increase in the percentage of faculty on tenure. Each university should consider initiating a projection of the number and percentages of tenured faculty under current policies and various alternatives. Such analysis would highlight the potential problems for resolution by faculty and administration.

2. Finance. In the area of finance the greatest discrepancy has been in the use of unit cost data for management control. In the business world it is second nature to depend on detailed cost accounting data. No one would attempt to operate a modern business without elementary unit cost data. Yet, a similar type of cost consciousness is just beginning to appear in university management. The essence of unit cost analysis in universities is a calculation of the cost-per-student credit hour of instruction and the cost per degree granted. For an excellent study on the development of this type of data at the University of Minnesota, see [10].

The benefits of cost analysis are twofold. First, an increasing emphasis on unit costs will bring out reasons for cost increases and decreases and hopefully some corrective actions. Secondly, analysis of the cost of degrees may bring about more equity between tuition charges and costs. There is currently such a movement in progress by the Minnesota Higher Education Coordinating Commission. Whether or not the recipients of a degree should bear a proportional cost of the degree by

tuition charges is not discussed here. But, the issue cannot even be addressed until the unit costs of various degrees are known.

3. Students. There are two potential areas of study for analysis related to students; (1) causes of student dropouts and (2) predictions of enrollments. The causes of student dropouts have not been extensively studied, according to Oliver [18]. However, only about 50% of students who enroll in four-year colleges graduate with a bachelors degree. Yet, we have little evidence of why students dropout and what can be done about it. One difficulty in doing this type of study is in separating vacationing students from those who dropout and never return. Thus a period of time is needed to determine whether a student has permanently dropped out or not. A second difficulty is in locating students after they have dropped out to determine the causes. These difficulties can be overcome, however, and the result can be a better understanding of this problem.

Student enrollment projection is also a potential area for improved analysis. Although enrollment projection is one of the first areas where analysis entered university life, many universities are still employing relatively crude methods [3], [16]. Why was the drop in engineering and secondary teacher enrollments not projected further in advance? These drops were largely due to the oversupply of trained people. Sophisticated methods can account for changing student preferences and job market conditions. Such projections are needed to form the basis for resource

allocation decisions and enrollment ceilings. Most universities could benefit from a centralized and systematic set of enrollment projections by majors to be used for all university planning.

4. Facilities. Finally, we believe that a type of space utilization study should be considered by most universities. An analysis of space utilization should be conducted by hour, day of the week and type of space (classroom, laboratory, etc.). Such a study may indicate that certain hours, usually late in the day, are under-utilized and certain days of the week may be under-utilized while others are strained to capacity. This type of data forms the basis for a review of scheduling practices and alternatives for improved utilization.

To summarize the possible studies to be considered and to give an indication of the effort required for the analysis, we have constructed Table 1. All of the studies are small, in our estimate, requiring less than one man year each to complete. However, these estimates are very crude, since the time required will depend on both the final scope of the study and the condition of the existing data base. In many universities, the data simply does not exist in the form needed and one must go back to source records to extract the necessary data. This is, of course, a time consuming process. We have also indicated in Table 1 whether the study should be considered as a one-time effort or a continuing program with updates on a periodic basis.

We must emphasize that all of the possible studies are relatively narrow in scope and are aimed at specific operational problems. We believe

Table 1

Proposed Analysis Studies

STUDY	SUBJECT	OBJECTIVES	INITIAL[2] EFFORT REQUIRED	TYPE[1]
1	Instruction Outputs	To exhibit high and low instructional output levels by departments and the associated causes.	3 to 9	C
2	Tenure Policy	To examine effects of current promotion rates to tenure and possible corrective actions	2 to 4	O
3	Unit Cost Analysis	To develop a system for calculating unit costs of instruction and cost per degree granted and to develop a means of using this data to control costs.	9 to 15	C
4	Causes of Student Dropouts	To discover reasons for dropouts and possible courses of corrective action.	6 to 9	O
5	Enrollment Projection	To provide a better basis for detailed enrollment projections by major field of study.	6 to 9	C
6	Facility Utilization	To examine usage by hours, day and type of facility and to develop improved scheduling practices.	3 to 6	O

[1]The type indicates one-time (O) studies or continuing (C) efforts.

