DOCUMENT RESUME

ED 060 823 | 24 | HE 002 975

AUTHOR	Tabor, C. Dwight, Jr.
TITLE	Feasibility Study of Simulation Model for Planning on an Urban Campus. Final Report.
INSTITUTION	Georgia State Univ., Atlanta.
SPONS AGENCY	National Center for Educational Research and Development (DHEW/OE), Washington, D.C.
BUREAU NO	BR-0-D-027
PUB DATE	29 Feb 72
GRANT	OEG-4-70-0049(509)
NOTE	57p.
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	*Educational Administration; *Educational Planning; *Higher Education; *Management Systems; Planning; *Urban Universities

ABSTRACT

This study is designed to determine if it is possible and worthwhile to develop a formal simulation model as an aid to urban university management. Evidence is introduced that indicates existing planning models may not be justified on a basis of benefits derived versus their development and operating costs. A survey of models and ideas indicates that CAMPUS and WICHE's RRPM are the most promising points of departure for the development of a new planning model. The stability of the elements of an induced-course-load matrix (ICLM), the core of both CAMPUS and RRPM, is examined using data from a large urban university. This examination is conducted on several levels of aggregation. In general, the ICLM is found to be viable as a basis for a planning model, assuming the model is flexible enough to allow the appropriate level of aggregation. Proposals are advanced for the implementation of a planning model. Major reliance on WICHE's development and documentation of the RRPM model is suggested. (Author/HS)

OE-NCERD
HE
Project 0-D-027

Final Report

Project No. 0-D-027
Grant No. OEG-4-70-0049(509)

C. Dwight Tabor, Jr.
Georgia State University
33 Gilmer Street, S.W.
Atlanta, Georgia 30303

FEASIBILITY STUDY OF SIMULATION MODEL FOR PLANNING ON AN URBAN CAMPUS

February 1972

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Office of Education

National Center for Educational Research and Development

(Regional Research Program)

Final Report

Project No. 0-D-027
Grant No. OEG-4-70-0049(509)

FEASIBILITY STUDY OF SIMULATION MODEL FOR PLANNING ON AN URBAN CAMPUS

C. Dwight Tabor, Jr.
Georgia State University
Atlanta, Georgia 30303

February 29, 1972

The research reported herein was performed pursuant to a grant with the Office of Education, U.S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgement in the conduct of the project. Points of view or opinions do not, therefore, necessarily represent official Office of Education position or policy.

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

Office of Education

National Center for Educational Research and Development

ABSTRACT

FEASIBILITY STUDY OF SIMULATION MODEL FOR PLANNING ON AN URBAN CAMPUS

This study is designed to determine if it is possible and worthwhile to develop a formal simulation model as an aid to urban university management.

Evidence is introduced which indicates that existing planning models may not be justified on a basis of benefits derived versus their development and operating costs.

A survey of models and ideas indicates that CAMPUS and WICHE's RRPM are the most promising points of departure for the development of a new planning model.

The stability of the elements of an induced course load matrix (ICLM), the core of both CAMPUS and RRPM, is examined using data from a large, urban university. This examination is conducted on several levels of aggregation.

In general, the ICLM is found to be viable as a basis for a planning model, assuming the model is flexible enough to allow the appropriate level of aggregation.

Proposals are advanced for the implementation of a planning model. The implementation role of line managers and their staffs is stressed.

Major reliance on WICHE's development and documentation of the RRPM model is suggested.

PREFACE

This feasibility study is an outgrowth of an idea which originated with Dennis Grawoig and Martin Roberts of Georgia State University. David Hart, who works on the staff of the Dean of the School of Business Administration of Georgia State University, developed the guidance-evaluation system from which the data used in this study was obtained. Mr. Hart also developed a system to convert this basic data into the crossover table format. June Wilson wrote the computer programs which implemented Mr. Hart's system. Research assistance was provided by Don Bickham, Debbie Dean, and Jerry Ross. I am deeply indebted to all of these people.

TABLE OF CONTENTS

LIST OF TABLES

7

FEASIBILITY STUDY OF SIMULATION MODEL

FOR

PLANNING ON AN URBAN CAMPUS

I. INTRODUCTION

This study is designed to determine if it is feasible to develop a formal simulation model as an aid in urban university management. Feasible, as used here, means not only possible, but also worthwhile.

A. Role of Model Versus Role of Decision-Maker

In order to more clearly define the role of a simulation model in the planning process, let us first consider that process in a conceptual framework. Juan Cassasco has drawn on widely accepted planning techniques to develop a planning cycle for university management.[1] This cycle, which is divided into an analysis phase and an operations planning phase, can serve to distinguish the role of the simulation model from that of the decision-makers.

1. Analysis Roles

In the analysis phase, the decision-makers must set objectives, identify specific goals, isolate problems, and develop alternative courses of action. A simulation model is useful in this phrase if it provides appropriate and accurate information to the person who needs it when it is needed. A useful model will lend structure to the situation. It will provide insights into the tradeoffs which may be effected. In short, a model should provide information which allows a planner to make better decisions. Planners should clearly understand that <u>models do not make decisions</u>.

2. Digression on Objectives

There has been considerable discussion in the literature of planning models concerning the need to understand objectives. While it is true that model developers must know generally about the processes and problems of university management, the main

[1]Casasco, Juan A., Planning Techniques for University Management, pp. 4-7.

focus of the model should be on capturing the important relationships within the system which is being modelled. Concern with objectives is in the province of the planner not the model developer, although the modeler must certainly understand how the model is to be used. In fact, excessive attention to objectives may lead to a sub-optimal model in the sense that it may be slanted toward providing specialized classes of information -- to the neglect of a more balanced picture. There is an interesting discussion in a report[2] on the Duke University Seminar on Management Information Systems: The State of the Art of the need for the planner and the model developer to be different people. Some would argue they should be different because of the different perspectives required in modelling and decision-making. Decision making requires a broad view of many considerations which cannot be included in a model, including some which may be irrational. Models, on the other hand, are completely rational and internally coherent. Also, decision makers must often work under extreme time pressure in the face of incomplete information, so that model results must be immediately available if they are to be useful. There is often little time for a decision-maker to develop a model in order to get information which he needs. These factors would indicate that a separation of the modelling and decision-making function is desirable.

The premise of my report is that whether a model is developed by the decision-makers or someone else there is a distinction between the role of the model and the role of the decision-maker. The model provides structure, illuminates tradeoffs, and gives other timely information. The decision-maker evaluates alternatives in the light of goals and objectives on the basis of model-originated information, but also on the basis of subjective information, such as intuition or a feel for political consequences, which cannot be reflected in a model.[3]

---

[2]Johnson, Charles B. and Katzenmeyer, William G., eds., Management Information Systems in Higher Education, pp. 40-41.

[3]See the article by Russell, John Dale, "Decision Making in Higher Education," in The Instructional Process and Institutional Research, pp. 19-27, and Baughman, George W., "Towards a Theory of University Management," in Johnson and Katzenmeyer, pp. 3-28.

My study presumes further that the incorporation of a goal structure and methodology for evaluation of alternatives as a part of the model may be dangerous. Objectives may change rather subtly. Creative decision-makers may find that too much structure in a model stifles innovation. So far as is possible, model structures should be independent of objectives, so that decisions are not dictated by model results or lack of them.

3. Implementation Roles

The second major phase of Casasco's conceptual framework centers about a completed decision. Once a decision has been made it must be translated into action through a statement of policies and priorities and by an allocation of resources. The decision must be evaluated through the results attained. The entire process must be re-cycled in view of new information and changing circumstances. The model will be useful in this phase if it provides a framework for timely data acquisition and develops this data into usable information. The decision-maker must translate, evaluate, and rethink.

B. The Need to Assess Potential Benefits from the University Simulation Model.

Several universities have developed operational data systems[4] and have used the information gathered in planning applications. This would seem to make somewhat academic the question of whether a planning simulation is feasible. In fact, however, there is reason to believe that many of the university planning models and the associated data systems are not self-supporting in terms of benefits derived compared with their costs. Consider the feelings of the president of a university which is spending over $2,000,000 a year on computer operations. He said, "I cannot see that the administration of this university is receiving any benefit from our computer operations but still have the feeling that we can and should."[5] If the expenditure of 20% additional administrative effort brings about a 10% savings in administrative salaries, there is some question as to whether such an expenditure is justified.

