
R. K. BRANDENBURG
PH. D.

103
055
THS

PH. D.


URG
PH. D.
103
055
THS



LIBRARY
Michigan State
University

This is to certify that the

thesis entitled

Development of a
Predictive Systems Model for
Course Research and Improvement

presented by

Richard Kenneth Brandenburg

has been accepted towards fulfillment
of the requirements for

Ph.D. degree in Secondary Education and Curriculum

Edward L. Smith

Major professor

Date November 14, 1980

O-7639



OVERDUE FINES:
25¢ per day per item

RETURNING LIBRARY MATERIALS:
Place in book return to remove charge from circulation records

DEVELOPMENT OF A PREDICTIVE SYSTEMS MODEL FOR COURSE RESEARCH AND IMPROVEMENT

By

Richard Kenneth Brandenburg

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Secondary Education and Curriculum

1980

ABSTRACT

DEVELOPMENT OF A PREDICTIVE SYSTEMS MODEL
FOR COURSE RESEARCH
AND IMPROVEMENT

By

Richard Kenneth Brandenburg

In this study, the systems modeling approach is applied to the investigation of the learning process in a college biology course. The course is examined in systems terms, dissected and reconstructed abstractly as a mathematical systems model. The model relates students' background, prior knowledge and instructional behavior to concept mastery based on data collected in the course during a term. Student performance is then predicted using the model during a second or validation term. The practical value of the model is also assessed by using it to group students for special instructional treatment. The model is examined for what it reveals about the instructional interactions occurring in the course and also to provide hypotheses for future study.

This is a feasibility study and is intended as an experimental application of the modeling technique to an educational process. The expectation was that this application could develop into a research tool which would provide the educational researcher with the ability to dissect and analyze highly complex instructional settings and processes. This tool would provide a conceptual organization and analytically functional framework to enhance the understanding of complexly interacting entities and processes.

The major biological concept of Ecology was used as the base for analysis and student performance evaluation. Two levels of Ecology content analysis were performed. The first level provided a reference

frame of disciplinary content and the second, from the actual content selected for the course, provided structure for the modeling process.

A variety of background variables were collected for the students in the course during the experimental term (n = 105) and the validation term (n = 75). Variables describing the students' instructional behavior and attendance were also collected. Variables describing the students' performance on forty-four (44) ecology concepts were calculated from testing data. The model, which is the functional relationships between background, instructional and ecology concept mastery variables, was developed using a series of multiple regression computer runs.

The findings of the study indicate that the systems modeling process appears to be useful in relating learning performance to background, prior knowledge and instructional behavior. Model variables accounted for a significant percentage of the variation in the original data and the power of the model is demonstrated by its ability to predict student performance during a second (validation) term. The practical utility of the model is also demonstrated using a student grouping analysis based on the model components. The student groups identified by this analysis have different academic and learning profiles. Also identified are a variety of hypotheses for improving course instruction.

ACKNOWLEDGEMENTS

Many thanks are due the individuals who helped with this project: Edward Smith for his guidance and support; Jean Enochs, James Gallagher and William Schmidt for their participation; Margaret Lorimer for her support and encouragement; Francis Fenn, Susan Anderson, Julie Courser, Tena French, Barbara Stuart and many others for their typing and preparation.

Special thanks are due to my wife, Susan, and son, John Paul, for their patience and support.

TABLE OF CONTENTS

1 The Problem

1.0 Introduction

2 Theory and Background

2.0 Theory

2.1 Background

2.2 Theoretical Model Development

2.3 The Instructional Session; A Simple Model

2.4 Possibilities

3 The Course and Content Analysis

3.0 The Course

3.1 Content Analysis

3.2 Quiz Content and Concept Mastery Assessment

3.3 Course Concepts Summary

4 The Model

4.1 Background Data

4.2 Instructional Data

4.3 Outcomes: the K Matrix

4.4 Viewing the Course as a System

5 Data Preparation, Data Analysis and Limitations on this Modeling Process

5.0 Data Preparation

5.1 Regression Analysis 1

5.2 Regression Analysis 2

TABLE OF CONTENTS

5.3 Regression Analysis 3

5.4 Limitations

6 Results and Analysis

6.0 Introduction

6.1 Week 1

6.2 Week 2

6.3 Week 3

6.4 Week 4

6.5 Week 5

6.6 Week 6

6.7 Week 7

6.8 Week 8

6.9 Week 9

6.10 Week 10

6.11 Final

6.12 Summary

6.13 Synopsis

7 Applications - An Example

8 Summary, Evaluation, Recommendations and Conclusions

APPENDIX A Course Description

APPENDIX B Background Variables

APPENDIX C Instructional Variables

APPENDIX D Factor Analyses

APPENDIX E Model Coefficients

LIST OF TABLES

3.1 Phase One Concept Definitions

3.2 Ecosystems Concepts Presented in Lecture

3.3 BS 202 Ecosystem Concept Definitions

3.4 Ecosystem Concepts Covered in the Small Assembly Sessions

3.5 Ecosystem Concepts Presented in the Tape Laboratory

3.6 Ecosystem Concepts Contained in the Weekly Textbook Readings

3.7 Ecosystem Concepts Covered in the Weekly Practice Quizzes

3.8 Quiz Items with Ecosystem Concepts

3.9 Test Item Coverage of Ecosystem Concepts

3.10 Ecosystem Concept Coverage Summary

3.11 Ecosystem Content Matric C

4.1 Background Variables

4.2 Instructional Variables

4.3 Weekly Additions and Updates of the K Matrix

5.4 Phase One Regression Summary Tables for a Sample Test Item

5.5 Phase Two Summary Table for a Sample Test Item

5.6 Residual Error Rate for Three Sample Test Items

5.7 K Matrix Elements and Definitions for Fall Term, 1977

5.8 Phase Three Regression for a Sample Test Item

6.1 Tested Ecosystem Concept Coverage

6.2 Week 1 Regression Equations Goodness of Fit and Extrapolation

6.3 Week 2 Regression Equations Goodness of Fit and Extrapolation

6.4 Week 3 Regression Equations Goodness of Fit and Extrapolation

LIST OF TABLES

6.5 Week 4 Regression Equations Goodness of Fit and Extrapolation

6.6 Week 5 Regression Equations Goodness of Fit and Extrapolation

6.7 Week 6 Regression Equations Goodness of Fit and Extrapolation

6.8 Week 7 Regression Equations Goodness of Fit and Extrapolation

6.9 Week 9 Regression Equations Goodness of Fit and Extrapolation

6.10 Week 10 Regression Equations Goodness of Fit and Extrapolation

6.11 Final Regression Equations Goodness of Fit and Extrapolation

6.12 Goodness of Fit and Extrapolation Summary

6.13 Frequency of Correlational Occurrences: Background Variables, (B) vs. Concept Knowledge Indices (K)

6.14 Frequency of Correlational Occurrences: Instructional Variables (I) vs. Concept Knowledge Indices (K)

6.15 Frequency of Correlational Occurrences: Concept Performance (K') vs. Prior Performance (K)

7.1 Grouping Variables

7.2 Hierarchical Grouping Analysis Output

7.3 Values of Grouping Variables B_{18} through I_{70} by Group Numbers

7.4 Values of Grouping Variables B_3, B_6, I_{101}

7.5 Groups

D.1 Pretest Factor Analysis

D.2 Affective Questionnaire Factor Analysis

D.3 Background Questionnaire Factor Analysis

E.1 Model Coefficients for Week 1

E.2 Model Coefficients for Week 2

E.3 Model Coefficients for Week 3

E.4 Model Coefficients for Week 4

E.5 Model Coefficients for Week 5

LIST OF TABLES

E.6 Model Coefficients for Week 6

E.7 Model Coefficients for Week 7

E.8 Model Coefficients for Week 9

E.9 Model Coefficients for Week 10

E.10 Model Coefficents for Week-Final

LIST OF FIGURES

2.1 Instructional Session

2.2 Instructional Sessions

3.1 Ecology Concept Relationships

4.2 BS 202 Systems Diagram

5.1 Data Processing and Course Modeling

5.2 Sample Phase Three Regression Residuals for Fall Term Data Base

5.3 Sample Phase Three Regression Residuals for Validation (Winter Term) Data Base

CHAPTER 1

THE PROBLEM

1.0 Introduction

A basic assumption of modern education is that as a student experiences instruction something happens to change the student. The student learns, that is acquires additional knowledge, develops skills or masters processes. This conception of cause and effect through instruction and learning serves as a primitive Kuhnian (1975) paradigm of educational researchers. Given a simple learning experience or set of experiences, it is not too difficult to investigate the effects. Such laboratory studies, complete with control groups, are conducted by researchers in great profusion. However, once the researcher moves from the lab to complex, real classroom instruction, the investigation of learning phenomena becomes considerably more complicated and difficult. Unfortunately the classroom is the arena of most concern to educators.

One form that such instruction takes is the college course; a costly, sometimes effective and little studied instructional mode. Large college courses usually require that the instructor and assistants spend most of their time with material preparation and presentation. The counseling and tutoring of individual students account for the remainder of their efforts. The economics of such a venture preclude any detailed research into the deep structure of the course content or the development of analytical devices for

monitoring the student progress or what might be called the "quality control" of the course. In courses some initial effort usually has been directed at defining the objectives, but the actual content of the course and methods of presentation are more often based on previous experience and professional intuition. The common testing routine is usually applied to assess the degree to which each student has fulfilled the course objectives. Periodic course revisions are made on the basis of the instructor's intuition and experience, often from his or her personal and students' biased feedback. Even in the unusual circumstances where the situation permits a rigorous examination of course objectives, further detailed study of actual student performance and understanding of the concepts composing the subject matter is rarely possible.

What is needed is a research tool which will provide the educational researcher with the ability to dissect and analyze highly complex instructional settings and processes such as those found in the college course. Such a tool would provide a conceptual organization and analytically functional framework to enhance the understanding of complexly interacting entities and processes.

This study presents and examines a tool which may fit these requirements. Here the system's approach and modeling techniques are applied to a college course. The course is examined in systems terms, dissected, and reconstructed abstractly as an artificial systems model. This model is examined for what it tells us about the instructional interactions taking place in the real course. The model is also used to provide hypotheses for future study.

CHAPTER 2

THEORY AND BACKGROUND

2.0 Theory

Investigations of the empirical world are based on two basic or primary presumptions:

1. The world exists, and
2. The world is, at least in some respects intelligibly ordered, and is open to rational inquiry. (Laszlo, 1972)

Such rational inquiry of the real, empirical phenomena of the world involve human conceptualizations which organize and lead to understanding. One such conceptual tool which has proven to be very useful in the organization and study of events and processes is the systems approach.

The systems approach may be defined as the logical analysis and breakdown of a system, whereby the connections, interrelationships, and organization of the constituent parts of the system are made explicit. A system in the sense used here is a "set of interconnected elements organized toward a goal or set of goals" (Manetsch and Park, 1974a). The set of interconnected elements which are the object of the systems analysis or approach may be as large or as small as is necessary to understand the phenomena under study. That is, the systems analyst chooses the relevant elements of study and assigns everything else to the system's environment,

outside its boundaries. Interactions may still occur between the system and its environment across these boundaries, but the external factors involved are considered to be completely independent of the system itself. Within the system, the analysis is more than a disection of parts, but rather leads to an understanding of how a system may often be more than the sum of those parts.

The systems approach has been applied in many fields or disciplines where there arose a need to understand, and often control, complex, multifeatured, interacting systems. This approach fundamentally allows a conceptual organizing scheme to be laid over what otherwise would be considered a chaotic jumble of interacting entities and processes, the result being the orderly organization of a complex system with definable characteristics, traceable processes and predictable responses to external stimuli. It must be remembered, however, that the structure imposed on the system by the analyst represents a subjective expression of opinion on its structure and behavior. Although the manifestation of this expression may be a sophisticated model, any model represents only one of many views of reality.

2.1 Background

This approach may be applied to existing systems or to the planning and construction of new systems. The latter of the two, systems planning, has enjoyed a wide popularity in educational development and administration (Tanner, 1971; Silvern, 1965; Haefele, 1971; LeBaron, 1969; Thompson, 1971), where enormous systems need to be developed for things as diverse as state wide curricula and school district food services. The systems planning approach usually develops the system graphically, so that interactions and feedback loops may be identified, but rarely goes into the mathematical or computer

modeling stage.

The application of systems analysis to existing systems, on the other hand, usually includes the development and testing of a mathematical computer model as well as experimentation with that model (Manetsch and Park, 1974 a, b). Such analysis and modeling has been applied to many seemingly unrelated areas including economics (Ellis, 1965; Abkin, 1965), the dynamics of world populations (Forrester, a, b; Meadows, 1972), and ecosystem analysis, control and prediction (Levine, 1975; May, 1974; Patten, 1972; Arnold and deWitt, 1976; etc.). Silvern (1967) successfully applied systems methodology to an educational system in order to develop a model describing feedback signal paths from outside the school or school district to an occupational teacher. Although he did not develop a computer model, he concluded that "models can be developed which have an immediate, practical application (to education)." In addition he suggests, ". . . consider a number of mathematical techniques, select promising mathematical techniques and synthesize a set of expressions, using both flowchart/mathematical model combinations similate to test the model. Using problems from real-life simulate to solve problems on the model, apply the problem solutions to real-life, improve the model based on real-life experiences, and extend this technique of systems analysis and synthesis (anasynthesis) to other problem areas."

In a paper unrelated to systems analysis, Carrol (1963) when discussing his proposed model of school learning, states; "What is needed is a schematic design or conceptual model of factors affecting success in school learning and of the way they interact." He then goes on to propose his five component model of school learning;

aptitude, ability to understand instruction, quality of instruction, learning opportunity (time related) and perseverance, and suggests several mathematical or functional relationships between the variables. In his conclusions he adds; ". . . it should be possible in principle to describe the pupil's success in learning a series of tasks by *summating* the results of applying the model successively to each component task."

Carrol and Silvern have both implicitly suggested that a learning experience may be simulated using a quantitative model, and that such a simultation might provide useful insights into the learning process. Additionally, such modeling might lead to mathematically predictable learning performance.

It is the purpose of this study to follow the leads given by Silvern and Carrol and investigate the application of some of the techniques of systems analysis and modeling to a series of learning experiences, and explore what the resultant quantitative model tells us about such experiences.

2.2 Theoretical Model Development

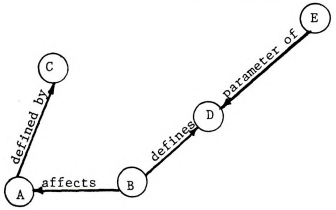
Although any experience may be, and probably is, a learning experience only formal or structured learning experiences such as the lecture, laboratory and group discussion will be considered in this study.

A student begins such a learning experience with a certain level of knowledge and understanding. During the experience something is transmitted so that the student emerges with a slightly altered state of knowledge and understanding. The purpose of the experience was to transmit or teach a certain amount of subject content, manual and

mental skills, and processes. Although all are of importance to the learner, the transmittal of subject content will serve as the chief focus of the model building. The learning experience may then, for the purpose here, be defined as a process of finite length through which a student (or learner) may be said to "pass", and during that passage is exposed to a certain amount of content knowledge, all or a fraction of which is learned or added to the previous knowledge base of the student.

The first step in this modeling process is to examine the subject content of the hypothetical learning experience. The subject content of any intentionally designed learning experience is usually a reflection of what might be called the "base" content of the relevant disciplinary field. The subject content presented to the learner is a simpler, less complex version of what is known by the experts in the field. The more complex, underlying content will be referred to as Phase I content, as compared with the Phase II or simpler content prepared for the student digestion during the learning experience. The Phase I content serves as a "reference frame" for the Phase II content to be taught.

Suppose that the Phase I content consists of five concepts (A, B, C D, and E) which are related in several ways. The relationships may be schematically illustrated as shown below:



Here concept C is defined in part by concept A (i.e., A is included in the definition of C), concept B affects concept A (perhaps a direct empirical relationship), B defines D, and E is a parameter of D (D could be a physical low and E a physical constant).

The simpler Phase II or selected content for the learning experience analogous to the above Phase I could be concepts A, B, C, and D; concept E being deemed by the teachers or curriculum developers to be unnecessarily complex or otherwise unsuited for the student audience. The phase II concepts may also receive simpler definitions or explanations for presentation to the students.

Once the Phase II subject content has been determined it is necessary to examine the match between it and the content actually tested or evaluated for at some time after the learning experience. This tested content, usually the only measure of student learning is generally a subset of the Phase II content. Thus, in our modeling of a learning experience the absolute or Phase I content, (all the subject content which could be taught), the Phase II content (which is actually presented) and the tested content must be examined and compared.

In the modeling of a system where entities pass through a series of transformation processes it is necessary to describe those entities with a collection of state variables reflecting the changes imparted on them by the processes. Here the learning experiences is the process and learners or students are the entities passing through the process. To develop the necessary state variables the general method of variable or information classification suggested by Tamir (1976) may be used. Relevant information on student learners is classified according to this method into one of three categories: antecedents, transactions, or outcomes. This corresponds to the data describing the individual

student upon beginning the learning experience (antecedents), what the student learner does and what happens to him or her during the course of instruction (transactions), and the effects of that instruction upon the student learner (outcomes). Thus, each student completing the learning experience is described by a set of background data (antecedents), a set of data describing the instruction (transactions) and a set of data describing the knowledge obtained during the instruction (outcomes). These variables describing each set of data are the students' state variables.

The partitioning of student state variables into antecedents, transactions, and outcomes is based on Tamir's (1977) practical adaptation of Bloom's Theory of school learning (1977). Bloom relates learning outcome as a variable to student characteristics and quality of instruction. Student characteristics may be divided into either cognitive entry behaviors or affective entry behaviors. The effect of the quality of instruction combined with the student's cognitive and affective behaviors determine learning outcomes. Outcomes are classed as affective level and type of achievement and rate of learning. Bloom's Theory, based on extensive research review, claims that up to 50% of the variation in school achievement may be accounted for by cognitive entry behaviors, 25% by affective entry characteristics, and up to 25% by quality of instruction. Taken together he claims that cognitive entry behaviors and affective entry characteristics account for up to 65% of achievement variation. Adding quality of instruction raises the limit up to 90% of the variation (Bloom, 1977).

As quality of instruction is difficult to measure, this study is concerned with the students' cognitive and affective behaviors

and measurable learning outcomes with existing levels of instructional quality. Variations of Carrol's Time-on-Task Theme (1963) are also reflected in the transactions variables.

For the purposes of this study all antecedent information on each student is assigned to a "Background" data set or matrix B ;

$$B = |B_1, B_2, B_3 \ldots B_n|^{-1},$$

where n = the number of antecedent or background variables describing each student learner.

The only transactional state variables which can meaningfully be measured for this type of study are attendance, methods of study, and time-on-task. Such measured variables are assigned to the Instructional Matrix I ;

$$I = |I_1, I_2, I_3 \ldots I_m|^{-1}$$

where m = the number of such transactional variables.

After an instructional session a student learner may be evaluated for knowledge or understanding of each of the concepts presented in the instruction. Following the example introduced earlier, suppose the concepts A, B, C, and D are presented in an instructional session. These concepts may be arranged in an array C such as;

$$C = |A, B, C, D|^{-1}$$

Testing after the learning experience may allow a value to be assigned to each variable in an analogous array.

$$K_s = |K_A, K_B, K_C, K_D|_s^{-1}$$

where K_A through K_D are quantitative measures (such as test scores) of the knowledge or understanding of students of each of concepts A, B, C, and D, respectively.

Expanding this notion, all the (Phase II) concepts presented in a learning experience may be represented in an array C,

$$C = |C_1, C_2, C_3, C_4 \ldots C_p|^{-1}$$

and measurements of the mastery of the p concepts represented in an analogous K matrix,

$$K = |K_1, K_2, K_3, K_4 \ldots K_p|^{-1}$$

Thus each student "passing through" a learning experience may be described by three arrays of state variables,

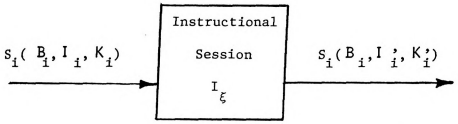
$$B, I, \text{ and } K;$$

representing antecedents, transactions and outcomes, respectively.

2.3 The Instructional Session; A Simple Model

Consider a student learner passing through a learning experience or instructional session. As a result of this experience changes occur in the student's knowledge and understanding of the material presented and discussed. In the model these changes are indicated as changes in the state variables describing the student. Specifically, after an instructional session, changes have occurred in the student's version of C. These changes are influenced by the student's background variables, B, by previous instruction I, by previous learning (C imaged as K), by unknown student idiosyncrasies, and by the nature of the instructional session itself. This is shown in the diagram of

of Figure 2.1 below:



$$K_i' = f_\xi (B_i, I_i, K_i) \quad , \quad I_i' = I_i + I \quad , \quad C_i' \propto K_i'$$

Figure 2.1

Student S_i described by the state variables of B_i, I_i (previous instruction) and K_i (reflecting entry level knowledge C_i) undergoes an instructional session represented by I_ξ. As a result of this session the student's state variables are transformed; the student has new understanding or mastery of particular concepts, described as alternations to C_i resulting in C_i' which are reflected as measurable alterations to K_i, resulting in K_i'. In addition, new instructional bookkeeping data is added to I_i. B_i is unaffected by the instruction. The changes in C_i reflected in K_i' are influenced by B_i, I_i and previous concept knowledge (measured in K_i). Thus, the instructional session may be described analytically by a transfer function, f_ξ, operating on the state variables, and represented by:

$$K_i' = f \ (B_i, I_i, K_i)$$

For any one student the transfer function may be viewed as exact, reflecting both the effect of the instructional session and the exactness of concept mastery measurement. However, for the modeling process we consider a large number of students passing through the same instructional sequence and the single transfer function representing the effect

of the instruction is based on an aggregate approximation and is inexact.

