DOCUMENT RESUME

ED 067 019 HE 003 321

AUTHOR	Bolin, John G., Ed.
TITLE	Management Information for College Administrators.
INSTITUTION	Georgia Univ., Athens. Inst. of Higher Education.
PUB DATE	71
NOTE	84p.
AVAILABLE FROM	Institute of Higher Education, University of Georgia, Athens, Georgia ($1.50)
EDRS PRICE	MF-$0.65 HC Not Available from EDRS.
DESCRIPTORS	*Educational Accountability; *Educational Administration; *Educational Planning; *Higher Education; Management; *Management Information Systems

ABSTRACT

This booklet was prepared to assist college administrators in understanding the nature and purpose of management information and how such information can be organized into a functional system. In the first section the author discusses the increasing need for management information in higher education. More than ever before it is necessary for administrators to show efficient management, to be able to justify budget requests and state objectives that can be measured with concrete data. The second section concentrates on the transformation of administrative data to management information, and the third section discusses the concept of planning, programming, and budgeting as an effective management tool to assist administrators in their decisionmaking responsibilities. The final section of this monograph is devoted to planning models. It focuses on the use of simulation models to project hypothetical outcomes from the selection of different alternative courses of action a college or university might pursue. (HS)

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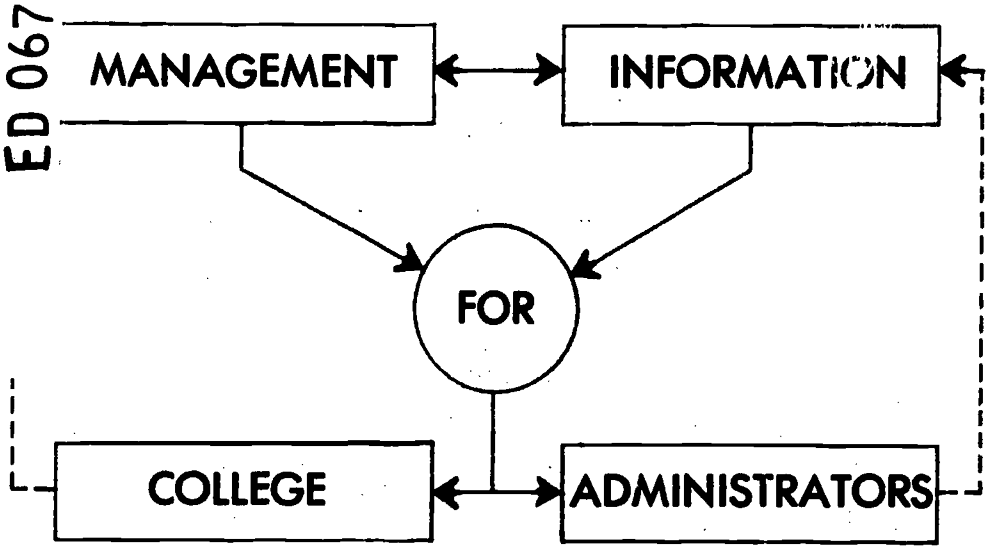

John G. Bolin

Editor

HE 003321

Institute of Higher Education

University of Georgia

ED 067019

MANAGEMENT INFORMATION

FOR

COLLEGE ADMINISTRATORS

John G. Boli..

Editor

INSTITUTE OF HIGHER EDUCATION

University of Georgia

Athens, Georgia 30601

1971

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CONTRIBUTORS

Gary C. Stock, Assistant Professor of Higher Education, University of Georgia

John W. Hamblen, Project Director for Computer Sciences, Southern Regional Education Board, Atlanta, Georgia

Edward P. Morris, Information Systems Specialist, The Center for Management Systems, University of Georgia

Fred H. Wise, Associate Professor of Management, Director, Center for Management Systems Design and Analysis, University of Georgia

INTRODUCTION

The organization and use of information is a crucial activity in the administration of today's colleges and universities. In the past two decades, institutions of higher education have grown both in size and complexity. Expanding instructional programs, increasing enrollments, greater service responsibilities and research commitments on the parts of colleges and universities require intricate planning and coordination within each institution to maintain a smooth operation and a continuous growth pattern. The delicate balance between planning and implementation is necessarily based upon information originating from all areas of the institutional setting. "Without systematic, accurate feed-back to management of the effects of its operations, an institution or system can waste its resources on ineffective or unnecessarily costly activities."*

With the continuing increases in costs, many college administrators find it is unwise, if not fatal, to spend their limited funds indiscriminately. Moreover, many of these administrators are being called upon to account for where and how the money is being spent. Unless they can validate their expenditures and show how such spending benefits the general program of the college, they risk being indicted for poor fiscal management and administrative procedure. To counter this potential threat, many administrators are searching for new ways to improve their decision-making efforts.

A way which is becoming more commonly accepted as an efficient technique for improving the operation of

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*"Objectives and Guidelines for the WICHE Management Information Systems Program," Western Interstate Commission for Higher Education, Boulder, Colorado, May, 1969.

the college is the development and effective use of management information. Only recently, however, have many college administrators begun to realize the benefits which can be derived from a comprehensive management information system. From the money aspect, for instance, the president can know at a glance not only how much money is being spent, but also he can determine from what sources the revenue was raised and to what activities it is being allocated. Expanding on this bit of information, the president may look for other information which will tell him how successful or how worthwhile an activity or set of activities were. Combining these two pieces of information, he will be able to evaluate the program and operation of the college more accurately, and ultimately be in a position to make better decisions and needed changes.

To assist college administrators in understanding the nature and purpose of management information and how such information can be organized into a functional system, the Institute of Higher Education is pleased to present the following series of papers.

In the first section of this monograph, Stock discusses the increasing need for management information in higher education. More than ever before it is necessary for administrators to show efficient management, to be able to justify budget requests and state objectives which can be measured with concrete data. MIS, he points out, provides a sound, systematic way in which tasks can be accomplished.

In the second section, Hamblen concentrates on the transformation of administrative data to management information. Administrators, he infers, must be well informed and must apply new and different management techniques to administration to meet the demands of the modern college operation. An efficient educational information system using all sources of information available is essential for the smooth operation of a complex institution.

In the third section, Morris discusses the concept of Planning, Programming and Budgeting as an effective management tool to assist administrators in their decision-making responsibilities. PPB, Morris points out, is goal or objective oriented, and can be most useful in helping to determine the optimum pattern for the allocation of the institution's resources.

The final section of this monograph is devoted to planning models. In this section, Wise focuses on the use of simulation models to project hypothetical outcomes from the selection of different alternative courses of action a college or university might pursue. The simulation model is an abstraction of the real world and allows for the development of equations which duplicate and illustrate what might happen in reality from the various decisions which the administration could make.

While this monograph treats but a small part of the world of management information systems, it can provide the reader with a better understanding of what management information is and how it can help the college and university administrator improve the efficiency and effectiveness of his administration.

These papers were originally presented during a program on Management Information Systems given at the University of Georgia in October, 1970. The original program was funded by the U. S. Office of Education under Part V-E of the Education Professions Development Act of 1967. It is hoped that this monograph will serve not only to illustrate the value of information based decision-making but to show also the value and impact of the Education Professions Development Act on higher education.

John G. Bolin, Editor and
Project Director

INFORMATION NEEDS FOR A COLLEGE'S INSTRUCTIONAL PROGRAM

by
Gary C. Stock

The expanding role and scope of university and college operations has diminished the top administrators' opportunity to "know" their students, staff, facilities, curriculum, and finances. Information systems of some type and quality are inherent in all institutions. Relevant information needed for sound decision-making becomes less accessible as the institution grows since the formal and informal information channels often fail to adjust and mature in step. Decisions are commonly made with incomplete or inadequate information if not, in fact, on the basis of intuition.

Although some of these decisions could be considered as sound, the administrator is sometimes overtly challenged to substantiate his decisions. When this challenge does occur, he is faced with the Herculean task of supplying supportive data. Often in panic, the administrator will call upon his staff to fight this "brush fire" by rapidly collecting information which supports his decision. By the time the first "brush fire" is under control, a second breaks out. _Ex post facto_ information is often of little value in the decision-making process. The effort expended in gathering data after the fact could be more effectively channeled into the establishment and maintenance of some type of management information system.

A Management Information System (MIS) is a formal or rational plan whereby administrators receive and transmit vital information. It is an attempt to match information needs with information sources. This, of course, is not an easy task when one realizes the difficulty of identifying (1) the precise location of the source of a decision, (2) the kinds of decisions a given administrator must make, and (3) the activities which each decision will affect.

An effective management information system offers a mode by which a decision-maker is provided with information he needs to know--when he needs to know it. It will, by its very nature, provide for an increased number of alternatives which are available to the manager. Since the decision-makers must consciously choose between the increased number of options available, a sense of institutional direction is enhanced, and effective long-range planning may become a reality.

While any definition of MIS implies organization with systematic data collection, analysis and updating, a good MIS does not necessarily imply computerization. Too often MIS and data processing are used synonymously. Many good information systems may be developed using non-computerized techniques such as the Royal McBee Key-Sort system or they may merely involve a well-organized filing system. The misconceptions about MIS involving computerization, nonetheless, have probably hindered the state of the art and have caused decision-makers either to shy away from MIS because of an insufficient understanding of the capabilities and limitations of data processing equipment or to expect miracles from the recently leased computer equipment. This paper, however, argues neither for nor against computer-based information systems but is concerned with some basic information needs of colleges, regardless of size. The desirability of electronic data processing will depend upon each college's situation.

Types of Information

At the outset, the differences between data and information must be understood. Data are the raw facts about a situation which are gathered through a variety of methods. Information implies the compilation and summarization of these data into some useable form. Useability and practicality are the important attributes of information and should be stressed. The information specialist, to prove the value of the system, must find the optimal balance between absolute detail (data) and absolute summarization. Often stacks of computer printouts on the desks of key decision-makers may suggest that good information is being used to assist in administrative judgments. Unfortunately, few decision-makers can use these printouts effectively because the data provided is too detailed and/or has not been screened to eliminate the irrelevant and obvious--the information is missing!

The American Accounting Association, in setting forth its statement on basic accounting theory, developed four basic standards to be used in the evaluation of data. These standards, which would also apply to management information, are concerned with relevance, verifiability, freedom from bias, and quantifiability. In the collection of data, we should be sure that (1) it is current and applicable to our problem, (2) we can return to our data source and retrieve the same information again, (3) it is as free from bias as possible, (4) it is or has been measured to the best of our ability.

Information may be classified into at least five dichotomies which can prove useful when planning a system: Action vs. Non-action; Recurring vs. Non-recurring; Documentary vs. Non-documentary; Internal vs. External; and Historical vs. Future.

1. Action vs. Non-action -- Is the information selected to be used in making judgments or is it merely interesting? Sometimes we tend to put extensive effort into the collection of information which is not important to the functioning of the institution. This frustrates the efforts to collect valuable information, e.g., space utilization data versus data on blue-eyed students. It may be very interesting to discover how many blue-eyed students are on campus and their particular characteristics, but the time could certainly be more meaningfully spent on an analysis of office and classroom utilization. For instance, is a new classroom building needed or would more effective scheduling techniques alleviate the space problems on campus?

2. Recurring vs. Non-recurring -- Will the information recur or is the situation unique, e.g., enrollment data vs. the initial reactions of students to the first moon walk? Recurring information such as enrollments by department may be gathered after careful planning and should become an almost automatic procedure which can be accomplished with a minimum of effort after the collection problems have been resolved. The collection of the non-recurring information mentioned above, however, would have to be carefully planned before the data were ever collected for there would be no opportunity to repeat its collection while maintaining the validity of the study.

3. Documentary vs. Non-documentary -- Is the data retrievable from official written sources or must it be gathered through informal or unstructured situations? Both types of data require careful planning before their collection, but the actual collection of documentary data usually requires less effort. A student's biographical data found on his transcript would be considered as documentary information, while data gathered on student attitudes concerning the campus environment can be considered as non-documentary.

The collection of documentary information usually lends itself to some type of system whether automated, semi-automated, based upon the key sort system, or on an efficient filing system. A different modus operandi is obviously required for each type of data. A study based upon non-documentary data, which usually demands a substantial degree of experience and expertise, often yields questionable results because of the collection techniques used (interviews, questionnaires, survey instruments, etc.). In general, people feel more confident about studies which are based upon documentary information.

4. Internal vs. External -- Is the data gathered from internal or external sources? Is the information for internal use only or for a report to an external public? If the data needed for a system involves collection outside the college, the task may become a formidable one since the source of the data is not under direct control of the college. The success of the data collection from an external source will depend upon data availability and the cooperation shown from this source. Since all agencies are being asked to complete a large quantity of questionnaires every year, it might be advisable to exhaust all routine sources of information, such as the U. S. Bureau of Labor Statistics or the U. S. Office of Education, before contacting an outside agency to determine if this information has already been collected in an acceptable or useable form.

As many college administrators are aware, a great deal of information is needed by outside agencies. While often not legally required to provide this information, institutions are compelled to cooperate since the information provided may be directly related to the acquisition of federal or state funds. The systems analyst or institutional researcher must also plan for the information needed by the governing boards of the institution.

5. Historical vs. Future -- Is the information for historical purposes only, or will it also be used for future planning? The construction dates of various buildings on campus, for example, are obviously historical in nature. Historical information usually involves a one-time collection and may be filed away for use in public relations, speeches, or publications. The collection of information relating to departmental enrollments, on the other hand, may be used for projecting space needs five years hence. This kind of information requires updating and validation. Comparing next year's actual enrollment with the enrollment projections in the long-range plan will serve as a check on the accuracy of the projection method and will allow for adjustments where necessary.

Information Needs

Many aspects of a college's operation need analyses for effective decision-making. College personnel often ask, "What information or data must I collect for an effective information system?" This question, of course, cannot be completely answered by an outside consultant or "expert". Since the information needs of a particular college will depend upon the characteristics and goals of that institution, the final selection of specific data elements must rest with those who are responsible for the decisions within each institution.

A list of possible information needs should be available to any intra-institutional MIS team so that the relative merits of each piece of data may be discussed. A comprehensive data element list has been compiled by the Western Interstate Commission on Higher Education (WICHE) and is available from its Boulder, Colorado office as a series of Data Element Dictionaries. These technical reports consider, in detail, data dealing with students, staff, facilities, finance, and courses. These dictionaries and their related literature are strongly recommended for any college contemplating the establishment of a functional management information system.