---

[4] Minter, John and Lawrence, Ben, eds., Management Information Systems and Their Development and Use in the Administration of Higher Education, contains a list of 45 colleges and universities which have "made significant progress in the development of operational data systems" on p. 97.

[5] Van Dusseldorp, Ralph, "Some Principles for the Development of Management Information Systems" in Johnson and Katzenmeyer, pp. 29-41.

A decision-maker contemplating the development of a planning model should ask these three questions:

1. Can we do a good job under the present system?

2. How much better can we do under the proposed system?

3. Is the added benefit worth the added cost?

A statement by Warren W. Gulko, director of WICHE's Planning and Management Systems Development and Applications, should serve as a warning here.

> "Simulation models in higher education are not sufficiently proven at this time to warrant a level of confidence sufficient to persuade administrators to change their current methods of budgeting and planning. In fact, developers of analytical models would insist that such models may not be useful for current year applications until they have been operational within an institution for some time. Consequently, when analytical models are eventually implemented within an institution, such implementation will be parallel to the existing system. Only as models become fully operational will the old system be supplemented by the new system."[6]

In the face of these opinions, it is not at all obvious that the development expense of a university simulation model will be justified by the benefits derived.

Further, it is not obvious that detailed feasibility studies are very useful in determining whether the ultimate benefits will justify the effort involved in developing a massive system. Further evidence on benefits derived from systems already developed may be the best guide for the feasibility of studies in the planning phase.[7]

C. Why Is Urban University Management Unique?

Universities are unique among institutions which must be managed, and large, public, urban universities are a unique subset among all universities.

---

ulko, Warren W., The Resources Requirements Prediction Model (RRPM-1): n Overview, WICHE Technical Report #16, p.2

an Dusseldorp, Ralph, "Some Principles for the Development of Management nformation Systems," points this out on pp. 35-36.

In universities, the product is difficult to define and the quality and quantity of output is difficult to measure.[8] The voice of the constituency (students and the general public) is relatively weak (although less so recently), and effective quality control is difficult. Academic programs are planned by people who have a strong allegiance to some disciplinary area, but may not have a clear view of the university as a whole. Funding comes from outside agencies, which are out of the direct sphere of influence of university managers. Each of these attributes make management of universities in general a different process from the management of an institution which produces an output which is sold in a market.

Large, public, urban universities are a rather unique subset of universities in that they serve a more volatile student body. This is true because many students work as well as go to school, many shift back and forth from day to night classes, and many drop out of school for a while and then re-enter. Definition of classes is difficult since there is no well-defined group of students who enter as freshmen in 197X and graduate in 197X + 4. Students may take from 3 to 10 years to complete an undergraduate degree program. Planning is more difficult than in other universities because of this inherent instability of the student body and consequently of its needs.

For these reasons, it is worthwhile to investigate planning models in a preliminary analysis even if they have been successfully used in other contexts. There is no basis for believing that a simulation model can be usefully applied in in universities simply because it has been used successfully by General Motors, for instance. Similarly, there is no basis for concluding that a model which yielded useful information at the University of Georgia will for that reason be successful at Georgia State University.

D. Specific Areas of Inquiry

The basic question is, "Does the structure of an urban university lend itself to modeling?" The following interrelated areas must be investigated in order to properly answer that question.

---

[8]This problem is discussed at length and very usefully in Lawrence, Ben, et. al., Outputs of Higher Education: Their Identification, Measurement, and Evaluation.

1. Stability of Model Elements

A structure lends itself to modeling if the relationships of interest are stable. Kenneth Boulding, the economist, as quoted in Jewett says, "Images of the World can only take the form of mathematical models if the world itself has orderly patterns which mathematical models can describe".[9] Quantitative models rest on the assumption that there is some regularity underlying the phenomenon being modelled. It is impossible to model a situation in which something unexpected happens time after time. In a university, for instance, if 75% of the freshmen always take the initial English course during their first quarter in residency, that relationship can be used in setting up a model of resource requirements. If no pattern exists however, it is quite difficult to set up a meaningful model.

2. Level of Aggregation

Closely related to the stability question is the choice of a level of aggregation of a model. More highly aggregated relationships are more likely to be more stable simply because the aberrations of individuals or quirks of circumstance are more likely to be "averaged out" if a large number of people or circumstances are involved. The appropriateness of various levels of aggregation of a model do not relate to the attendent stability, however, so much as to the uses to which the model is to be put. A long range planning model for land acquisition might be highly aggregated, for instance, while a quarterly model for planning course offerings should be based on a low level of aggregation. Models which contain unstable elements at the required level of aggregation simply are not usable.

3. The Planning Horizon

A dimension of modelling which is closely related to both the stability and level of aggregation problems is that of the planning horizon. Many important questions which university managers face, such as

---

[9] Jewett, Frank I., Fedderson, Alan P., Lawson, Donald F., and O'Grady, William D., "The Feasibility of Analytic Models for Academic Planning--A Preliminary Analysis of Seven Quarters of Observations on the 'Induced Course Load Matrix,'" p. i.

class scheduling, involve a relatively short time horizon. Others, such as building and land acqusition, require so much time between a decision and the occurrance of the planned event that quite a long time horizon is involved. Models are useful if they deal with relationships that are sufficiently stable at the appropriate level of aggregation to allow accurate projections far enough in the future so that sufficient lead time exists between the need for a decision and the need for the outcome dictated by the decision.

4. Data Availability and Model Implementation

Given that the stability, aggregation, and time horizon requirements are fulfilled, a model is feasible if the data which supports it is available or can be acquired. Given data and a feeling that the simulation model is worthwhile, the remaining question concerns the implementation of the system simulation.

Each of these questions will be dealt with in the sections which follow.

II. METHODS

In summary, the method used in this study consists of a comprehensive review of model types which have been developed. While the study was started on the premise that a stochastic microanalysis would be an acceptable model type, it soon became obvious that there were several alternative model types which were also promising.

This feasibility study is not directed toward the justification of a particular model type, but toward a broad review and synthesis of work which has been done across the range of university planning model types. The use of this prior developmental work as a point of departure promises to eliminate the need for much costly and time consuming basic analysis.

A. Survey of Literature in Simulation Models

A search of the literature concerning simulation models turned up the following significant bibliographies. The bibliography of this report contains complete reference information concerning each of these.

First, there is a bibliography containing 1333 items, which was compiled by Klaus Hüfner.[1] This bibliography categorizes literature on the economics of higher education and educational planning through 1967.

Another useful source was Models for Planning, prepared by the ERIC Clearinghouse on Educational Administration. This document analyzes research trends in the applications of planning models to broad educational systems and extends Hüfner's survey through 1969.

Other important reference sources for this study are those of Chamberlin, Diener and Trower, ERIC, Hall, Twelker, and Review of Educational Research.

A useful reference source for more current work is Research in Education (RIE), the monthly catalog of abstracts which is published by the Educational Resources Information Center (ERIC), the national information center operated by the U.S. Office of Education.

[1] Hüfner, Klaus, "Economics of Higher Education and Educational Planning -- A Bibliography," pp. 25-101

More philosophical insights were provided by documents such as the annual Proceedings of the Forum on Institutional Research, sponsored by the Association for Institutional Research, and by reports of seminars such as that edited by Minter and Lawrence of the Western Interstate Commission for Higher Education (WICHE).

Two publications which are most significant for this study, however, are Casasco's Planning Techniques for University Management and A Structural Comparison of Analytical Models for University Planning, by Weathersby and Weinstein. Casasco's report catalogs 21 existing models by types and summarizes their objectives, methods, findings, applications and limitations. The Weathersby-Weinstein report contains a conceptual framework against which a number of mathematical models which are currently available are compared with respect to their comprehensiveness, structure, mathematical approach, and relative desirability. This report also contains a very useful bibliography.

In view of the wealth of material which is available, it is apparent that the development of an extensive bibliography as an attachment to this report would not be useful. This effort would simply consist of a rearrangement of materials contained in the bibliographies referred to above. The bibliography for this study will refer only to works which are mentioned in the narrative.

The insights gained from the literature were supplemented with conversations or correspondence with researchers and administrators who are currently involved in either developing management models or in managing in the absence of a formal model.