Suppose now that students were exposed to a number of learning experiences sequentially. That passage from one instructional session to the next may be modeled graphically as shown in Figure 2.2 below.

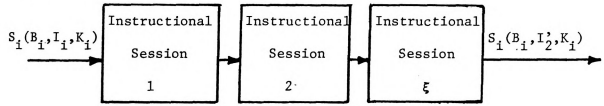


Figure 2.2

Each instructional session could have a transfer function associated with it if student concept mastery was evaluated between sessions, or the entire string of sessions could have just one transfer function if concept mastery were tested for after session ξ. In either case the transfer functions or function describe in some sense the effects of the instructional sessions in this type of model.

In this study this simple concept of systems analysis shown in Figure 2.2 has been applied to the instructional systems of a college biological science course which consists of a series of lectures, laboratories, small group discussions, and other learning activities. Students are viewed as the entities passing through the instructional processes of the course, and the changes in their knowlege of a subset of the content taught in the course as measured through their test performance is considered to be the result or product of the course. Ecology, a main component of modern biology, is used as the subset of content on which student performance is monitored. Each course component is viewed as an instructional session contributing to the students'

knowledge of biology, and ecology in particular. The effects of the instructional sessions are aggregated on a weekly basis and related through the model to student performance in ecology concepts based on items from the weekly quiz. Student concept performance is also related through the model to a large array of background information collected at the beginning of the course. Successively applied and updated through the ten weeks of the course, the model provides a somewhat different view of a standard academic course. The model is also tested for transferability across terms to validate the goodness of fit between the model and the process.

2.4 Possibilities

The model presented in this study may provide the experimenter with a new viewpoint on conceptualization of sequential learning experiences. The model itself is a very simplistic, structured construct which reflects the basics of the instructional processes of the course. It is the intent of the modeling scheme to organize and uncover the relations of content, background, instructional behavior, and learning output. Such an organization may prove useful to future researchers who need constructs for organizing and analyzing instructional experiences and may lead to the study of previously unrecognized relationships.

In Chapter 7 a possible application of the model is presented. The parameters of the model developed during this study are analyzed and student groups are developed which differ on instructional activity and performance in the course. Suggestions or hypotheses on methods of improving the learning performance of each group based on the group characteristics was developed. This grouping analysis based on the results of the model building process may be a link between a

research tool and classroom implementation. The systems model organizes the process into an intelligible schema from which definite relationships emerge, relationships that may be useful in course improvement.

CHAPTER 3

THE COURSE AND CONTENT ANALYSIS

3.0 The Course

The course chosen for modeling was Biological Science 202 (BS 202). At Michigan State University BS 202 is a medium sized course serving approximately one hundred students each term. It is one of six science and mathematics courses required in the undergraduate science and math option of the Elementary Education curriculum, and is the only opportunity in this curriculum for the comprehensive study of biology. The student population in BS 202 is composed of over 60% Elementary Education majors and is an extremely heterogenous group, varying widely in academic background, aptitude and attitude. Previous studies (Enochs, 1977; Tamir, 1977) have shown that the group as a whole is academically representative of the lower half of the University's undergraduate population.

The course typically consists of one hour of lecture, two hours of group laboratory or small assembly session (SAS), open hours for independent laboratory study using auto-tutorial cassette tapes, and a quiz each week for ten weeks. A comprehensive final examination is given at the end of the course. The student is expected to work with an average of two cassette tapes for several hours each week. The 17 tapes are in sequence following the general outline of the course. There has also been a set of behavioral objectives covering a wide area of biological content developed for the course. The course is

closely centered around these objectives.

One of the problems with BS 202 is that although a fair proportion of students do well in the course, a significant number perform at a poor or mediocre level (Enochs, 1977). This occurs in many science courses and is usually not considered a problem. However, the majority of students in BS 202 receive Elementary Teacher Certification and go on to teach in elementary schools. Since these students through their contact with young children exert an influence on society disproportionate to their number, it is particularly important that they develop a thorough mastery and understanding of course material. The economic and time boundaries of this course, as are most others, are finite and limit what may be far reaching effects. Thus, any analytical findings which point toward increased optimization of instructional resources and student mastery are important.

A complete course outline for BS 202 as taught during the term studied (Fall 1977) is included in Appendix A.

3.1 Content Analyses

The concept of Ecosystem represents one of the major unifying themes of the BS 202 course. It was chosen as the concept focus on this study not only because it is a central thread in BS 202 but also because it is important to the understanding of many contemporary political and social issues or problems. The concept of Ecosystem at the level appropriate for the BS 202 student has the additional advantage of being composed of a small, finite number of simpler concepts.

There are a number of different techniques available to the curriculum analyst for the decomposition of content. For this study, it was necessary that the concept of Ecosystem be broken down into simpler, component concepts and the relationships between these

concepts elucidated. The analytical method used here is described by Smith (1974, 1975) as the first stage in the process of developing analytic and exemplary systemic networks for a specific discipline or subdiscipline. The author has used this method (Brandenburg, 1976) and it has proven to be a useful technique for the analytical decomposition of a content area. Basically, the method requires that the content analyst be conversant with the content area under scrutiny. The analyst systematically decomposes the content, using reference sources until the "fundamental" concepts and relationships are clearly revealed. These relationships are then expressed diagrammatically. It is an iterative process with much left to the creative ingenuity of the analyst.

The content analysis for this study was divided into two phases. In Phase I a complete content analysis of the concept of Ecosystems was performed to a greater "depth" than appropriate for the students in the BS 202 course. This was done by detailing the component concepts of Ecosystem to a level appropriate for a course in the fundamentals of ecology for college biology majors. From this in-depth analysis, the origins and relationships of the Ecosystem concepts taught in BS 202 are apparent. Phase II consisted of analyzing the content presented in each instructional component of the course using the first phase analysis as a reference frame. In the lectures, small assembly sessions, tape labs, textbook readings and practice quizzes a simplified, reduced version of the content elucidated in the first phase was uncovered. This was the level of detail deemed appropriate by the course designers for a ten week course for preservice elementary education majors with little previous science experience. The Phase II ecosystem concepts serve as

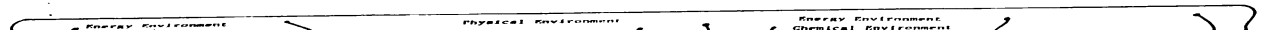
a basis for the concept mastery or performance indices used in the systems model describing the course.

Phase I Content Analysis

The first phase of content analysis consisted of detailing the component concepts subsumed under the concept "Ecosystem", and illustrating their interrelationships. The level of complexity, or "depth" chosen for this analysis was one which would be appropriate for a course in the fundamentals of ecology for college biology majors; a level considerably more sophisticated than necessary for the BS 202 course.

Eugene Odum, a noted authority in the fields of Ecology and Ecosystems, has authored a textbook designed for three levels of students. Fundamentals of Ecology (1971) is partitioned into three "Books" by the level of difficulty. Book 1 (chapters 1, 2, 3, 4, 9, 15, 16 and 21) was designed for study by "lay students" those in the social sciences, humanities, and other non-biological professions. It provides a macroscopic view of ecology. For the undergraduate college course in ecology for biology students, Book 2 (chapters 1 through 10, 15, 16 and 21) may be used. All twenty-one chapters (Book 3) may be used as a comprehensive reference work or graduate course textbook. Book 2 was subjected to content analysis in order to provide a reference frame for the ecosystem concepts taught in BS 202.

Figure 3.1 presents the results of the phase one content analysis. In this graphic representation each concept subsumed under "Ecosystem" is represented as a node connected by propositional "bridges" to other concepts. The total, interrelated web of concepts represents the complex concept of Ecosystem. Each of the subsumed concepts in the web, may be broken down into simpler, more primitive concepts, and could be represented by a smaller but equally complex web of concepts. However,


Energy Environment
Physical Environment
Energy Environment
Chemical Environment

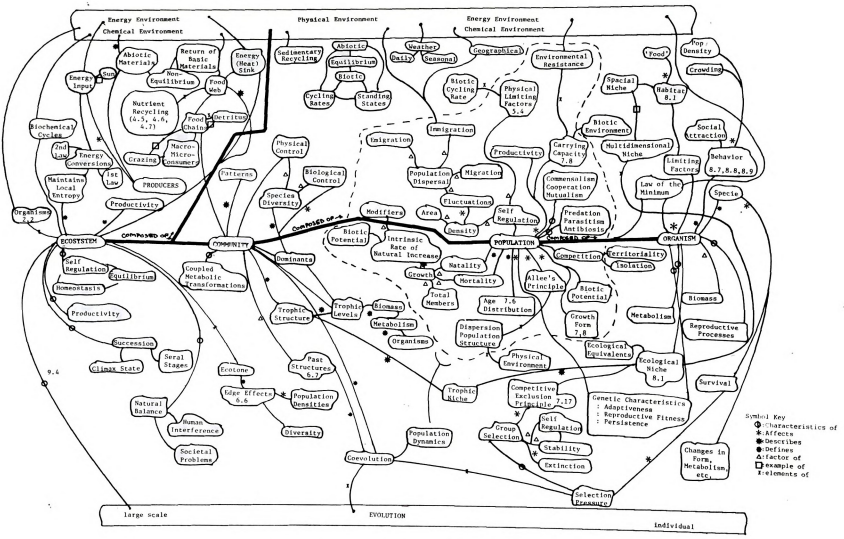


FIGURE 3.1 Ecology Concept Relationships (Odum, 1971)

it serves no purpose here to break these concepts down further. Rather, a definition of each is presented in Table 3.1.

In addition to the definitions provided many of the concepts in Figure 3.1 include a reference to a particular section of Odum's book (1971) which more fully explains the principles and expands the relationships involved. For instance, in the relationships among the concepts in Figure 3.1 the Ecological Niche describes an organism as detailed in Odum, section 8.1: "The ecological niche...is a term that includes not only the physical space occupied by an organism, but also its functional role in the community and its position in environmental gradients of temperature, moisture, pH, soil and other conditions of existence." The Competitive Exclusion Principle further details the complexity of the concepts; (from Odum, section 7.17) "Interspecific competition is any interaction between two or more species populations which adversely affects their growth and survival...The tendency for competition to bring about an ecological separation of closely related, or otherwise similar, species is known as the competitive exclusion principle." Thus, the bridges shown attempt to represent the more complex definitional linkages.

Phase II Content Analysis

Using the set of concepts detailed in the previous section, the content of the BS 202 course was searched for Ecosystem concepts. The ten lectures were first analyzed in detail for ecosystem concepts. Then, each small assembly session, tape lab, textbook reading, and practice quiz was thoroughly examined for references to these concepts and catalogued by the nature of concept coverage. The weekly quizzes and the final exam were similarly analyzed for concept coverage.

TABLE 3.1

PHASE ONE CONCEPT DEFINITIONS
(from Odum, 1971)

Concept	Definition
Abiotic	Not biological; not involving organisms or that produced by organisms.
Abiotic Materials (Substances)	Basic inorganic and organic compounds, such as water, carbon dioxide, oxygen, calcium, nitrogrn and phosphorus salt, amino and humic acids, etc., generally found outside of living organisms. Abiotic materials comprise one of the basic units of ecosystem.
Allee's Principle	For some populations the degree of aggregation and overall density which results in optimum population growth and survival varies with conditions. Undercrowding as well as overcrowding may be limiting factors.
Antibiosis	An interaction between two populations in which one population produces a substance harmful to the competing population.
Age Distribution	The age structure of individuals within a population.
Area	The unit in which ecological interaction takes place.
Behavior	The response of an organism to its biotic and physical environment.
Biogeochemical Cycles	The chore or less circular paths by which the chemical elements, including all the essential elements of protoplasm, tend to circulate in the biosphere, from environment to organisms and back to the environment.
Biotic Cycling Rates	The rate of transfer of organic compounds through the ecosystem.
Biotic Environment	The organisms and organic materials within an organism's environment.
Biological Control	The use of biological factors to control a population; the introduction of predators, parasites, etc., into a particular ecosystem to induce a population reduction of the controlled organisms, causing an equilibrium condition with a smaller population size.
Biotic	Biological, pertaining to organisms and their products.

Concept

Biotic Po

Carrying

Chemical

Climax S

Coevolut

Competit
Princi

Commensa

Communit

Competit

Protocoo

Coupled
Trans

Crowdin

TABLE 3.1 (Continued)

Concept	Definition
Biotic Potential	"The inherent property of an organism to reproduce, to survive, i.e., to increase in numbers." Maximum reproductive power. The maximum population growth rate under ideal conditions.
Carrying Capacity	The maximum population that a given environment can support indefinitely.
Chemical Environment	The chemical elements, compounds, and conditions within the ecosystem.
Climax State	A relatively stable stage reached in some ecological successions.
Coevolution	A type of community evolution (i.e., evolulutionary interactions among organisms in which exchange of genetic information among the kinds is minimal or absent) involving reciprocal selective interaction between two major groups of organisms with a close relationship, such as plants and herbivores, large organisms and their microorganism symbionts, or parasites and their hosts.
Competitive Exclusion Principle	The tendency for competition to bring about an ecological separation of closely related, or otherwise similar species.
Commensalism	An interaction between populations of two species in which one population is benefited but the other is not affected.
Community (Biotic)	Any assemblage of populations living in a prescribed area or physical habitat.
Competition	In ecology, utilization by two or more individuals, or by two or more populations, of the same limited resource; an interaction where both parties are harmed or limited.
Protocooperation	Type of interaction between two species in which both populations benefit by the association but relations are not obligatory.
Coupled Metabolic Transformations	Coupled energy flows and matter cycles within a community; where the organic compounds produced by one segment are necessary metabolic inputs for another.
Crowding	The situation arising when a large number of organisms of the same species inhabit a confined area; occurs in areas of high population density.

Concept

Cycling I

(Populat:

Detritus

Detritus

Diversit

Dominant

Ecologic

Edge Eff

Ecologi(

Ecosyst(

Ecotone

Emigrat

Energy

TABLE 3.1 (Continued)

Concept	Definition
Cycling Rates	The rate of process within the ecosystem; the rate of a complete cycle of transformations.
(Population) Density	Population size in relation to some unit of space--generally assayed and expressed as the number of individuals, or the population biomass, per unit area or volume.
Detritus	All the particulate organic matter involved in the decomposition of dead organisms.
Detritus (food chain)	One of the two basic types of food chain, which goes from dead organic matter into microorganisms and then to detritus-feeding organisms (detritivores) and their predators.
Diversity	The condition of being different. The multiplicity of differences among organisms.
Dominants	The organisms which exert the chief control or influence over an ecological community.
Ecological Equivalent	Organism that occupy the same or similar ecological niches in different geographical regions.
Edge Effects	The tendency for increased variety and density at community junctions or areas of interaction.
Ecological Niche	The physical space occupied by an organism, its functional role in the community, and its position in environmental gradients of temperature, moisture, pH, soil, and other conditions of existence.
Ecosystem	Any unit that includes all of the organisms (i.e., the "community") in a given area interacting with the physical environment so that a flow of energy leads to clearly defined trophic structure, biotic diversity, and material cycles within the system.
Ecotone	A transition between two or more diverse communities as, for example, between forest and grassland or between a soft bottom and hard bottom marine community.
Emigration	A form of population dispersal with one-way outward movement.
Energy Conversion	The transformation of one form of energy to another; usually involving heat loss.

Concept

Energy

Energy

Energy

Entrop

Enviro

Equili

Evolut

Extinc

1st La

Fluct

Food

Food

Genet

Graz

Grow

Grou

TABLE 3.1 (Continued)

Concept	Definition
Energy Environment	The forms and amounts of energy within an ecosystem.
Energy Input	A source and amount of energy entering a process.
Energy (Heat) Sink	An element or area which collects unusable, usually heat, energy.
Entropy	A measure of the unavailable energy in a closed thermodynamic system.
Environmental Resistance	The sum total of the environmental limiting factors acting on a population.
Equilibrium	A state of balance between opposing forces.
Evolution	The change in the genetic make-up of a population with time.
Extinction	The process or state of no longer existing pertaining to a population or species.
1st Law of Thermodynamics	For a closed thermodynamic system the total amount of energy present remains constant regardless of the transformations it undergoes.
Fluctuations	The uncertain shiftings about some point.
Food Chain	The transfer of food energy and organic matter from the source in plants through a series of organisms with repeated eating and being eaten, through a final decomposition to inorganic materials.
Food Web	The interlocking pattern by which food chains are interconnected with one another.
Genetic Characteristics	Characteristics of an organism or population caused by gene activity.
Grazing (food chain)	One of the two basic types of food chains which, starting from a green plant base, goes to grazing herbivores and on to carnivores.
Growth	The increase or expansion of a population or community.
Group Selection	The natural selection between groups of organisms not necessarily closely linked by mutualistic associations, leading to the maintenance of traits favorable to populations and communities, but selectively disadvantageous to genetic carriers within populations.

Concept

Growth For

Habitat

Homeostasi

Human Inte

Immigratic

Intrinsic
Natural

Isolation

Law of th

Limiting

Macrocons

Metabolis

Microcon

Migratic

TABLE 3.1 (Continued)

Concept	Definition
Growth Form	The shape of the arithmetic plots of the population growth curves. May be J or S-shaped.
Habitat	The place where an organism normally lives.
Homeostasis	The term generally applied to the tendency for biological systems to resist change and to remain in a state of equilibrium.
Human Interference	Human meddling and disruption of ecosystems.
Immigration	One-way inward movement form of population dispersal.
Intrinsic Rate of Natural Increase	The growth rate of a population under ideal or unlimited conditions.
Isolation	Complete geographical separation from other individuals or populations.
Law of the Minimum	Liebigs law of the minimum: Under steady state conditions the materials essential for organism growth and reproduction available in amounts most closely approaching the critical minimum needed will tend to limit the organism.
Limiting Factors	Factor retarding the natural growth rate of a population.
Macroconsumers	Phagotrophs (phago=to eat) heterotrophic organisms, chiefly animals, which ingest other organisms or particulate organic matter.
Metabolism	The sum of the chemical reactions within a cell or organism including the energy-releasing breakdown of molecules and the synthesis of complex molecules and new protoplasm.
Microconsumers	Saprotrophs osmotrophs, heterotrophic organisms, chiefly fungi and bacteria, which break down the complex compounds of dead protoplasms, absorb some of the decomposition products, and release by the producers together with organic substances, which may provide energy sources or which may be inhibitory or stimulatory to other biotic components of the ecosystem.
Migration	The periodic departure and return of individual organisms from an area. A form of population dispersal.

Concep

Modife

Mortal

Multid

Mutual

Natal

Natur

Nutri

Nutri

Organ

Paras

Patte

Phys

Phys

Phys

Popu

Popu

TABLE 3.1 (Continued)

Concept	Definition
Modifers	Factors limiting or restricting a process.
Mortality	Equivalent to the "death rate" in human demography. Refers to the death of individuals in the population more or less the antithesis of natality.
Multidimensional Niche	A multidimensional space or hyper volume within which the environment permits an individual or species to survive indefinitely.
Mutualism	A type of two-species population interaction, in which growth, and survival of both populations is benefited and neither can survive under natural conditions without the other.
Natality	The inherent ability of a population to increase. Natality is equivalent to the "birth rate" in the terminology of human population study. It is simply a broader term covering the production of new individuals of any organism.
Natural Balance	The dynamic equilibrium between the components of an ecosystem with no external, man made influences.
Nutrients	A substance usable in metabolism.
Nutrient Recycling	The continual passage and transformation of nutrients through an ecosystem.
Organism	An individual living thing.
Parasitism	A symbiosis in which one organism benefits at the expense of the other.
Pattern	The structure that results from the distribution of organisms in, and their interaction with, their environment.
Physical Control	The use of physical, non-biological means to control a population.
Physical Environment	The abiotic surroundings of an organism.
Physical Limiting Factors	Factors of the physical environment which limit a population's growth.
Population	A collective group of organisms of the same species occupying a particular space.
Population Dispersal	The movement of individuals or their diseminules or propagules (seeds, spores, larvae, etc.) into or out of the population or population area.

Concep

Predat

Produc

(Prima

Popula

Popula

Repro

2nd L

Sedim

Selec

Self

Sera

Soci

Spac

Spec

TABLE 3.1 (Continued)

Concept	Definition
Predation	The feeding of freeliving organisms on other organisms.
Producers	Autotrophic organisms, largely green plants, which are able to manufacture food or organic compounds from simple inorganic substances.
(Primary) Productivity	The rate at which radiant energy is stored by photosynthetic and chemosynthetic activity of producer organisms, in the form of organic substances which can be used as food materials.
Population Density	Population size in relation to some unit of space. Generally assayed and expressed as the number of individuals, or the population biomass, per unit area or volume.
Population Structure	The age distribution, stages and other parameters which describe a population.
Reproductive Processes	The processes involved in the replication of organisms.
2nd Law of Thermodynamics	A natural process within a system that begins in one state of equilibrium and ends in another will go in the direction that results in the largest entropy increase for the system and environment.
Sedimentary Recycling	The cycle of matter in which erosion, sedimentation, mountain building, volcanic activity, and biological transport are the primary processes.
Selection Pressure	Factors within the environment which influence the natural selection of traits within a population.
Self Regulation	The control and regulation of a system through feedback to maintain some equilibrium condition.
Seral Stages	Each of the transitory communities or developmental stages in the ecological succession of an area.
Social Attraction	Behavior resulting in the aggregation or clumping of social populations.
Spacial Niche	An organisms microhabitat.
Species	The largest unit of population within which effective gene flow occurs or could occur.