Other sources for helping colleges identify specific information needs are the myriad questionnaires and survey instruments which are foisted on them by numerous accrediting associations, governmental agencies, doctoral candidates, funding agencies, etc. These questionnaires deserve careful consideration when an information system is being designed. In some instances, adequate funding of special programs will depend upon whether requested information is provided by the college. If this fact is kept in mind when designing an information system, the data needed for the completion of these instruments can be woven into the general structure of the design.

It might be helpful to look at various aspects of a college in isolation even though we realize that relationships do exist. A schematic diagram of a student-based model of a typical college is shown in Figure 1 to facilitate the conceptualization of needed information for the instructional program. This diagram is an adaptation of a model promulgated by WICHE.

We might consider the nine different areas illustrated in the diagram as the primary ingredients in a management information system. While there are at least six resource inputs which have been identified by WICHE, this discussion will deal with only three. One of these inputs, which is considered as most important by the author, deals directly with the student--for without the student, the institution would not exist. College personnel need to make every effort to understand their student body. Basic student biographical information is a prerequisite for any type of meaningful long-range

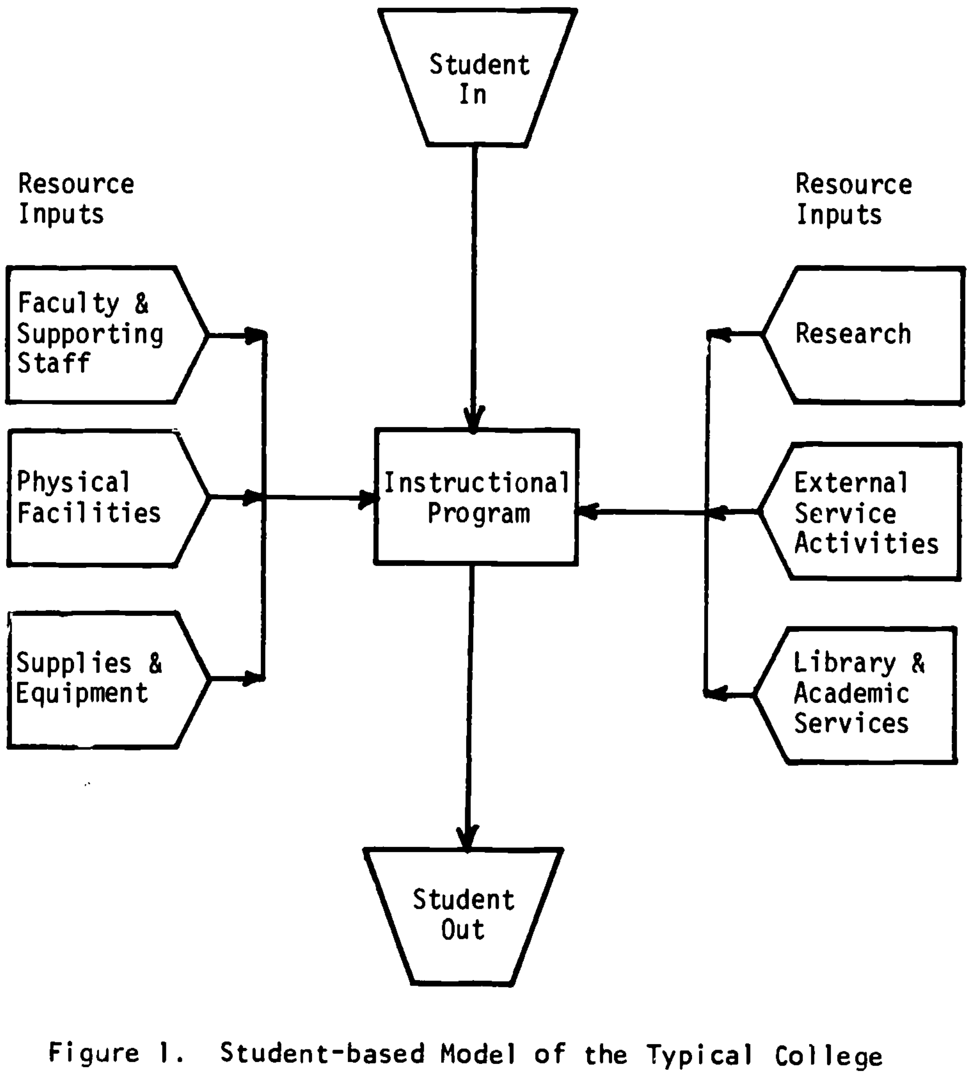


Figure 1. Student-based Model of the Typical College

planning or program evaluation. Collection of other student variables such as past academic performance, career plans, current enrollment status, and perceptions of the college environment are ingredients which should not be overlooked. The information specialist should be aware of the need to collect student data which may prove beneficial in the evaluation of the college experience. In order to measure educational outcomes, we must have knowledge about the student when he initially enters the institution to establish an information base which may be used to measure growth.

It was extremely difficult to conceptualize which resource input should be classified as second most important or needed because of the interdependencies underlying the information model; the instructional program, for example, is determined by the type and quality of faculty, adequacy of physical facilities, quality of library and support equipment, etc. However, since most colleges seem to be suffering from chronic space shortages, the second most important input might be considered as that pertaining to physical facilities. How well are the classrooms being used? Does the class size coincide with the scheduled classroom size? Are classes scheduled uniformly throughout the day or are the majority of the classes scheduled between 10 and 2? Are classes scheduled uniformly throughout the week or is there a preponderance of classes scheduled Monday, Wednesday, and Friday with few classes scheduled Tuesday and Thursday? These and other similar questions must be resolved if the college is to realize the maximum utilization of its available space.

One way to find the solutions to these questions is to collect and process information relating to the utilization of space. A space utilization study requires data which is relatively easy to gather. The methodology is uncomplicated. The task is basically one involving the compilation and analysis of data which probably has been collected by various offices on campus. A physical inventory of all classrooms on campus, however, will be required to document their dimensions, the number of student stations (chairs) in each, and any classroom anomalies. It is not uncommon to discover one or two classrooms which the scheduling office knows nothing about. Classrooms do get "lost" because of clerical errors or building modifications. The inventory can be used as the source document to construct a master schedule of space allocation and utilization. The master schedule and class lists in turn are used to determine when each classroom is in use and the number of students in each class. It is then relatively easy to construct a "use" table for (1) each classroom, (2) each building, and (3) the total campus. The administrator may then, at a glance, determine which classrooms and buildings are being used efficiently and where the scheduling can be improved.

Although faculty mobility is not as an acute problem today as it was five years ago, there is still considerable value in knowing the composition or characteristics of a college faculty. A president or dean frequently will need to know the percentage of faculty who hold doctorates, who are women, who are black, etc. Although this information is not always needed in the decision-making process, it might prove quite valuable when applying for grants or increased funding from the governing boards.

While this brief paper on information needs may not have completely answered critical questions posed by the reader, it is designed to convey a general feeling for management data which must be present before any specifics are attempted. Many publications are available in the field which are readily accessible and any serious attempt to identify management information needs should include some library research. The WICHE publications should prove to be an excellent initial information source.

FROM ADMINISTRATIVE DATA TO MANAGEMENT INFORMATION

by
John W. Hamblen

Administrative Data vs. Management Information

According to Webster's definitions, management, "the judicious use of means to accomplish an end," is a much stronger term than administration, "the act of superintending the execution, use or conduct of ...." "Judicious" implies "discerning" or "well-advised," i.e., that the necessary information is available before decisions are made regarding the "means." Such information is properly called "management information." Management information, if it is to be useful, must usually be concise summaries, analyses, digests, charts, etc. of volumes of data generated at lower levels in the administrative heirarchy.

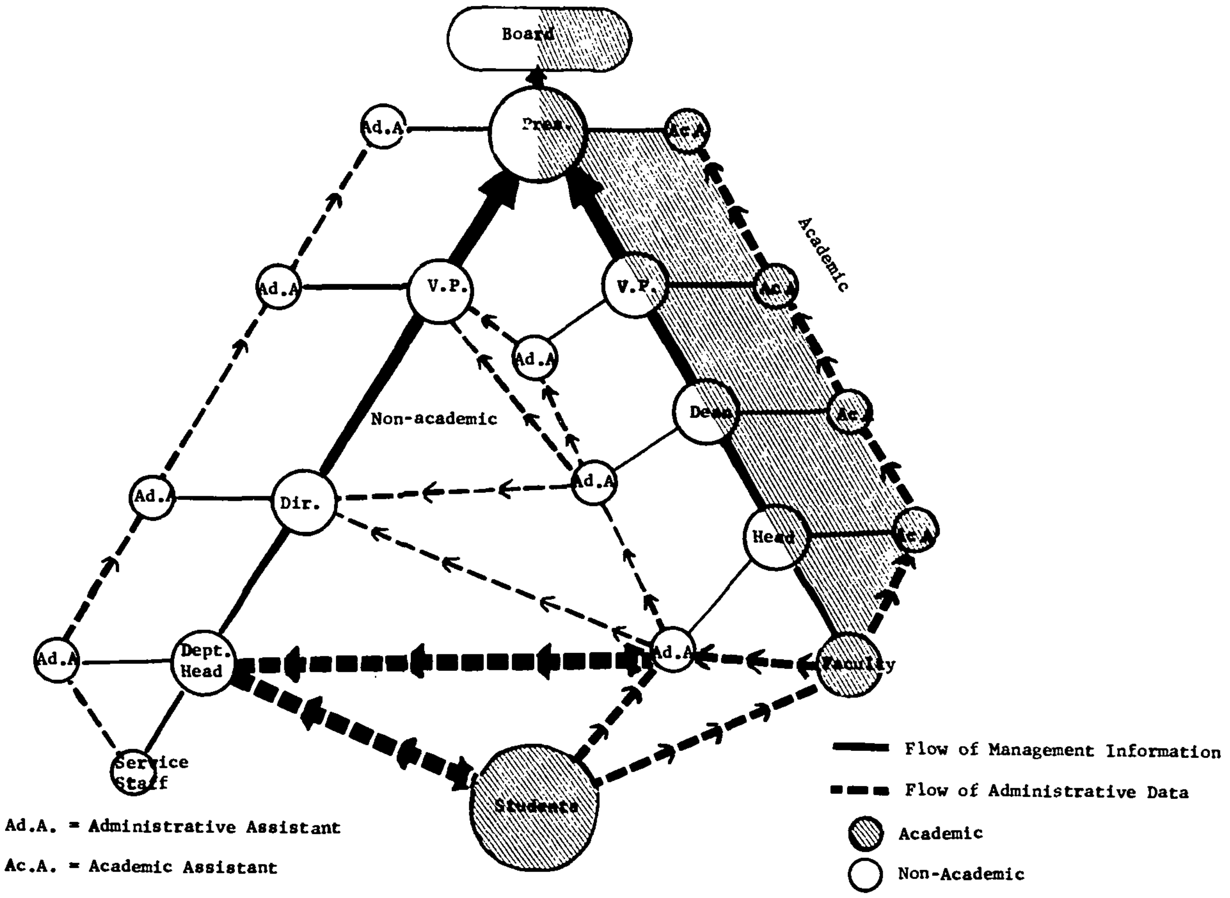
The distinction becomes clouded because one level is looked upon as management by those two levels below it but as administrators to those in the level directly under it. Administrative data consists of the data used on a day-to-day basis for operations at one or two levels of the heirarchy. The complete data set is likely to reside permanently at these levels, whereas summaries, exception reports, analyses, subsets, etc. are generated from it and passed to higher levels to become management information. For example, the president of a large university would not be interested in seeing the complete registration file on the 20,000 or so students in his institution, yet this file is massaged and queried daily by the registrar's office and others. On the other hand, the president must see certain reports generated from this large data set in order that he may make "well-advised" or "judicious" use of the means placed at his disposal to accomplish the goals (ends) of the institution.

Flows of Administrative Data and Management Information

Figure 1 is an attempt to describe the general flow of the bulk of administrative data and management information. The width of the connecting lines is roughly proportional to the amount of data or information flowing. The flow of administrative data is heavier near the faculty and students whereas the management information flow is heavier near the president.

On the academic side of the chart it is emphasized that the administrative positions from department head to the president and board must have dual concerns with both academic and non-academic matters. The degree to which they are able to maintain a proper balance as to understanding and appreciation for the relative importance of the two, in any given instance, measures their success in these positions. The chart suggests that in large institutions this balance may be obtained by the proper choice of assistants.

The chart in Figure 1 is representative of the medium-sized institution only. The non-academic area shrinks considerably for the small institution and the flows should be quite simple to depict graphically. However, in the case of the large university the non-academic side becomes quite complex and the line between academic and non-academic concerns is not always visible. Indeed there is much overlap in the administrative data needs in today's university organizations. This often leads to development of duplicate data systems which are often incompatible.



Ad.A. = Administrative Assistant

Ac.A. = Academic Assistant

Figure 1
Primary Flows of Administrative Data (horizontal or zig-zag) and Management Information (vertical)

Roles of Management and Administration

Much has been written about the roles of management and administration in higher education. Numerous experts in the field have tried to define, delineate, and otherwise pin down exactly what management is and what it does. Baughman and Brady (1) in reference to Shelly Berman's, Cleans and Dirtys, suggest that "university management" is a triplodirty (where one clean plus one clean makes a dirty).

Parden (2) states in his introduction, "The term 'management' has traditionally been considered the very antithesis of the community of scholars concept (of a college). This concept holds that no one person, or group of persons should 'manage' anyone in this cooperative endeavor." This is softened somewhat if the role of management for a college or university is understood to be that of creating and maintaining a proper environment for learning.

Baughman and Brady (1) point out that "The university since its inception has had the primary objective of conserving, augmenting and promulgating all higher knowledge.... A collateral objective of the university has been to provide an academic environment for the secure and pleasurable pursuit of knowledge."

Frantzreb (3) states that "Trustees must function to be effective but they must function at the policy level--informed, understanding--. The human tendency of presidents to insulate trustees from the facts of institutional life must be watched carefully by trustees to assure that all facts and facets are fully disclosed, preferably in advance of crises."

In an earlier paper on institutional research and systems analysis (4), I cautioned that "The creation and maintenance of efficient educational data systems demand teamwork on the part of all personnel in the institution and particularly of those who are in key positions with respect to data origination and flow."