B. Macroanalytical Models

It seems that a useful distinction between approaches to modeling is that between macroanalysis and microanalysis.[2] Macroanalysis is concerned with relationships among aggregated variables. An example of such a relationship is the average number of credit hours completed per student per quarter. The concern is not with any individual or his particular motivations,

[2] See Cohen, Malcolm S., "Quantitative Methods: Models and Simulation -- A Summary of Techniques," p. 153 for this and other distinctions. An extremely useful overview of university modeling considerations is found in Wallhaus, Robert A., "Modeling for Higher Education Administration and Management," pp. 125-144.

but with an average relationship within the student body. Microanalysis, on the other hand, is concerned with individual actions and motivations. For instance, a microanalytical approach might concern itself with understanding the reasons for which a student might take one, two, or three courses per quarter. In the following four sections, several macroanalytical approaches will be examined.

1. CAMPUS

The first operational comprehensive university simulation model was CAMPUS, developed by the Systems Research Group (SRG) of Toronto. This is a complex, flexible model which requires an extensive data base. This model may be purchased from a merchandising office of SRG. It is reported to require about 18 months to set up and uses the computer equivalent of an IBM 360/65 in large university applications.[3] It is operational in a number of colleges in Ontario and is being extended to some colleges in the United States.

2. RRPM

The major alternative to CAMPUS is the Resources Requirements Prediction Model (RRPM), which was developed through the Western Interstate Commission for Higher Education (WICHE). WICHE is a public agency supported by both government and private groups. The RRPM model is still in a developmental stage, although the initial version, RRPM-1, is operating at eight institutions in a pilot test.[4]

The RRPM-1 version estimates resources necessary to support a given student body, subject to certain administratively determined parameters, such as average faculty teaching load, class sizes, and faculty salary schedules. Outputs include faculty requirements, space requirements, and various projected costs.

[3] Casasco, Juan A., Planning Techniques for University Management, p. 18.

[4] Gulko, Warren W., The Resources Requirements Prediction Model (RRPM-1): An Overview, p. 25.

An expanded version, RRPM-2, is under development. It will contain a student flow module, a faculty flow module, and a revenue forecasting module and will allow the study of more complex relationships. It will allow a more sophisticated treatment of the research and public service function of a university.

3. Other Comprehensive Models

Other comprehensive university planning models which were examined as a part of the study have been developed at the University of California, Michigan State University, Tulane University, the University of Miami, and by Peat, Marwick, Mitchell and Company. Detailed references to these models are included in the bibliography under "Planning Models." Some of these are primarily of academic interest, while others, while operational, are of more limited scope or not as fully documented as the CAMPUS and RRPM models. For these reasons, my study is directed toward an examination of CAMPUS and RRPM in an effort to discover developmental work which has been completed and which may serve as a starting point in judging the feasibility of a comprehensive university simulation model. The decision to concentrate on CAMPUS and RRPM has been reinforced by conversations and correspondence with experts. They generally agree this is the best starting point.

4. The Induced Course Load Matrix (ICLM)

Of critical importance in both the CAMPUS and RRPM models is the induced course load matrix (ICLM). As used in these models, the ICLM specifies the demands on the courses in various disciplines (for example, economics, accounting or quantitative methods) made by students at various levels (for example, freshmen, sophomores, etc.) in various degree programs (for example, BBA in Insurance, etc.). The ICLM is a flexible concept adopted from the input-output table developed by Professor Leontief, an economist. It may be appropriately used to organize data at several different levels of aggregation.

For example, an ICLM could be developed to represent the demands by majors on the courses of various disciplines in an MBA program. At this level of aggregation the distinction between first and second year students may not be important. Appendix 1 contains a sample ICLM for such a program along with a demonstration of how it may be used.

The ICLM is an important concept in comprehensive planning models, in that it makes unnecessary the need to trace the path of any individual student through the curriculum. While such a path could be traced out based on degree requirements and normal course sequences, it is extremely complex for a very large system with many alternatives. This problem is compounded in urban universities because students drop in and out of school from quarter to quarter. If the elements of the ICLM are reasonably stable, or if their variation can be related to trends or changes in the curriculum, then it will be useful as a planning device. If, however, the elements are not stable and the instability cannot be predicted or understood, the ICLM is of limited use as a planning device.

The legitimacy of both CAMPUS and RRPM as planning models rests with the stability of the elements of the ICLM's, which are the bases around which these models are built. The developers of RRPM state that "there is some question as to the stability of the ICLM at any one institution."[5] A recent study by Jewett, et. al.[6] confirms that there is some question as to the desirability of implementing a planning model based upon an ICLM.

A major effort in this feasibility study is consequently centered around an examination of the elements of ICLM's representing various levels of aggregation. If these elements prove sufficiently stable, then it is reasonable to use the ICLM as the basis for a comprehensive planning model of the type described in Appendix 2.

C. Microanalytical Models

Microanalysis differs from macroanalysis in that it deals with motivations for choices made by individuals within a system rather than with trends and averages. This allows a much more detailed simulation and analysis, but also requires much more detailed data.

5 Gulko, Warren W., RRPM: An Overview, p. 17.

6 Jewett, Frank I., et. al., "The Feasibility of Analytic Models for Academic Planning -- A Preliminary Analysis of Seven Quarters of Observations on the 'Induced Course Load Matrix'", p. 16.

A microanalytical model of a university might deal with questions such as:

1. Why does a student decide to go to college?

2. Why does he select a particular college?

3. Why does he select a particular major?

4. Why does he decide to work part-time while attending school?

5. Why does he decide to take 15 credit hours rather than 10 credit hours?

6. Why does he select a particular set of courses in a particular quarter?

The analysis of a set of decision points can quickly become unmanageably complex. For instance, a series of fifteen sequential decisions, each involving only two possible choices, will result in 32,768 (2^{15}) possible combinations of decisions. Twenty such decisions would result in 1,048,576 (2^{20}) possible combinations.

Since a preliminary analysis of the decisions made by students as they move from high school through graduation from a university indicates that many more than twenty decisions are involved with many more than two choices at most decision points, it is clear that a comprehensive model using a microanalysis is not feasible.

The literature of simulation studies contains several references to the problems of unmanageably complex structures which simply cannot be adequately modeled using microanalytic methods. A pioneering effort by Guy Orcutt and his colleagues[7] resulted in an approach which was manageable so long as the system was not too complex. Even so, Orcutt's approach was extremely expensive in terms of computer time required.

A later study reported on an attempt of the University of Minnesota to develop a microanalysis to predict college enrollments. The conclusions from this report seem to be that major

[7] Orcutt, Guy; Greenberger, Martin; Korbel, John, and Rivlin, Alice, Microanalysis of Socioeconomic Systems

emphasis should be placed on macro level analysis, but that microanalysis may be useful in developing a fuller understanding of enrollment trends.[8]

It appears that recent developments in decision analysis, such as the Automatic Interaction Detector (AID)[9] program, will allow meaningful microanalysis of reasonably complex systems. It does not appear, however, that complexities of the magnitude encountered in a comprehensive university planning model can be reasonably modeled using microanalytic techniques. Apparently, the contribution of microanalysis in university modeling come primarily from the more detailed analysis it allows in looking at some sub-system, such as enrollment projections.

D. Enrollment Projections

The comprehensive planning models which appear most useful at this point assume a sequence of causality which runs from student enrollments to faculty and space requirements to equipment, staff, and budgetary requirements. A useful model will take enrollment projections as an input and produce resource requirements.

Given this analytical scheme, it is necessary to accurately project student enrollments. L. J. Lins, in a very useful article,[10] describes four methods for making enrollment projections. These include the curve-fitting method, the ratio method, cohort-survival methods, and correlation analysis. Any of these, or some combination, may be appropriate for a particular university at a particular point in time, but it is unlikely that any one approach is universally applicable.

Two methods were used in determining whether meaningful enrollment projections can be obtained. The first consisted of talking with experienced academic administrators and institutional researchers at Georgia State University. A second approach consisted of fitting curves to historical data at several levels of aggregation. The results of these investigations are reported in Chapter III and in Appendix 3.

---

[8]Corcoran, Mary and Anderson, Douglas H., "Rationale for Using Micro-Analytic Approaches in Predicting the Character and Size of College Student Enrollments," p. 59.

[9]Sonquist, John A. and Morgan, James N., The Detection of Inter-action Effects.

[10]Lins, L. J., "Enrollment Projections for Public Institutions," pp. 12-14.