Concept

Species

Success

Stabili

Standir

Survival

Territ

Total

Trophi

Trophi

Trophi

TABLE 3.1 (Continued)

Concept	Definition
Species Diversity	The multiplicity of differences among organisms.
Succession	The progressive change in the plant and animal life of an area.
Stability	Resistance to change; the ability of a system to restore equilibrium after being disturbed.
Standing States	Reserves of elements of compounds.
Survival	The continuation of existance, the process of maintaining existance against environmental pressures.
Territoriality	Any active mechanism that spaces individuals or groups apart from one another.
Total Members	The total number of individual organisms within a population.
Trophic Levels	A nutritional level within the food chain.
Trophic Niche	The nutritional of food chain role and position of an organism in the ecosystem.
Trophic Structure	The structure of the food web in an ecosystem.

Lectur

T

concep

concep

tions

3.2 c

defin

lectu

conce

befor

tions

previ

Table

in t

were

Lecture Content

Table 3.2 presents a summary of the lecture coverage of the concepts subsumed under Ecosystem. For each of the ten lectures the concepts covered, the method of treatment, examples, and the connections made between concepts are detailed. The first column in Table 3.2 contains the concepts presented in lecture. These concepts are defined in Table 3.3 as they were used in the course. The set of lecture Ecosystem concepts listed in Table 3.3 contains many of the concepts defined in the Phase I content and several not presented before. These new Ecosystem concepts are amalgamations or simplifications of the basic set of concepts. The relationship of these and previously introduced concepts are contained in the definitions of Table 3.3.

A discussion of the method of concept presentation is contained in the second column of Table 3.2. The following presentation methods were commonly used in lecture:

1) Definition; a concept definition was presented and several examples provided.
2) Expanded Definition; a concept definition was presented and discussed at length, with many examples provided.
3) Definition by example; a concept was defined by providing a number of common examples--"water and silicon dioxide (sand) molecules are common examples of inorganic molecules."
4) Review definition; definition restated often with restatement of examples and addition of new examples.
5) Implicit definition; concept definition implicit in discussion --the sun produces energy (therefore it acts as an energy source).

the t

conce

able

lectu

in th

6) Undefined; concept is undefined and is understanding presumed--i.e., "energy flows into the ecosystem...," (without previously providing a definition of energy).

7) Mentioned--a previously defined concept is referred to without elaboration.

Examples mentioned in connection with the concepts are listed in the third column of Table 3.2. Connections and interrelations between concepts cited in lecture are contained in the fourth column.

The lectures were tape recorded and these tapes were made available for student use on the day after the lecture was presented. These lecture tapes are, of course, identical in content to those presented in the live lecture.

TABLE 3.2

ECOSYSTEMS CONCEPTS PRESENTED IN LECTURE

TABLE 3.2

ECOSYSTEMS CONCEPTS PRESENTED IN LECTURE

INSTRUCTIONAL SESSION: LECTURE 1 Date: 10/3/77

CONCEPTS	TREATMENT	EXAMPLES	CONNECTIONS
Ecosystem	Review, Short Definition 'Composed of...'	Species and Non-living materials (enumerated)	Organisms, Non-living environment, area species, producers, consumers, decomposers
Population	Definition	Humans in room	Organisms, species, area
Community	Definition	Woodlot (expanded)	Area, organisms, species
Specie	Two Definitions	Humans, squirrel, Horses, 1 nonexample mules, etc.	Organisms
Area	Definition Assumed	Implicit: Woodlot	
Organism	Definition Assumed	Implicit: Numerous	Population, species community, producer, consumer, decomposer
Biosphere	Definition (word origins)	Unique example non-examples	Ecosystem
Producers	Expanded Definition	Green plants	Organisms, molecules
Consumers	Expanded Definition	Humans, cows, Animals	Producers Organisms
Decomposers	Expanded Definition	Microorganisms	Producers Organisms Molecules

environment, matter energy (implicit:flow/cycle)

TABLE 3.2 (Continued)

TABLE 3.2 (Continued)

CONCEPTS	TREATMENT	EXAMPLES	CONNECTIONS
Environment	Definition Assumed		Ecosystem
Energy Source	Defined by Example	Sun (implicit: light, chemical heat, energy)	Flow of Energy producers, consumers, implicit: ecosystem
Flow of Energy	Expanded Definition	Simple flow in ecosystem	Biosphere, light energy, ecosystem, chemical energy, heat, decomposer
Molecules	Defined by Example	Organic, Inorganic	
Matter	Defined by Example	Water, soil air, molecules	Ecosystem Flow of matter
Matter Cycle	Definition	Simple Cycle in Ecosystem	Ecosystem, molecules, consumers, producers, decomposers
Energy	Undefined		Flow, Source Ecosystem

TABLE 3.2 (Continued)

INSTRUCTIONAL SESSION: Lecture 2 Date: 10/10/77

TABLE 3.2 (Continued)

INSTRUCTIONAL SESSION: Lecture 2 Date: 10/10/77

CONCEPTS	TREATMENT	EXAMPLES	CONNECTIONS
Energy Source	Definition by Example	Sun (light)	Energy Flow Ecosystem, Organic Molecules, Chemical Bonds, Photosynthesis, Producers, Equilibrium
Energy	Definition by Example	Heat Solar (light)	Energy Flow, efficiency Equilibrium, Organic Molecules
Efficiency	Undefined	—	Energy Flow Producers, Consumers, Decomposers, Energy
Equilibrium	Undefined equated to "Balance"	"light in-heat out" Energy balance of Earth	Efficiency (Ecosystem)
Energy Conversion	Definition by Example "Energy Change"	"Energy Capture by Producers" "Energy Use by Consumers and (Decomposers)"	Efficiency, heat loss, Equilibrium Respiration Producers (Consumers, Decomposers)
Energy Storage	Definition by Example	Carbohydrates Fats etc.	(Energy Conversion) (Capture) (Energy Source) Respiration Photosynthesis, Chemical Bonds
Temperature	Undefined	Temperature of Earth	Energy, Energy Flow
Energy Type	Undefined	Light Chemical	Energy Conversion, Equilibrium, Energy Storage, Energy Flow, Temperature

TABLE 3.2 (Continued)

INSTRUCTIONAL SESSION: Lecture 2 Date: 10/10/77

TABLE 3.2 (Continued)

INSTRUCTIONAL SESSION: Lecture 2 Date: 10/10/77

CONCEPTS	TREATMENT	EXAMPLES	CONNECTIONS
Energy Flow	Review Definition	"not cycle" "lost as heat" "Earth: light in, heat out"	Chemical Bond Producers, Consumers, Decomposers Energy Source, Organic Molecules Energy Conversion, Efficiency (Equilibrium)
Organic Molecules	Definition expanded	Multiple Examples: Carbohydrates, Fats, Proteins, etc.	Producers, Consumers Chemical Bonds Organisms
Chemical Bonds	Definition	Multiple Examples	Organic, Inorganic Molecules, Photosynthesis, Producers, Consumers, Energy Storage, Source (Energy Flow)
Inorganic Elements	Definition (from non-living	H_2O, Phos. (Carbon) CO_2, nitrate	Organic Molecules Chemical Bonds, Energy Storage (Photosynthesis) (Respiration)
Photosynthesis	Expanded Definition	Multiple Examples	Producers, Inorganic, Organic Molecules
Respiration	Definition		(Implicit: Producers, Consumers, Decomposers) Organic Molecules, Chemical Bonds (Energy)

TABLE 3.2 (Continued)

INSTRUCTIONAL SESSION: lecture 2 Date: 10/10/77

EXAMPLES CONNECTIONS

TABLE 3.2 (Continued)

INSTRUCTIONAL SESSION: lecture 2 Date: 10/10/77

CONCEPTS	TREATMENT	EXAMPLES	CONNECTIONS
Ecosystem	Review Redefined (Structure and Function)	—	Producers, Consumers Decomposers, Atmosphere, Hydrosphere, Lithosphere Material Cycle, Energy Flow
Producers	Review Definition	—	Energy Conversion (Capture) Material Cycle, Energy Flow, Inorganic Molecule, Organic Molecule. Energy (Sun) Source. Matters Cycle
Consumers	Review Definition	—	Material Cycle, Energy Flow, Producers, Energy Conversion (Capture)
Decomposers	Review Definition	—	Material Cycle, Energy Flow, Producers, Energy Conversion (Capture)
Atmosphere	Definition (Non-living Environment)	"Air"	Ecosystem
Lithosphere	Definition (Non-living Environment)	"Water"	
Hydrosphere	Definition (Non-living Environment)	"Dirt"	
Material Cycle (Matter)	Review Definition	Phosphate Cycle	Producers, Consumers, Decomposers, Inorganic, Organic Molecules

TABLE 3.2 (Continued)

INSTRUCTIONAL SESSION: Lecture 3 Date: 10/17/77

CONCEPTS	TREATMENT	EXAMPLES	CONNECTIONS

TABLE 3.2 (Continued)

INSTRUCTIONAL SESSION: Lecture 3			Date: 10/17/77
CONCEPTS	TREATMENT	EXAMPLES	CONNECTIONS
Producers	Expanded Definition (Autotrophic) (Photoautotrophic) (Chemoautotrophic)	Green Plants Algae..	Matter recombination Energy Storage (ATP) Energy Conversion Temperature
Ecosystem	Redefined via Diagram	—	Consumer, Producer, Decomposer, Inorganic, Organic Molecules, Producers, Energy Source, Cycle of Matter, Energy Flow, Energy Types
Inorganic Material	Mentioned	—	(Ecosystem) Producers, Photosynthesis, Organic Molecules
Organic Molecules (Matter)	Mentioned	Sugar, Amino Acids...	Producers, Photosynthesis
Matter Cycle	Mentioned via Diagram	—	Energy, Photosynthesis Producers (implicitly- Food Chain)
Energy Flow	Definition Mentioned, Diagram (Review)	"Plant → Herb → Carnivore", Heat loss, "Sun plants → animals → space"	Energy Producers Consumers
Consumers	Redefined heterotrophic, holozoic saprophytic, parasitic	Human	Producers Energy, Energy Flow Food Chain
Decomposers	Mentioned		Ecosystem Producers, Consumers

TABLE 3.2 (Continued)

TABLE 3.2 (Continued)

INSTRUCTIONAL SESSION: Lecture 3			Date: 10/17/77
CONCEPTS	TREATMENT	EXAMPLES	CONNECTIONS
Energy Storage	Implicit to discussion, Undefined	ATP, Food, Carbohydrates, etc.	Producers Energy Flow, Energy
Energy Conversion	Implicit to discussion, Undefined	Chemical Growth, Reproduction, Fire	Chemical Bond, Energy Producers Energy Flow, Photosynthesis (Chlorophyll) Temperature
Energy Source	Defined implicitly by examples	Sun ATP ADP	Producers Energy Chemical Bond
Energy	Simply Defined as "capacity to do work: (-Activation energy?)	light heat food (energy storage)	Energy form Matter Cycle Chemical Bond, Energy Source, Energy Conversion, Food Chain
Food Chain	Defined as Energy Chain (Short mention)	"Plant ⟶ Herb ⟶ Carnivore"	Energy Flow, Energy (Energy Storage, Energy Conversion)
Temperature	Undefined	Plants Animals Heat loss	Energy Energy Flow (Producers, Consumers)
Photosynthesis	Defined	—	Matter Recombination, Inorganic Molecules Organic Molecules, Energy Flow, Energy
Matter Recombination	Implicit Definition	Redwood tree, Green Plants	Producers, Energy (Organic, Inorganic Matter) (Energy Flow, Conversion Matter Cycle, Consumers, Energy Storage)

TABLE 3.2 (Continued)

TABLE 3.2 (Continued)

INSTRUCTIONAL SESSION: Lecture 4 Date: 10/24/77

CONCEPT	TREATMENT	EXAMPLES	CONNECTIONS
Producers	Function Summarized	Green Plants, Algae, Ferns, Flowering Plants...	Organic, Inorganic Molecules, Energy, Environment (Ecosystem) (Energy Form)
Consumers	Defined ("dependence on Producers") (Holozoic, saprophytic)	Multiple Exampler: Protozoa - Human, Animals..	Producers Organic Molecules, Inorganic Matter Environment (Ecosystem)
Energy	Mentioned	—	Producers, Consumers, Organic Matter
Energy Flow	Implicit-not directly mentioned		(Producers, Consumers Ecosystem)
Organic Molecules (Matter)	Mentioned	Amino Acids Carbohydrate, Fat Protein...	Consumers (Producers)
Inorganic Molecules (Matter)	Mentioned	Nitrogen CO_2 (Soil)	Consumers (Producers)
Homeostasis	Definition: "steady state in a changing environment"	Liver as Maintainer of H. situation	—
Decomposers	Mentioned	Bacteria, Fungi	

TABLE 3.2 (Continued)

TABLE 3.2 (Continued)

INSTRUCTIONAL SESSION: Lecture 5			Date: 10/31/77
CONCEPT	TREATMENT	EXAMPLES	CONNECTIONS
Consumer	Mentioned	Multicellular Animals	Organic, Inorganic Molecules, Environment (Ecosystem) "food", oxygen, Respiration Energy, Energy Source
Respiration	Expanded Discussion	—	Organic, Inorganic Molecules Energy, Energy Source Energy Conversion (efficiency)
Organic Molecules	Reference	Monomers-polymers Sucrose, Amino Acid, Glycogen	Energy Source Respiration Inorganic Molecule, Chemical Bonds
Energy Sources	Implicitly	Food Molecules, Sucrose Glycogen ATP, ADP, Sun	Chemical Bonds (Ecosystem)
Energy	Undefined, Reference	ATP, ADP Sunlight, heat	Organic Molecules Energy Conversion Efficiency
Inorganic Molecules (Matter)	Reference	Phosophate CO_2, H_2O...	Energy (Chemical Bonds Organic Molecules)
Producers	Mentioned	Green Plants	Photosynthesis, Energy, Energy Source, Inorganic Matter, Respiration
Energy Cycle	Defined on cellular level	ATP ↔ ADP	Respiration, Energy, Energy Source
Efficiency	Undefined	ATP ↔ ADP ↙ Glucose	Energy Conversion (Energy Flow)

TABLE 3.2 (Continued)

TABLE 3.2 (Continued)

INSTRUCTIONAL SESSION: Lecture 6			Date: 11/7/77
CONCEPTS	TREATMENT	EXAMPLES	CONNECTIONS
Reproduction (Molecular)	Expanded definition, discussion	Expanded use of chemical means of reproduction, DNA, RNA, Chromosomes	(Organism)
Metabolism	Mentioned briefly		(Organism), life Environment
Environment	Mentioned briefly		(Organism), life Environment
Parasitism	Used as analogy, undefined	Cell is parasitic on body when dividing	(Organism)

INSTRUCTIONAL SESSION: Lecture 7			Date: 11/14/77
CONCEPTS	TREATMENT	EXAMPLES	CONNECTIONS
Reproduction	Mentioned		Metabolism, Environment, (Organism)
Metabolism	Mentioned		Reproduction, Environment, (Organism)
Homeostatic Mechanisms	Mentioned, Undefined	Plants; Hormonal Systems, Animals-Nervous and Hormonal Systems	(Organisms)
Feedback (Mechanism)	Mentioned, Undefined	Feedback between reproductive, nervous, pituitary	(Organisms)

TABLE 3.2 (Continued)

TABLE 3.2 (Continued)

INSTRUCTIONAL SESSION: Lecture 8			Date: 11/21/77
CONCEPTS	TREATMENT	EXAMPLES	CONNECTIONS
Ecosystem	Mentioned briefly		Organisms, Producers, Consumers, Decomposers
Organism	Mentioned briefly, examples given without reference	Daphnia, Herring Gull, Celenese Barb, Oyster Catcher, Stag, 3 Spine Stickleback	
Producer	Mentioned briefly		Ecosystem, Organism, Consumer, Decomposer
Consumer	Mentioned briefly		Ecosystem, Organism, Producer, Decomposer
Decomposer	Mentioned briefly		Ecosystem, Organism, Producer, Consumer
Environment	Mentioned, undefined		Behavior, Stimulus
Stimulus (Environmental)	Defined	Auditory, Visual, Chemical, Tactile Courtship displays (threat display)	Environment, Organism, Response
Response	Defined	Taxis, reflex, (Daphnia) (threat display)	Organism Environment, Stimulus
Behavior (Animal)	Defined	Learned, Instincts	Environment, Stimulus, Response, Organism
Territory	Defined	Herring Gull	Organism (Environment)
Aggression	Defined	Defense	Organism (Stimulus, Response) Submission
Submission	Undefined	Female display	Organism (Stimulus, Response) Aggression
Dominance	Undefined	Group Order	Aggression, Submission, (Organism, Stimulus, Response)

TABLE 3.2 (Continued)

INSTRUCTIONAL SESSION: Lecture 9	Date: 11/28/77
	CONNECTIONS

TABLE 3.2 (Continued)

INSTRUCTIONAL SESSION: Lecture 9			Date: 11/28/77
CONCEPTS	TREATMENT	EXAMPLES	CONNECTIONS
Ecosystem	Review Expanded definition	Pond	Energy Source, Biosphere Energy Flow, Cycle of Matter, Physical Environment, Matter Cycle, Producers, Consumers, Decomposers
Energy Source	Mentioned Defined	Sun Chemical Storage	Producers, Ecosystem, Energy, Energy Flow Food Web, Cycle of Matter
Energy Flow	Defined	Ecosystem	Ecosystem, biosphere, Energy Source, Physical Environment, Efficiency
Cycle of Matter	Mentioned Review	Pond, Water Cycle Oxygen Cycle, Carbon Cycle, Nitrogen Cycle	Organic and inorganic Molecules, Organisms, Producers, consumers, decomposers, physical environment, respiration, energy flow, food web
Producers	Defined	Algae, lily pads, green plants	Ecosystem, photosynthesis energy source, organic and inorganic molecules, Cycle of Matter, Efficiency
Consumers	Review	Herbivores, carnivores	Ecosystem Cycle of Matter, Efficiency, Energy Flow, Food Web
Decomposers	Review	Bacteria	Inorganic and Organic Molecules, Ecosystem, Cycle of Matter, Efficiency, Energy Flow
Organic Molecules	Mentioned	Carbohydrates Peat, fossil fuels Amino Acids, Fatty Acid	Photosynthesis, Energy, Producers, Cycle of Matter Respiration, Food Web

TABLE 3.2 (Continued)

INSTRUCTIONAL SESSION: Lecture 9			Date: 11/38/77
CONCEPTS	TREATMENT	EXAMPLES	CONNECTIONS

TABLE 3.2 (Continued)

INSTRUCTIONAL SESSION: Lecture 9			Date: 11/38/77
CONCEPTS	TREATMENT	EXAMPLES	CONNECTIONS
Inorganic Molecules	Mentioned	CO_2 NO_3^-, N_2	Producers Cycle of Matter, Respiration
Energy	Mentioned	Chemical Light	Producers Ecosystem
Efficiency	Implicit Definition	Plants → herbivores → carnivore Loss of Energy with trophic level	Producers Photosynthesis, Consumers, Food Web, Metabolism, Respiration, Decomposers
Food Web	Defined Reviewed	Plants → herbivores → carnivores	Consumers, Producers, Decomposers, Organic and Inorganic Molecules
Photosynthesis	Review	Green Plants	Ecosystem, Energy Flow, Cycle of Matter, Producers, Consumers, Efficiency
Symbiosis	Implicit Definition	Nitrogen Fixing Bacteria	Organic and Inorganic Molecules, Energy Flow, Ecosystem
Succession	Defined Extended Discussion	Ponds, Lakes Eutrophication Bog	Decomposers, Producers, Consumers, Inorganic and Organic Molecules, Matter Cycle

TABLE 3.2 (Continued)

INSTRUCTIONAL SESSION: Lecture 10 Date 12/5/77

TREATMENT	EXAMPLES	CONNECTIONS

TABLE 3.2 (Continued)

INSTRUCTIONAL SESSION: Lecture 10 Date 12/5/77

CONCEPTS	TREATMENT	EXAMPLES	CONNECTIONS
Populations	Definition, review	Human, pigeon, fungi, bacteria, fish, mammals.	Density, area, organisms
Density	Definition, expanded discussion	Human, pigeon, fungi, bacteria	Birth/death rate, immigration emigration
Area	Implicit definition		Density, populations
Birth/Death Rate	Definitions	Human 30/1000/yr.	Population, growth, density
Energy	Implicit definition	Electric, solar	Populations, growth, energy source
Organism	Definition by Example	Humans, pigeons, fungi, fish, mammals	Populations, density, area, Birth/death rate
Energy Source	Definition	Sun, coal, natural gas, oil	Energy, population, growth
Growth	Definition	Population, growth, energy use growth	Population, energy

Conc

Age

Area

Auto

Beha

Biom
Bic

Bloc

Blo
Blo

Bio

Bir

Car

Che

Cli

Co

Co

TABLE 3.3

BS 202 ECOSYSTEM CONCEPT DEFINITIONS

(Keeton, 1973; Odum and Odum, 1976; Woolf, 1976)

Concept	Definition
Age Distribution	The relative distribution of age cohorts within a population
Area	The unit in which ecological interaction takes place.
Autotroph	An organism capable of manufacturing organic compounds from inorganic raw materials. A producer.
Behavior	The response of an organism to its biotic and physical environment.
Biomagnification or Biological Magnification	Increasing concentration of relatively stable chemicals as they are passed up a food chain from initial consumers to top predators.
Biomass	The total weight or volume of all the organisms, both plant and animal, in a given area.
Biome	A major climax plant formation.
Biosphere	The part of the Earth in or on which life can occur.
Biotic Potential	The maximum population growth rate under ideal conditions.
Birth/Death Rate	The ratio of the number of births or deaths divided by the number of individuals in the population.
Carrying Capacity	The maximum population that a given environment can support indefinitely.
Chemical Bond	The energy or force uniting two or more chemical atoms or molecules in a molecular state.
Climax	A relatively stable stage reached in some ecological successions.
Commensalism	A symbiosis in which one party benefits and the other is neither benefited nor harmed.
Community	A unit composed of all the populations living in a given area.