Pinnell (5) stresses the importance of setting objectives for the institution and allocation of resources based upon the results of analytical studies. He says "I strongly believe that a large measure of the solution to our mounting problems in higher education may be found in the proper application of scientific management techniques to college and university administration."

Bagley (6) noted that "The role of institutional research in the formulation of policy is an advisory function...." "The advisory role is to faculty as well as administrative planning, but the administrative side has in the past been given the most emphasis. The role of institutional research in internal evaluation, as to policies and their implementation, has placed institutional research as a planning as well as an evaluation function."--"There is a concern for planning and operations, these cannot be done without information, there still being a serious lack of continuity in data gathering and analysis."

Chaney (7) discusses at length the role of administrative-systems-analysis and data processing in policy-making. With regard to systems analysts he says "The effective use of data depends on an ability to analyze relationships and present alternative courses of action to policy makers," (i.e. to create management information from administrative data). "This analytical ability is of a high level generally found in the systems analysts with a background in systems engineering and management sciences." He says, in effect, that although the processors and users of administrative data and the creators of management information are supportive in nature and do not establish policy, the interactions with higher-level systems analysis are not always clear and to the extent that they are not clear, their affect on policy is also not clear. Further he charges, "The way in which management chooses to use administrative-systems-analysis data-processing support services has much to do with the way in which policy is affected, since management objectives are reflected in the kind of systems implemented."

Ziegler (8) distinguishes between management and administrative personnel, "The former are charged with the responsibility to formulate policy and to make decisions which may have significant effect upon the direction of an institution. Valid decisions are usually best made when management has available enough information to adequately assess alternatives. On the other hand, administrative personnel may be viewed as implementers of policy decisions. It is they who deal with day-to-day operations and also provide information required by management."

Casasco (9) presents twenty-one case studies on "Developments in Computer-Assisted University Planning." Almost three pages are devoted to each of the models. The following general outline is used to summarize the nature of the models.

Objectives
Scope
Method
Findings
Applications
Limitations

As John Caffrey states in his foreword, "Juan Casasco's report serves a simple but useful function. It permits the academic administrator to find out what progress has been made, on a variety of campuses, in using computers and systems analysis in academic administration."

Management of colleges and universities must work toward improving their administrative data systems in order that the requirements for management information may be met completely, swiftly and accurately. Such techniques as PPBS (Planning, Programming, Budgeting Systems) demand this and external pressures are beginning to support its use. As James Farmer (10) points out, "It is reasonable that public representatives would now ask for program budgets hoping to get an explicit statement of objectives, measures of effectiveness, and costs by program."

Also much is being said and written about cost-effectiveness and cost/benefit analyses. Keller (11), in one of the many fine papers sponsored by the Ford Foundation supported Research Program in University Administration at the University of California, Berkeley, discusses measurement with regard to the instructional process. "Measures of 'benefits' (as opposed to those of effectiveness and output) can now be thought of as the longer-term assessment of the quantity and quality of outputs using external, less academic, more total measures of the economic, social, and personal attributes of alumni." He goes on to suggest fourteen "proxy measures of the benefits of the instructional program" of a given institution. In another paper in the same series, Balderston (12) says, "All of us have reason to be concerned about the costs and resource requirements of higher education....But we have bumped hard into the question of output and its measurement because, among other things, we are seeking now to link the resources used to the results achieved...in other words, to link inputs with outputs." These two papers review many of the difficulties encountered in defining measures of output, yet higher education management must improve its arguments for increased budgets.

To do this, management must continue to improve the institution's administrative data systems so that better management information can be provided.

Roles of Administrators, Systems Analysts, Programmers and Operators in the Development and Maintenance of Administrative Data Systems*

The evolution of computer hardware and software to their present state, along with the ever-increasing demand for administrative data processing, has imposed specialized roles on many people involved with data processing. This is particularly true in the large institutions. Prior to the production of medium to large scale computers and their associated software in the form of operating systems programs, schedulers, etc., data processing personnel functioned as jacks-of-all-trades. When contacted by a representative of administration, one person would perform all tasks such as the analysis of the problem, reproducing, interpreting, control panel wiring, programming, computer operating, and finally he would serve as a consultant to the administrative office--the one and only expert on the procedure which he himself had created. This system may be suitable for the small shop, but for an integrated data system to be achieved by a large institution, there is a critical need to efficiently utilize both man and machine. In such a system, it becomes necessary to have analysts who analyze, programmers who program, operators to operate, and computers which process information from central data files that cross all departmental lines. Of course, it is desirable to have people who are capable of all functions but operationally it is necessary for them to perform specialized duties.

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*(This section is comprised of a revision of papers by Oldehoeft [13, 14] and Hamblen [15].)

Systems Analysts must have a complete understanding of the needs of Administration. This group is the contact point for Administration and must resolve differences in interest and avoid redundant effort. (See Figure 2). As liaison between Administration and Programming, this group must understand the data files and advise on purposeful and constructive use of the information. Once an application is agreed upon by all administrative parties concerned as one which strengthens the integrated information system, Systems Analysis creates the document of specifications which is passed on to Programming.

The Programming Group has the most intimate knowledge of the basic hardware and structure of the data files. It is their responsibility to implement the application on the existing hardware. The task of the Programmer is lengthy and arduous and necessarily dedicated, requiring numerous test runs on sample data before the last known "bug" is eliminated. Because their job depends on the peculiarities of the computer and the structure of the data, it becomes necessary for Programming to have a close working relationship with Systems Analysis. Unanticipated problems requiring new analysis may arise during the programming stage. After documentation is completed, including the preparation of operating instructions, the application is turned over to the Operations Group for the production stage.

The function of the Operations Group is indeed large and important. As operators of all machines, this group must schedule and run all new requests for production as well as those already scheduled. In addition, Operations must handle test runs which are requested by Programming on new programs since these test runs are necessary to develop the production of the future. Peak loads occur and must be resolved in order for the Administration to

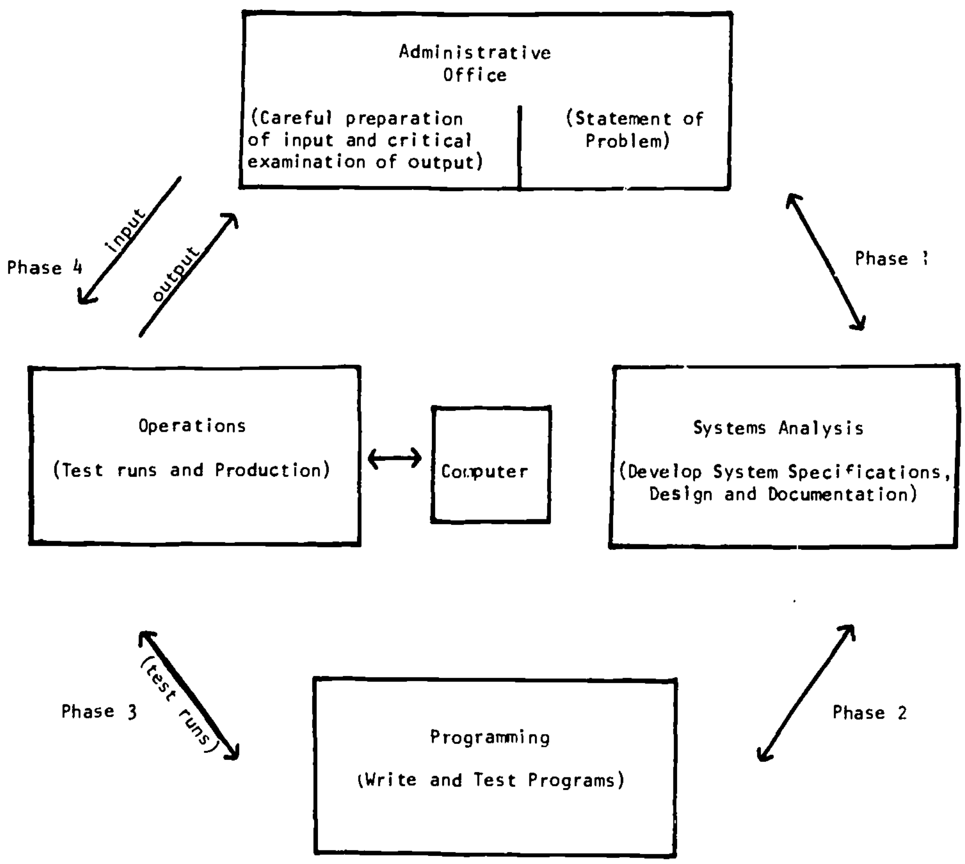


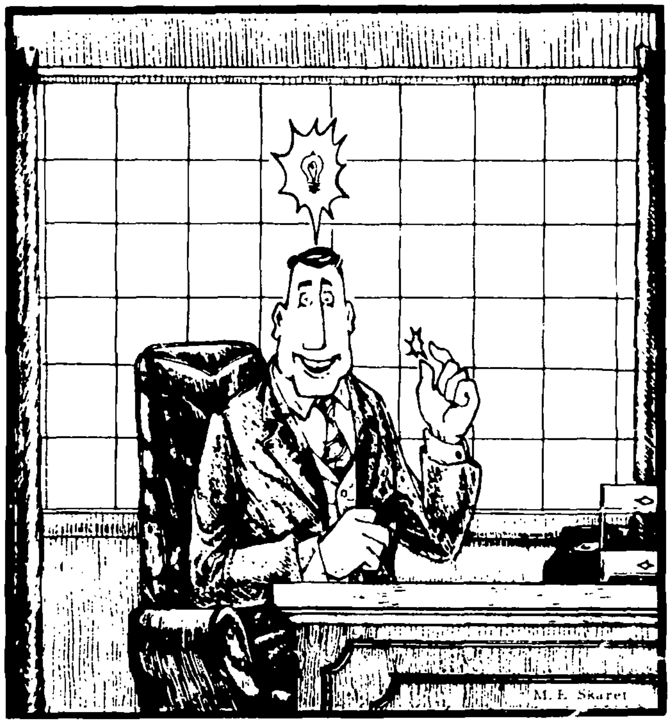
Figure 2. Major Functional Responsibilities of Administration, Systems Analysis Programming and Operations

continue its daily operation. Production results are returned by Operations to the respective administrative offices for final inspection.

Finally, it may be desirable to modify the existing application in order to obtain more or different results. Once again, Administration contacts Systems Analysis who again investigates the request in light of the integrated information system. Depending on the severity or complexity of the change, each group must devote time and effort to implement the modification.

Figure 2, shown earlier, and illustrations 1-12 are two ways of depicting the relationships among the functions of administration, systems analysis, programming, and operations. Figure 3 utilizes the flow chart, a common technique used in data processing planning, for still another way of presenting these relationships. (The illustrations were drawn by Michael Skaret while a student employee of the Data Processing and Computer Center of Southern Illinois University).

ADMINISTRATION CONCEIVES IDEA FOR IMPROVEMENT IN INFORMATION SYSTEM



"Hmm, I wonder if ..."

ADMINISTRATION CONTACTS SYSTEMS ANALYSIS

"I've got this little problem for you."

"Oh?"

SYSTEMS ANALYSIS CONFERS
WITH ALL PARTIES CONCERNED

"Yes that's fine with us, except ..."

FINAL SPECIFICATIONS ARE AGREED
UPON BY ADMINISTRATION, SYSTEMS
ANALYSIS, AND PROGRAMMING

"As soon as we get this typed up
it will be ready for programming."

APPLICATION IS READY FOR PROGRAMMING

"This is urgent!"

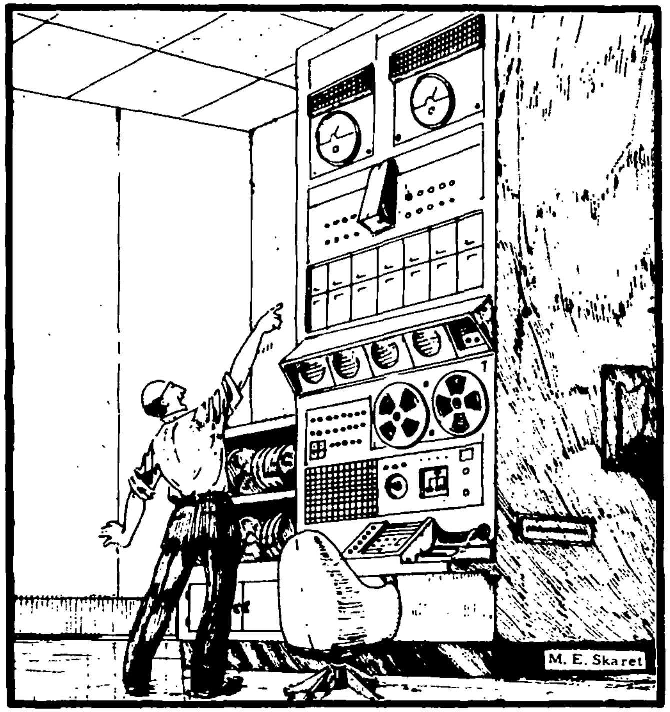
PROGRAMMING MAKES FINAL CHECK WITH SYSTEMS ANALYSIS AFTER PROGRAM IS WRITTEN AND TESTED

"Are you sure you got all the bugs out?"

APPLICATION IS READY FOR PRODUCTION SCHEDULING BY OPERATIONS

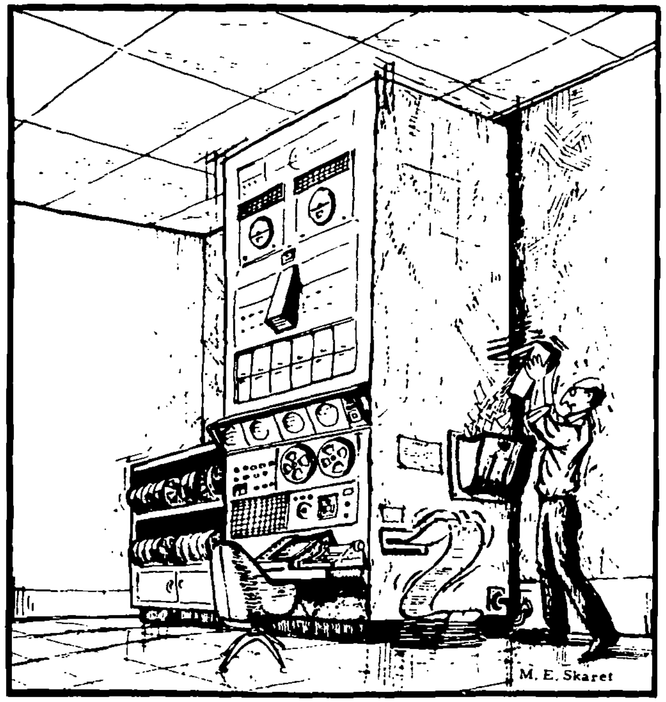
"When can you schedule this new job?"