III. RESULTS

Since this is a feasibility study, the bulk of the results from the research accomplished comes from a "feel" for the overall situation. This "feel" comes from a synthesis of the literature searched and from conversations with those who are knowledgeable. Such a "feeling" is worthwhile if one is able to ask the right questions and select an overall direction which is most likely to be fruitful. For the feasibility of a university planning model, the appropriate questions for which empirical evidence is available seem to be (1) How closely can enrollments be predicted and (2) How stable are the relationships within the induced course load matrix (ICLM).

The chapter on conclusions contains the impressions from the synthesis of the literature and conversations. These are probably more important, although less demonstrable, than the results presented in this chapter, which are based on empirical evidence from historical data.

A. Analysis of Enrollment Trends

This section is included because of the important place of enrollment projections in the models under serious study. In each case, the starting place is enrollment projections. It follows that if enrollment cannot be projected with reasonable accuracy, the model loses some of its effectiveness.

Two approaches were taken to this problem. First, seasoned administrators, who have projected enrollment trends as a part of their job, were asked about their experiences. Their feelings were that generally enrollment trends can be projected with a reasonable degree of accuracy at the graduate and senior division levels, but that reasonable forecasts were more difficult for the junior division (freshmen and sophomores) at Georgia State University. This seems to imply that the junior division students are somewhat more transient, as might be expected for a commuting school.

The second approach consisted of an analysis of historical enrollment figures by the curve-fitting method. It was reasoned that if this somewhat simplistic approach yielded reasonable results, then a more sophisticated approach employed by a capable administrator, who can impose subjective judgements on the results, would yield even more satisfactory results.

1. Data Description

The data used in this part of the analysis came from 44 quarters (back to 1960) of enrollment statistics for the various schools within the Georgia State University. This information was divided into three parts -- the junior division (freshmen, sophomores and pre-baccalaureate), the senior division (juniors and seniors) and the graduate division.

2. Analysis

The data was tested first for seasonal trends in enrollment. All divisions exhibited marked and consistent seasonal patterns. Part A of Appendix 3 shows these results.

Next, the data was subjected to regression analysis to find the form of the time trend which yielded the most explanatory power. Each season was regressed separately because of the seasonal pattern. While the results were mixed, (See part B of Appendix 3) they generally confirmed the administrators feelings that projections were better in the upper divisions. About 90 to 95% of the enrollment variation could be related to a trend line. A logarithmic transformation allowed the explanation of virtually all of the variation in the total enrollment.

A more elaborate regression, containing years and seasonal factors, explained 98.4% of the variation of the logarithm of total university enrollment. The resulting equation, which was quite significant in the statistical sense, indicated an 18.5% annual growth rate for the university enrollment. Probably by coincidence, the growth of the business school graduate enrollment from Fall, 1970, to Fall, 1971, was 19%. (See parts C and D of Appendix 3 for these results.)

A final examination of the enrollment history came by using data through 1970 as a basis for predicting 1971 enrollment by quarters for the entire university and for the business school. The data was deseasonalized and processed through an exponential smoothing routine. This produces a prediction which weighs recent history more heavily than early history. The results are shown in part D of Appendix 3. The average deviation of the projection from what actually happened is greater for the business school than for the total university. This is understandable, because the business school projection is based on a much smaller number of people.

B. Analysis of ICLM Elements

The ICLM lies at the heart of the most useful comprehensive university planning models. It is important, therefore, to investigate the applicability of the ICLM concept in a real environment. For this study, the ICLM is applied to the graduate level business program at Georgia State University.

1. Data Description

The data used to examine the ICLM concept is from the fall quarters of 1969, 1970, and 1971. It was assembled from magnetic tape files of evaluation-guidance information. This information is available for all quarters of several years, but, becomes of dubious value in the earlier years because of the developmental status of the evaluation-guidance system during that period. A known weakness of the data collected for this study is that the major field of study for each individual is that as of the time of his graduation, but not necessarily the same as at the time he took the credit hours shown. A sample of the crossover table printout is contained in Appendix 2. More highly aggregated crossover tables for 1969, 1970, and 1971 are given in Tables 1, 3, and 5 respectively in Appendix 4. These crossover tables are converted to ICLM's by the process described in Appendix 1. The resulting ICLM's for 1969, 1970, and 1971 are given in Tables 2, 4, and 6 respectively.

2. Analysis

The elements from the ICLM's for all three years are brought together in Table 7. Probably the most remarkable characteristic of these elements is their lack of stability from year to year. Some of the more stable relationships seem to occur in the management (MG) discipline. For example, the management discipline (MG), management major, (MG) intersection contains the elements 2.956, 3.286, and 3.097. This indicates that on the average a management major demands about 3 credit hours per quarter in the management discipline. The stability of these particular elements is explainable because there were about 400 management majors during this time, the largest major in the table.

It is also interesting to note that there are only three pairs of 1969-1970 elements which are the same at the second significant digit -- for example, the 1.077 and 1.117 at the MK major-AC discipline intersection. On the other hand, there are eight 1970-1971 elements which are the same at the second significant digit and four or five others very nearly so. The percentage increase in graduate business enrollment was 69% from 1969 to 1970 and 19% from 1970 to 1971. It seems clear that there is less correspondence of element values in the face of a higher growth rate.

This illustrates a dilemma which was pointed out in the Jewett work cited earlier.[1] Briefly, the ICLM is more useful the less you need it. Inefficiencies are built into the data base. The more dynamic the situation, the more difficult the planning; and, consequently, the greater the inefficiencies that are likely to get built into the data base. At the same time, some basis for planning is needed most when the situation is most dynamic.

It is likely that the elements of the ICLM will stabilize for the graduate school of business, simply because it is unlikely to experience a 69% increase in enrollment in one year in the future.

[1]Jewett, Feasibility of Analytic Models for Planning, pp. 2-4.

It appears that the use of student major as a divisor in calculating the ICLM's for this study is inappropriate. A large amount of the credit hour demand on the disciplinary areas in the graduate business school is generated by Master of Business Administration (MBA) degree candidates. MBA's are only loosely attached to a major field of study. A more fruitful aggregation of the ICLM would involve dividing all disciplinary credit hours by the total number of graduate students enrolled.

Tables 8 and 9 represent predictions based on elements from ICLM's. The factors in Table 8 are taken from the ICLM in Tables 2, 4, and 6. The factors in Table 7 are computed by dividing by total students in every case, rather than the students' majors in each field. Prediction factors are then developed by increasing the 1971 factor by as much over 1970, as the 1970 factor increased over 1969. This is named TREND. The average of the 1969 and 1970 factors is also used. This is named AVERAGE.

Two characteristics of these tables are notable. First, the factors in Table 9 are more stable than those in Table 8. The average change is 39.5% for Table 9 and 19.7% for the same disciplines taken from Table 8. This suggests that division by total students may be preferable to division by student majors as a basis for the ICLM. It is also interesting to note that the deviations of the predicted 1971 figures from the actual 1971 figures is less when the AVERAGE factor is used than when the TREND factor is used. This suggests that an average of several years' factors may be an aid to stability of the elements of an ICLM.

A final aggregation, shown in Table 10, was developed, based on the fact that nine courses (out of 91 offered in the Fall of 1971) accounted for 42% of the credit hours taken. An ICLM is developed which uses these courses as a basis for aggregation. The average percentage change of factors and percentage deviations from the actual 1971 enrollments were about the same in this instance as they were in Table 10. The superiority of the use of AVERAGE rather than TREND as a prediction factor was confirmed in this new ICLM.

IV. CONCLUSIONS AND IMPLIED RECOMMENDATIONS

The basic question is "Does the structure of an urban university lend itself to modeling?"

This study indicates:

1. Microanalytic models are inappropriate for a comprehensive university model. They may be applied usefully to a sub-sector of the university, such as enrollment projections.

2. There is evidence in the literature which indicates that comprehensive planning models are very expensive relative to the benefits derived. They should be thought of as in the process of development. Several developmental efforts have resulted in models which seem to be primarily of academic interest in that they are built around sophisticated applied mathematical techniques and embody rather restrictive theoretical assumptions.

3. Comprehensive models based on macroanalysis are likely to be useful. While the relationships are often loose, and predictability at some levels of aggregation may be poor, the model nevertheless provides a useful overview and structure for data acquisition and development. Many of the relationships seem quite stable and should lead to useful predictions and analysis.