TABLE 3.3 (Continued)

Concept	Definition
Competition	In ecology, utilization by two or more individuals, or by two or more populations, of the same limited resource; an interaction where both parties are harmed, or limited.
Competitive Exclusion Principle	An ecological principle: Two species cannot for long simultaneously occupy the same niche in the same area.
Consumer	An organism which feeds on other organisms.
Decomposer	An organism responsible for the breakdown of organic matter to simpler forms.
Density (Population)	The number of individuals per unit area.
Density Dependent/ Independent Factors	Factors which affect the growth of a population, and are either related or not related, respectively, to the density of the population.
Diversity	The condition of being different. The multiplicity of differences among organisms.
Ecosystem	The sum total of physical features and organisms occurring in a given area, and their interrelationships and interactions.
Efficiency	The ratio of the useful energy delivered by a dynamic system to the energy supplied to it.
Energy	A fundamental quantity, measuring the ability to accomplish a process; the capability to do work; the ability to produce heat.
Energy Conversion	The transformation of one form of energy to another (i.e., chemical to heat).
Energy Source	A physical entity which produces or stores energy in some form.
Energy Storage	The maintenance of energy in a single form (i.e., chemical energy is stored within the ATP molecule).
Environmental Resistance	The sum total of the environmental limiting factors acting on a population.

TABLE 3.3 (Continued)

Concept	Definition
Equilibrium	A state of balance between opposing forces.
Eutrophication	The process in which body of water becomes rich in nutrients but often shallow and seasonally deficient in dissolved oxygen.
Evolution	Change in the genetic makeup of a population with time.
Flow of Energy	The movement or passage of energy through an ecosystem.
Food Chain	Sequence of organisms, including producers, consumers, and decomposers, through which energy and materials may move in a community.
Food Web	The complex interrelationships of food chains.
Growth	The increase or expansion of a population or community.
Habitat	The kind of place where a given organism normally lives.
Hetertroph	An organism incapable of manufacturing organic compounds from inorganic raw materials; requiring organic nutrients from other sources; consumers and decomposers.
Homeostasis	The tendency of a system toward maintenance of stability.
Immigration	The movement of individuals into a population area from other areas.
Inorganic Molecule/Element	A chemical compound not based on carbon.
Life Cycle	The stages an organism passes through between conception and death.
Matter Cycle	The movement or passage of matter within an ecosystem.
Metabolism	The sum of the chemical reactions within a cell (or a whole organism), including the energy-releasing breakdown of molecules and the synthesis of complex molecules and new protoplasm.

Conc

Mutu

Nate

Natu

Nic

Nut

Org

Org

Par

Pho

Phy

Po

Pr

Pr

Ra

R

S

TABLE 3.3 (Continued)

Concept	Definition
Mutualism	A symbiosis in which both parties benefit.
Natality	Birthrate.
Natural Selection	Differential reproduction in nature, leading to an increase in the frequency of some genes or gene combinations and to a decrease in the frequency of others.
Niche	The functional role and position of an organism in the ecosystem.
Nutrient	A substance usable in metabolism.
Organic Molecule	A chemical molecule containing carbon.
Organism	An individual living thing.
Parasitism	A symbiosis in which one party benefits at the expense of the other.
Photosynthesis	Autotrophic synthesis of organic materials in which the source of energy is light.
Physical Environment	The abiotic surroundings of an organism.
Population	A group of individuals belonging to the same species.
Predation	The feeding of free-living organisms on other organisms.
Producer	An organism responsible for the construction of organic molecules from inorganic matter, facilitating the capture of energy within the ecosystem.
Reproduction	The process by which organisms give rise to offspring.
Respiration	(1) The release of energy by oxidation of fuel molecules. (2) The taking in of O_2 and release of CO_2; breathing.
Saprophyte	A heterotrophic plant or bacterium that lives on dead organic material, a decomposer.

Conce

Speci

Succ

Symb

Temp

Terr

Tro

TABLE 3.3 (Continued)

Concept	Definition
Species	The largest unit of population within which effective gene flow occurs or could occur.
Succession	The progressive change in the plant and animal life of an area.
Symbiosis	[Gk bios life]. The living together of two organisms in an intimate relationship.
Temperature	The degree of hotness or coldness of a physical object measured on a definite scale.
Territory	A particular area defended by an individual against intrusion by other individuals, particularly of the same species.
Trophic Level	A nutritional level within the food chain.

Small Assembly Session Content

The Ecosystem concepts covered in each of the nineteen small assembly sessions are presented in Table 3.4. Each SAS was taught by one of the three assistants assigned to the course. The assistants were provided with an outline of the topics to be covered in eash SAS, but the details of the session were left to the individual's initiative and teaching style. Consequently, there was a considerable variation among concept coverage. Although we can be certain that the concepts were covered, no parameter describing the extent of that coverage can be assigned to the SASs.

Tape Laboratory Content

A catalogue of the Ecosystem concepts presented in the prerecorded tapes used in the individualized instructional sessions is presented in Table 3.5. This listing was developed by analyzing the scripts of each of the seventeen tapes and the objectives for each of the individualized instructional sessions.

Textbook Readings

The main textbook used for BS 202 was Keeton's Elements of Biological Science (1973). Burnett's Zoology (1973) and Botany (1970) were also used as supplementary resources. The Ecosystem concepts covered in each of the ten weekly reading assignments are presented in Table 3.6. No attempt was made to quantify the extent of concept coverage in the reading assignments.

Practice Quiz Content

A practice quiz was made available to the students each week several days before the official quiz. The practice quizzes were not a mandatory requirement of the course, but served as an exercise for

TABLE 3.4

PROCEDURES/CONCEPTS COVERED IN THE SMALL ASSEMBLY SESSIONS

TABLE 3.4

ECOSYSTEM CONCEPTS COVERED IN THE SMALL ASSEMBLY SESSIONS

Instructional Session	Week	Dates (1977)	Description	Ecosystem Concepts Covered
SAS 1	1	10/3 & 4	Models of Elementary Biology Teaching	—
SAS 2	1	10/5 & 6	Nature of Life/Science Classifying Organisms in Pond Water	Organism, Producer, Consumer, Metabolism, Respiration, Homeostasis, Adaption, Reproduction
SAS 3	2	10/10 & 11	Physical Basis of Life	Equilibrium
SAS 4	2	10/12 & 13	Field Trip	Consumers, Decomposers, Organism, Producers, Ecosystem, Energy Flow, Matter Cycle
SAS 5	3	10/17 & 18	Photosynthesis	Photosynthesis, Organic and Inorganic Molecules, Energy, Energy Flow, Energy Cycle
SAS 6	3	10/19 & 20	Insects and Crustacea	Organism, Physical Environment, Life Cycle, Reproduction
SAS 7	4	10/24 & 25	Consumer Anatomy and Disease	Consumer, Respiration, Organism
SAS 8	4	10/26 & 27	Consumer Anatomy and Disease	Consumer, Respiration, Organism
SAS 9	5	10/31 & 11/1	Skeletal Systems	Respiration, Behavior, Organisms, Reproduction
SAS 10	5	11/2 & 3	Birds and Mammals	Respiration, Behavior, Organisms, Reproduction
SAS 11	6	11/7 & 8	DNA, Genetic and Cellular Disease	Mutation, Organic Molecules
SAS 12	6	11/9 & 10	Plant Growth and Development	Producers, Decomposers, Reproduction, Energy, Physical Environment.
SAS 13	7	11/14 & 15	Animal Development	Producers, Reproduction, Physical Environment
SAS 14	7	11/16 & 17	Human Development	Reproduction, Producer

TABLE 3.4 (Continued)

Instructional	Ecosystem

TABLE 3.4 (Continued)

Instructional Session	Week	Dates (1977)	Description	Ecosystem Concepts Covered
SAS 15	8	11/21 & 22	Animal Behavior	Producers, Behavior, Physical Environment
SAS 16	9	11/28 & 29	Water and Air Quality Flowering Plants	Organic, Inorganic Molecules, Producers
SAS 17	9	11/30 & 12/1	Ecology	Ecosystem, Stratification, Succession, Biotic Factors, Physical Environment, Consumers, Producers, Decomposers
SAS 18	10	12/5 & 6	Food and Population	Growth, Producers, Consumers, Reproduction
SAS 19	10	12/7 & 8	Plant Management	Growth, Producers, Consumers, Physical Environment, Biotic Factors, Species, Organisms.

TABLE 3.5

ECOSYSTEM CONCEPTS PRESENTED IN THE TAPE LABORATORY

	Ecosystem

ECOSYSTEM CONCEPTS PRESENTED IN THE TAPE LABORATORY

Instructional Session	Week	Description	Ecosystem Concepts Covered
TAPE 1	1	The Microscope	N.A.
TAPE 3	2	Mollusks, Annelids Echinoderms	Consumers, Organisms
TAPE 4	2	Cells	Producers, Consumers, Organisms
TAPE 5	3	Arthropods	Consumers, Organism, Habitats, Life Cycle, Physical Environment
TAPE 6	3	Producers	Producers, Physical Environment, Matter Cycle, Ecosystem, Photosynthesis, Energy, Organic and Inorganic Molecules, Energy Flow, Biosphere, Efficiency, Food Web
TAPE 7	4	Chordates	Consumers, Organisms
TAPE 8	4	Consumers	Consumers, Parasitic, Holotrophic, Saprophytic, Physical Environment, Respiration, Organic and Inorganic Molecules, Metabolism, Homeostasis, Reproduction
TAPE 9	5	Chordates 2	Consumers, Organisms, Producers
TAPE 10	5	Consumers 2	Anaerobic Respiration, Physical Environment, Energy Flow, Matter Cycle, Behavior, Energy Storage
TAPE 11	6	Decomposers	Decomposers, Growth, Organic and Inorganic Molecules, Physical Environment
TAPE 12	6	Reproduction 1	Life Cycle, Reproduction, Producers, Consumers, Growth, Metabolism, Homeostasis, Energy Source, Respiration
TAPE 13	7	Plants 1	Producers, Habitat, Ecosystem, Life Cycle, Reproduction
TAPE 14	7	Reproduction 2	Producers, Consumers, Habitat, Reproduction, Physical Environment
TAPE 15	9	Flowering Plants	Producers, Reproduction
TAPE 16	9	Ecology 1	Ecosystem, Habitat, Niche, Food Chain and Web, Efficiency, Physical Environment, Growth, Biomass, Energy Flow, Mutualism, Competition, Commensalism, Predation, Parasitism, Saprophytism, Biome, Community, Population, Producers, Consumers, Decomposers, Evolution, Succession, Matter Cycle, Trophic Level, Photosynthesis, Energy, Biome, Climax

TABLE 3.5 (Continued)

TABLE 3.5 (Continued)

Instructional Session	Week	Description	Ecosystem Concepts Covered
TAPE 17	10	Organism Review	Specie, Organism, Producer, Consumer, Decomposer, Evolution
TAPE 18	10	Ecology 2	Biotic Potential, Environmental Resistance, Carrying Capacity, Growth, Behavior, Biomagnification, Food Chains, Food Webs, Energy Flow, Matter Cycle, Density, Physical Environment, Density Dependent and Independent Factors, Producers, Consumers, Decomposers, Population

TABLE 3.6

ECOSYSTEM CONCEPTS CONTAINED IN THE WEEKLY TEXTBOOK READINGS

Reading Assignment Pages:	Ecosystem

ECOSYSTEM CONCEPTS CONTAINED IN THE WEEKLY TEXTBOOK READINGS

Week	Reading Assignment Pages: Keeton	Botany	Zoology	Ecosystem Concepts Covered
1	1-4, 66-69	18-25	24-39	Evolution, Natural Selection, Organism, Specie, Population, Density, Reproduction, Birth/Death Rate, Life Cycle, Parasitic, Producers, Consumers, Decomposers, Physical Environment
2	13-31,35-46 46-56,62-66	—	40-44	Inorganic and Organic Molecules, Energy Storage, Energy, Producers, Photosynthesis, Consumers
3	57-62,82-84 95-101,118-119 127-137	—	45-64	Producers, Photosynthesis, Energy Source, Energy Storage, Nutrient, Autotroph, Heterotroph, Consumer, Inorganic Molecules, Matter Cycle, Energy Flow
4	31-34,109-115 119-126,137-161	—	65-81	Inorganic and Organic Molecules, Energy Flow, Energy, Respiration, Consumer, Producer, Food Web, Physical Environment
5	200-208 226-231 234-239	—	82-96	Producers, Consumers, Behavior, Physical Environment, Evolution, Food Web
6	279-289 327-341 165-177	28-41	—	Reproduction, Organism, Energy, Producers, Consumers, Organic Molecule, Energy Source, Physical Environment, Inorganic Molecule, Decomposers, Symbiosis, Mutualism
7	186-196 341-346	45-55 104-105	—	Reproduction, Consumer, Energy Source, Energy, Physical Environment, Producers
8	248-274	—	—	Consumers, Behavior, Physical Environment, Organism, Inorganic and Organic Molecules, Evolution, Specie
9	392-402 418-425	56-63 106-115		Ecosystem, Population, Community, Organic and Inorganic Molecules, Biosphere, Energy Flow, Matter Cycle, Energy, Food Chain, Food Web, Producers, Consumers, Decomposers, Eutrophication, Climax, Biome, Reproduction, Trophic Level, Efficiency, Physical Environment, Diversity, Succession
10	402-418 388-390	12-15	4-7	Population, Density, Birth/Death Rate, Biotic Potential, Environmental Resistance, Density-Independent and Density Dependent Limiting Factors, Carrying Capacity, Parasitism, Predation, Competition, Behavior, Territoriality, Energy Source, Symbiosis, Commensalism, Mutualism, Niche, Habitat, Comptetitive Exclusion Principle, Reproduction, Life Cycle, Consumers, Producers

those students who elected to use them. The content covered in each of the nine practice quizzes is catalogued in Table 3.7. All the practice quizzes were available for student review in preparation for the final exam.

In each of the practice quizzes all the ecosystem concepts which occurred in the questions and in all of the possible responses are listed in Table 3.7.

3.2 Quiz Content and Concept Mastery Assessment

Table 3.8 contains the results of the content analysis of the course quizzes and the final exam. Each test item was examined for ecosystem content and catalogued accordingly. Only those concepts which appeared in the body of the question and in the correct response are listed in Table 3.8. Many test items included additional ecosystem concepts in the incorrect responses, but these concepts were not catalogued. If a student answered an item correctly, then it may be assumed that either the student has some understanding of the concepts in the body of question and the correct response, or made a good guess. If an incorrect response was chosen, it is not possible to ascertain whether the student did not understand the concepts in the correct response, did not understand one or more of the concepts in the response chosen, did not understand the concepts in the body of the question, or did not understand some combination of these three possibilities.

Table 3.8 lists only those test items which contained ecosystem concepts. For each test item the concepts covered and examples used are cited. Under the Comments column the possible methods or combination of methods employed by students to answer the question are listed. For instance in the quiz item below (item 11 of Quiz 10),

Frac
Qui

1

2

3

4

5

6

7

9

10

TABLE 3.7

ECOSYSTEM CONCEPTS COVERED IN THE WEEKLY PRACTICE QUIZZES

Practice Quiz	Ecosystem Concepts Covered
1	Population, Species, Community, Ecosystem, Biosphere, Organisms, Energy Source, Physical Environment, Energy Flow, Reproduction, Behavior, Producers, Consumers
2	Organic and Inorganic Molecules, Organism, Decomposer, Energy, Physical Environment, Energy Storage, Producer, Consumer
3	Energy, Energy Source, Inorganic and Organic Molecules, Energy Flow, Photosynthesis, Physical Environment, Producer, Consumer, Respiration
4	Holotroph, Organism, Producer, Consumer, Decomposer, Organic and Inorganic Molecules, Nutrients, Photosynthesis, Energy Source, Physical Environment, Respiration
5	Respiration, Energy Storage, Efficiency, Organic and Inorganic Molecules, Energy Flow, Photosynthesis, Consumers, Producers, Physical Environment
6	Organic and Inorganic Molecules, Energy Storage, Evolution, Producers, Consumers, Reproduction, Photosynthesis, Decomposer, Organism, Biosphere, Autotroph, Heterotroph
7	Reproduction, Consumer, Physical Environment, Organic and Inoganic Molecules, Producer, Habitat
9	Behavior, Physical Environment, Matter Cycle, Organic and Inorganic Molecules, Producers, Consumers, Decomposers, Respiration, Eutrophication, Nutrient, Ecosystem, Food Web, Biomass, Energy Flow, Competition, Commensalism, Mutualism, Symbiosis, Parasitism, Trophic Level, Biome, Niche, Succession, Climax, Diversity, Community, Reproduction
10	Birth/Death Rate, Age Distribution, Immigration, Growth, Population, Density, Life Cycle, Biotic Potential, Environmental Resistance, Behavior, Density Independent and Dependent Factors, Physical Environment, Predation, Competition, Food Chain, Producers, Consumers, Decomposers, Biomagnification, Biotic Potential, Natality, Energy Source, Organism

TABLE 3.8

QUIZ ITEMS WITH ECOSYSTEM CONCEPTS

QUIZ ITEMS WITH ECOSYSTEM CONCEPTS
Fall 1977

Quiz	Quiz Item	Concepts	Examples	Comments
1	001	ORGANISM		Applying a definition or recognizing an example
		ECOSYSTEM	Pond	
	003	MATTER CYCLE	CO_2 C Organic	Recognizing an example
		ORGANIC MOLECULE	Matter	Recognizing an incorrect definition
	004	MATTER CYCLE		Applying a definition
		ECOSYSTEM		
		PRODUCERS		
		CONSUMERS		Recognizing component parts
		DECOMPOSERS		
	005	PRODUCERS	Green Plants	Recognizing an example, Recognizing Non-example, Applying a definition
	006	MATTER CYCLE		Recognizing a definition
		ECOSYSTEM		
		ORGANISM		
		PRODUCER		
		NUTRIENT		
	007	DECOMPOSER		Applying a definition.
		ORGANIC MOLECULE		Recognizing incorrect term usage
	008	ENERGY FLOW		Applying a definition.
		ECOSYSTEM		Recognizing interrelationships
		BIOSPHERE		Recognizing incorrect usage of examples or terms
		PRODUCERS		
		DECOMPOSERS		
		CONSUMERS		
	009	INORGANIC MATTER		Applying a definition
		ORGANIC MATTER		
		PRODUCER		Recognizing correct/incorrect term usage
		ORGANISM		

TABLE 3 .8 (Continued)

Quiz	Quiz Item	Concepts	Examples	Comments
1	018	NUTRIENT ORGANIC MOLECULE		Applying a definition

Quiz	Item	Concepts	Examples	Comments
1	018	NUTRIENT ORGANIC MOLECULE PRODUCER ORGANISM		Applying a definition Recognizing correct/incorrect term usage
	019	METABOLISM		Applying a definition or recognizing an example (Recall)
	021	ORGANISMS		Recognizing a definition (Recall)
2	001	ORGANIC MOLECULE INORGANIC MOLECULE	Compound Protein Carbohydrates Fat, Sugar, Water	Applying a definition (Recall)
	002	ORGANIC MOLECULE	CO_2, $KMnO_4$ NH_4, H_2O $C_6H_{12}O_6$	Applying a definition
	004	ORGANIC MOLECULE INORGANIC MATTER	Glycogen Sucrose, Starch, Amino Acids, Cellulose	Recall and Applying definitions
	005	ORGANIC MOLECULES	Protein Carbon, Hydrogen Oxygen Sulfur Phosphor- our, Nitrogen Sodium, Potassium Iron	Recall and applying a definition
	006	ENERGY FLOW ENERGY STORAGE	Chemical Energy of Glucose	Recall of a definition

TABLE 3.8 (Continued)

Quiz

Quiz	Item	Concepts	Examples	Comments
3	001	ENERGY FLOW ENERGY STORAGE ORGANIC MOLECULE	Solar Energy CO_2 H_2O ADP Plants	Recall of a relationship Applying a definition
	002	ENERGY FLOW		Recall, Application of a definition. Recall of a series of relations
	005	MATTER CYCLE	Algae Chlorophyll Carbohydrates CO_2, O_2	Recall a definition. Recall of a relation. Recall of an example
	007	MATTER CYCLE	Hydrogen Carbohydrates Photosynthesis	Recall of an example. Recall of correct and incorrect definitions
	008	PHOTOSYNTHESIS	CO_2 Starch, Light	Recall of an example (experiment) Applying a definition or principle
	019	PHYSICAL Environment	Fog, Wind, Sunshine Plant	Recalling an example
	027	HABITAT	Specific Organism Marine Terrestrial Freshwater Litter	Recalling an example Applying an example.
4	001	CONSUMER	Saprophytism Student-meat Tick-dog Fish-fish Mold-fish(dead) Human-tapeworm	Recall, Applying a definition Recognizing an example
	002	CONSUMER PRODUCER MATTER CYCLE ENERGY FLOW	Plants Carbohydrates Amino Acids Fatty Acids Vitamins	Recall of definitions Application of definition or principles

TABLE 3.8 (Continued)