OPERATIONS SETS UP THE COMPUTER FOR PRODUCTION



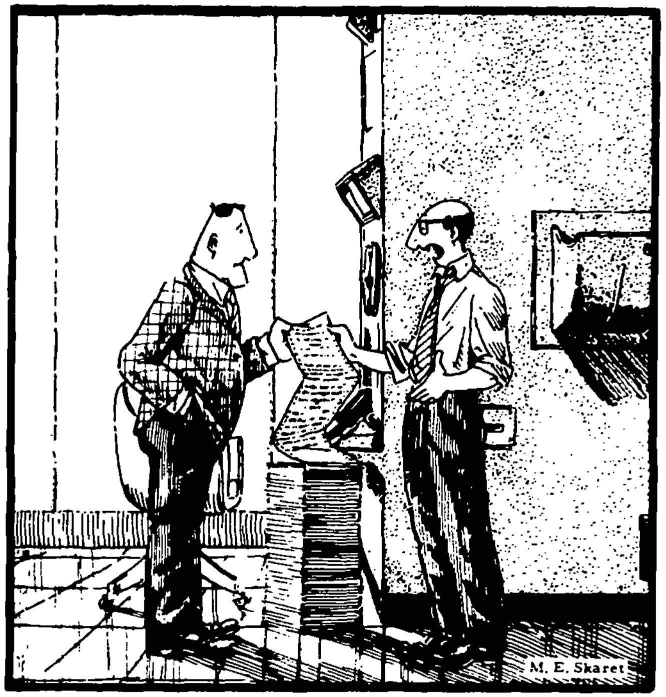
"Remember, you're nothing
till I give you the program."

PRODUCTION



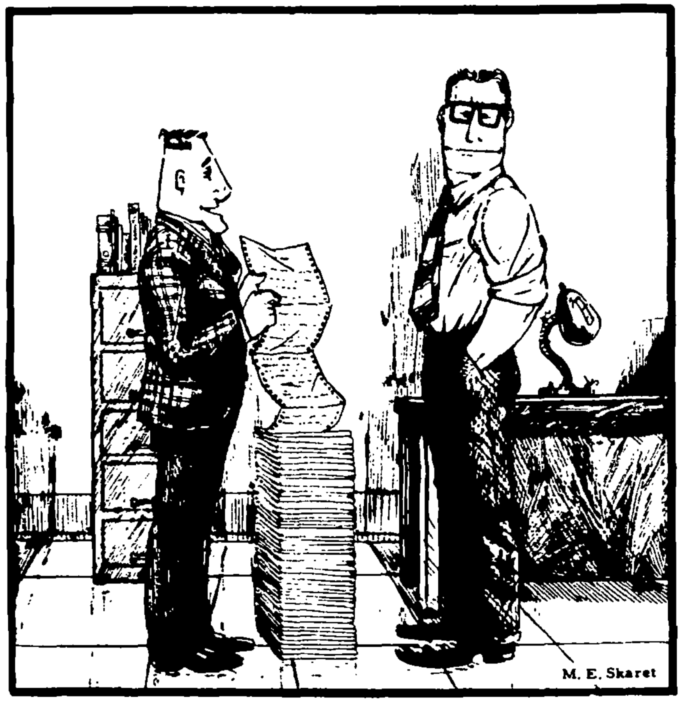
"Go man, go!"

ADMINISTRATION EXAMINES OUTPUT



"It looks all right to me,
but if anything looks suspicious
call Systems Analysis."

ADMINISTRATION DESIRES
CHANGE IN SYSTEM



"I've got this little problem for you."

GO BACK TO 3

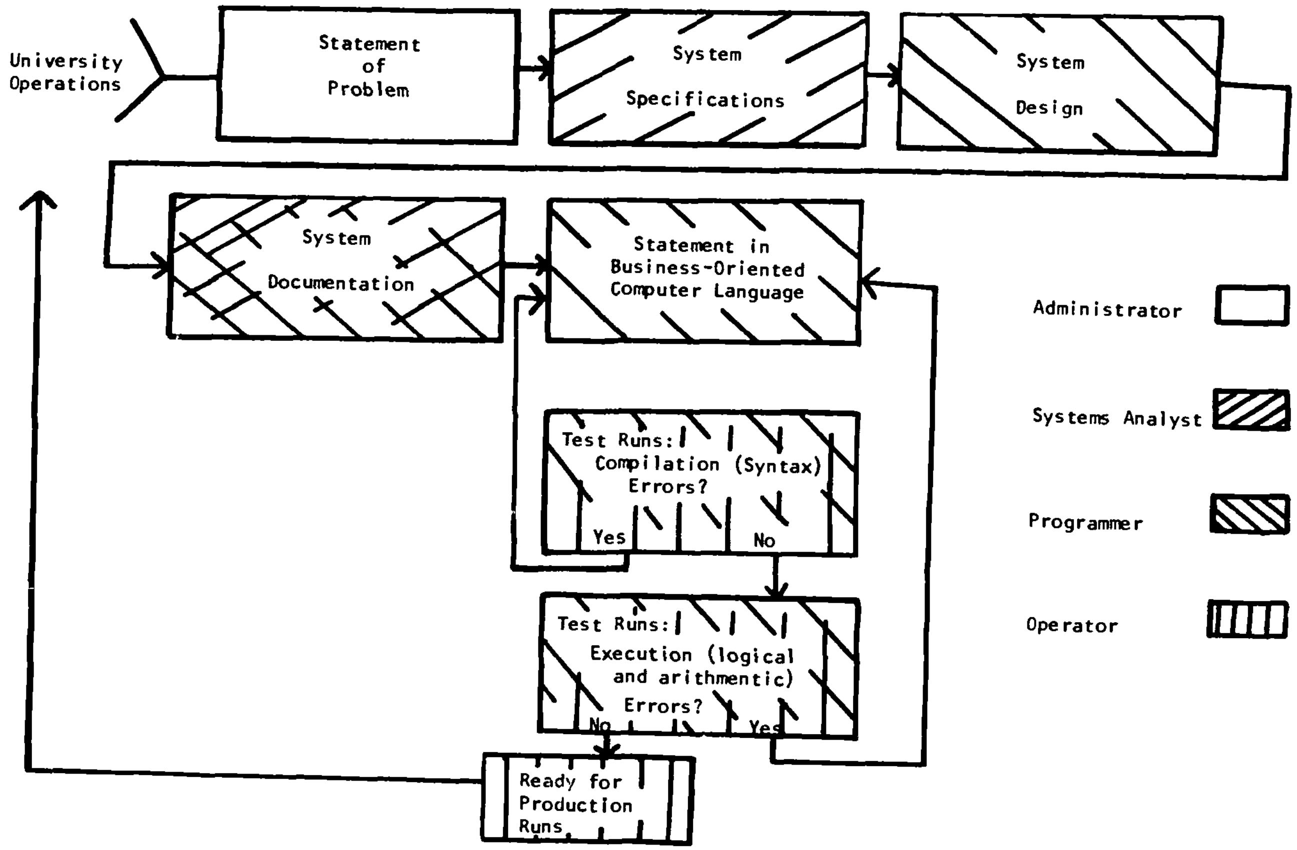


Figure 3. Flow Chart of Steps to the Creation of an Administrative Data Processing System with a Computer

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PLANNING, PROGRAMMING, BUDGETING

by
Edward P. Morris

Probably one of the most highly-publicized prospective tools of the modern educational administrator is the planning, programming, budgeting system known as PPBS. This has come about through federal influence and is currently attracting considerable attention of the "ivory towers" group. It is among the newest management concepts in higher education, and represents a significant step forward in the drive to improve and streamline college and university administration. Yet because of its novelty and the dynamic action which it has tended to foster, PPB has taken on somewhat of the halo of a panacea or cure-all for the many problems and dilemmas presently facing higher education.

The development of PPB in higher education has been by a rather sly and devious route, as indicated in Figure 1. It started in New York City in 1912 and slowly developed in the federal government. This resulted from efforts to achieve more rational and efficient congressional decisions in national programs. By mid-century, the representatives of the people of the United States accepted the principle of program budgeting. As the result of a RAND study for the Air Force in the early sixties, it gained a firm toe-hold in the Department of Defense. In the fall of 1965, a presidential mandate was issued to all federal agencies to gear themselves to apply PPB to the management of their programs. State and local governments stimulated by the apparent success at the federal level have joined the current efforts to change over to program planning and budgeting.

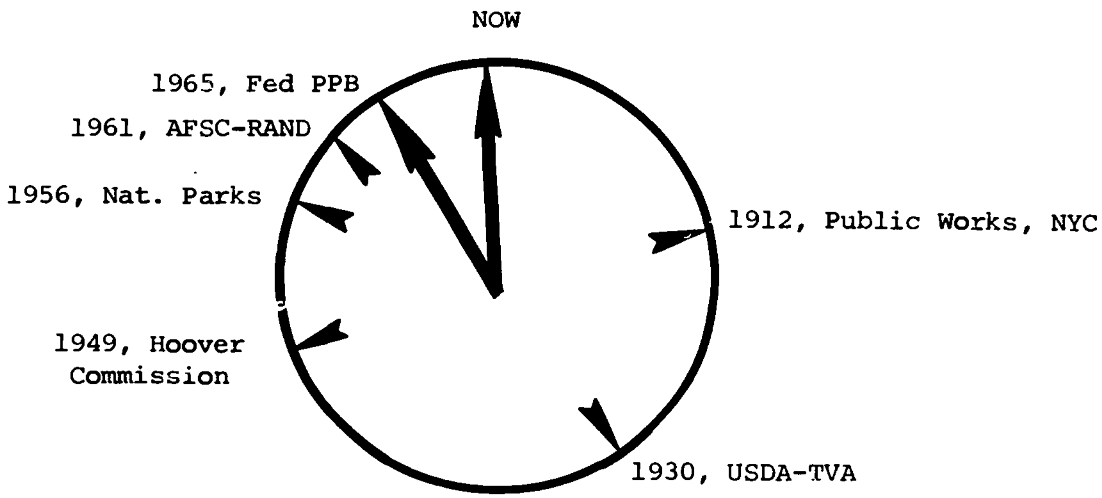

Figure 1. Program Budget Clock

Business and industry also have seen obvious benefits in management by objectives and program planning. For one thing, it gives them a better idea of the effectiveness with which dollars are spent. In this regard, many businessmen have been directly exposed to the advantages offered by the planning, programming and budgeting process. Numerous others have been indirectly exposed to the terminology and techniques through national and state associations and publications. As a result of these experiences, they are starting to question public expenditures of tax dollars.

Still, not all pressures are being applied externally. Internally we see the "community of scholars concept," which really hasn't been compatible with anyone managing anyone! In this environment, the efforts of an organization would be at best the random expression of individuals. Politics and the "squeaking wheel" principle tend to govern the allocation of available funds. Consequently, there are usually more "traditional" courses and "pet" projects than there are funds to support them. Innovative programs, without "new" money to support them, die a horrible death. So we can see that pressures to apply PPB are also internal. In the heart of each one involved in college and university administration, beats the hope that here at last is something to provide a handle for grasping an increasingly complex situation.

Before moving into what PPB is, and how it can help the college administrator improve the operation of the college it might help to examine those things it is <u>not</u>!

First, PPB is <u>not</u> a substitute for the experience, the intuition, and the judgment of the decision-maker. Its aim is to sharpen that intuition and judgment by stating problems more precisely, by discovering new alternatives, and by making explicit the comparison among alternatives.

Second, PPB is not decision-making by computer. Decisions will continue to come, as they have in the past, influenced by value judgments, and the pressures coming from the various interested parties as well as by systematic analyses. PPB seeks to aid the policy debate by being clearer and more explicit about objectives, and assumptions, and facts. It seeks to distinguish relevant issues from irrelevant ones. It also traces out the costs and consequences of the alternatives, to the extent that these are identifiable.

Third, PPB is not a computer operation, although computers may be helpful or necessary from time to time. The thinking that precedes well-conceived plans can't be produced by "machine-like" analysts. Nor can the problems requiring judgment be completely solved by highly abstract mathematical or economic techniques. These may contribute to the solution of important parts of the problem, but a good analyst must be able to explain his study and its results to the decision-maker, in clear, concise language, free of jargon.

Fourth, PPB is not limited to cost-accounting, or to specific economic considerations in the narrower sense. Yet, while it should not neglect a wide range of human factors, PPB also should not be used, naively, to measure those factors that are really unmeasurable. Good systematic analysis called for in PPB does not necessarily try to assign numbers to every element of a problem and ignore the intangible. It also does not rule out subjective evaluation and the appropriate use of judgment, as long as these are made explicit. It does not neglect questions of values.

What then, is the concept of planning, programming, budgeting?

PPB combines strategic planning with programs which are supported by related budgets into a product/ clientele-oriented approach. Probably the most condensed definition of PPB would be--an analysis tool for assisting management in the allocation of resources to accomplish foreseen objectives in a given time period.

This tool consists of four major parts:

1. An end-product, clientele-oriented program structure based upon objectives.

2. An information system for collecting, disseminating, and reporting program accomplishments and financial data.

3. An analytic competency for examination of alternatives for reaching objectives considering costs and benefits.

4. A multi-year framework to forecast budgetary implications of programs reflecting current decisions.

The program structure provides the framework around which the PPB systems can be developed. The program structure which has been proposed by the Western Interstate Commission for Higher Education (WICHE) is an example of the type of programs desired in the PPB approach. (See Figure 2) This structure would not necessarily be contained within the organizational lines of a college. In this example, the objectives of instruction, research and service are represented as primary programs. Those activities required to support the primary programs are indicated separately.