4. The ICLM seems to be a viable basis upon which to build a comprehensive model, provided flexibility in its application allows different levels of aggregation in different situations. An attempt to aggregate all ICLM's at the same level, regardless of the level of the problem is likely to result in the generation of inferior information or the expenditure of too many resources in the modeling effort. It appears that the year to year instability of the ICLM elements can be offset by two methods. First, an administrator who is thoroughly familiar with the operation of the university, and with its recent history, should interpret the trends and reflections of inefficiencies in the elements. Second, an averaging of elements over a period of time will apparently yield some reduction in the variation which remains (which hopefully comes from random causes).

5. A major effort must be made in any implementation of a planning model to insure that decision-makers properly understand their roles relative to the model. Only through in-depth involvement by the line managers of a university can the model results be properly tempered by the subjective considerations that cannot be incorporated in the model. Given a choice, it seems much better to place major responsibility for bringing a model into the management system of a university on a team of in-house administrators and systems experts than to use a staff of outside people who will leave upon completion of the implementation.

6. The work by the Western Interstate Commission for Higher Education (WICHE) on the RRPM series seems to be the best starting point for a university which is considering the development of a planning model. WICHE's documentation promises to be such (inexpensive and extensive) that it can be used for a gradual or partial implementation. This seems to be a more workable approach than a task force oriented crash program to implement a model, especially given the state of development of the models available (unless, of course, the present management system is unworkable and dangerously inefficient).

7. There seems to be no need to organize a task force to investigate new comprehensive model types. More useful work can probably be done in developing approaches to the understanding of sub-systems of universities. Usefulness of modeling should be demonstrated in smaller applications so that its value will be perceived and welcomed by decision-makers and others who will ultimately benefit from it.

APPENDIX 1

Calculation of an Induce' ourse Load Matrix

Historical data showing the number of credit hours taken in the various disciplines by majors in several fields is referred to as a crossover table. The crossover table serves as a basis for the development of the induced course load matrix (ICLM). A sample crossover table is shown below. A crossover table containing real data is contained in Appendix 2.

Field of Study		1	2	3
Discipline	A	400	50	100
	B	100	600	50
	C	50	50	700
	D	200	300	100
		750	1000	950
Number of Student Majors		100	125	95

In this crossover table, the elements represent the number of credit hours taken in the disciplinary areas A, B, C, and D by the students majoring in fields 1, 2, and 3. For instance, majors in field 1 took 400 credit hours in discipline A during the quarter represented by these data. There are 100 students majoring in field 1. Therefore, the average demand of a student majoring in field 1 on discipline A is 4 credit hours per quarter. This average demand is the content of the ICLM.

The ICLM is developed by dividing the number of credit hours taken by majors in a field by the number of majors in that field.

The ICLM which relates to the crossover matrix shown above is as follows:

Field of Study		1	2	3
Discipline	A	4.0	0.4	1.05
	B	1.0	4.8	.53
	C	0.5	0.4	7.37
	D	2.0	2.4	1.05

The elements of the ICLM reflect the average demand per student of the fields of study on the disciplinary areas. For instance, the average student in field 2 demands .4 credit hours per quarter from discipline A.

Given a projection of the number of majors expected by major fields, it is possible to use the ICLM to predict the demands which will be made in the disciplinary areas. For instance, if the number of students expected next year in the fields of study are 125, 140, and 150 for fields 1, 2, and 3 respectively; then we can predict that the disciplinary areas must offer 713.5, 876.5, 1224, and 743.5 credit hours for disciplines A, B, C, and D respectively.

These figures are derived from using the ICLM and the student major projection to calculate a crossover table. Multiplying the elements in the ICLM by the student majors predicted for each field yield the following results:

Field of Study		1	2	3	Total
Discipline	A	500	56	157.5	713.5
	B	125	672	79.5	876.5
	C	62.5	56	1105.5	1224
	D	250	336	157.5	743.5
		937.5	1120	1500	
Students Expected		125	140	150	

To illustrate the derivation of this matrix, the 1105.5 was obtained by multiplying 150 (the number of majors projected for major 3) by 7.37 (the average demand by a major in field 3 on credit hours offered in discipline C). Horizontal addition of the elements indicates that 713.5 credit hours will be needed from discipline A to serve the needs of the projected enrollment.

The total credit hours required can serve as a basis for estimating faculty, space, staff, equipment, and budget requirements, based on various management options available to the administration and also based on statistical relationships which can be derived from historical data.

The ICLM may be calculated at a lower level of aggregation if planning needs dictate. For instance, if raw data is available the breakdown by discipline could be on specific courses and times. This would facilitate the planning for sections of courses.

A higher level of aggregation may be desirable for longer range or broader gauge situations. Rather than field of study, student levels (for example, undergraduate, masters, doctoral) could be used. Rather than disciplinary areas, major divisions of the university (for example, School of Business, Arts and Sciences, etc.) could be used. This might be appropriate for planning construction programs, which require a longer lead time, or for determining feedbacks among university divisions caused by majors in one division taking courses in another.

APPENDIX 2

Sample Crossover Table (Raw Data)

The four pages which follow are copies of a computer printout which yielded the raw data from which the crossover tables and induced course load matrices were constructed.

The designations across the top of the page stand for major areas of study -- AC for accounting, AS for actuarial science, and so forth. The courses offered in each disciplinary area are listed in a column on the left side of the page. The numbers in the body of the table refer to the number of credit hours taken during a particular quarter in the course at the left of the same row by all of the students majoring in the area designated by the column heading. For example, accounting majors took 90 credit hours of AC 409 during the quarter represented here.

The totals on the final page indicate the total student majors in each area of study, along with the total credit hours they took in all disciplines.

AC	409	[illegible]			5					10					1
AC	410	[illegible]			5										
AC	433	[illegible]													
AC	450	[illegible]													
AC	601	55		15	165	30	40	60	20	305	50	55	10		8
AC	803	45	10	15	195	30			60	280	90	50	20	5	8
AC	805	10[illegible]			[illegible]										1
AC	829	40			[illegible]									5	
AC	845	175								5					1
AC	899	195			[illegible]										2
AC	850	80			[illegible]					10					1
AC	910	30													
		680	10	30	41[illegible]	[illegible]	40	60	60	610	140	105	30	15	24
ACTUARIAL SCIENCE															
AS	311		10												
AS	801		15												
AS	802		20												
AS	806		40												
AS	820		35												
			150												1
BUSINESS LAW															
BL	301	5													
BL	800									5	10	5			
BL	805	5			[illegible]					35	5	10			
BL	807	10		15	35		5		5	50	10				1
BL	825	25			2[illegible]				5	30	5	5			
		45		15	[illegible]		5		10	120	30	20			3
ECONOMICS															
EC	201													5	
EC	496							5							
EC	601	20	5	5	115	10	5	30	25	170	50	15	20		4
EC	803		5	55											
EC	805	110		15	235			35	55	265	55	35	30	5	8
EC	806	60		30	185	100	10	5	40	195	75	20		5	7
EC	811		5	25	10										
EC	815		5	15						5					
EC	816			5											
EC	830			15					5						
EC	845			15	5									5	
EC	850			15	20					5				5	
EC	860			30											
EC	890			5					10						
EC	909	10		20		5				15	5				
EC	910			20						5					
EC	925			10											
EC	960			10											

SUMMARY OF COURSES TAKEN BY MAJOR AREA - 714 - 714 RUN DATE 02/26/72

[illegible]	[illegible]	[illegible]	EC	FI	HA	IN	IS	IB	MG	MK	RE	QS	UN	OTH	TOTAL
	[illegible]	[illegible]	270	570	115	15	75	155	660	165	70	50	25		2410
FINANCE															
FI 820				130				5	5		5	5	5		155
FI 830	30		20	255		10		10	180	50	20	15	5		595
FI 831				155	5			5	15		5				185
FI 832	5			120					10	5	5				145
FI 840				70					10						80
FI 841	5			25											30
FI 850				50				30		5		5			90
	40		20	805	5	10		50	220	60	35	25	10		1280
HOSPITAL ADMINISTRATION															
HA 401									5						5
HA 810					130										130
HA 835					125										125
HA 850					80										80
HA 925					5										5
					340				5						345
INSURANCE															
IN 801				5		35			10						50
IN 802				5		30									35
IN 813						10									10
IN 831		5		10		30			5						50
IN 890		5													5
		10		20		105			15						150
INFORMATION SYSTEMS															
IS 302	5														5
IS 410							50								50
IS 801	20	5	15	25		25	60	5	40	15			10		220
IS 802	15		10	25			50		45			5	5		155
IS 820	5						75	5							85
IS 830							15	5							20
IS 834							25		10	5					40
IS 852	5						45		5						55
	50	5	25	50		25	320	15	100	20		5	15		630
INTERNATIONAL BUSINESS															
IB 809				5				30	10	5					50
				5				30	10	5					50
MANAGEMENT															
MG 350								5							5
MG 601	10			70		15	15	20	125	20	30	5			305
MG 801	95		30	155	10		30	5	185	60	45	5	10		630
MG 802	45	5	5	140			40	5	140	70	20	25	50		545
MG 810				5					60						65