Quiz	Quiz Item	Concepts	Examples	Comments

Quiz	Quiz Item	Concepts	Examples	Comments
7	024	PRODUCERS FOOD WEB	Green Algae Pond	Applying a definition, Recalling an example
	025	PHYSICAL ENVIRONMENT	Fern, Moss Tree, Pinetree	Recalling an example Applying a definition
	027	LIFE CYCLE	Moss Plant	Recalling a definition
9	002	BEHAVIOR- TERRITORIALITY	Male Stickleback	Recalling a definition
	008	PHOTOSYNTHESIS	CO_2	Recalling a definition
	009	ORGANIC MOLECULE	Nitrogen Protein	Recalling and applying a definition
	010	MATTER CYCLE ENERGY FLOW PHOTOSYNTHESIS PHYSICAL ENVIRONMENT BIOTIC ENVIRONMENT		Recognizing a correct definition Recognizing an incorrect definition Recalling an example Applying a definition
	012	SUCCESSION	Eutrophication	Recalling a definition
	013	SUCCESSION	Lake	Recalling and applying a definition
	014	FOOD WEB		Recalling and applying a definition
	015	FOOD WEB		Recalling and applying a definition
	016	FOOD WEB		Recognizing an incorrect definition or example
	017	FOOD WEB PREDATION	Racoon and Toad	Recognizing a relationship Applying a definition
	019	ENERGY FLOW EFFICIENCY FOOD WEB		Applying a definition
	020	SUCCESSION BIOME	Temperate deciduous forest	Recognizing, recalling a definition
	021	SUCCESSION BIOME	1000 ft. Michigan elevation	Recalling an example Applying a definition
	022	NICHE	Grasshopper Herbivore	Recalling an example, Applying a definition Recognizing incorrect examples

TABLE 3.8 (Continued)

Quiz	Quiz Item	Concepts	Examples	Comments
		SUCCESSION		Applying a definition

Quiz	Quiz Item	Concepts	Examples	Comments
9	023	SUCCESSION COMMUNITY		Applying a definition
	024	FOOD WEB POPULATION	Plants and Animals Chart	Interpreting a chart, Defining relationships, Applying a definition
	025	FOOD WEB	Plants and Animals Chart	Interpreting a chart, Defining relationships, Applying a definition
	028	CONSUMERS DISPERSAL	Watermelon Seeds	Recalling an example, Applying a definition
10	001	DENSITY, TERRITORY POPULATION		Applying a definition
	002	POPULATION BIRTH RATE	Humans	Recalling an example.
	004	POPULATION AGE DISTRIBUTION	Pyramid Shape	Recalling an example, Applying a definition
	005	CARRYING CAPACITY		Applying a definition, Interpreting a graph, Recognizing an incorrect example.
	006	POPULATION GROWTH/STABILITY		Interpreting a graph, Applying a definition, Recognizing an incorrect example
	007	POPULATION GROWTH/STABILITY	Human growth curve	Interpreting a graph, Applying a definition, Recognizing an incorrect example
	009	CARRYING CAPACITY		Interpreting a graph, Applying a definition Recognizing a correct/incorrect example
	010	POPULATION GROWTH/STABILITY		Interpreting a graph, Applying a definition Recognizing a correct/incorrect example
	011	DENSITY DEPENDENT FACTORS	Predation Competition Behavior Parasitism, Fire	Recognizing examples and non-examples Applying a definition
	012	BEHAVIOR-TERRITORIALITY POPULATION	Density dependent factors, Predation, Magnification, Carnivores, Crowded conditions	Recognizing examples and non-examples

TABLE 3.8 (Continued)

Quiz		Comments

Quiz	Item	Concepts	Examples	Comments
4	027	PHYSICAL ENVIRONMENT	Temperature Alligators... Sharks... Snakes... Sea Urchins... Hawks...	Recall of definitions.
5	001	EFFICIENCY		Recognizing an example. Recalling a definition
	002	ORGANIC MOLECULE ENERGY FLOW RESPIRATION	Mitochondrion	Recalling a definition
	004	ORGANIC MOLECULE INORGANIC MATTER INSPIRATION	Oxygen Hydrogen H_2O	Recalling a definition Relation
	005	ENERGY STORAGE EFFICIENCY	Aerobic Respiration Amoeba	Recalling and applying definitions
	010	INORGANIC MATTER PHOTOSYNTHESIS RESPIRATION	Glucose O_2, H_2O CO_2	Recalling and applying definitions
	012	ENERGY STORAGE	Glucose CO_2, H_2O	Recalling and applying a definition
6	026	ORGANISM, MUTUALISM		Recognizing a definition
	029	PRODUCERS	Autotrophic Monera Glue-green Algae	Recognizing an example
	030	DECOMPOSERS		Recalling a definition

TABLE 3.8 (Continued)

Quiz	Quiz Item	Concepts	Examples	Comments
10	013	FOOD WEB POPULATION INTERACTIONS	Virus-lynx-Snowshoe hare-Grass	Applying a definition
	014	BEHAVIOR-TERRITORIALITY POPULATION DENSITY POPULATION GROWTH/STABILITY	Starvation Pollution Metabolicrate increase Lack of predators Behavior changes	Recalling a definition, Applying a definition, Recalling an example
	015	POPULATION GROWTH/STABILITY	Human	Recalling an example
	016	POPULATION GROWTH/STABILITY	Human	Recalling an example
	018	DEATH RATE POPULATION GROWTH/STABILITY	Human	Recalling an example Applying a definition
	020	ECOSYSTEM FOOD WEB	Algae minnows Fish man Pesticide	Applying a definition, Recalling an example
	021	ECOSYSTEM MAGNIFICATION	Fat soluble Pesticides	Recalling an example
	023	ENERGY FLOW	Fusion, fission oil, natural gas, falling water, solar energy	Recalling an example

TABLE 3.8 (Continued)

Final Exam	Item	Concepts	Examples	Comments
	002	ORGANIC MOLECULE	Protein	

Exam	Item	Concepts	Examples	Comments
	002	ORGANIC MOLECULE	Protein Carbohydrates Fat, Sugar Water	Recalling an example.
	004	ENERGY STORAGE ORGANIC MOLECULE	ADP, Bonds Carbon atoms, Hydrogenations	Recalling an example, Recalling a definition
	009	SUCCESSION PHYSICAL ENVIRONMENT	Climax stage	Recalling a definition
	011	POPULATION, DENSITY POPULATION GROWTH/STABILITY DENSITY DEPENDENT FACTORS		Recalling a definition, Applying a definition. Recognizing incorrect examples.
	012	POPULATION POPULATION INTERACTIONS FOOD WEB CARRYING CAPACITY		Interpreting a graph, Applying a definition Recognizing incorrect interpretations
	015	ENERGY FLOW FOOD WEB		Recalling a definition, Recognizing an example/non-example
	018	ENERGY STORAGE ORGANIC MOLECULE	Glucose → $CO_2 + H_2O$	Recalling a definition
	023	ENERGY FLOW FOOD WEB		Applying a definition
	024	ENERGY FLOW FOOD WEB EFFICIENCY		Recalling an example, Applying a definition
	025	SUCCESSION FOOD WEB		Recalling and applying definitions

TABLE 3.8 (Continued)

Exam	Item	Concepts	Examples	Comments
	028	BIRTH RATE DEATH RATE POPULATION GROWTH/STABILITY EQUILIBRIUM		Interpreting a graph, Applying definitions
	033	ORGANIC MOLECULES ENERGY STORAGE RESPIRATION		Applying a definition
	036	BIOME, SUCCESSION	Climax plants and Animals	Recalling a definition
	037	POPULATION GROWTH/STABILITY CARRYING CAPACITY	Human	Recalling a definition, Recognizing an example
	043	RESPIRATION	Green Plants	Recalling a definition, Applying a definition
	044	SUCCESSION	Eutrophic lake	Recalling a definition
	045	PHYSICAL ENVIRONMENT		Applying a definition, Recalling an example
	046	POPULATION GROWTH/STABILITY	Human	Interpreting a graph, Recognizing a correct/ incorrect example
	048	MUTUALISM	Termites	Recalling a definition, Applying a definition, Recognizing an example
	049	PHOTOSYNTHESIS		Recalling a definition, Recalling an example, Interpreting an experiment
	052	DECOMPOSER MATTER CYCLE INORGANIC MATTER	Bacteria and Nitrogen	Recalling a definition
	057	POPULATION GROWTH/STABILITY CARRYING CAPACITY		Interpreting a graph Applying a definition
	058	POPULATION GROWTH/STABILITY CARRYING CAPACITY		Interpreting a graph Applying a definition, Recognizing non-examples

a student might recall that responses 1 through 4 are examples of density dependent factors, or the student might apply the definition

Density dependent factors effecting populations include all the following except

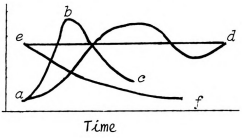
1. *predation.*
2. *competition.*
3. *behavior.*
4. *parasitism.*
5. *fire.*

of density dependent factors against the definitions of items 1 through 5 and find that the 5th response's definition is not in agreement with that required by the question. Either method would result in the correct choice of response 5.

In another instance a series of operations might be required to answer a question correctly. For the following item (item 9, Quiz 10), the student was first required to interpret the graph presented, apply

Which of the lines below best illustrates carrying capacity?

1. *ab*
2. *bc*
3. *ad*
4. *ed*
5. *ef*



the definition of carrying capacity, and then recognize the incorrect examples. Response "ab" represents (exponential) population growth, "bc" rapid population collapse, "ef" slow population decline, "ad" population equilibrium about "ed", the carrying capacity of the population's environment. Thus, 1, 2, 3, and 5 are incorrect responses, and 4 is correct.

Table 3.9 presents a summary of the test item concept coverage.

TABLE 3 .9

TEST ITEM COVERAGE OF ECOSYSTEM CONCEPTS

Fall Term 1977

Concept Number	Concept	Test Items: Pretest	One	Two	Three	Four	Five	Six	Seven	Nine	Ten	Final
1	Organism		1,6,9 21					26				
2	Ecosystem	18,28	1,4,6, 8								20,21	
3	Matter Cycle	23	3,4,6		5,7	2				10	52	
4	Producer	5,23	4,5,6, 8,9			2		29	24			
5	Consumer		4,8			1,2				28		
6	Decomposer	23	4,7,8					30			52	
7	Carnivore		4									
8	Organic Molecule	3	3,7,9 18	1,2, 4,5	1		2,4			9		2,4,18 33
9	Energy Flow	19,20 25,30	8	6	1,2	2	2			10,19	23	15,23, 24
10	Inorganic Matter		9	1,4,5			4,10					52
11	Nutrient		6,18									
12	Metabolism		18,19									
14	Energy Storage	3		6	1		5,12					4,18, 33
15	Photosynthesis				8		10			8,10		49
16	Physical Environment	7,27			19	27			25	10		9,45
18	Habitat				27							
19	Efficiency	20,30					1,5			19		24
20	Respiration	32					2,4,10					33,43
22	Mutualism							26				48
23	Food Web	5,9,17 19,20, 21,25, 30							24	14,15, 16,17 19,24, 25	13,20	12,15, 23,24, 25

TABLE 3.9 (Continued)

Concept Number	Concept	Test Items: Pretest	One	Two	Three	Four	Five	Six	Seven	Nine	Ten	Final
31	Life Cycle								27			

25	Behavior Territoriality		2	12,14	
26	Biotic Environment		10		
27	Succession	7,15, 24	12,13, 20,21 23		9,25, 36,44
28	Predation	26	17		
29	Biome	15	20,21		36
30	Niche	22,29	22		
31	Community		23	19	
32	Population	4,16, 17,20	24	1,2,4, 12,14, 19	11,12
33	Dispersal		28		
34	Density	16		1,14	11
35	Territory			1	
36	Birth Rate			2	28
37	Death Rate			18	28
38	Age Distri-bution			4	
39	Carrying Capacity	17		5,9, 19	12,37, 57,58
40	Population Growth/ Stability			6,7,10 14,15, 16,18	11,28, 37,46, 57,58
41	Density Dep. Factors	16		11	11
42	Population Interactions	17		13	12
43	Equilibrium			19	28
44	Magnification			21	

n of the concepts tested for in the course has been assigned a
ber and is listed in the left hand column of this table. Each
cept is then cross referenced with the relevant test items. This
rix of concepts versus test items serves as a basis for the con-
t mastery or performance indices discussed in the next several
pters. Not all of the ecosystem concepts presented in the course
e covered in the weekly tests, thus any assessment on the degree
mastery or understanding of the total Ecosystem concept is based
nly a subset of the subsumed concepts.

Course Concepts Summary

The Ecosystem concepts treated in the course have been presented
Tables 3.2 through 3.9. Table 3.10 summarizes the concept coverage
ughout the various instructional sessions of the course. Of this
l set of concepts, student mastery or learning indices could only
eveloped for those concepts that were included in the questions
he weekly quizzes and the final exam. Although students must have
ly mastered other concepts, no evidence was collected to measure
extent of that learning. Thus, for the purposes of this study the
ent's mastery or performance on those quiz items testing Ecosystem
epts provides the only measure of the students' understanding of
total Ecosystem concept.

These measured concepts were arranged in a matrix format follow-
the convention developed in section 2.2;

$$C = |C_1\ C_2\ C_3 \ldots\ldots C_{44}|^{-1}$$

e each element, C_i, is defined in Table 3.11. C contains the

TABLE 3.10

ECOSYSTEM CONCEPT COVERAGE SUMMARY

Concept	Week	Lecture										SAS										Tape Lab										Textbook										Practice Quiz									
		1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
Ecosystem		X	X	X					X	X			X							X				X					X								X												X	
Population		X									X																		X	X		X						X		X										X
Community		X																											X									X												
Specie		X																	X									X		X						X											X		
Area		X								X																																								
Organism		X								X		X	X	X	X	X				X		X	X	X	X				X		X					X	X		X		X							X
Biosphere		X																					X													X												
Producers		X	X	X	X	X			X	X		X	X			X	X	X	X	X		X	X			X	X	X	X	X		X	X	X	X	X	X	X		X		X	X	X	X	X	X	X	X
Consumers		X	X	X	X	X			X	X		X	X		X			X	X	X		X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X		X		X	X	X	X	X	X	X	X
Decomposers		X	X	X	X				X	X			X				X			X							X		X	X		X	X						X			X				X		X	X
Environment		X																																															
Energy Source		X	X	X		X				X	X																	X						X	X		X	X											X
Flow of Energy		X	X	X	X	X	X			X			X	X									X							X							X		X								X		
Organic Molecule		X	X	X	X					X				X				X			X		X	X			X							X		X	X	X	X	X							X		
Inorganic Molecule		X	X	X	X	X				X				X				X					X	X			X							X	X	X		X	X	X	X	X					X		
Matter		X																																														
Matter Cycle		X	X	X						X			X										X			X				X	X				X												X		
Energy		X	X	X	X	X				X	X			X				X					X							X				X	X	X		X	X						X	X			
Physical Environment			X				X		X					X				X	X	X	X	X		X	X	X	X	X			X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X
Chemical Bonds			X																																														
Photosynthesis			X	X						X				X										X						X	X											X	X	X	X			
Respiration			X			X						X				X	X								X	X	X						X										X	X	X			X	
Efficiency			X			X				X														X												X								X				
Equilibrium			X										X																																				
Energy Conversion			X	X																																													
Energy Storage			X	X																					X								X	X									X	X				
Temperature			X	X																																													
Energy Type			X																																														
Food Chain				X																										X								X										X
Matter Recombination				X																																													
Homeostasis					X			X				X												X		X																							
Reproduction						X	X					X		X		X	X	X			X			X		X	X		X			X			X	X		X		X	X			X	X		X		
Metabolism						X						X												X		X									X	X									X	X			
Parasitism						X				X																			X		X																X		
Feedback							X																																										
Stimulus									X																																								
Response									X																																								

TABLE 3.10 (Continued)

Concept Behavior	Lecture Week 1 2 3 4 5 6 7 8 9 10	SAS 1 2 3 4 5 6 7 8 9 10	Tape Lab 1 2 3 4 5 6 7 8 9 10	Textbook 1 2 3 4 5 6 7 8 9 10	Practice Quiz 1 2 3 4 5 6 7 8 9 10
Territory	X	X X	X X	X X X	X X X
Aggression	X			X	
Submission	X				
Dominance	X				
Food Web	X				
Symbiosis	X		X X	X X X	X
Succession	X				X
Adaptation	X	X	X	X	
Life Cycle	X				X
Mutation	X		X X X	X X	
Stratification		X			
Biotic Factors		X			
Growth		X X			X
Habitat	X	X	X X X		
Parasite			X X	X	X
Holotroph			X		X
Saprophyte			X		
Biomass			X		X
Mutualism			X	X X	X
Competition			X	X	X X
Commensalism			X	X	X
Predation			X	X	X
Saprophyte			X		
Biome			X	X	X
Evolution			X X	X X X	X
Trophic Level			X	X	X
Climax			X	X	X
Biotic Potential			X	X	X
Environmental Resistance			X	X	X
Carrying Capacity					
Biomagnification			X		X
Density	X		X X	X X	X
Density Dep./Indep. Factors			X	X	X
Natural Selection				X	
Birth/Death Rate	X			X X	X

TABLE 3.10 (Continued)

Concept	Lecture										SAS										Tape Lab										Textbook										Practice Quiz									
Week	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
Nutrient																															X											X									
Autotroph																															X																X			
Heterotroph																															X																X			
Symbiosis																																		X															X	
Diversity																																					X												X	
Eutrophication																																					X												X	
Niche																																						X											X	
Competitive Exclusion Principle																																						X												
Age Distribution																																																	X	
Immigration																																																	X	
Natality																																																		X	

TABLE 3.11

ECOSYSTEM CONTENT MATRIX C

Matrix ement	Concept	C Matrix Element	Concept
	Organism	C_{31}	Community
	Ecosystem	C_{32}	Population
	Matter Cycle	C_{33}	Dispersal
	Producer	C_{34}	Density
	Consumer	C_{35}	Territory
	Decomposer	C_{36}	Birth Rate
	Not Defined	C_{37}	Death Rate
	Organic Molecule	C_{38}	Age Distribution
	Energy Flow	C_{39}	Carrying Capacity
)	Inorganic Matter	C_{40}	Population Growth/Stability
	Nutrient	C_{41}	Density Dependent Factor
	Metabolism	C_{42}	Population Interactions
	Not Defined	C_{43}	Equilibrium
	Energy Storage	C_{44}	Magnification
	Photosynthesis		
	Physical Environment		
	Not Defined		
	Habitat		
	Efficiency		
	Respiration		
	Not Defined		
	Mutualism		
	Food Web		
	Life Cycle		
	Behavior/Territoriality		
	Biotic Environment		
	Succession		
	Predation		
	Biome		
	Niche		

conten

for, a

Matrix

outcom

ent which was both taught in the course and effectively tested
and will be referred to as the Content Matrix. The Content
ix will serve as a central basis for the discussion of the
ome components of the course model.

4.0

info

info

infc

deve

one

ins

des

beg

hap

and

Thu

bac

tic

ta

in

4.

ea

T

CHAPTER 4

THE MODEL

Student Information

In order to efficiently gather, compile, organize, and analyze ormation on students in BS 202 the general method of variable or ormation classification suggested by Tamir (1976) was used. This ormation scheme is discussed in section 2.2, the theoretical model elopment. Relevant information on students was classified into of three categories: antecedents or background, transactions or tructional outcomes or performance. This corresponds to the data cribing the individual student upon entering the course at the inning of the term (antecedents), what the student does and what pens to him or her during the course of instruction (transactions), the effects of that instruction upon the student (outcomes). , each student after completing BS 202 is described by a set of ground data, the B matrix, a set of data describing the instruc-, the I matrix, and a set of data describing the knowledge ob-ed during the instruction, the K matrix. The variables describ-each set of data are referred to as the students' state variables.

Background Data

For the purposes of this study all antecedent information on student was assigned to a Background Matrix, B, where:

$$B = \left|B_1, B_2, B_3 \ldots\ldots B_{236}\right|^{-1},$$

236 background variables are listed and defined in Table 4.1.

The in

standa

variab

4.2 I

P

Each s

sessi

expec

lab 1

the s

and s

Sessi

tape

expos

metho

were

Matr

Stat

tor

and

How

instruments used to collect this information and the means, ndard deviations and other statistical information for these iables are given in Appendix B.

Instructional Data (Transactions)

Biological Science 202 has a fairly rigid instructional routine. ı student must attend one lecture session and two small assembly sions each week for approximately ten weeks. Each student is also cted to spend some additional hours in the individual instructional listening and working with 17 prerecorded lessons. In addition to structured class time, the student also spends some time reading studying.

Attendance data was recorded for each lecture and Small Assembly ion. Time spent in the instructional lab was also recorded by number for each student to give an indication of the individual's sure to taped instruction. Data on the number of hours spent and od used for reading and studying the textbook and practice quizzes also solicited on each student's weekly exam.