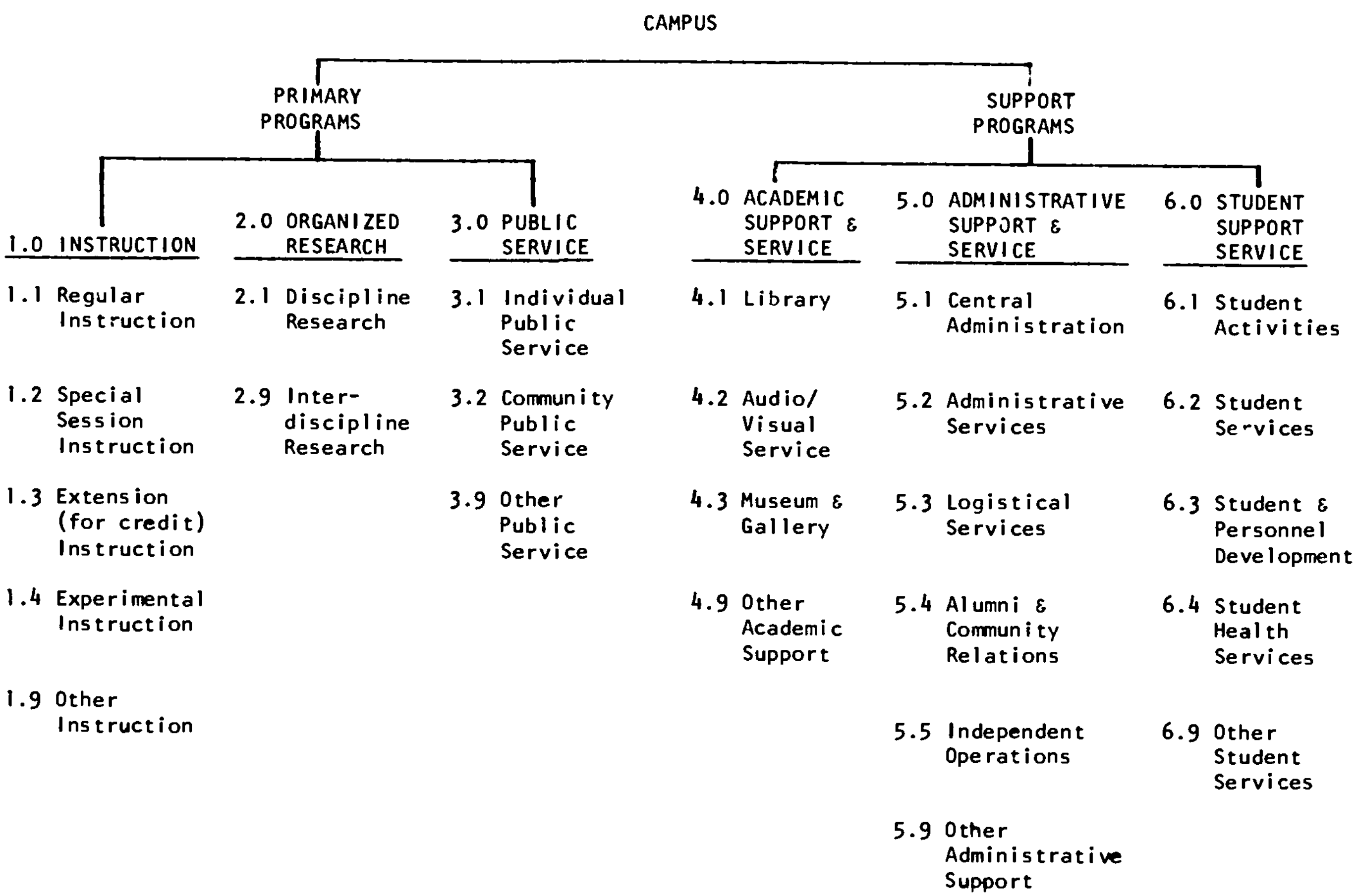

Figure 2. Program Structure (WICHE Documentation)

The second part of this paradigm for a PPB system is a management information system. (See Figure 3) An MIS can be thought of as the men, machines, and methods combined for the collection, classification, storage and retrieval of data and information required for management decisions. It provides the link between planning and controlling functions through day-to-day operations.

The third part of the PPB system is the analytical competency needed to evaluate benefits and approaches used to accomplish objectives. This competency is closely related to the management information system. In fact, it is inherently contained in the MIS. To a considerable extent, this part depends upon the capabilities and training of the individuals involved in setting up the PPB system. For this reason, evaluative steps and criteria should be established so that the relative success the organization has had in achieving its objectives may be determined.

The multi-year budgetary framework includes the ability to forecast resource requirements for the institution's 10-year plan, by 5-year programs within this plan, or to derive a summary by fiscal year for the institution's budget within the 5-year programs. (See Figure 4) The 5-year program framework admits new programs and drops old ones as objectives change or as money availability affects planning. (See Figure 5) Programs X, Y, and Z are shown placed in a 5-year period. The current budget is determined by a time-slice through X, Y, Z and support programs. The initial program resource requirements, however, may be derived from critical path network activities costed and keyed to a time base. (See Figure 6)

To get a better idea of the concept involved, one might examine the ten steps included in a typical PPB cycle. (See Figure 7)

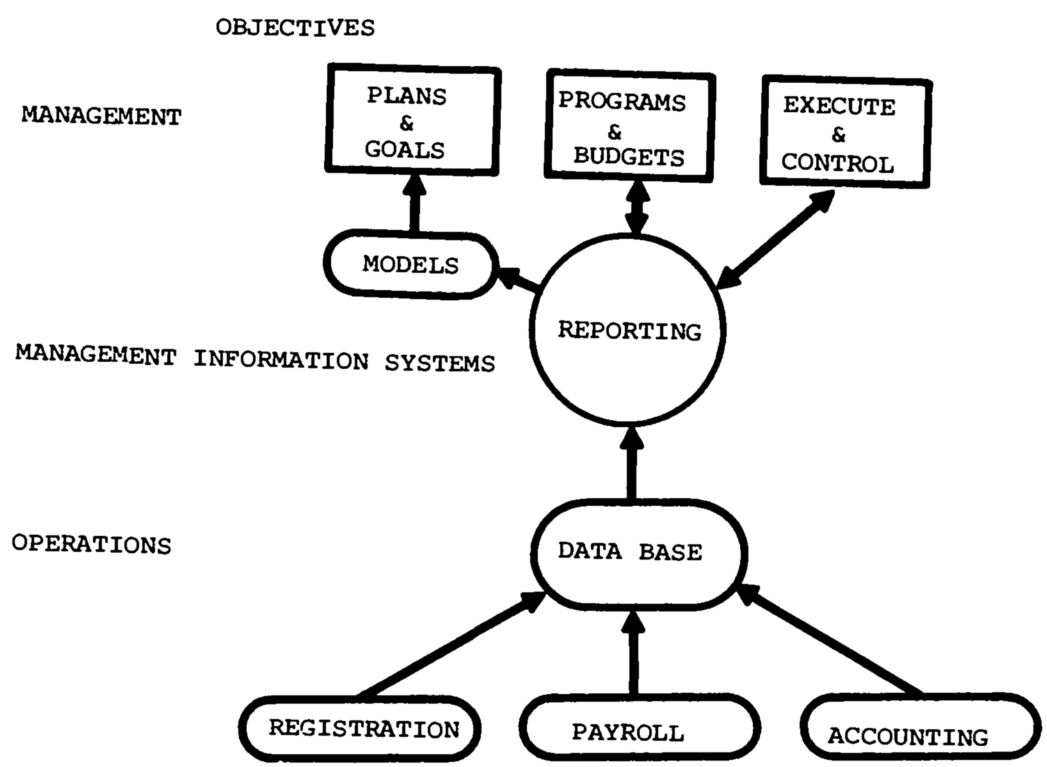

Figure 3. Management Information System
(WICHE Documentation)

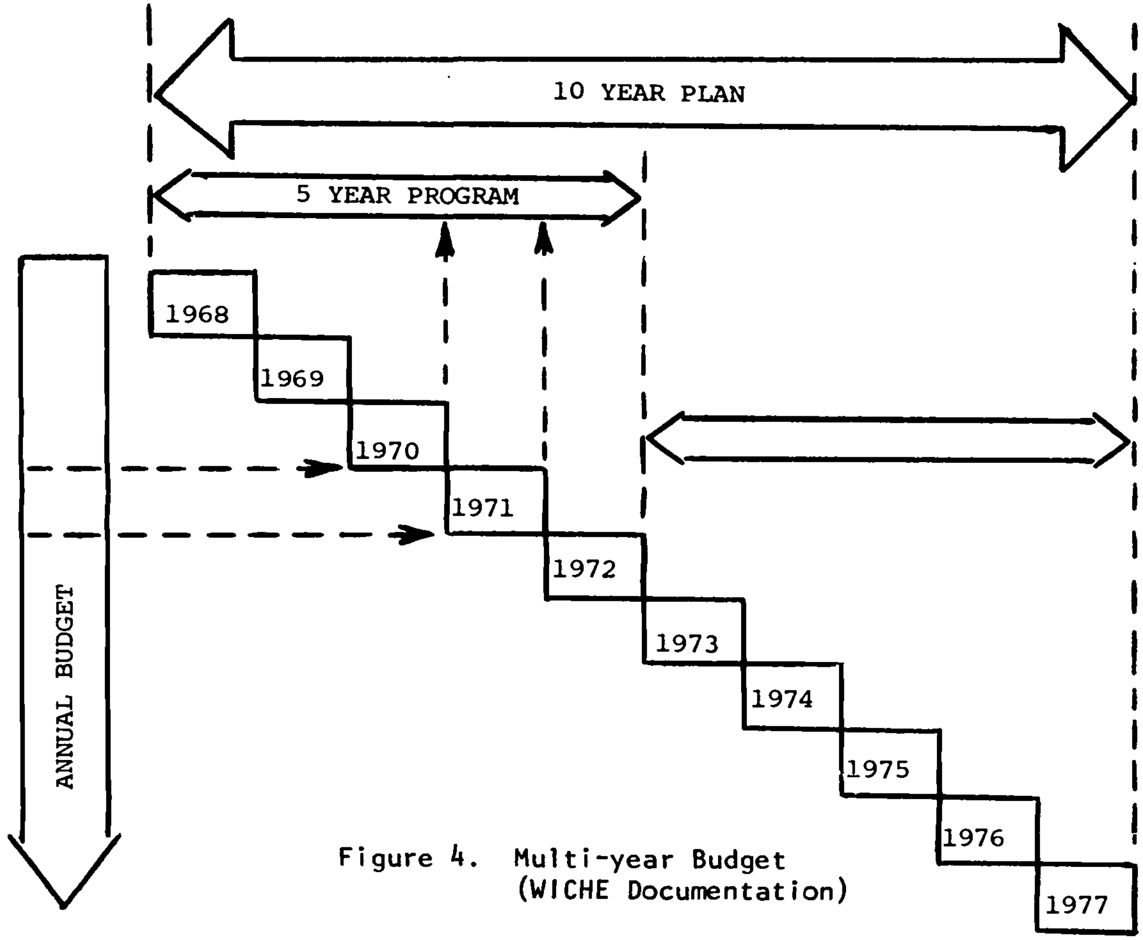

Figure 4. Multi-year Budget (WICHE Documentation)

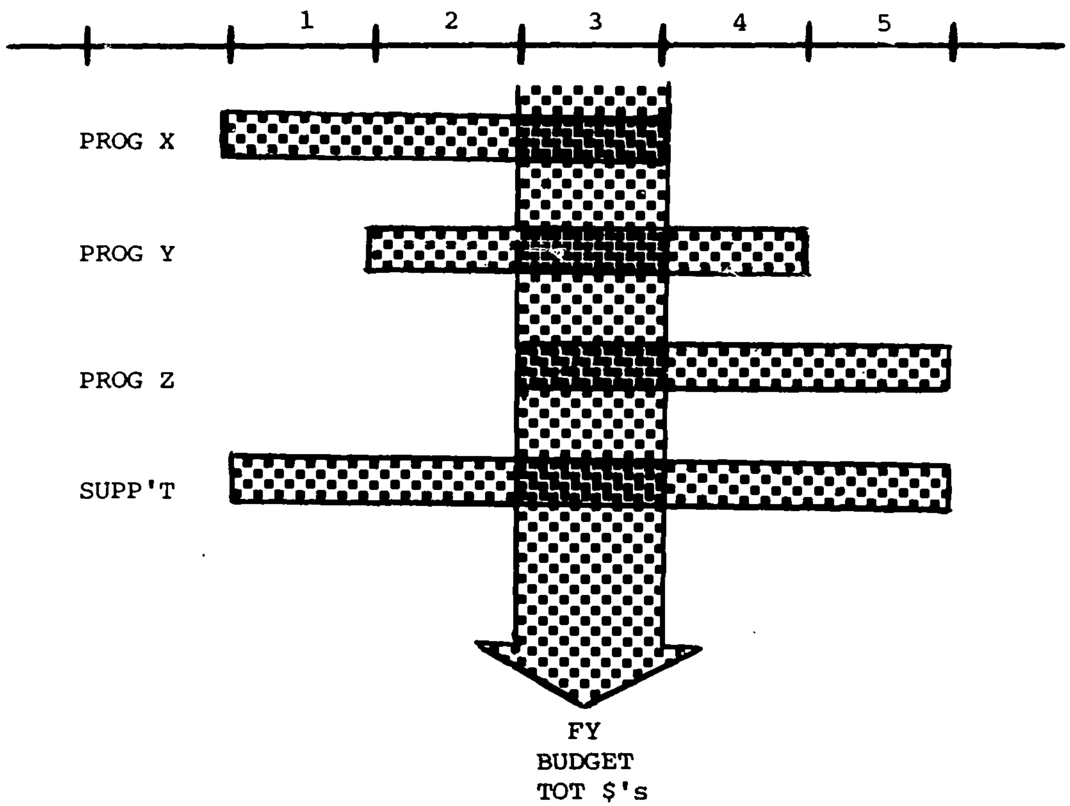

Figure 5. Five-year Program Framework
(WICHE Documentation)