[illegible] OF COURSES TAKEN BY MAJOR AREA - 714 - 714 RUN DATE 02/26/72

	.C	[illegible]	EC	FI	HA	IN	IS	ID	MG	MK	RE	DS	UN	OTH	TOTAL
[illegible]															
MG [illegible]				5			65		230	10	15		5		330
MG 825				55					165	25	5				250
MG 830				5	10				35						50
MG 840			5	15		5			160		10				195
MG 850							20		55	5		5			85
MG 855									45						45
MG 860				5				5	15						25
MG 880			5				5		45						55
MG 890								5	30						35
MG 920									40						40
MG 925									5						5
MG 930									40						40
	150	5	45	455	20	15	175	45	1375	190	125	40	65		2705
MARKETING															
MK 301	5														5
MK 810	10		5	50	5		10		95	90	5	5	5		280
MK 820				5					20	75	5	5	10		120
MK 835				5			5	5		10					25
MK 860	5							35		30					70
	20		5	60	5		15	40	115	205	10	10	15		500
REAL ESTATE															
RE 450				5											5
RE 460													5		5
RE 480													5		5
RE 810						5			10	10	55				80
RE 820									20		15				35
RE 830	5								10		20				35
RE 840	5		5	15					25		20				70
RE 888			5						20		10				35
RE 925									5						5
	10		10	20		5			90	10	120		10		275
DECISION SCIENCES															
DS 231							15								15
DS 312									10						10
DS 615	85		25	130		10	20	25	155	45	25		5		525
DS 800	5	5	10	5		5	45		15			50			140
DS 810	85		15	120				45	215	25	40				545
DS 811	40		15	145				30	215	50	5				500
DS 814							5	5	5			60			75
DS 824									10			55			65
DS 912	15				5	10			25	15		10	5		85
DS 914									25						25
DS 916	20			5				5	20						50
	250	5	65	405	5	25	85	110	695	135	70	175	10		2035
MISCELLANEOUS															
BA 920	5			5				10	5						25
BA 950	40		20	35	5	35		20	60	10					225

SUMMARY OF COURSES TAKEN BY MAJOR AREA - 714 - 714 RUN DATE 02/26/72

[illegible]	[illegible]	[illegible]	[illegible]	FI	[illegible]	[illegible]	[illegible]	[illegible]	MG	NR	RE	DS	UN	OTH	TOTAL
[illegible]			[illegible]						5						10
CHE 111	[illegible]														5
CHEM 115	1														1
CHEM 393									3						3
EAS 800									5						5
EAS 856									5						5
ENG 202									5						5
ENG 212							5								5
ESL 109		[illegible]				5									10
FED 305											5				5
FED 601											5				5
FED 331											5		10		15
FR 101												5			5
GEOG 109							5								5
GEOG 664											5				5
GEOL 101										5					5
HIST 653										5					5
MATH 212		5													5
MATH 851							5								5
HS 301									2						2
HS 401		2		1	[illegible]						2	2			10
PHYS 101	[illegible]														5
POLS 891									5						5
PSY 501									5						5
PSY 873									5						5
PSY 899									5						5
RUS 101												5			5
SOC 809											5				5
UL 820									5						5
	55	12	25	[illegible]	5	40	15	30	115	20	27	12	10		411
MISCELLANEOUS															
TOTAL HOURS	1701	217	530	2937	575	285	745	545	4130	1000	582	347	175		13771
TOTAL STUDENTS	175	23	57	337	57	28	44	56	465	108	62	35	29		1986

APPENDIX 3

Statistical Analysis of Enrollment Trends

A. Results of test for seasonality of enrollment trends.

	Junior Division	Senior Division	Graduate Division	Total
Winter	1.15	1.11	1.12	1.08
Spring	1.03	.87	1.02	1.01
Summer	.57	.87	.72	.75
Fall	1.24	1.15	1.13	1.16

These factors indicate the variation of attendance levels by quarters relative to the average for the year. For instance, the table indicates that winter quarter attendance is 108% of the year's average for the entire university, while summer quarter attendance is only 75% of the total.

B. Results of test for specification of relationship which best fits historical trends.

Linear Equation

	Junior Division	Senior Division	Graduate Division	Total
Winter	.91	.91	.95	.96
Spring	.91	.93	.93	.95
Summer	.92	.96	.94	.94
Fall	.78	.97	.98	.98

The numbers presented here are measures of goodness of fit. The higher the number, the better the fit of a particular curve to a set of data. For instance, the .91 for the Junior Division indicates that 91% of the variation in enrollment was accounted for by the trend line.

Logarithmic Transformation

	Junior Division	Senior Division	Graduate Division	Total
Winter	.89	.92	.94	.99
Spring	.88	.94	.92	.99
Summer	.95	.94	.93	.99
Fall	.86	.94	.98	.98

C. Results of multiple regression run on 44 quarters of historical enrollment data for the entire university.

Time and seasonal dummy variables are used to explain the variation in the logarithm of enrollment. This specification of the relationship between time and enrollment implies a constant rate of growth through the years.

This regression yielded a result which was significant at .001 for all variables. 98.4% of the variation in enrollment was accounted for by the trend. The indicated annual growth rate was 18.5%. The accuracy of the resulting prediction was such that, if the trend continues, next year's prediction is twice as likely to fall within a range of 1500 from the predicted value as it is to fall outside this range. That is, given a prediction of 18,300, the odds are 2 to 1 that next year's value will fall between 16,800 and 19,800 if the historical trend continues unchanged.

D. Results of enrollment projections based on 36 quarters of historical data, deseasonalized, and exponentially smoothed.

TOTAL UNIVERSITY

	PREDICTED	ACTUAL	DEVIATION FROM ACTUAL %
Winter 71	15,168	15,145	+.2
Spring 71	14,647	15,315	-4.4
Summer 71	11,204	12,422	-9.8
Fall 71	18,117	16,945	+6.9
		Average Deviation	5.3

GRADUATE BUSINESS

	PREDICTED	ACTUAL	DEVIATION FROM ACTUAL %
Winter 71	1355	1383	-2.0
Spring 71	1229	1428	-10.4
Summer 71	942	995	-5.3
Fall 71	1566	1446	+8.3
		Average Deviation	6.5

E. Enrollment trends in selected majors for the graduate division of the Business School.

Number of Students

	MAJOR						
	AC	EC	FI	MG	MK	ALL OTHER	TOTAL
1969	78	43	147	252	65	151	736
1970	118	53	286	398	103	288	1246
% Increase 1970 over 1969	+51	+23	+95	+58	+58	+91	+69
1971	175	57	307	465	108	374	1486
% Increase 1971 over 1970	+48	+8	+7	+17	+5	+30	+19

40

APPENDIX 4

TABLE 1

CROSSOVER TABLE

1969 - Six Majors X Nine Disciplines

	MAJORS						
DISCIPLINES	AC	EC	FI	MG	MK	ALL OTHER	TOTAL
AC	210	20	160	270	70	85	815
BL	5	10	30	75	5	35	160
EC	40	160	195	355	125	185	1060
FI	40	20	225	65	25	40	415
IS	5	0	10	0	5	10	30
MG	82	115	243	745	152	402	1739
MK	15	3	45	112	94	37	306
DS	140	15	270	350	110	185	1070
All Other	5	15	0	35	5	335	395
Total Students	78	43	147	252	65	151	736

TABLE 2

INDUCED COURSE LOAD MATRIX (ICLM)