This attendance and study data were assigned to the Instructional ix I ;

$$I = \left| I_1, I_2, I_3, \ldots\ldots I_{108} \right|^{-1}$$

The 108 instructional variables are listed and defined in Table 4.2. stical information for these variables is given in Appendix C. Random student discussions or tutoring sessions with the instruc- re difficult to accommodate within the framework of this model, uch data was not to be entered into I for reasons of economy. er, each instructor was encouraged to keep a log of such interactions,

TABLE 4.1

B Background Variables

Element		Variable Acronyn	Variable Definition
B_1	=	CLASS	MSU Class Level
B_2	=	TCRE	Total College Credits Earned
B_3	=	TRCR	Credits Transferred to MSU
B_4	=	CRCAR	MSU Credits Carried Previous to Term of Study
B_5	=	CRERN	MSU Credits Earned Previous to Term of Study
B_6	=	MSUPTS	MSU Points Earned - Sum over all courses of credit x grade
B_7	=	BL20	MSU Points Below a 2.00 GPA
B_8	=	GPA	MSU Grade Point Average
B_9	=	RPTS	MSU Points Earned in courses repeated
B_{10}	=	CRNC	MSU credits earned in credit-no credit courses
B_{11}	=	PRE001	Pretest Item 1, Correct Response = 1, Incorrect = 0
B_{12}	=	PRE002	Pretest Item 2, Correct Response = 1, Incorrect = 0
B_{13}	=	PRE003	Pretest Item 3, Correct Response = 1, Incorrect = 0
B_{14}	=	PRE004	Pretest Item 4, Correct Response = 1, Incorrect = 0
B_{15}	=	PRE005	Pretest Item 5, Correct Response = 1, Incorrect = 0
B_{16}	=	PRE006	Pretest Item 6, Correct Response = 1, Incorrect = 0
B_{17}	=	PRE007	Pretest Item 7, Correct Response = 1, Incorrect = 0
B_{18}	=	PRE008	Pretest Item 8, Correct Response = 1, Incorrect = 0
B_{19}	=	PRE009	Pretest Item 9, Correct Response = 1, Incorrect = 0

TABLE 4.1 CONTINUED

Matrix B Element	Variable Acronyn	Variable Definition
$B_{20} =$	PRE010	Pretest Item 10, Correct Response = 1, Incorrect = 0

B_{20}	=	PRE010	Pretest Item 10, Correct Response = 1, Incorrect = 0
B_{21}	=	PRE011	Pretest Item 11, Correct Response = 1, Incorrect = 0
B_{22}	=	PRE012	Pretest Item 12, Correct Response = 1, Incorrect = 0
B_{23}	=	PRE013	Pretest Item 13, Correct Response = 1, Incorrect = 0
B_{24}	=	PRE014	Pretest Item 14, Correct Response = 1, Incorrect = 0
B_{25}	=	PRE015	Pretest Item 15, Correct Response = 1, Incorrect = 0
B_{26}	=	PRE016	Pretest Item 16, Correct Response = 1, Incorrect = 0
B_{27}	=	PRE017	Pretest Item 17, Correct Response = 1, Incorrect = 0
B_{28}	=	PRE018	Pretest Item 18, Correct Response = 1, Incorrect = 0
B_{29}	=	PRE019	Pretest Item 19, Correct Response = 1, Incorrect = 0
B_{30}	=	PRE020	Pretest Item 20, Correct Response = 1, Incorrect = 0
B_{31}	=	PRE021	Pretest Item 21, Correct Response = 1, Incorrect = 0
B_{32}	=	PRE022	Pretest Item 22, Correct Response = 1, Incorrect = 0
B_{33}	=	PRE023	Pretest Item 23, Correct Response = 1, Incorrect = 0
B_{34}	=	PRE024	Pretest Item 24, Correct Response = 1, Incorrect = 0
B_{35}	=	PRE025	Pretest Item 25, Correct Response = 1, Incorrect = 0
B_{36}	=	PRE026	Pretest Item 26, Correct Response = 1, Incorrect = 0
B_{37}	=	PRE027	Pretest Item 27, Correct Response = 1, Incorrect = 0
B_{38}	=	PRE028	Pretest Item 28, Correct Response = 1, Incorrect = 0
B_{39}	=	PRE029	Pretest Item 29, Correct Response = 1, Incorrect = 0
B_{40}	=	PRE030	Pretest Item 30, Correct Response = 1, Incorrect = 0
B_{41}	=	PRE031	Pretest Item 31, Correct Response = 1, Incorrect = 0

TABLE 4.1 CONTINUED

Matrix B Element	Variable Acronyn	Variable Definition

B_{42} =	PRE032	Pretest Item 32, Correct Response 1, Incorrect = 0
B_{43} =	PRE033	Pretest Item 33, Correct Response 1, Incorrect = 0
B_{44} =	PRE034	Pretest Item 34, Correct Response 1, Incorrect = 0
B_{45} =	PRETOT	Total Score on the Pretest
B_{46} =	PRF001	Pretest Factor Score 1, Composed of Pretest Items 21,23,24,26,31,33,34
B_{47} =	PRF002	Pretest Factor Score 2, Composed of Pretest Items 1,2,3,5,17,18,30
B_{48} =	PRF003	Pretest Factor Score 3, Composed of Pretest Items 1,3,5,7,14,21,32
B_{49} =	PRF004	Pretest Factor Score 4, Composed of Pretest Items 1,7,9,12,21,24,26,27, 30,33
B_{50} =	PRF005	Pretest Factor Score 5, Composed of Pretest Items 2,19,20,21,24,30,32
B_{51} =	PRF006	Pretest Factor Score 6, Composed of Pretest Items 3,17,18,24,26,31,34
B_{52} =	PRF007	Pretest Factor Score 7, Composed of Pretest Items 3,5,12,23,24,26,29, 30,34
B_{53} =	PRF008	Pretest Factor Score 8, Composed of Pretest Items 4,5,6,8,11,16,18,21,22 23,24,30
B_{54} =	PRF009	Pretest Factor Score 9, Composed of Pretest Items 2,12,17,26,27,31,34
B_{55} =	PRF010	Pretest Factor Score 10, Composed of Pretest Items 6,8,17,19,21,26,27
B_{56} =	PRF011	Pretest Factor Score 11, Composed of Pretest Items 2,3,6,14,18,21,27,28,33
B_{57} =	PRF012	Pretest Factor Score 12, Composed of Pretest Items 2,9,15,17,18,23,24
B_{58} =	PRF013	Pretest Factor Score 13, Composed of Pretest Items 2,5,6,10,14,22,25
B_{59} =	PRF014	Pretest Factor Score 14, Composed of Pretest Items 12,18,21,22,25,29,31

TABLE 4.1 CONTINUED

Matrix B Element	Variable Acronyn	Variable Definition

B_{60}	=	PRF015	Pretest Factor Score 15, Composed of Pretest Items 5,6,7,10,11,17,18,23 24,25,30,31,32
B_{61}	=	AFF001	Affective Questionnaire Item 1
B_{62}	=	AFF002	Affective Questionnaire Item 2
B_{63}	=	AFF003	Affective Questionnaire Item 3
B_{64}	=	AFF004	Affective Questionnaire Item 4
B_{65}	=	AFF005	Affective Questionnaire Item 5
B_{66}	=	AFF006	Affective Questionnaire Item 6
B_{67}	=	AFF007	Affective Questionnaire Item 7
B_{68}	=	AFF008	Affective Questionnaire Item 8
B_{69}	=	AFF009	Affective Questionnaire Item 9
B_{70}	=	AFF010	Affective Questionnaire Item 10
B_{71}	=	AFF011	Affective Questionnaire Item 11
B_{72}	=	AFF012	Affective Questionnaire Item 12
B_{73}	=	AFF013	Affective Questionnaire Item 13
B_{74}	=	AFF014	Affective Questionnaire Item 14
B_{75}	=	AFF015	Affective Questionnaire Item 15
B_{76}	=	AFF016	Affective Questionnaire Item 16
B_{77}	=	AFF017	Affective Questionnaire Item 17
B_{78}	=	AFF018	Affective Questionnaire Item 18
B_{79}	=	AFF019	Affective Questionnaire Item 19
B_{80}	=	AFF020	Affective Questionnaire Item 20

TABLE 4.1 CONTINUED

Matrix B	Variable Acronym	Variable Definition

B_{81} =	AFF021	Affective Questionnaire Item 21
B_{82} =	AFF022	Affective Questionnaire Item 22
B_{83} =	AFF023	Affective Questionnaire Item 23
B_{84} =	AFF024	Affective Questionnaire Item 24
B_{85} =	AFF025	Affective Questionnaire Item 25
B_{86} =	AFF026	Affective Questionnaire Item 26
B_{87} =	AFF027	Affective Questionnaire Item 27
B_{88} =	AFF028	Affective Questionnaire Item 28
B_{89} =	AFF029	Affective Questionnaire Item 29
B_{90} =	AFF030	Affective Questionnaire Item 30
B_{91} =	AFF031	Affective Questionnaire Item 31
B_{92} =	AFF032	Affective Questionnaire Item 32
B_{93} =	AFF033	Affective Questionnaire Item 33
B_{94} =	AFF034	Affective Questionnaire Item 34
B_{95} =	AFF035	Affective Questionnaire Item 35
B_{96} =	AFF036	Affective Questionnaire Item 36
B_{97} =	AFF037	Affective Questionnaire Item 37
B_{98} =	AFF038	Affective Questionnaire Item 38
B_{99} =	AFF039	Affective Questionnaire Item 39
B_{100}=	AFF040	Affective Questionnaire Item 40
B_{101}=	AFF041	Affective Questionnaire Item 41

TABLE 4.1 CONTINUED

Matrix B Element	Variable Acronym	Variable Definition

B_{102}=	AFF042	Affective Questionnaire Item 42
B_{103}=	AFF043	Affective Questionnaire Item 43
B_{104}=	AFF044	Affective Questionnaire Item 44
B_{105}=	AFF045	Affective Questionnaire Item 45
B_{106}=	AFF046	Affective Questionnaire Item 46
B_{107}=	AFF047	Affective Questionnaire Item 47
B_{108}=	AFF048	Affective Questionnaire Item 48
B_{109}=	AFR001	Affective Factor Score 1, Composed of AFF Ques. Items 2,3,5,6,7,25,30, 32,33,41
B_{110}=	AFR002	Affective Factor Score 2, Composed of AFF Ques. Items 10,20,22,25,31,33 36,42,45,46
B_{111}=	AFR003	Affective Factor Score 3, Composed of AFF Ques. Items 2,4,9,16,18,25,32,33 41,43,44
B_{112}=	AFR004	Affective Factor Score 4, Composed of AFF Ques. Items 1,4,9,25,28,34,37,39 40,42
B_{113}=	AFR005	Affective Factor Score 5, Composed of AFF Ques. Items 1,5,10,13,14,34,37,44 48
B_{114}=	AFR006	Affective Factor Score 6, Composed of AFF Ques. Items 2,7,9,24,33,34,36,39, 40,43
B_{115}=	AFR007	Affective Factor Score 7, Composed of AFF Ques. Items 2,3,8,16,20,23,25,28 29.33.34.37,45,46
B_{116}=	AFR008	Affective Factor Score 8, Composed of AFF Ques. Items 2,3,10,14,22,23,24,25, 28,31,33,35,37,40,42 44,46

TABLE 4.1 CONTINUED

Matrix B Element	Variable Acronym	Variable Definition

B_{136}=	BKG017	Background Questionnaire Item 17
B_{137}=	BKG018	Background Questionnaire Item 18
B_{138}=	BKG019	Background Questionnaire Item 19
B_{139}=	BKG020	Background Questionnaire Item 20
B_{140}=	BKG021	Background Questionnaire Item 21
B_{141}=	BKG022	Background Questionnaire Item 22
B_{142}=	BKG023	Background Questionnaire Item 23
B_{143}=	BKG024	Background Questionnaire Item 24
B_{144}=	BKG025	Background Questionnaire Item 25
B_{145}=	BKG026	Background Questionnaire Item 26
B_{146}=	BKG027	Background Questionnaire Item 27
B_{147}=	BKG028	Background Questionnaire Item 28
B_{148}=	BKG029	Background Questionnaire Item 29
B_{149}=	BKG030	Background Questionnaire Item 30
B_{150}=	BKG031	Background Questionnaire Item 31
B_{151}=	BKG032	Background Questionnaire Item 32
B_{152}=	BKG033	Background Questionnaire Item 33
B_{153}=	BKG034	Background Questionnaire Item 34
B_{154}=	BKG035	Background Questionnaire Item 35
B_{155}=	BKG036	Background Questionnaire Item 36
B_{156}=	BKG037	Background Questionnaire Item 37

TABLE 4.1 CONTINUED

Matrix B Element	Variable Acronym	Variable Definition

B_{117}=	AFR009	Affective Factor Score 9, Composed of AFF Ques. Items 3,5,22,23,25,40,41,42, 45,46
B_{118}=	AFR010	Affective Factor Score 10, Composed of AFF Ques. Items 3,8,15,16,17,18,19 23,25,33,34,46
B_{119}=	AFR011	Affective Factor Score 11, Composed of AFF Ques. Items 2,5,12,14,19,33,38 40,42,46
B_{120}=	BKG001	Background Questionnaire Item 1
B_{121}=	BKG002	Background Questionnaire Item 2
B_{122}=	BKG003	Background Questionnaire Item 3
B_{123}=	BKG004	Background Questionnaire Item 4
B_{124}=	BKG005	Background Questionnaire Item 5
B_{125}=	BKG006	Background Questionnaire Item 6
B_{126}=	BKG007	Background Questionnaire Item 7
B_{127}=	BKG008	Background Questionnaire Item 8
B_{128}=	BKG009	Background Questionnaire Item 9
B_{129}=	BKG010	Background Questionnaire Item 10
B_{130}=	BKG011	Background Questionnaire Item 11
B_{131}=	BKG012	Background Questionnaire Item 12
B_{132}=	BKG013	Background Questionnaire Item 13
B_{133}=	BKG014	Background Questionnaire Item 14
B_{134}=	BKG015	Background Questionnaire Item 15
B_{135}=	BKG016	Background Questionnaire Item 16

TABLE 4.1 CONTINUED

Matrix B Element	Variable Acronyn	Variable Definition

B_{157}=	BKG038	Background Questionnaire Item 38
B_{158}=	BKG039	Background Questionnaire Item 39
B_{159}=	BKG040	Background Questionnaire Item 40
B_{160}=	BKG041	Background Questionnaire Item 41
B_{161}=	BKG042	Background Questionnaire Item 42
B_{162}=	BKG043	Background Questionnaire Item 43
B_{163}=	BKG044	Background Questionnaire Item 44
B_{164}=	BKG045	Background Questionnaire Item 45
B_{165}=	BKG046	Background Questionnaire Item 46
B_{166}=	BKG047	Background Questionnaire Item 47
B_{167}=	BKG048	Background Questionnaire Item 48
B_{168}=	BKG049	Background Questionnaire Item 49
B_{169}=	BKG050	Background Questionnaire Item 50
B_{170}=	BKG051	Background Questionnaire Item 51
B_{171}=	BKG052	Background Questionnaire Item 52
B_{172}=	BKG053	Background Questionnaire Item 53
B_{173}=	BKG054	Background Questionnaire Item 54
B_{174}=	BKG055	Background Questionnaire Item 55
B_{175}=	BKG056	Background Questionnaire Item 56
B_{176}=	BKG057	Background Questionnaire Item 57
B_{177}=	BKG058	Background Questionnaire Item 58

TABLE 4.1 CONTINUED

Matrix B Element	Variable Acronyn	Variable Definition

B_{178}=	BKG059	Background Questionnaire Item 59
B_{179}=	BKG060	Background Questionnaire Item 60
B_{180}=	BKG061	Background Questionnaire Item 61
B_{181}=	BKG062	Background Questionnaire Item 62
B_{182}=	BKG063	Background Questionnaire Item 63
B_{183}=	BKG064	Background Questionnaire Item 64
B_{184}=	BKG065	Background Questionnaire Item 65
B_{185}=	BKG066	Background Questionnaire Item 66
B_{186}=	BKG067	Background Questionnaire Item 67
B_{187}=	BKG068	Background Questionnaire Item 68
B_{188}=	BKF001	Background Factor Score 1, Composed of BKG Ques. Items 7,22,24,30,31,32 47,50,51,56,57,67
B_{189}=	BKF002	Background Factor Score 2, Composed of BKG Ques. Items 5,7,22,26,33,38,41 44,45,47,51,67
B_{190}=	BKF003	Background Factor Score 3, Composed of BKG Ques. Items 6,28,29,35,36,47,48 51,55,56,61,67
B_{191}=	BKF004	Background Factor Score 4, Composed of BKG Ques. Items 4,27,30,31,38,40,45, 46,47,48,50,51,52,67
B_{192}=	BKF005	Background Factor Score 5, Composed of BKG Ques. Items 4,25,31,32,33,34,35, 44,47,51,53,63
B_{193}=	BKF006	Background Factor Score 6, Composed of BKG Ques. Items 2,7,28,30,33,34,39,51, 55,56,57,58
B_{194}=	BKF007	Background Factor Score 7, Composed of BKG Ques. Items 7,19,24,28,34,35,44, 48,55,56,59,66

TABLE 4.1 CONTINUED

Matrix B Element	Variable Acronym	Variable Definition

B_{195}=	BKF008	Background Factor Score 8, Composed of BKG Ques. Items 4,7,9,14,22,24,27 31,34,40,41,43,45 47,51,55,60
B_{196}=	BKF009	Background Factor Score 9, Composed of BKG Ques. Items 5,6,17,19,21,24,25, 28,29,32,33,36,40, 44,45,55,57,58,60,61
B_{197}=	BKF010	Background Factor Score 10, Composed of BKG Ques. Items 4,28,29,30,31,34,40, 41,42,48,52
B_{198}=	BKF011	Background Factor Score 11, Composed of BKG Ques. Items 22,28,29,31,35,44,47 49,54,63
B_{199}=	BKF012	Background Factor Score 12, Composed of BKG Ques. Items 9,24,25,28,31,34,40, 43,47,48,51,55,57, 63,67
B_{200}=	BKF013	Background Factor Score 13, Composed of BKG Ques. Items 2,4,5,24,31,34,36,39, 47,48,51,55,57,61,63 67
B_{201}=	BKF014	Background Factor Score 14, Composed of BKG Ques. Items 5,7,17,24,26,27,32,34 35,39,44,47,48,51,54 55,56,57,58,66
B_{202}=	BKF015	Background Factor Score 15, Composed of BKG Ques. Items 5,7,12,19,22,24,30 34,46,55,63,64
B_{203}=	STAI	
B_{204}=	PRBSB1	Problem Solving Subtest 1 Score
B_{205}=	PRBSB2	Problem Solving Subtest 2 Score
B_{206}=	PRBSOL	Problem Solving Test Total Score

TABLE 4.1 CONTINUED

Matrix B Element	Variable Acronyn	Variable Definition

B_{207}=	SPSCR	Score on Modified Controlling Variables Written Test
B_{208}=	EI	Myers-Briggs Extravert-Introvert Continuous Score
B_{209}=	NS	Myers-Briggs Intuitive-Sensing Continuous Score
B_{210}=	TF	Myers-Briggs Thinking-Feeling Continuous Score
B_{211}=	JP	Myers-Briggs Judging-Perceiving Continuous Score
B_{212}=	MSUA	MSU Orientation-Placement Arithmetic Test Score
B_{213}=	MSUM	MSU Orientation-Placement Mathematics Test Score
B_{214}=	MSUAP	MSU Orientation-Placement Arithmetic Test Score Percentile
B_{215}=	MSUMP	MSU Orientation-Placement Mathematics Test Score Percentile
B_{216}=	MSAMP	MSU Orientation-Placement Combined Arithmetic-Mathematics Test Percentile
B_{217}=	MSUR	MSU Orientation-Placement Reading Comprehension Test Score
B_{218}=	MSURP	MSU Orientation-Placement Reading Comprehension Percentile
B_{219}=	MSUENG	MSU Orientation-Placement English Test Score
B_{220}=	MSUVOC	MSU Orientation-Placement Vocabulary Test Score
B_{221}=	MSUCEM	MSU Orientation-Placement English Test Score Percentile
B_{222}=	MSUVOCP	MSU Orientation-Placement Combined Vocabulary and Reading Comp. Percentile
B_{223}=	MSUEGP	ACT Math Test Score Percentile
B_{224}=	MSUVCP	ACT Social Studies Test Score Percentile
B_{225}=	ACTMP	ACT Natural Science Test Score Percentile
D_{226}=	ACTSSP	ACT Combined Test Score
B_{227}=	ACTNSP	ACT English Test Score

TABLE 4.1 CONTINUED

Matrix B Element	Variable Acronyn	Variable Definition

Element	Acronyn	Variable Definition
B_{228}=	ACTC	ACT Combined Test Score
B_{229}=	ACTENG	ACT English Test Score
B_{230}=	ACTMTH	ACT Mathematics Test Score
B_{231}=	ACTSS	ACT Social Science Test Score
B_{232}=	ACTNS	ACT Natural Science Test Score
B_{233}=	ACTCMP	ACT Combined Test Score Percentile
B_{234}=	ACTEGP	ACT English Test Score Percentile
B_{235}=	HSGPA	High School Grade Point Average
B_{236}=	HSPTLE	High School Percentile Ranking

TABLE 4.2

I INSTRUCTIONAL VARIABLES

I INSTRUCTIONAL VARIABLES

I MATRIX ELEMENT	VARIABLE ACRONYM	VARIABLE DEFINITION
I_1	LEC001	Attendance at Lecture 1
I_2	LEC002	Attendance at Lecture 2
I_3	LEC003	Attendance at Lecture 3
I_4	LEC004	Attendance at Lecture 4
I_5	LEC005	Attendance at Lecture 5
I_6	LEC006	Attendance at Lecture 6
I_7	LEC007	Attendance at Lecture 7
I_8	LEC008	Attendance at Lecture 8
I_9	LEC009	Attendance at Lecture 9
I_{10}	LEC0010	Attendance at Lecture 10
I_{11}	LECATD	Total Lecture Attending Sum of I_1 to I_{10}
I_{12}	SAS001	Attendance at Small Assembly Session 1
I_{13}	SAS002	Attendance at Small Assembly Session 2
I_{14}	SAS003	Attendance at Small Assembly Session 3

TABLE 4 .2 (Cont'd)