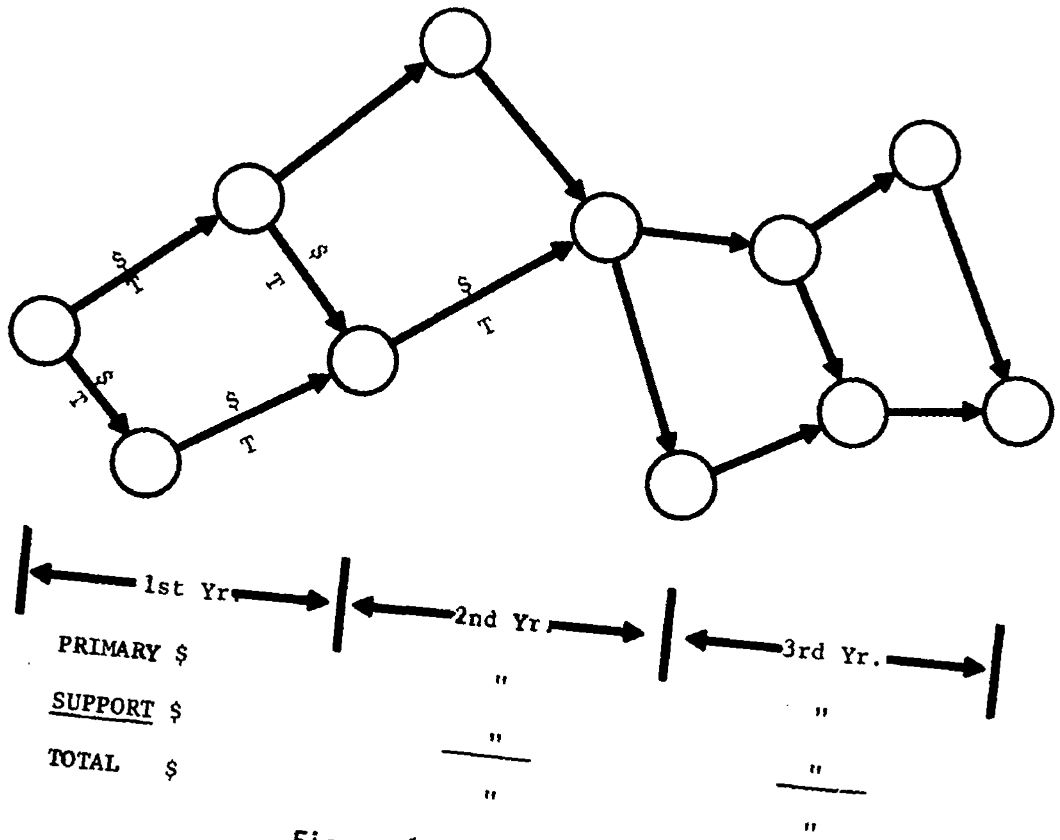

Figure 6. CPM - Program X

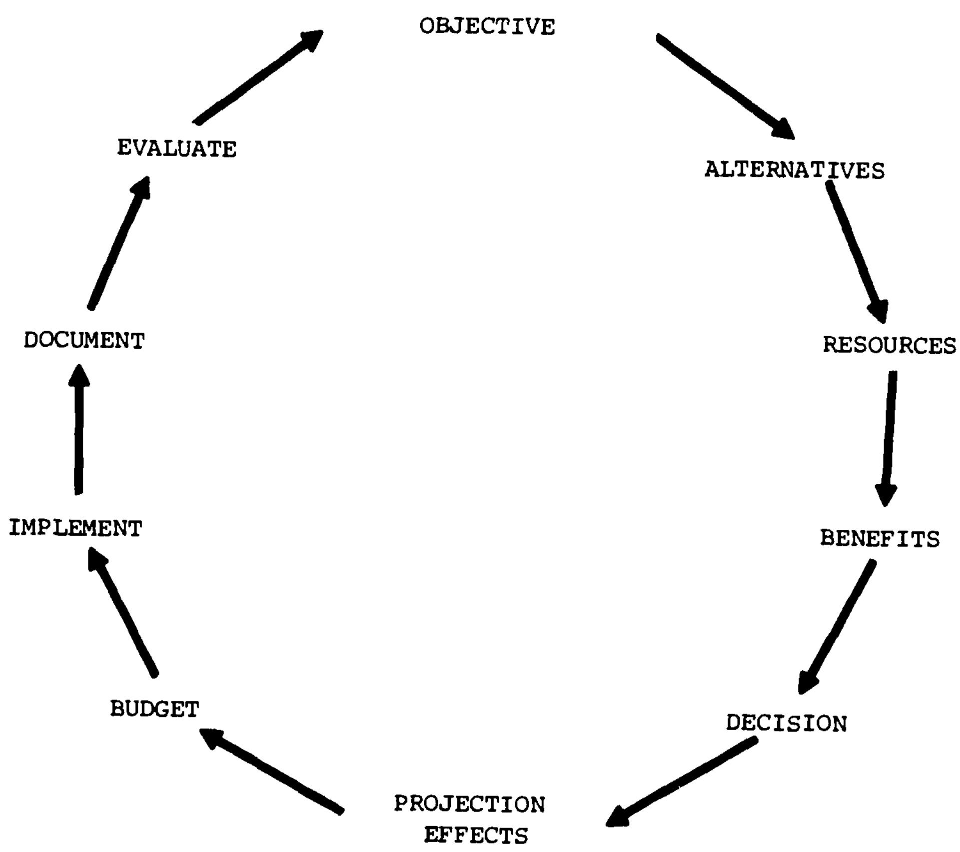

Figure 7. PPB Cycle (WICHE Documentation)

1. The objectives of the institution must be identified and goals suggested to satisfy them. This activity focuses on "What is our business? What are our products (outputs)? To whom are they delivered? What is the deadline?"

2. Alternatives for accomplishing goals or reaching objectives are developed. These include not only the presently accepted means, but all possible means. If "brain-storming" and innovation are not encouraged, the organization may overlook viable alternatives. For new programs, planning techniques such as PERT or CPM might be used as shown in Figure 6.

3. Resource requirements such as people, facilities, and equipment, are then assigned to each of the alternative programs and costed.

4. Benefits to be derived from each of the alternative programs are then estimated. This feature is new and quite difficult to accomplish, but it is necessary for establishing priorities for programs.

5. For the difficult-to-quantify or intangible benefits, the decision-maker must consider quality, personnel, political costs and potential, and select those alternatives which appear to satisfy the objectives of the organization best.

6. The long-range implications of those decisions are tested by projecting alternative programs over the designated time period. Simulation models are used at this point in assisting the decision-maker to select those which are most acceptable to the organization and which will be used as a basis for budgeting.

7. The annual budget is derived then by taking a "this-year slice" across the long-range fiscal

projections to accomplish the objectives of the institution.

8. The selected programs are implemented and actual progress and benefits evaluated against estimated progress and benefits on a continuing basis.

9. Costs of selected programs are charted and projected for future resource requirements.

10. The cycle is reviewed on a minimum-yearly basis to consider the status of the institution's operation, the changes in objectives, goals, alternatives, priorities and the environment in which the organization operates. Objectives for the next year are subsequently re-cycled for new and on-going projects.

The major benefit of PPB is that it enhances decision-making affecting the allocation of resources of the institution. Its introduction will affect everyone--even the "community of scholars." Doubtless, it will require additional effort to gather information in formats not now used, but the end object is to free key people for more planning.

In most colleges and universities, centralized planning is normally a function of the president's office. But with presidential time at a premium, a staff person, working with a small steering committee, could well be assigned to organize the PPB activity. Wide involvement would be the ideal approach, but it's often difficult to get the academic community together even when they want to accomplish something. Hence, a committee might effectively represent the consensus of this group. If a formal planning staff now exists, its relationship to a steering committee must be spelled out. Staff members would probably provide studies at the call of the administration and assistance for the steering committee. Even in small colleges, some formal organizational relationships should be established.

A matter which is extremely important to the success of institutions of higher education on the way to PPB is an official pronouncement "To Work Toward A Form of Program Budgeting." Hand-in-hand with this formalization of intent is the orientation of the top people of the institution to PPB through visually-oriented work sessions. These sessions and "shirt-sleeve" participation should be "mandatory" under the sponsorship of the president's office. Don't forget--federal agencies dawdled along for 15 years after the Hoover Commission report on the advantages of program budgeting until the Presidential Order for PPB in 1965! If this approach isn't followed in institutions of higher education, those who fear the affects of PPB on existing "empires" will passively cooperate a "grass roots" approach out of business.

The experience in defining the objectives, goals, and programs for an institution can't be predicted by anyone who has not visited the campus. A large degree of PPB's usefulness apparently results from the examination of institutional objectives. Each college has a history on which it prides itself. Frequently this has served to incubate and maintain traditions, customs, and practices which haven't been questioned for ages. In many cases, goals have been distilled into meaningless generalities and, unfortunately, many departments and individual faculty members have established their own objectives in the interim. These may or may not match the intended purposes of the institution.

A total review of the institution's environment, clientele and staff should always precede getting into PPB. A look should be taken to the outside to determine who uses the graduates and what strengths and weaknesses the alumni have. This will insure that the institution is not just an "in-bred" sum of its parts. Without a plan to reach objectives, the institution would be a patchwork of individual strengths and weaknesses. In essence, it probably would have little direction and would perform as a political weather-vane rather than as a purposeful response to society.

Since formulating objectives seems to be the most beneficial but most difficult part of the PPB cycle, the administrative and planning staffs should concentrate considerable effort in this area. Statements of objectives should avoid vague and non-operational terms to keep from becoming "home-and-mother" platitudes. At the other extreme they shouldn't be stated in such narrow and conventional terms that they rule out any consideration of relevant alternatives. (See Figure 8) For further example, the objective of a highway program is not just to "lay miles of concrete"; nor are the objectives of an educational program to "attain a 1:35 teacher-pupil ratio" or "provide a 50,000 volume library." Publicized objectives may be quite different from the real operational goals. The institution needs to get behind the overt objectives to deal with the deeper ones. In approaching the setting of objectives in this manner, the administration risks uncovering a few "skeletons in closets" and probably herds of "white elephants." As an end result, this process of goal and objective setting should provide a functional approach for defining a meaningful direction toward which the institution can move.

The basic step in establishing an institutional objective is to define as sharply as possible why the institution exists. Here, administrators need to drop inhibitions due to the evolved scope and nature of current activities and get down to "brass tacks" through the following questions:

"Help students prepare
mentally, physically for
moral, social, intellectual
aesthetic self-fulfillment
and leadership---"

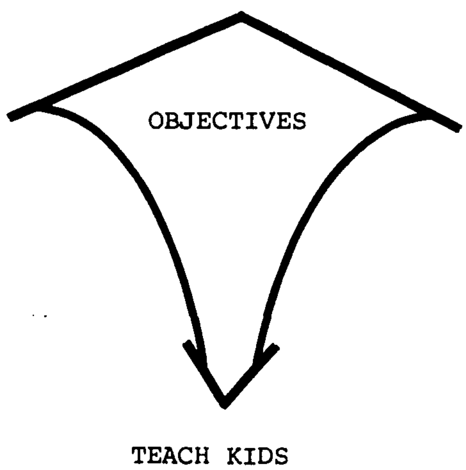

Figure 8. Stating Objectives

1. What is to be done?
2. For whom is it to be done?

Then looking at current (and proposed) activities:

1. Why are we (or why should we be) doing it?
2. What is the target group?

Finally, if objectives have been defined, but are not accomplished or are only partially being accomplished, the administrator needs to ask:

1. Are these basic to the institution?
2. What is the comparative priority?
3. Have they ever been done? (What economics forced us to drop them?)

Second in importance to stating objectives in PPB, is the clear and unbiased presentation of alternative goals for reaching them. (See Figure 9) A planning document which doesn't present and compare different ways of achieving objectives is one which makes a case for a pre-determined position. The old "Don't confuse me with the facts--I've already made up my mind" routine has probably caused many good ideas to be cast aside. Unfortunately, PPB can't resolve this "organizational" problem for the administrator if he persists in planning from the bottom-up.

Alternatives may not be obvious substitutes and it may be an important achievement to show that there are some additional ones that have not been recognized (or previously covered up). Let's take the example of raising the educational level of some group by some amount. The level may be raised by several alternatives--increase in student participation, R & D in education, model facilities, improvements in staff, addition of new equipment, reorganization of instruction, adult retraining, etc. each of these categories also involves many alternatives. Looking

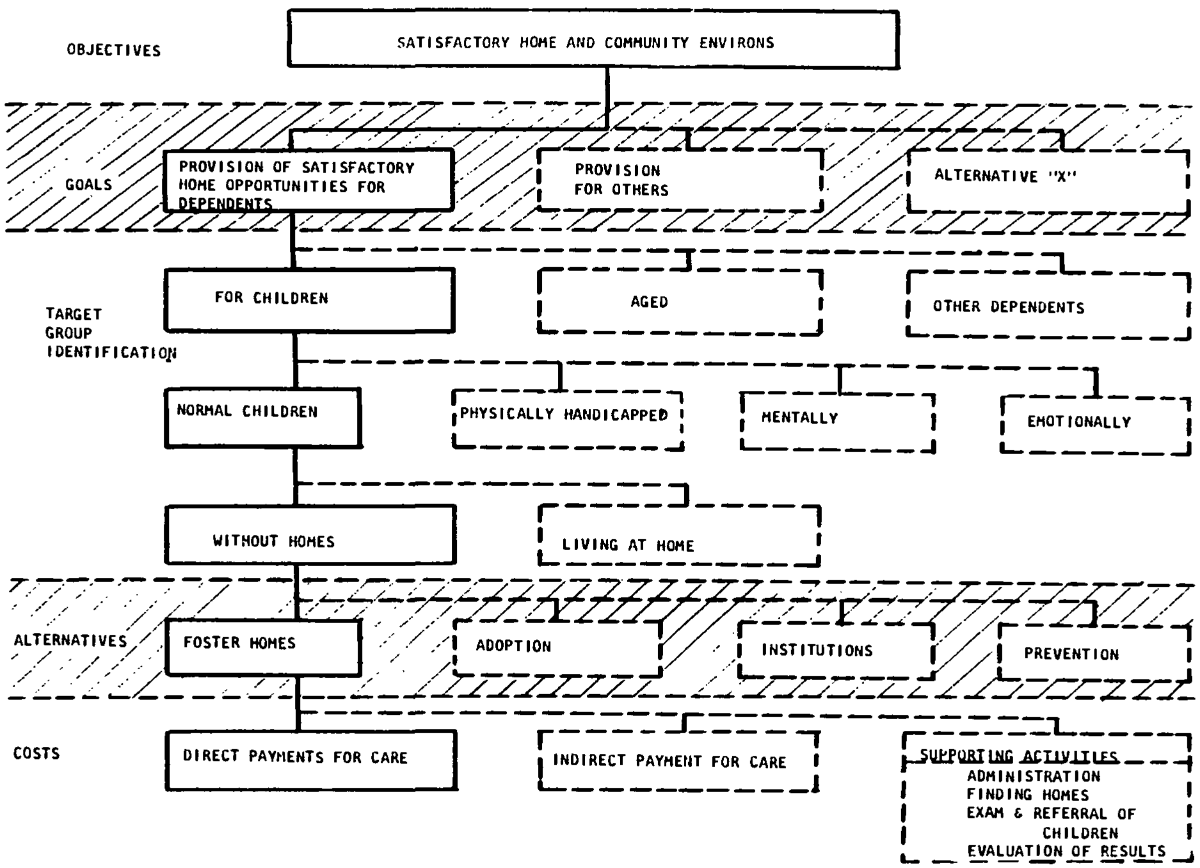

Figure 9. Alternatives vs Goals - Government Documents (From H.S. Rowen, "Planning-Programming-Budgeting -- Selected Comment")

at student participation, we can increase that by loan funds, work-study in industry, educational leaves, new patterns aimed at drop-outs, and others.