[2]The initial effort is expressed in terms of man months of analysis time required to complete the study. The estimates assume that data is readily available in the form required. The time estimates should be doubled, if data is difficult to get.

that small studies of this nature will be much more fruitful than large efforts such as a PPBS or Cost Simulation Model implementation for most institutions. The reason for our emphasis is that these studies can be implemented within the present organizational environment and management system without changing the existing political relationships. However, PPBS and CSM's require system reform for success and therefore they are extremely difficult to implement, as evidenced by the successes of ten years of PPBS efforts.

Not all of the six studies need to be pursued at all universities. At particular institutions, some of these areas are already under good control while still other problem areas exist. In any case, the analysis program must be tailored to each institution. We have only indicated some fruitful areas which could have wide appeal and would provide a starting point for an analysis program.

Section 3: Implementation Issues

Now that we have indicated what we believe should be considered, it is necessary to comment on how it can be accomplished. Often in the past, analysis programs have failed due to a lack of perspective on how to implement analysis even though the analysis itself was quite good. It is, therefore, appropriate to review some of the common causes for failure of analysis efforts. Since analysis is relatively new in universities, it is necessary to draw on failure data from analysis groups in industry. We

believe that these lessons are general enough to apply to educational institutions as well. According to [19] there are three primary reasons for failure of analysis groups. This data has been collaborated by fifteen other studies of various types as indicated in [19].

1. The analysis group is improperly organized and staffed.
2. Lack of top management involvement and support.
3. Lack of implementation of analysis efforts.

These problems can be avoided by proper management attention and direction. The steps below with regard to organization, planning and control can be taken to insure a successful analysis program.

1. Organization. In order to insure access to top administrators, an analysis group should report directly to the President or Vice Presidential level of the university--no lower. Analysis is essentially a planning function and planning can't be done, at least on the type of problems which are outlined above, at a low level in the organization. An analysis group should consist of from 2 to 6 full-time analysts and some of the group should have operational experience in the institution--they should not all be new people, nor should they all be technical people. However, most of the analysts should have some formal training in quantitative techniques. It is necessary that the director of the analysis group have good communications with all management levels so that a concerted effort can be made to implement results.

2. Planning and Control. After an analysis group has been established, it is extremely important that their activities be planned and directed properly. Busy administrators feel that they should not be involved in the actual activities of the group and they easily lose control of the groups' output. To avoid this problem the following approach is suggested.

a. Approval by the responsible operating officer should be obtained on a project by project basis. This not only provides administrative control but forces the group to plan and carry out commitments. In a short time, management can review the objectives and resources required for each particular project. This type of project management approach has been widely adopted in industry.

b. The projects should be staffed with operational people. A group should be formed for each project with one or two analysts and several operational representatives from the offices concerned. Operational staffing helps improve the chances for implementation of the project recommendations. The chairman of the project group should be an operational person, not an analyst. It is not possible to impose analysis from the outside or from the top down. Analysis is only an aide to management judgment. Therefore, operating people should be leading these projects from the start.

c. Some type of charge-back system should be used to charge the costs of the analysis group to the various operational departments

concerned. If all of the costs of analysis are borne by the potential beneficiaries, the tendency for meaningful projects will be enhanced. There is nothing worse than "free" analysis programs. The charge-back system has been successfully used in many Operations Research groups and data processing efforts in industry.

d. There must be a review and evaluation system to monitor analysis results. Good planning requires feedback of results to correct errors in planning and to continually improve the project selection and planning process.

The approach to implementing an analysis program will necessarily vary somewhat from one university to another. The keys to success are organization, communications, planning, control and top management support. Such an approach is at least as important as the actual analysis which is undertaken.

Section 4: Summary

We have emphasized two major points with regard to the use of analysis in universities and colleges. Meaningful projects must be selected; six potential studies were outlined in some detail. At the present time, expenditure of large efforts in implementing PPBS and CSM's is contrary to the direction suggested here. More attention must be paid to operational problems which can be solved without reorganizing the whole institution. Our second major point is related to the management approach which should be employed to support an analysis program. We have suggested how analysis

can and should be monitored and controlled and how participation by all levels of management can be insured. We believe that this approach will be more beneficial than a number of other directions which are currently being pursued.

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