I MATRIX ELEMENT	VARIABLE ACRONYM	VARIABLE DEFINITION
I_{15}	SAS004	Attendance at Small Assembly Session 4
I_{16}	SAS005	Attendance at Small Assembly Session 5
I_{17}	SAS006	Attendance at Small Assembly Session 6
I_{18}	SAS007	Attendance at Small Assembly Session 7
I_{19}	SAS008	Attendance at Small Assembly Session 8
I_{20}	SAS009	Attendance at Small Assembly Session 9
I_{21}	SAS010	Attendance at Small Assembly Session 10
I_{22}	SAS011	Attendance at Small Assembly Session 11
I_{23}	SAS012	Attendance at Small Assembly Session 12
I_{24}	SAS013	Attendance at Small Assembly Session 13
I_{25}	SAS014	Attendance at Small Assembly Session 14
I_{26}	SAS015	Attendance at Small Assembly Session 15
I_{27}	SAS016	Attendance at Small Assembly Session 16
I_{28}	SAS017	Attendance at Small Assembly Session 17
I_{29}	SAS018	Attendance at Small Assembly Session 18
I_{30}	SAS019	Attendance at Small Assembly Session 19

TABLE 4.2 (Cont'd)

ELEMENT	VARIABLE ACRONYM	VARIABLE DEFINITION
I_{31}	SASATD	Total Small Assembly Session Attendance, Sum of I_{12} to I_{30}
I_{32}	LTP001	Student Use of Lecture Tape 1
I_{33}	LTP002	Student Use of Lecture Tape 2
I_{34}	LTP003	Student Use of Lecture Tape 3
I_{35}	LTP004	Student Use of Lecture Tape 4
I_{36}	LTP005	Student Use of Lecture Tape 5
I_{37}	LTP006	Student Use of Lecture Tape 6
I_{38}	LTP007	Student Use of Lecture Tape 7
I_{39}	LTP008	Student Use of Lecture Tape 8
I_{40}	LTP009	Student Use of Lecture Tape 9
I_{41}	LTP010	Student Use of Lecture Tape 10
I_{42}	LTPTOT	Total Lecture Tape Use, Sum of I_{32} to I_{41}
I_{43}	PQZ001	Student Use of Practice Quiz 1
I_{44}	PQZ002	Student Use of Practice Quiz 2
I_{45}	PQZ003	Student Use of Practice Quiz 3
I_{46}	PQZ004	Student Use of Practice Quiz 4

TABLE 4.2 (Cont'd)

I MATRIX ELEMENT	VARIABLE ACRONYM	VARIABLE DEFINITION
I_{47}	PQZ005	Student Use of Practice Quiz 5
I_{48}	PQZ006	Student Use of Practice Quiz 6
I_{49}	PQZ007	Student Use of Practice Quiz 7
I_{50}	PQZ008	Student Use of Practice Quiz 9
I_{51}	PQZ009	Student Use of Practice Quiz 10 (final exam)
I_{52}	PQZTOT	Total Practice Quiz Use. Sum of I_{43} to I_{51}
I_{53}	TC1	Length of Time Student Used Lab Tape 1
I_{54}	TC3	Length of Time Student Used Lab Tape 3
I_{55}	TC4	Length of Time Student Used Lab Tape 4
I_{56}	TC5	Length of Time Student Used Lab Tape 5
I_{57}	TC6	Length of Time Student Used Lab Tape 6
I_{58}	TC7	Length of Time Student Used Lab Tape 7
I_{59}	TC8	Length of Time Student Used Lab Tape 8
I_{60}	TC9	Length of Time Student Used Lab Tape 9
I_{61}	TC10	Length of Time Student Used Lab Tape 10
I_{62}	TC11	Length of Time Student Used Lab Tape 11

TABLE 4.2 (Cont'd)

	ACRONYM	VARIABLE DEFINITION
I_{63}	TC12	Length of Time Student Used Lab Tape 12
I_{64}	TC13	Length of Time Student Used Lab Tape 13
I_{65}	TC14	Length of Time Student Used Lab Tape 14
I_{66}	TC15	Length of Time Student Used Lab Tape 15
I_{67}	TC16	Length of Time Student Used Lab Tape 16
I_{68}	TC17	Length of Time Student Used Lab Tape 17
I_{69}	TC18	Length of Time Student Used Lab Tape 18
I_{70}	ONE031	Student reported Method of Use of Practice Quiz 1
I_{71}	ONE032	Student reported Study and Preparation Method for Quiz 1
I_{72}	ONE033	Student reported Study and Preparation Time for Quiz 1
I_{73}	TWO031	Student reported Method of Use of Practice Quiz 2
I_{74}	TWO032	Student reported Study and Preparation Method for Quiz 2
I_{75}	TWO033	Student reported Study and Preparation Time for Quiz 2
I_{76}	TRE031	Student reported Method of Use of Practice Quiz 3
I_{77}	TRE032	Student reported Study and Preparation Method for Quiz 3
I_{78}	TRE033	Student reported Study and Preparation Time for Quiz 3

TABLE 4.2 (Cont'd)

VECTOR ELEMENT	VARIABLE ACRONYM	VARIABLE DEFINITION
I_{79}	FORO31	Student reported Method of Use of Practice Quiz 4
I_{80}	FORO32	Student reported Study and Preparation Method for Quiz 4
I_{81}	FORO33	Student reported Study and Preparation Time for Quiz 4
I_{82}	FVEO31	Student reported Method of Use of Practice Quiz 5
I_{83}	FVEO32	Student reported Study and Preparation Method for Quiz 5
I_{84}	FVEO33	Student reported Study and Preparation Time for Quiz 5
I_{85}	SIXO31	Student reported Method of Use of Practice Quiz 6
I_{86}	SIXO32	Student reported Study and Preparation Method for Quiz 6
I_{87}	SIXO33	Student reported Study and Preparation Time for Quiz 6
I_{88}	SVNO31	Student reported Method of Use of Practice Quiz 7
I_{89}	SVNO32	Student reported Study and Preparation Method for Quiz 7
I_{90}	SVNO33	Student reported Study and Preparation Time for Quiz 7
I_{91}	NINO31	Student reported Method of Use of Practice Quiz 9
I_{92}	NINO32	Student reported Study and Preparation Method for Quiz 9
I_{93}	NINO33	Student reported Study and Preparation Time for Quiz 9
I_{94}	FINO61	Student reported Method of Use of Practice Quiz 10

TABLE 4.2 (Cont'd)

VECTOR ELEMENT	VARIABLE ACRONYM	VARIABLE DEFINITION
I_{95}	FIN062	Student reported Study and Preparation Method for Quiz 10
I_{96}	FIN063	Student reported Study and Preparation Time for Quiz 10
I_{97}	FIN064	Student Reported Method of Use of Practice Final Exam
I_{98}	FIN065	Student reported Study and Preparation Method for Final Exam
I_{99}	FIN066	Student reported Study and Preparation Time for Final Exam
I_{100}	Q1	Score on Weekly Quiz 1
I_{101}	Q2	Score on Weekly Quiz 2
I_{102}	Q3	Score on Weekly Quiz 3
I_{103}	Q4	Score on Weekly Quiz 4
I_{104}	Q5	Score on Weekly Quiz 5
I_{105}	Q6	Score on Weekly Quiz 6
I_{106}	Q7	Score on Weekly Quiz 7
I_{107}	Q9	Score on Weekly Quiz 9
I_{108}	Q10	Score on Weekly Quiz 10

record

length

inatio

4.3 [illegible]

on a

(orga

spons

Respo

Respo

Vecto

Each

item

recc

entr

Eac

cor

* fc

f

ording the student(s) name, topic of discussion, and approximate gth of the session. Such information may be useful in future examions of the data.

Outcomes: The K Matrix

During the course of the Fall 1977 term each student was tested number of items related to the concepts subsumed under Ecosystem anized within C). For each test item the student chose a rese which he or she considered to be the correct answer. This Item onse, IR_i for item i, ranged between 1 and 5. The set of all Item onses for an individual student is the student's Item Response or:

$$\overline{IR} = \left| IR_1, IR_2 \ldots\ldots IR_p \right|^{-1}$$

p = total number of test items related to C .

student's IR vector serves as a record of that student's test choices.

The Item Performance vector, $\overline{IP}$, is designed to serve as the rd of the individual student's performance on each of the items or ies in $\overline{IR}$.

$\overline{IP}$ is defined:*

IP_i = 1 when IR_i = correct response

IP_i = 0 when IR_i = any other response

i = 1, p

element of $\overline{IP}$, IP_i, is an indicator variable, indicating the ectness of choice of the corresponding entry in $\overline{IR}$, IR_i.

---

example; suppose 3 is the correct choice for item 14, then;

IP_{14} = 1, when IR_{14} = 13

IP_{14} = 0, when IR_{14} = 1, 2, 4, 5

each student.

As indicated previously the Matrix

$$C = \left| C_1 C_2 \cdot \cdot \cdot \cdot \cdot C_{44} \right|^{-1},$$

esents all the concepts associated with Ecosystem at the appro-
te level of instructional difficulty. The student's mastery or
rstanding of each element of C contributes to his or her under-
ding of the total, complex concept. The concern here is with the
ee of understanding or mastery of C by each student in the course
the only method available for assessing this mastery is through the
ent's response and performance on each of the test items related to
ecorded in $\overline{IR}$ and $\overline{IP}$, respectively.

The understanding or mastery of each C_i is theoretically measured
ne or more test items, recorded in $\overline{IR}$ and $\overline{IP}$. Each test item may
sure the understanding of more than one concept, however, and in
instances if a test item is answered incorrectly it is difficult
scertain whether it is because the student has not mastered all the
epts present, or has mastered all but one. The student's mastery
nowledge of a particular concept, C_i, is defined as:

$$K_i = \frac{\sum_{q} IP_q}{n}$$

e q = numbers of items related to C_i, and n = number of such items.
This yields a K_i, such that $0 \leq K_i \leq 1$.
probability that the student has mastered concept C_i increase as
pproaches 1.0. Conversely, as K_i approaches 0.2 (the probability of
sing the correct answer) the student may be assumed not to have
ered C_i. The certainty of separating mastery from guessing increases
increasing n.

for e

C_1, c

C ,

stude

Init

on s

set

item

the

gres

from

K_1 t

(se

thr

vio

val

new

If

for

fir

K

ϵ_i

Ch

The computation of a series of K_is based on $\overline{IP}$, produces a matrix

$$K = \left| K_1 K_2 \cdot \cdot \cdot \cdot \cdot K_{44} \right|^{-1}$$

r each student, K_i corresponding to the student's mastery of an element, , of the concept matrix C. K is thus a measurement of the mastery of , and as any measurement tool represents a distorted reflection of the tudent's true understanding.

The K matrix was updated each week as the term progressed. nitially Pretest (Week 0) items provided an indication of understanding n some of the C_is. The first weekly quiz (Week 1) provided the first et of items on which to update some of the elements of K . As the tems on each weekly quiz were added to the students' $\overline{IR}$ and $\overline{IP}$ vectors he K matrix was gradually filled in. Table 4.3 illustrates the pro- ressive addition of information to the K matrix as the term progressed rom the Pretest to the final exam. After Week 1 (column 1 in Table 4.3) $_1$ through K_6 and K_8 through K_{12} were computed from the appropriate items. see Table 3.9). After Week 2 no new information was available on K_1 hrough K_6, K_{11}, and K_{12}, so they retained the same values as in the pre- ious week. K_8 and K_9 were recomputed based on new information, and a alue for K_{14} was computed from the new information. Each week whenever ew data was available from the quiz, the appropriate K_is were recomputed. f no new information was available, the previous K_i values were brought rward. This process was continued weekly for the nine quizzes and the inal. Column 10 in Table 4.3 represents the final version of the matrix.

.4 Viewing the Course as a System

This study, following the theoretical directions discussed in apter 2 applies the structure and techniques of system analysis to a

TABLE 4 . 3

TABLE 4.3

WEEKLY ADDITIONS AND UPDATES
OF THE K MATRIX

Concepts C_i	i \ Pretest 0	Week 1	2	3	4	5	6	7	8	9	10
1	____	0101	____	____	____	____	0106	____	____	____	____
2	0200	0201	____	____	____	____	____	____	____	0209	____
3	0300	0301	____	0303	0304	____	____	____	0308	____	0310
4	0400	0401	____	____	0404	____	0406	0407	____	____	____
5	____	0501	____	____	0504	____	____	____	0508	____	____
6	0600	0601	____	____	____	____	0606	____	____	____	0610
7	____	____	____	____	____	____	____	____	____	____	____
8	0800	0801	0802	0803	____	0805	____	____	0808	____	0810
9	0900	0901	0902	0903	0904	0905	____	____	0908	0909	0910
10	____	1001	1002	____	____	1005	____	____	____	____	1010
11	____	1101	____	____	____	____	____	____	____	____	____
12	____	1201	____	____	____	____	____	____	____	____	____
13	____	____	____	____	____	____	____	____	____	____	____
14	1400	____	1402	1403	____	1405	____	____	____	____	1410
15	____	____	____	1503	____	1505	____	____	1508	____	1510
16	1600	____	____	1603	1604	____	____	1607	1608	____	1610
17	____	____	____	____	____	____	____	____	____	____	____
18	____	____	____	1803	____	____	____	____	____	____	____

$$\begin{bmatrix} K_1 \\ K_2 \\ K_3 \\ K_4 \\ K_5 \\ K_6 \\ K_7 \\ K_8 \\ K_9 \\ K_{10} \\ K_{11} \\ K_{12} \\ K_{13} \\ K_{14} \\ K_{15} \\ K_{16} \\ K_{17} \\ K_{18} \end{bmatrix}$$

TABLE 4.3 (Continued)

TABLE 4.3 (Continued)

Concepts C_i \ i	Pretest 0	Week 1	2	3	4	5	6	7	8	9	10	
19	1900	____	____	____	____	1905	____	____	1908	____	1910	K_{19}
20	2000	____	____	____	____	2005	____	____	____	____	2010	K_{20}
21	____	____	____	____	____	____	____	____	____	____	____	K_{21}
22	____	____	____	____	____	____	2206	____	____	____	2210	K_{22}
23	2300	____	____	____	____	____	____	2307	2308	2309	2310	K_{23}
24	____	____	____	____	____	____	____	2407	____	____	____	K_{24}
25	____	____	____	____	____	____	____	____	2508	2509	2510	K_{25}
26	____	____	____	____	____	____	____	____	2608	____	____	K_{26}
27	2700	____	____	____	____	____	____	____	2708	____	2710	K_{27}
28	2800	____	____	____	____	____	____	____	2808	____	____	K_{28}
29	2900	____	____	____	____	____	____	____	2908	____	2910	K_{29}
30	3000	____	____	____	____	____	____	____	3008	____	____	K_{30}
31	____	____	____	____	____	____	____	____	3108	3109	____	K_{31}
32	3200	____	____	____	____	____	____	____	3208	3209	3210	K_{32}
33	____	____	____	____	____	____	____	____	3308	____	____	K_{33}
34	3400	____	____	____	____	____	____	____	____	3409	3410	K_{34}
35	____	____	____	____	____	____	____	____	____	3509	____	K_{35}
36	____	____	____	____	____	____	____	____	____	3609	3610	K_{36}
37	____	____	____	____	____	____	____	____	____	3709	3710	K_{37}
38	____	____	____	____	____	____	____	____	____	3809	____	K_{38}

TABLE 4 .3 (Continued)

Concepts C_i	i	Pretest 0	1	2	Week 3	4	5	6	7	8	9	10
	39	3900	____	____	____	____	____	____	____	____	3909	3910
	40	____	____	____	____	____	____	____	____	____	4009	4010
	41	4100	____	____	____	____	____	____	____	____	4109	4110
	42	4200	____	____	____	____	____	____	____	____	4209	4210
	43	____	____	____	____	____	____	____	____	____	4309	4310
	44	____	____	____	____	____	____	____	____	____	4409	____

$$\begin{bmatrix} K_{39} \\ K_{40} \\ K_{41} \\ K_{42} \\ K_{43} \\ K_{44} \end{bmatrix}$$

NOTATION: C_i Week

$\wedge$ $\wedge$ for week 3, K_{16} = K 1603

16 03

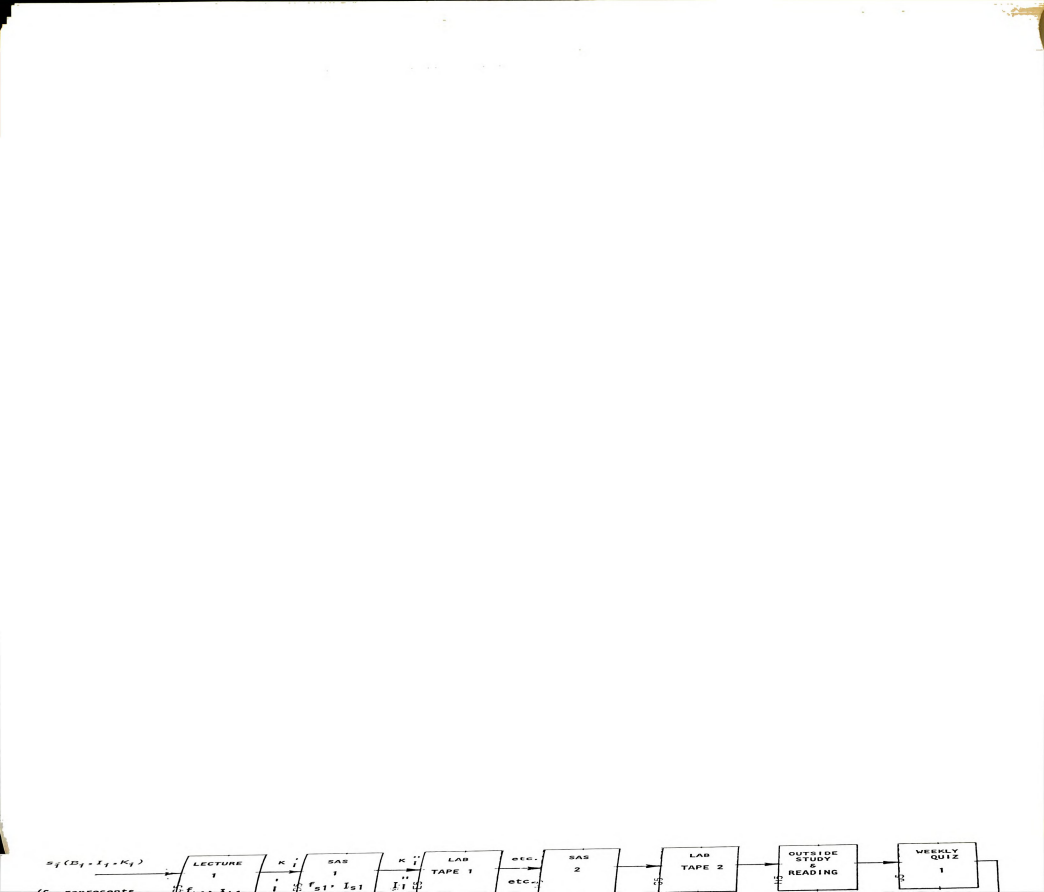
structured college biology course, BS 202. To do this, a system structure analogous to that shown in Figure 2.2 was imposed upon the course. In reality the course exists only as a difuse group of students passing with time through a series of instructional activities organized in some manner. The system structure, defined as "the set of interactions of elements, and related variables that intervene in the causal chain that links system outputs to system inputs" (Manetsch and Park, 1974a), is the abstract analogue to the physical entities and processes of an automated assembly-line. The mathematical model of the system developed is in effect a catalog of the mathematical or statistical relationships between the elements of the system through action on the students state variables.

Although the mathematical computer model developed for this study is an important tool in itself, most notably through its use in identifying "weak spots" in instruction, its chief contribution to educational research is as an organizational framework for student information and data on instructional processes. Such organization places the rigorous definition and analytical usefulness of systems methodology on the somewhat nebulous variables suggested by Bloom's Theory.

A student enrolled in BS 202, may be viewed as undergoing a sequential instructional process. As a result of the student's daily or weekly "processing" through various instructional sessions and activities changes occur in the students knowledge and understanding of the material presented and discussed. These changes are indicated as changes in the state variables describing the student. Specifically, after each instructional session (lecture, SAS, LAB,

outside study, etc.) changes have occurred in the student's version of C. These changes are influenced by the student's background variables, B, by previous instruction I, by previous learning (C imaged as K), by unknown student idiosyncrasies, and by the nature of the instructional session itself. This is shown in the diagram of Figure 2.1 where student S_i described by the state variables of B_i, I_i and K_i (reflecting entry level knowledge C_i) undergoes an instructional session. As a result of this session the student's state variables are transformed; the student has new understanding or mastery of particular concepts, described as alternations to C_i resulting in C_i' which are reflected as measurable alterations to K_i, resulting in K_i'. In addition, new instructional bookkeeping data is added to I_i. B_i is unaffected by the instruction. The changes in C_i (reflected in K_i') are influenced by B_i, I_i and previous concept knowledge C_i (measured in K_i). The instructional session may be described analytically by the transfer function, f_ξ. The process may then be described by $K_i' = f_\xi (B_i, I_i, K_i)$. This development is discussed in more detail in Chapter 2.