The program structure (Figure 10) for reaching government objectives was initially described in the following terms:

1. Program Category - A grouping of programs serving the same objective. Program categories would each state a broad goal for reaching the objective. These statements may be capable of broad quantification.

2. Program Sub-categories - A grouping under the program category to serve that particular stated goal. The objectives (goals) of each sub-category will be more limited and capable of specifying expected quantified output.

3. Program Element - A specific departmental activity directed toward a specified goal. These are the basic building blocks of the operations which are quantified and costed for analysis of program performance. It is here that hours are spent, pupils are taught, rooms are occupied and equipment is used.

In talking about objectives, goals, and program structures, terms such as benefits, products and output were glibly included. These could easily be lumped together under the one term "output indicator" and defined as "a measure of goods and services delivered." This indicator will provide a means of representing "the product gained for the expenditures made." Since quality is often hard to quantify, its indicator should usually provide for a crude measure of volume or program magnitude. For example, the "number enrolled" or "number graduated" gives no indication of the quality of education offered. However crude, indicators on program-budget documents

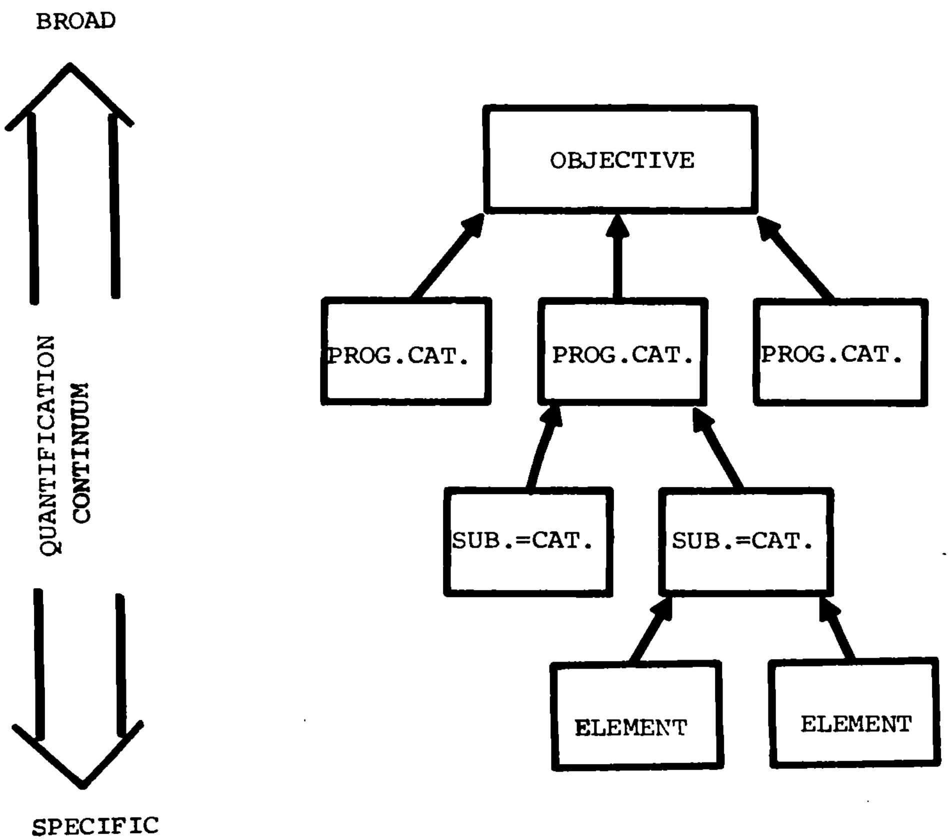

Figure 10. Program Structure for Reaching Objectives

are needed for the following:

1. To provide a basis for comparison of current with prior program sizes.

2. To provide an indicator of program change for changed expenditures.

3. To raise questions or "flag" issues on projected expenditures for new programs.

As such, output indicators generally fall into one of the three following groups:

1. Volume Indicators - These display the output in terms of quantities such as number of "persons assisted," or "students in average daily attendance." They may be selected to show peak-time use or off-peak-hour use with relation to cafeterias or libraries, etc. "Number of degrees granted" is generally found as a volume indicator.

2. Quality Indicators - If a quality indicator is desired, it can be stated in terms of characteristics, duration, content, degree or extent to which it is performed. Simple examples of these might be "number of undergraduates admitted to graduate level," "attrition rates," or "number of graduates receiving fellowships."

3. Comparative Indicators - These indicators may be designed to show volume in relation to population, area or some other specific "potential scope" area. These might be "placements per total work force," "placements per total in graduating class" or some other standard ratio to be used as a measurement.

The spectrum of measures of program output and evaluation criteria apparently is continuous. At one end, measures of magnitude are easily understood and quantified but don't really indicate program accomplishments. At the other end, the measures are more closely related to the end values reflecting the program's purpose but are difficult to assess. The trick is to get a relevant indicator, providing as much information as possible which is readily obtainable for the program duration.

In summary, PPB is "as individual as a thumb print," since by definition a "system" must be surveyed in its own environment. One institution's PPB implementation will have many elements in common with others, but the recipe can't be lifted from a "cook book" or "standard formula" approach, for it will also have many elements of uniqueness "tailored to fit" its community, its objectives, and its staff. Ultimately, if an institution chooses to move into PPB it will have to create its own special brand which will be similar (but superior) to "Brand X."

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SIMULATION MODELS IN COLLEGE PLANNING AND ADMINISTRATION

By
Fred H. Wise

There is general agreement that resources for higher education are scarce and should be allocated to those programs where the greatest payoff will be realized. Further, the allocated resources should be utilized in the most efficient manner possible. College officials should, therefore, make use of all available and appropriate management tools to administer these scarce resources. They need analytic tools just as powerful and sophisticated as those used by managers in business and government. Only when such tools are made available to and used by college administrators can a maximum return be expected on resources consumed by the educational process. Simulation models are one such sophisticated management tool.

A simulation model may be viewed as a kind of management tool which will assist higher education decision-makers to a broader understanding of long-range resource implications of planning decisions. Mode vary widely in type and application. The system simulation model will be discussed in this paper.

The simulation model can provide a means for the administrator to collect and analyze information relative to a large number of problems. It can provide the college administrator with an integrated view of college operations and thus give him a new perspective. It can provide him with a means of testing alternative courses of action before choosing. Further, it can provide him data to create more accurate and better substantiated statements of financial requirements. A simulation model can become for the administrator and decision-maker what the laboratory test facility is for the scientist and engineer.

It would be helpful to examine how a simulation model might operate. Suppose that the registrar has provided the planning office with projected enrollments for the next seven years. The questions that come to the forefront for the administrator are what will be the impact of this enrollment on the resource requirements of the college? How many faculty of various qualifications will be needed? How many classrooms and what type will be needed? What are the financial implications? Unfortunately, the best that could be done in the past was to arrive at some "guesstimations" by percentage or so-called growth formulas.

But suppose a carefully constructed simulation model existed. Upon input of enrollment projections the computer would provide projection of facilities, staff and financial resources necessary to handle the enrollment for each of the seven years. The results could be presented in various levels of detail--first for the entire college and then by department. It conceivably could provide a breakdown by class within the department to determine specific types of facilities such as physics labs vs. biology labs.

The big advantage of the simulation model would be that the computation could be repeated numerous times with different basic assumptions about key ratios, and with different distributions of students in courses offered.

Another important question in the use of the model is how sensitive are the answers of facilities, faculty and finances to error in the projected enrollments. These can also be varied on re-runs of the model. The administrator can thus become aware of the degree of sensitivity.

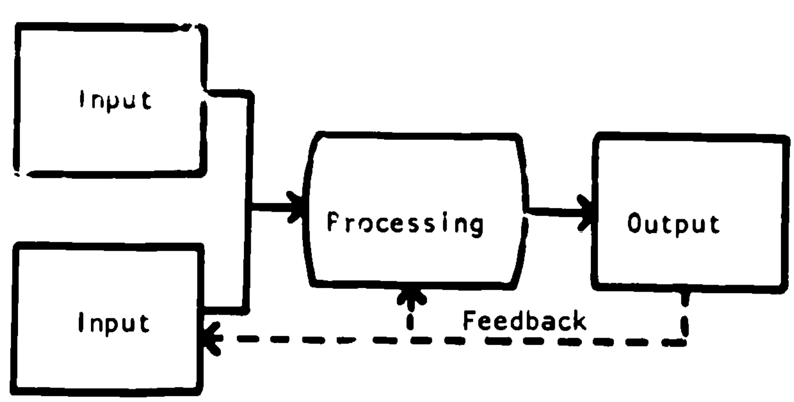
To understand how such a model could be developed, some basic understanding of modeling is necessary.

Definition of Model

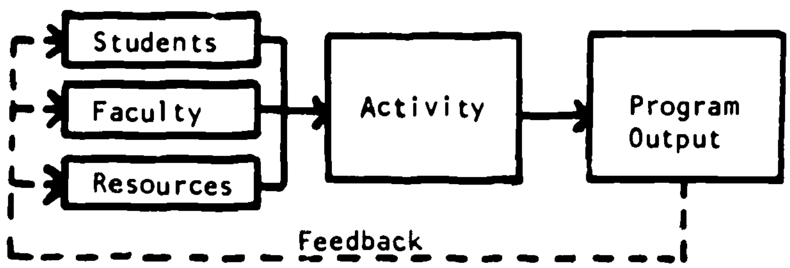
A model is an abstraction of the real world. A model of a system, therefore, could be defined as an aggregation of information about a system gathered for the purpose of studying that system.

A system may be defined as a collection of elements or entities interrelated in such a manner that they fulfill a desired purpose.

The diagram below is a simple model of an information system. Inputs (elements) are processed (interrelated) in such a manner that an output (purpose) is accomplished. Feedback completes the system. Feedback indicates how elements need to be processed in a little different manner or what different inputs are needed to create the desired output.



This basic systems model can, of course, be related to an educational system. The basic system entities can be identified in this model as well.



Diagrams such as these are models by our definition. They are a collection of information about a system gathered for the purpose of studying that system. Detailed pictorial models of this type are used extensively in systems analysis. They, of course, are static and are a representation of a system at a given point in time.

One type of model which is familiar is the physical model that can be purchased at the hobby shop. The model airplanes, cars, boats and trains available are abstractions of the real world. They are abstractions in the sense that not all detail is included and they may not be operational. Some of these models are dynamic physical models. Many a young pilot has developed basic understanding of plane construction and performance and even has developed some flying skills through the use of model airplanes. There is a story told, (the author cannot vouch for its authenticity), that the Russians were able to save many months in their development of a Polaris-type missile-submarine as a result of studying the detail of a plastic model of the

U. S. Polaris sub purchased at a hobby shop. Maybe our models are not so abstract.

Probably the best known physical models used for scientific study are the scale models used in wind tunnels and water tanks to study the design of aircraft and ships. Well-established laws of similitude permit conclusions to be drawn about performance of full sized systems.

Laws of similitude also make it possible to use one type system to model another. For example, complex mechanical systems are frequently modeled by electrical circuits. Electrical circuits are easy and inexpensive to modify where as a mechanical system may not be. By studying the impact of changes made in the electrical system it is possible to predict, rather precisely, impact of changes in the mechanical system.

In a mathematical model, the elements of a system and their attributes are represented by mathematical variables. The activities or processes in the system are described by mathematical functions that interrelate the variables.

Mathematical models, just like physical models, can be either static or dynamic. A static mathematical model shows the relationships between the system elements when the system is in equilibrium. When the equilibrium is disturbed one or more of the element attributes change in value. The model enables the new values for all attributes to be derived. The static model does not show how they changed to their new values.

A dynamic mathematical model allows the changes of system attributes to be derived as a function of time. The derivation of the new values may be made with an analytical solution or by numerical computation, depending upon the complexity of the model.

System Simulation

Given a mathematical model of a system, it is sometimes possible to derive information about the system by analytic means. Where this is not possible, it is necessary to use numerical computation methods for solving the equations. A rich variety of numerical computation methods have been developed for solving the equations of mathematical models. In the case of dynamic mathematical models, a particular technique has become identified as system simulation. System simulation involves a technique whereby all the equations within the model are solved simultaneously. The process is repeated with steadily increasing values of time.

System simulation, therefore, is a technique of solving systems problems by following changes over time within a dynamic model of the system.

A major advantage of the simulation model is the freedom the analyst has in its construction. Many of the constraints set by the analytic technique can be by-passed. The simulation model is usually built in a series of sections. Each section is described mathematically in a straightforward and natural manner without undue concern for the complexity introduced by having many such sections. The various equations do have to be constructed and organized in a way that enables a routine procedure to be used for solving them simultaneously.

The goal of building a system simulation model is not to recreate reality. The goal is to abstract the most important aspects and identify the associated relationships from the real world and express them in a form suitable for analysis. By operating upon the model we hope to draw conclusions that are valid for the real system which, for example, could be a college. In this respect, simulation models are not unlike other kinds of models. The advantage of simulation models over other mathematical models is that many aspects and relationships can be included that would render other models unmanageable. It should be mentioned, however, that large simulation models become possible only when use is made of high speed computers. The number of computations to be made presents an almost insurmountable task for the otherwise unassisted human.

Can A College Be Modeled?

The answer to the question, can a college be modeled, must be a qualified "yes". A simulation model requires quantification and many aspects of a college can, of course, be stated quantitatively. Such aspects as student/faculty ratios, classroom size, salary and cost schedules, equipment costs and laboratory space can be quantified. However, there are subjective constraints on the administrator's decision-making process which stem from political, social and academic consideration which may be beyond the current state-of-the-art of quantification. But therein lies the strength of simulation models. A wide variety of assumptions can be made and the simulation model can be "run" with each likely situation.