1969 - Six Majors X Nine Disciplines

MAJORS

DISCIPLINES	AC	EC	FI	MG	MK	ALL OTHER	TOTAL
AC	2.69	.465	1.09	1.07	1.08	.563	1.11
BC	.064	.233	.024	.298	.077	.232	.217
EC	.513	3.72	1.33	1.41	1.92	1.23	1.44
FI	.513	.465	1.53	.258	.385	.265	.564
IS	.064	0	.068	0	.077	.066	.041
MG	1.051	2.67	1.65	2.96	2.34	2.66	2.36
MK	.192	.070	.306	.444	1.45	.245	.416
DS	1.80	.349	1.84	1.39	1.69	1.23	1.45
All Other	.064	.349	0	.139	.077	2.22	.537

TABLE 3

CROSSOVER TABLE

1970 - Six Majors X Nine Disciplines

MAJORS

DISCIPLINES	AC	EC	FI	MG	MK	ALL OTHER	TOTAL
AC	345	20	365	450	115	335	1750
BL	15	5	45	120	35	85	305
EC	165	315	425	590	165	270	1930
FI	40	25	660	160	30	130	1045
IS	50	20	35	135	20	175	435
MG	150	59	470	1308	154	408	2549
MK	21	5	77	139	237	126	605
DS	170	30	465	555	185	370	1785
All Other	5	10	70	65	15	665	830
Total Students	118	53	286	398	103	288	1246

TABLE 4

INDUCED COURSE LOAD MATRIX (ICLM)

1970 - Six Majors X Nine Disciplines

MAJORS

DISCIPLINES	AC	EC	FI	MG	MK	ALL OTHER	TOTAL
AC	2.92	.377	1.28	1.13	1.12	1.16	1.40
BL	.127	.094	.157	.302	.825	.295	.245
EC	1.40	5.94	1.49	1.48	1.60	.938	1.55
FI	.339	.472	2.31	.402	.291	.451	.839
IS	.424	.377	.122	.339	.194	.608	.349
MG	1.27	1.11	1.64	3.29	1.50	1.42	2.05
MK	.178	.094	.269	.349	2.30	4.38	.486
DS	1.44	5.66	1.63	1.39	1.80	1.29	1.42
All Other	.042	.189	.245	.163	.146	2.31	.666

TABLE 5

CROSSOVER TABLE

1971 - Six Majors X Nine Disciplines

	MAJORS						
DISCIPLINES	AC	EC	FI	MG	MK	ALL OTHER	TOTAL
AC	720	30	400	600	140	145	2305
BL	40	15	90	120	30	35	330
EC	200	290	570	660	185	500	2405
FI	40	20	805	220	60	135	1280
IS	45	25	50	100	20	335	575
MG	195	65	495	1440	200	555	2950
MK	15	5	60	115	205	95	495
DS	250	65	405	685	135	470	2010
All Other	10	10	40	115	15	720	910
l Students	175	57	307	465	108	374	1486

TABLE 6

INDUCED COURSE LOAD MATRIX (ICLM)

1971 - Six Majors X Nine Disciplines

MAJORS

DISCIPLINES	AC	EC	FI	MG	MK	ALL OTHER	TOTAL
AC	4.11	.526	1.30	1.29	1.30	1.11	1.55
BL	.229	.263	.293	.258	.278	.094	.222
FI	.229	.351	2.62	.473	.556	.361	.861
IS	.257	.439	.163	.215	.185	.896	.387
MG	1.11	1.14	1.61	3.10	1.85	1.48	1.99
MK	.086	.088	.195	.247	1.90	.254	.333
DS	1.43	1.14	1.32	1.47	1.25	1.26	1.35
All Other	.057	.175	.130	.247	.139	1.93	.612

47

TABLE 7

COMPARISON OF ELEMENTS OF ICLM'S

1969, 1970 and 1971 - Six Majors X Nine Disciplines

DISCIPLINE		MAJORS AC	EC	FI	MG	MK	ALL OTHER	TOTAL
1969	AC	2.692	.465	1.089	1.071	1.077	.563	1.107
1970		2.924	.377	1.276	1.131	1.117	1.163	1.404
1971		4.114	.526	1.303	1.290	1.296	1.110	1.551
1969	BL	.064	.233	.204	.298	.077	.232	.217
1970		.127	.094	.157	.302	.825	.295	.245
1971		.229	.263	.293	.258	.278	.094	.222
1969	EC	.513	3.712	1.327	1.409	1.923	1.225	1.440
1970		1.398	5.943	1.486	1.482	1.602	.938	1.549
1971		1.143	5.088	1.857	1.419	1.713	1.337	1.618
1969	FI	.513	.465	1.531	.258	.385	.265	.564
1970		.339	.472	2.308	.402	.291	.451	.839
1971		.229	.351	2.622	.473	.556	.361	.861
1969	IS	.064	0	.068	0	.077	.066	.041
1970		.424	.373	.122	.339	.194	.608	.349
1971		.257	.439	.163	.215	.185	.896	.387
1969	MG	1.051	2.674	1.653	2.956	2.342	2.662	2.363
1970		1.271	1.113	1.643	3.286	1.495	1.417	2.046
1971		1.114	1.140	1.612	3.097	1.852	1.404	1.985
1969	MK	.192	.070	.306	.444	1.446	.245	.416
1970		.178	.094	.289	.349	2.301	.438	.486
1971		.086	.088	.195	.247	1.898	.254	.333
1969	DS	1.795	.349	1.837	1.389	1.692	1.225	6.454
1970		1.441	.566	1.626	1.394	1.796	1.285	1.424
1971		1.429	1.140	1.319	1.473	1.125	1.257	1.353
1969	All	.064	.349	0	.139	.077	2.219	.539
1970	Other	.042	.189	.245	.163	.146	2.309	.666
1971		.057	.175	.130	.247	.139	1.925	.612

TABLE 8

PREDICTIONS FROM ICLM BASED ON
DISCIPLINE VERSUS STUDENT MAJORS

	Disciplines with Majors				
	AC	EC	FI	MG	MK
1969 Factor	2.692	3.721	1.531	2.956	1.446
1970 Factor	2.924	5.943	2.308	3.286	2.301
% Change	+8.6	+60	+51	+11	59
1971 Projection Based on					
Trend	3.156	8.165	3.085	3.616	3.156
Average	2.808	4.832	1.918	3.121	1.873
1971 Student Majors	175	57	307	465	108
1971 Projections					
Using Trend	552	465	947	1681	341
Using Average	491	275	589	1451	202
1971 Actual	720	290	805	1440	205
Deviation of Trend	-168	+175	+142	+241	+136
from Actual %	-23	+60	+18	+17	+66
Deviation of Average	-229	-15	-216	+11	-3
from Actual %	-32	-5.2	+27	+0.8	-1.5

TABLE 9

PREDICTIONS FROM ICLM BASED ON DISCIPLINE
VERSUS TOTAL MAJORS

	Disciplines						
	AC	BL	EC	FI	MG	MK	DS
1969 Factor	1.107	.217	1.440	.564	2.363	.416	1.454
1970 Factor	1.308	.245	1.549	.839	2.046	.489	1.417
% Change	+18	+13	17.6	+40	-13	+18	-2.5
1971 Projection Based on:							
Trend	1.509	.273	1.658	1.214	1.729	.556	1.380
Average	1.207	.231	1.495	.751	2.205	.451	1.436
1971 Total Students	1486	1486	1486	1486	1486	1486	1486
1971 Projections Using Trend	2242	406	2464	1804	2569	826	2051
Using Average	1794	343	2222	1116	3277	670	2134
1971 Actual	2305	330	2400	1280	2950	495	2010
Deviation of Trend	-63	+76	+64	+524	-381	+331	+41
from Actual %	-2.7	+23	+2.6	+41	-13	+67	+2.0
Deviation of Average	-511	+13	-178	-164	+327	+175	+124
from Actual %	-22	+3.9	-7.4	-12.8	+11	+35	+6.1

TABLE 10

PREDICTIONS FROM ICLM BASED ON
COURSES VERSUS TOTAL MAJORS

	Courses								
	A601	E601	B801	B802	B803	B805	B806	B810	B811
1969 Factor	.414	.326	.448	.537	.455	.496	.319	.299	.272
1970 Factor	.478	.293	.453	.349	.566	.518	.389	.413	.341
% Change	+15	-10	+1.1	-35	+24	+4.4	+22	+38	+25
1971 Projection Based on:									
Trend	.544	.260	.458	.161	.677	.540	.459	.527	.410
Average	.446	.310	.450	.433	.510	.506	.354	.256	.307
1971 Total Students	1486	1486	1486	1486	1486	1486	1486	1486	1486
1971 Projections Using Trend	808	386	681	239	1006	802	682	783	609
Using Average	663	461	669	643	758	752	526	380	456
1971 Actual	805	470	630	545	820	840	725	545	500
Deviation of Trend	+3	-84	+51	-306	+186	-38	-42	+238	+109
from Actual %	+0.4	-18	+8.1	+56	+23	-4.5	-5.8	+43.7	+22
Deviation of Average	-142	-9	+39	+98	-62	-88	-199	-165	-44
from Actual %	+18	-1.9	+6.2	+18	-7.6	-10.5	-27	-30	-8.8

51

APPENDIX 5

An Illustrative Comprehensive Model

The listing of sub-systems and their related parameters is presented here to suggest the general contents of a comprehensive planning model. The sub-systems are arranged in approximate order of dependency, assuming that enrollment determines faculty requirements, faculty and students determine staff needs, and so forth.