The basic task of the college administrator is resource management and is not too far different from the basic task of a corporation manager. To use modern tools of management to assist in resource allocation decisions there must first be clear thinking about objectives. The manager must know what the objectives are, the priorities among them, and how their achievement is to be measured. The decisions of the administrator then center around the allocation of resources to the activities which lead to the accomplishment of the identified objectives.

Unfortunately, the objectives of colleges are many and traditionally tend to be abstract in nature. They are mainly intuitive ideas of what a college should do. They are frequently found as so-called "motherhood" statements in charters or they may simply reside in the minds of trustees, faculty and administrators. The clear and quantitative statement of objectives is a difficult but not impossible task. There are a number of techniques utilizing systems analysis which can assist college leaders in thinking about and eventually stating objectives. It is not the purpose of this paper to elaborate on the task of stating quantitative objectives but it is a necessary task which must be accomplished before modern management techniques can be utilized. Other papers in this collection may discuss this action.

Each activity of the college should relate to one or more of the stated objectives. There are various ways of identifying activities. WICHE, for example, classifies all activities under three major program areas - instruction, research and service. The Systems Research Group of Toronto, Canada, have this same major classification, but construct a hierarchy under this, i.e., Arts, Sciences and Engineering within undergraduate studies. As study continues there will hopefully be a generally accepted classification of activities. The activities and their relationships must be identified in order to build a model. The total number of activities within a college can be very high and need for simplification in a model forces a selection of those activities deemed most important. The total performance of the institution is, of course, the sum total of its activities in the real world. A model, it will be remembered, is an abstraction of this real world. The model will thus contain those activities identified as most relevant.

Once the important activities have been identified, the problem then becomes one of measuring activity level and resultant output. Some activities can be easily measured while others may be found to be next to impossible. Also there may be a wide variety of measuring categories. For example, the activity "instruct physics" might be measured by a number of sections to be taught, size of section, total number of students to be instructed, money to be spent in the activity. Any one of these quantities or possibly some combination of the quantities can be used to indicate activity level. Decisions must be made as to how activity level is to be measured. For example, it may be decided that activity level will be measured in terms of number of students to be instructed. System parameters can then be entered into the model to convert a given activity level into resource requirment, e.g. student/faculty ratio, salary/faculty rank, space /student, lab equipment/student. Outcome of an activity level, for example, skills in the basic language arts such as reading must be measured by appropriate instruments to determine if the specific activity level is adequate. Since good measuring instruments are scarce or totally lacking, activity levels may have to be set initially on an intuitive basis.

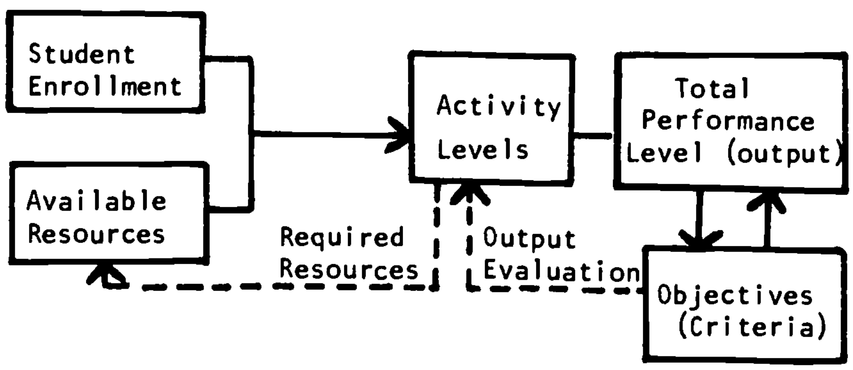
It might be said that the role of management in a college is to choose activity levels that will maximize the total performance of the institution in achieving its stated objectives within a given amount of resources. As the administrator learns more and more about the resource implications of activity levels and their outcomes, he will, by his experienced judgment, be able to select the most preferred combination.

The value of a simulation model is that it will provide the administrator the opportunity to test the resource implications of a variety of combinations before he makes the choice. As the performance outcomes of each level are measured in terms of the objectives he will, over time, be able to make even better experienced judgments regarding combinations.

Activity levels are thus the control variables in a simulation model. They can be manipulated by the administrator. There are, however, constraining factors in the real world which limit this manipulation. There may be pressures brought to bear by students, political powers, the academic community or society in general. There are also other outside parameters over which the administrator has little or no control, e.g. costs of new facilities, academic salaries, cost of equipment, that may affect his decisions on activity levels. Selected system parameters may need to be changed to partially offset these uncontrollable parameters, i.e., student/ faculty ratios, space allocation.

Yes, a college can be simulated. It is a complex task and many decisions will have to be made which presently tend to be passed over. The control variables must be identified and the uncontrollable variables must be recognized. It is possible over time through the utilization of a model to optimize the allocation of resources to acquire a desired level of performance (output).

A simple conceptualization of such a model can be diagramed as follows:



Model Must Be Specific To Question

A generalized model to answer all possible questions is impossible to build. The model must be built to answer specific questions. In other words, questions must be known before the model is constructed. The more numerous the questions the more complex the model becomes. Also the greater the difference in the questions the more complex becomes the model. One way to answer many questions with one model is to answer them through some common base. For example, it may be possible to answer many questions concerning activity levels in terms of resource requirements. The resource implications of (1) projected enrollment increases of a specified amount, (2) a sharp increase in engineering students, (3) change in a general policy such as student/faculty ratio, (4) changes in curriculum such as required course content for a particular degree can probably all be answered by one model. In reality there is only one question being asked in all of these. What are the resource implications? The parameters are being changed not the question. The objective is to design a model such that a series of "what if" questions can be asked by the administrator.

Building A System Simulation Model

The task of building a model of a college can be divided roughly into two subtasks: (1) conceptualization and design and (2) collection and organization or relevant data.

The two jobs of creating a design or structure and collection of data are defined as parts of one task. The jobs are so interrelated that neither can be done alone. In reality they are concurrent.

In creating the design the designer/analyst must determine the system boundary, identify the system elements (inputs), the attributes (values of the elements) and the interrelationships of the elements. The data provides the values of the attributes and the relationships involved in activities.

The administrator, working with the designer/analyst, must specify the questions to be answered by the model. The administrator must also assist in identifying the most important interrelationships among the elements. For example, describing how enrollment is transformed into teaching load in each department, student/teacher ratios in each course, equipment requirements, space requirements and also secretarial and administrative needs.

The designer/analyst usually finds systems analysis techniques useful in the above process of design. He will collect information about the elements of the system, their attributes and interrelationships. He will flowchart the process of transformation described by the administrator and derive formulae and equations that depict this transformation. After the logic of the model has thus been spelled out the model will be prepared as a computer program so that it may be used efficiently.

It is important that communication between the user and the model be carefully designed. Input and output must be designed with the user in mind. The model must be designed so that the user can easily change the values of the attributes or system parameters and the activity levels. The model must be designed for convenient use and output must be easily interpreted or it will soon fall into disuse.

Collection and organization of data is no small task. Because of the nature of the elements in a college simulation model the attributes and relationships tend to be abstract. Nonetheless, to function in a simulation model they must be expressed in mathematical terms. Since it may be impossible to assign a constant value, they may be parameterized; that is, they can take on any assigned range of values. Assumptions may be made and, as the model is used over time, these assumptions can be confirmed or refuted.

During the process of collecting and organizing data unsuspected relationships may be uncovered and thus stimulate a design change. This cyclic process of feedback to the design of the model is why it is important that data collections and organization should proceed concurrent with the design activity.

The process of establishing numeric values for the parameters of the model may at first seem like an insurmountable task to the administrator. A variety of techniques may need to be utilized by the designer/analyst and the administrator. Some, such as student/faculty ratios or ratio of secretarial support staff to full-time faculty may have to be arbitrarily set by the administrator. Many values can of course be set by analyzing past experience or existing situations. In other cases, methods of statistical estimation and averaging may need to be used. Where values are known to change over time, such as would be the case for salaries and wages, it may be necessary to use forecasting techniques and/or probability studies. The latter techniques are most frequently used in establishing values for uncontrollable variables or those that have a degree or uncertainty such as building and equipment costs.

The value of the model is realized by being able to determine the resource implications of changing the values of variables that are within the purview of the administrator's control, e.g., teaching load, curriculum, and classroom utilization rate. These can be varied for experimental purposes one at a time while other values are held constant.

Debugging And Validating The Model

The logic of the model must be checked and double checked. An error in logic can totally destroy the usefulness of the model. Logic is usually checked by repeated "walk through" exercises conducted jointly by the designer/analyst and the administrative staff of the college. The importance of this cannot be overemphasized.

Computer programs must also be debugged and finally tested using live data. Confidence that a model is providing good data for decision-making can be acquired by the administrator only when he has assurance that it is functioning as it was designed to function. Tests must be made with live data, possibly selected from a past situation, to see if the model's predictions correlate with real-world happenings in the past. It should be remembered that development of a planning model is an evolutionary process. The model improves as the data base expands and as assumptions become confirmed over time. As input data becomes more accurate and as experience is gained in use of the model and in interpreting its output, confidence in the validity of the model will increase.

Lack of recognition of the fact that development of a simulation model is evolutionary is probably the most common cause of failure in modeling attempts. Successful modelers will usually look back with considerable embarrassment on their first design. Important relationships are frequently overlooked the first time. When carefully designed, a model and its parameters can be changed and its validity will improve continually with use.

Recognition of this evolutionary process will point up the need for one person or one particular office to be assigned the responsibility of maintaining and improving the model. This is usually the Planning and Analysis Office, the Office of Institutional Research or the individual charged with this type activity within the institution.

Staffing For Model Development

A variety of skills are required to build, operate and maintain a system model. It requires an interdisciplinary staff.

The initial developmental team should include an information system specialist and an experienced model designer. The information system specialist can apply systems analysis techniques including information flow analysis to identify the relevant interrelationships critical to the model. He will be able to assist in identifying the decision points and the information needed, and subsequently to provide a detailed analysis of the existing flow of information within the institution.

The experienced model designer can provide the high level of technical competence necessary for the initial design and programming of the simulation model. The model designer and the systems analyst may need to come from outside the college. Their services will be expensive, but on the other hand, costly mistakes can be avoided and the task can be accomplished in much less time.

A third team member should be selected from within the institution. He should be the individual who will operate the model. He must pick up where the systems analyst and model builder leave off. He must, therefore, work closely with them during the initial development. He must have a thorough knowledge of the logic used in the model, parameter development, modification procedures and model operation procedures. In short, he must understand all aspects of the model. The best way to obtain this knowledge is to participate in the design.

It is impossible to build a college system simulation model without the full cooperation of the administration. This means shirt-sleeve participation on their part. An all-hands memo is not enough. Even frequent meetings and briefings are not enough. One or more top-level administrative officers must maintain close working contact with the model building team. Not only will this ensure greater validity in the model and concentration on specific problems but it will assist the administrative staff in learning the potentials and limitations of the model.

Resource Requirements

The time and manpower costs of designing and developing a simulation model will vary directly with the size and complexity of the college being modeled. They will vary inversely with the skill and experience of the design team and support of top-level administration. Based on experiences of other universities and colleges and business firms it is safe to say an experienced team can develop a systems model of a small college with two to three man/years of effort.

Both in developing and operating a systems model the larger the computer available the better. This is not to say that it is impossible on a smaller computer or that simple models cannot be operated manually. Greater aggregations and blocking of data and certain assumptions must be made when operating manually or on small computers.

Manpower requirements for maintaining and operating the model will vary with intensity of use.

One full-time staff member with clerical support should be able to handle it easily. To make this possible a constant or year-round use of the model is essential rather than a peak only at budget decision time. Many colleges, university, government and business organizations now recognize that a budget is a plan and for a plan to be useful it must be kept alive and well through continued use.

Simulation modeling for the support of planning in a small college is a major effort in terms of time and money. It requires a long-term committment on the part of the administration. It requires a willingness to closely examine internal operations of the institution, quantify many aspects not formerly quantified and to make changes. If the best use of scarce resources is to be made, the best available management tools must be used. System simulation modeling is one management tool which deserves the serious consideration of small college administrators.

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Institute of Higher Education
University of Georgia

ADDITIONAL REQUESTED INFORMATION FOR
EPDA TRAINING PROGRAM ON
MANAGEMENT INFORMATION SYSTEMS

1. How are student and faculty records stored at your institution? (Please check where applicable)

   A. File Folders only 6

   B. File Folders & Edge-Punch Cards (Royal McBee System) 2

      1. Edge-Punch Cards (Royal McBee System) ___

      2. "IBM" Cards (key punched) 11

      3. Data Tapes 1

      4. Other (Please specify) (two of these as DISCPACKS) 4

2. What type of electric or electronic data processing equipment, if any, is presently installed or planned for your institution? (Please check where applicable)

   A. None 1

   B. Unit Record Equipment

      1. Card Punch 13
      2. Card Verifier 8
      3. Reproducing Punch 8
      4. Card Sorter 12
      5. Card Collator 8
      6. Accounting Machine 9
      7. Interpreter 1

Computing equipment:

IBM 1401, 12K, Two disc drive

2 IBM 360/20
IBM 360/25

2 IBM 1620
IBM 1130
IBM 1056 Computer terminal
IBM 1050 terminal with card reader to IBM 360/65 or RCA Spectra 70
Century 100
Honeywell H-1250

Approximate Lease and Purchase Costs
for Selected IBM Punched Card Equipment

Item	Rent/Mo.	Purchase
026 Card Punch	$ 58	$ 3370
029 Card Punch	$ 67	$ 3490
056 Card Verifier	$ 49	$ 2135
059 Card Verifier	$ 70	$ 3660
082 Card Sorter (650 cards/min.)	$ 53	$ 2520
083 Card Sorter (1000 cards/min.)	$107	$ 7275
085 Collator	$ 92	$ 6425
087 Collator	$209	$11060
403 Accounting Machine	$285	$19635
407 Accounting Machine	$310	$27935
514 Reproducing Punch (summary and compare on 45 card columns)	$107	$ 5385
514 Reproducing Punch (as above with mark sense capabilities)	$136	$ 6840
548 Interpreter	$ 97	$ 5140

Notes:

1. The exact price will depend upon the number of accessories or optional features which are used.

2. Costs quoted as of August 28, 1969.

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