The right hand column contains typical, but by no means all, parameters which must be developed or assigned administratively. Some must obviously be developed from historical information, such as the time trends which relate to enrollment projections. Some may be assigned by decision-makers, such as class sizes or salary schedules.

It seems that regression analysis, tempered by managerial judgement, is widely accepted as a basis for the development of many of these relationships. It is in the area of understanding these sub-systems that microanalysis may be useful.

Sub-System	Examples of Relationships to be Developed or Assigned (PARAMETERS)
Enrollment Projection	Time Trends Functional Relationships
Course Requirements	ICLM Elements
Faculty Requirements	Average Faculty Load Average Class Size Contact Hour/Credit Hour
Staff Requirements	Faculty/Staff Ratios and/or Staff/Student Ratios
Equipment Requirements	Equipment/Credit Hour and/or Equipment/Faculty and/or Equipment/Staff

Space Requirements	Office Space/Faculty Class Space/Student et cetera
Library Requirements	Volumes/Faculty Volumes/Student Volumes/Degree Program
Research Output	Output/Faculty Output/Library
Budget Requirements	Salary Schedules Expenses/Faculty Expenses/Staff Expenses/Student
PPBS System	Cost/Graduate Cost/Degree Program Cost/Research Output

BIBLIOGRAPHIES

Chamberlain, Robert W., "A Selected Annotated Bibliography on Important Aspects of University Planning," Educational Facilities Laboratory, 1967.

Diener, Thomas J. and Trower, David L., Editors, "An Annotated Guide to Periodical Literature: Higher Education," Institute of Higher Education, University of Georgia, Athens, 1969.

ERIC Abstracts: Systems Approaches in Education, American Association of School Administrators, 1970.

Hall, John S., "Models for Rational Decision Making. Analysis of Literature and Selected Bibliography," ERIC Clearinghouse on Educational Administration, 1970.

Hüfner, Klaus, "Economics of Higher Education and Educational Planning -- A Bibliography," _Socio-Economic Planning Sciences_, Volume 2. (1968), Pergamon Press, pp. 25-101.

Minter and Lawrence, cited under general references.

Models for Planning. Analysis of Literature and Selected Bibliography. ERIC Clearinghouse on Educational Administration. 1970.

"Review of Higher Education Literature Since 1960," _Review of Educational Research_, October, 1965, pp. 253-371.

Research in Education (RIE), Educational Resources Information Center (ERIC), U.S. Office of Education. Numerous issues.

Twelker, Paul A., "A Basic Reference Shelf on Simulation and Gaming," ERIC Clearinghouse on Educational Media and Technology. 1970.

Weathersby and Weinstein, cited under general references.

PLANNING MODELS

Daniel, James N.; Robinson, Daniel D., and Scarborough, Collin W., "Remote Access Planning and Institutional Development (RAPID)," Peat, Marwick and Livingston, Boston, 1967.

Firmin, Peter A.; Goodman, Seymour A.; Hendricks, Thomas E., and Linn, James J., "University Cost Structure and Behavior," Final Report, Contract NSF C451, National Science Foundation, Washington, D.C., August 31, 1967.

Gulko, Warren W., The Resources Requirements Prediction Model (RRPM-1): An Overview, WICHE Technical Report #16, Western Interstate Commission for Higher Education (WICHE), Boulder, 1971.

Koenig, H. E.; Keeney, M. G., and Zemach, R., "A Systems Model for Management, Planning, and Resource Allocation in Institutions of Higher Education," Final Report, Project C-518, National Science Foundation, Washington, D.C., September 30, 1968.

Steele, Matt W., "University of Miami Model," IRR #80, University of Miami, 1968.

Systems Research Group, "CAMPUS: Comprehensive Analytical Methods for Planning in University Systems," Toronto, 1969.

Thompson, Robert K., "Higher Education Administration: An Operating System Study Utilizing a Dynamic Simulation Model," in Corporate Simulation Models, edited by Albert N. Schrieber, College on Simulation and Gaming of the Institute of Management Science, Providence, R.I., and Graduate School of Business Administration of the University of Washington, Seattle, Washington.

Weathersby, George, "The Development and Application of a University Cost Simulation Model," Office of Analytical Studies, University of California, Berkeley, June 15, 1967.

A number of additional planning models are described in the Casasco and Weathersby-Weinstein references. Those listed under the Planning Models section are only those reviewed by the author in some detail.

GENERAL REFERENCES

Annual Proceedings of the Forum on Institutional Research, Association for Institutional Research, 1965-1970.

Baughman, George W., "Towards a Theory of University Management," in Johnson and Katzenmeyer, pp. 3-28.

Casasco, Juan A., Planning Techniques for University Management, American Council on Education with the ERIC Clearinghouse on Higher Education, Washington, D.C., 1970.

Cohen, Malcolm S., "Quantitative Methods: Models and Simulation -- A Summary of Techniques," in The Challenge and Response of Institutional Research, Association for Institutional Research, 1969, pp. 151-157.

Corcoran, Mary and Anderson, Douglas H., "Rationale for Using Microanalytic Approaches in Predicting the Character and Size of College Student Enrollments," in Institutional Research and Academic Outcomes, Association for Institutional Research, 1968, pp. 53-59.

Jewett, Frank I., Fedderson, Alan P., Lawson, Donald F., and O'Grady, William D., "The Feasibility of Analytic Models for Academic Planning -- A Preliminary Analysis of Seven Quarters of Observations on the 'Induced Course Load Matrix,'" Division of Information Systems, California State College, September, 1970.

Johnson, Charles B. and Katzenmeyer, William G., Editors, Management Information Systems in Higher Education: The State of the Art, Duke University Press, Durham, N.C., 1969.

Lawrence, Ben, Weathersby, George, and Patterson, Virginia, Editors, Outputs of Higher Education: Their Identification, Measurement, and Evaluation. Western Interstate Commission for Higher Education, Boulder, 1970.

Lins, L. J., "Enrollment Projections for Public Institutions," in Design and Methodology in Institutional Research, Association for Institutional Research, 1965, pp. 7-16.

Minter, John and Lawrence, Ben, Editors, Management Information Systems and Their Development and Use in the Administration of Higher Education, American Council on Education, Washington and Western Interstate Commission for Higher Education, Boulder, 1969.

Orcutt, Guy, Greenberger, Martin, Korbel, John, and Rivlin, Alice, Microanalysis of Socioeconomic Systems. New York: Harper and Brothers, 1961.

Russell, John Dale, "Decision Making in Higher Education," in The Instructional Process and Institutional Research, Proceedings of the Seventh Annual Forum of the Association for Institutional Research, 1967., pp. 19-27.

Sonquist, John A., and Morgan, James N., The Detection of Interaction Effects, Monograph No. 35. Survey Research Center, University of Michigan, 1964.

Van Dusseldorp, Ralph, "Some Principles for the Development of Management Information Systems" in Johnson and Katzenmeyer, previously cited, pp. 29-41.

Wallhaus, Robert A., "Modeling for Higher Education Administration and Management," in Johnson and Katzenmeyer, previously cited, pp. 125-144.

Weathersby, George B. and Weinstein, Milton C., "A Structural Comparison of Analytical Models for University Planning," Paper P-12, Ford Foundation Research Program in University Administration, University of California, Berkeley, August, 1970.

END