Following the archetypal system's model introduced in Figure 2.2 a model was developed for BS 202. Figure 4.2 illustrates a 'systems model' describing the BS 202 instructional plan based on the fundamental instructional session unit. The students were formally exposed to approximately 10 lectures and 19 small assembly sessions (SAS), as described in Appendix A. Each student was also urged to spend an undetermined amount of time listening to 17 tapes and working in the individual instruction lab. In addition, each student spent some time outside of class reading and studying. The model allows one to


LECTURE
1
SAS
1
LAB
TAPE 1
SAS
2
LAB
TAPE 2
OUTSIDE
STUDY
&
READING
WEEKLY
QUIZ
1

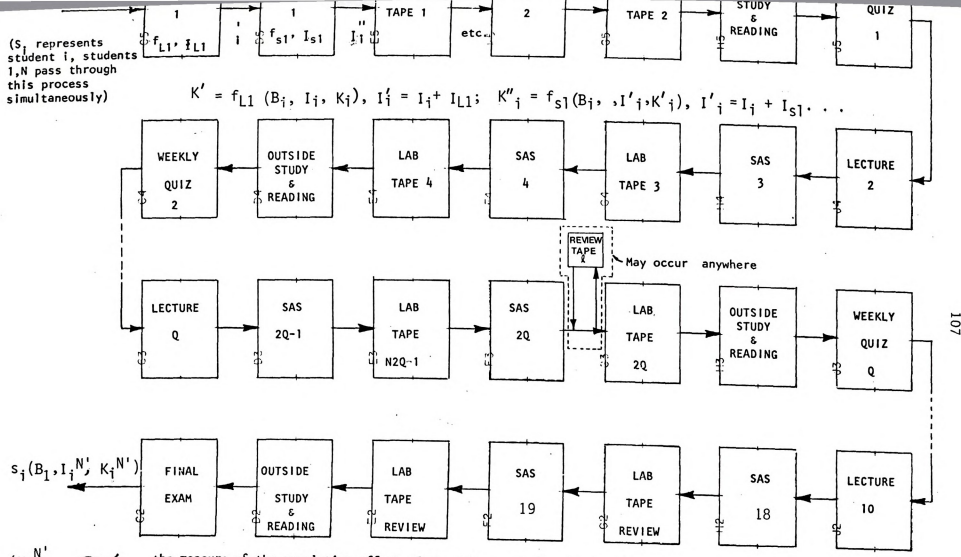


Figure 4.2

B.S. 202 Systems Diagram

visualize and comprehend the process of a large number of students simultaneously passing through distinct sequential instructional units. The change of each student's state variables by the transfer functions associated with each instructional session provides a mathematical analogue to the learning process inherent in a course of this type.

This model is a theoretical construct designed to mimic and simulate the function and processes of the BS 202 course. In many ways the model does not resemble the "reality" of the course - but it is only a construct meant to simplify reality and aid in our understanding of a complex process.

Condensing the Model

In the BS 202 course the students were tested only once each week. Thus, the performance variables were updated once each week and not after each instructional session. For any individual student performance on a particular concept C_i, measured in K_i, reflects the aggregate effect of the week's instruction and study. For a typical week, student performance on any C_i is related to previous background and knowledge, the lecture, two small assembly sessions, two tape lab sessions, outside study and reading and work with the practice test. For the purposes of this study the effects of each week's instruction and study were aggregated as a series of transfer functions relating the performance measures taken from the weekly quiz (K ') to the performance measures taken the week before (K), the week's instruction (I '), previous instruction (I) and background (B).

The "weekly" transfer functions are represented in the following matrix equation:

$$K' = F(B, I', K) = \beta B + \lambda I' + \mu K + \alpha$$

$$\begin{bmatrix} K'_1 \\ K'_2 \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ K'_{44} \end{bmatrix} = \begin{bmatrix} \beta_{1,1} & \beta_{1,2} & \cdots & \beta_{1,236} \\ \beta_{2,1} & & & \vdots \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \beta_{44,1} & & \cdots & \beta_{44,236} \end{bmatrix} \begin{bmatrix} B_1 \\ B_2 \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ B_{236} \end{bmatrix} +$$

$$\begin{bmatrix} \lambda_{1,1} & \lambda_{1,2} & \cdots & \lambda_{1,108} \\ \lambda_{2,1} & & & \\ \cdot & & & \\ \cdot & & & \\ \cdot & & & \\ \cdot & & & \\ \cdot & & & \\ \lambda_{44,1} & \cdots & \cdots & \lambda_{44,108} \end{bmatrix} \begin{bmatrix} I'_1 \\ I'_2 \\ \\ \\ \\ \\ \\ I'_{108} \end{bmatrix} + \begin{bmatrix} \mu_{1,1} & \mu_{1,2} & \cdots & \mu_{1,44} \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \mu_{44,1} & \cdots & \cdots & \mu_{44,44} \end{bmatrix} \begin{bmatrix} K_1 \\ K_2 \\ \\ \\ \\ \\ \\ K_{44} \end{bmatrix}$$

$$+ \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ \alpha_{44} \end{bmatrix}$$

Where K'j is the performance related to concept C_j shown in Table 3.11; β_{ij} is the coefficient of B_j shown in Table 4.1; I' is the update instructional vector reflecting the student's instructional behavior during the week; λ_{ij} is the coefficient I_j shown in

Table 4

perform

additiv

A

is

K

A

compon

to fi

(N =

the r

manne

contr

Table 4.2; λ_{ij} is the coefficient of K_j reflecting the previous performance on concept C_j defined in Table 3.11, and α_j is an additive constant.

A sample equation that could be expressed with this notation is

$$K_1' = f_1 (B_1, B_{18}, I_{14}, K_2\ K_{22})$$

$$= \beta_{11}B_1+\beta_{1.18}B_{18}+\lambda_{17}I_7+\lambda_{114}I_{14}+\mu_{1.2}K_2+\mu_{122}K_{22}+\alpha_1$$

Although for any individual student the effects of each model component are blurred together, using multiple regression techniques to find coefficients β, λ, μ and α for the student population (N = 105) produces relative weights of each component. By expressing the relationship of antecedents, transactions and outcomes in this manner it is possible to examine the relationships and relative contributions of each component of the model.

5.0 D

W

Scienc

deal w

necess

ysis,

This

are u

cant

analy

numbe

possi

analy

smal

ence

howe

labo

Mich

(St

CHAPTER 5

DATA PREPARATION, DATA ANALYSIS, AND LIMITATIONS ON THIS MODELING PROCESS

5.0 Data Preparation

When dealing with large and varied amounts of data in the Social Sciences the most important initial analytical steps are those that deal with correctness and error. Too often it is assumed that it is necessary to move as quickly as possible from data collection to analysis, without the important intermediate steps of data preparation. This is especially true when computer scored and coded instruments are used for information collection. Very often the lack of significant findings in a study is not due to inappropriate instruments or analyses, but rather to sloppy data. Thus, this study incorporates a number of inspections and checks to keep the data base as "clean" as possible.

Figure 5.1 illustrates schematically the data preparation and analysis used in this study. This type of analysis also requires a small amount of intuition, adding a touch of practical art to the science, which is not representable on a diagram. Figure 5.1 does, however, give a true picture of the steps, although not the amount of labor involved.

All the data analyses detailed in this chapter were done on the Michigan State University CDC 6500 computer using standard SPSS (Statistical Package for the Social Sciences, Nie et al, 1975; MSU

Ba
Que
Proc
Sp
Ch
Inc
Ma

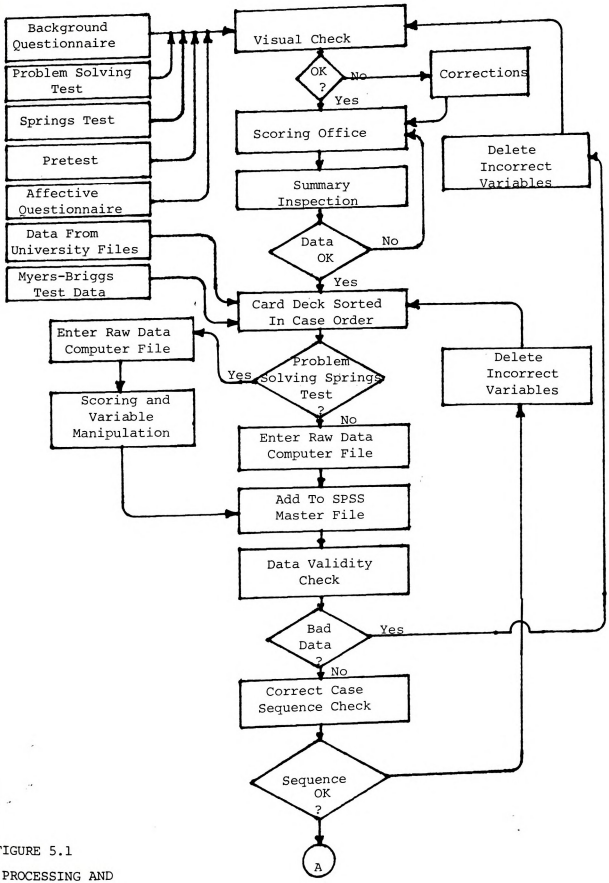
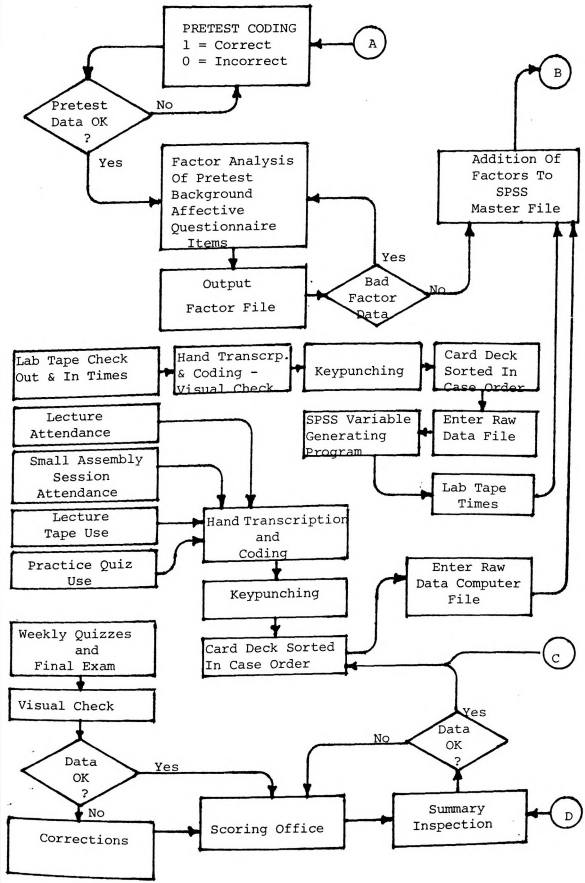


FIGURE 5.1

PROCESSING AND
URSE MODELING

FIGURE 5.1 CONTINUED



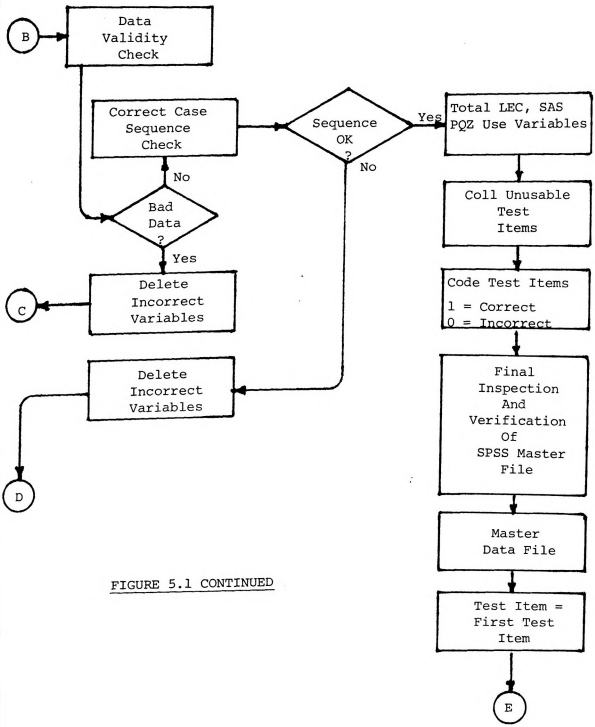
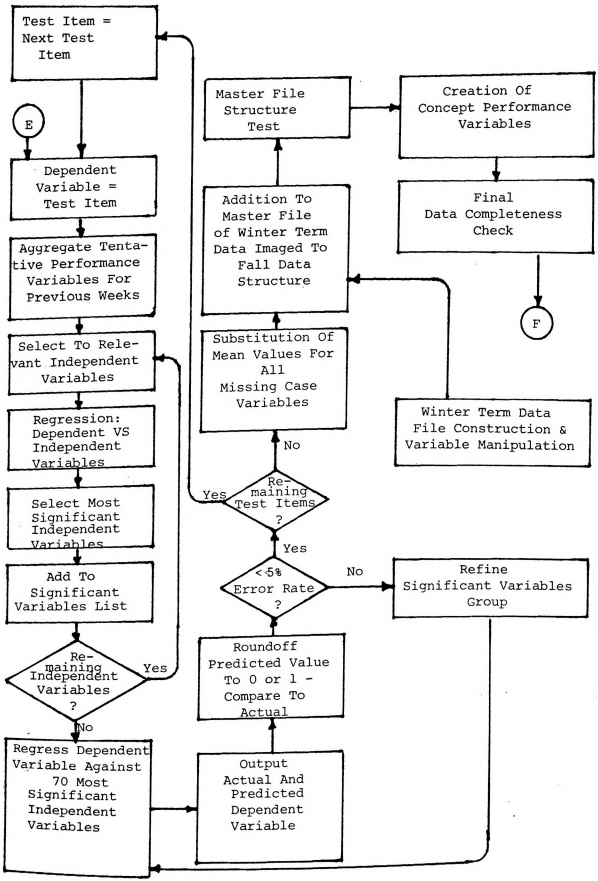


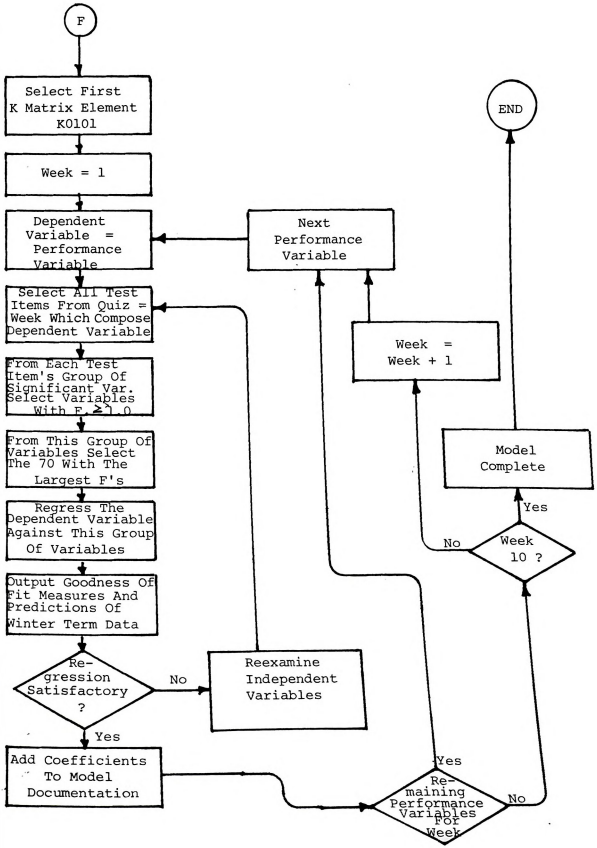
FIGURE 5.1 CONTINUED

FIGURE 5.1 CONTINUED



S
K M
It We Do
Ex
Ex
Ac
Ac

FIGURE 5.1 CONTINUED



Computer Lab Supplement, 1978) routines and several Fortran programs developed by the author. The Pretest, the Background Questionnaire, the Affective Questionnaire, the Problem Solving Test, and the Springs' (controlling variables) Test were all administered to the student population within the first several weeks of the term. All of these instruments except the last, consist of multiple choice items. The students answered each item by selecting and marking a number choice on a computer answer sheet. Responses to the Springs' Test were transcribed to the same type of answer sheet by research assistants. It was necessary to first visually check and correct these answer sheets before submission for computer coding. Often students would neglect to fill in their names and student numbers, or fail to adequately darken the answer boxes. The answer sheets were then submitted to the MSU scoring office which provided a computer card deck containing the test information and a summary. The summary provided a variety of information which was checked for data anomalies such as unexpected or meaningless responses. If no problems were found with the test data, the card deck was manually sorted into the proper order for the 105 Fall term cases (75 for Winter). Data from the University's records (ACT scoeres, High School GPA and Percentile Rank, MSU Orientation Test Scoeres, MSU class level, MSU credits earned and transferred, MSU points and points below 2.0 and MSU GPA on computer cards and cards with Myers-Briggs Test scores (which had been administered early in the term but was scored by the MSU Counseling Center) were also sorted into the proper case order. Each card deck was then entered as a raw data file into the Computer (MSU's CDC 6500). The Problem Solving and Springs' Tests raw data were then processed using a series of SPSS programs. The raw data for

each of the other instruments were entered and added sequentially to a SPSS Master file created to hold the term data. Problem Solving and Springs' Test processed variables were also added to the Master file. After each set of data was added, the new variables were checked for errors. The mean, standard deviation and range of each variable was examined for any anomalies which might suggest data error or incorrect file entry. When errors were found the variables were purged from the file, the errors corrected, the data reentered into the Master file and the variables reexamined. The case sequencing was also checked after each set of variables was added to the file, and the data purged and correctly reentered if any individual case was out of sequence.

At this stage of file construction the thirty four Pretest items represented all that was known about the students' entry level knowledge of biology and ecology. Here the student responses to the Pretest items were recorded in the IR vector format; a series of choices of one of five possible answers. The next step was to convert $\overline{IR}$ to $\overline{IP}$ by assigning a correct or incorrect code to each item. If a student chose the correct answer for Pretest item i, then IP_i was set equal to 1. If the incorrect response was chosen, IP_i was set equal to 0. (If data was missing for any student case the SPSS "missing value" designation was retained for IP_i).

After the Pretest items were recoded and checked for errors, the values of the elements of the Pretest $\overline{IP}$ vector were assigned to elements B_{11} through B_{44} of the Background Matrix, B . The total score on the Pretest was assigned to B_{45}. The forty-eight item responses on the Affective Questionnaire were assigned to elements B_{61} through B_{108}, and the sixty-eight item responses on the Background Questionnaire

wer

wer

abc

and

D3

Af

re

Pr

(N

a

wi

th

th

at

th

th

o

t

B

a

V

were assigned to elements B_{120} through B_{187}. (see Table 4.1)

At this point in the data preparation a series of Factor Analysis were performed on the three sets of Background variables discussed above. It was hoped that by rearranging these sets of variables, new and useful background indices might be generated. Tables D1, D2, and D3 in Appendix D summarize these Factor analyses for the Pretest, Affective Questionnaire, and Background Questionnaire variables, respectively.

Each of the three analyses performed applied the techniques of Principal Factoring with Iteration and Varimax Orthogonal Rotation, (Nie et al, 1975). This is the most commonly used method of reducing a data set to a smaller set of factors which account for the variance within the larger set and point of some underlying regularities within that data set.

Table D1 presents the results of the factor analysis on the thirty-four Pretest variables. This data set was reduced to 15 factors after 21 iterations of the factoring procedure. The contributions to the explanation of the variance of each of the 15 factors is shown in the top right section of the table. Commonalities, the total variance of each variable accounted for by the combination of all common factors (Nie et al, 1975) are shown in the top left portion of the Table. Below, the major component Pretest items are shown with the mean, range and standard deviations of each of the 15 factors. The major component variables are those which significantly contribute to the computation of the factor. Part of the outprint from a SPSS Factor analysis is a Factor score coefficient matrix, listing the component coefficients of each standardized variable (in this case for the Pretest variables)

for

vari

devi

of i

thir

er t

var

ere

pon

ele

Aff

dev

sc

to

na

fo

er

(E

of

w

y

h

v

i

for each factor. Since the coefficients are computed for standardized variable values (the variable minus its mean, divided by its standard deviation), the relative magnitude of each coefficient is a measure of its contribution to the total factor score. Thus, if three of thirty-four factor score coefficients for a particular factor are greater than 0.1 and the remaining thirty-one are less than 0.01, the three variables corresponding to the three large coefficients may be considered the major component variables of the factor.

The 15 Pretest factor scores were prepared using the major component variable questions for addition to the Master file or B matrix elements B_{46} through B_{60}.

Tables D2 and D3 show the results of the Factor analyses for the Affective and Background Questionnaire variables. Eleven factors were developed for the Affective variables (B_{61} through B_{108}) and factor scores were prepared for addition to the Master file as elements B_{109} to B_{111}. Fifteen factors were developed for the Background Questionnaire variables (B_{120} through B_{187}) and factor scores were prepared for addition to the Master file as elements B_{188} through B_{202}. Several Background variables were omitted from the factor analysis (B_{120}, B_{122}, B_{127}, B_{129}, B_{132}, B_{142}, B_{187}) because they had a variance of 0.

These factor analyses were done in the hope that the factors would reduce the number of variables entered into the regression analyses described in sections 5.1, 5.2, and 5.3. This was not the case, however. The Factors developed did not contribute to a reduction in variables. Individual variables played an important part in describing student characteristics; the factors scores did not.

After each of the three Factor analyses were completed, an output file containing values for each of the eleven to fifteen factor variables for each student case in the correct case order was generated. These three files were visually checked for bad data, then added to the SPSS Master file. Data validity and correct case sequence checks were performed again and bad or improperly sequenced data purged, corrected, reentered, and reexamined until the Master file was in order.

Throughout the term data on the instructional variables, listed in Table 4.2, were collected. Lecture and Small Assembly Session attendance data, information on the use of tape recorded elctures and the practice quizzes, and the length of time each student spent using the lab tapes in the carrel session were recorded by hand. After the course was completed this data was transcribed and coded manually from the term records, and then keypunched onto computer cards. Lecture (I_1 through I_{10}) and SAS attendance (I_{12} through I_{30}) variables were coded 1 if the student attended, 0 if he or she did not. Similarly, Lecture Tape use (I_{32} through I_{41}) and Practice Quiz Use (I_{43} through I_{51}) variables were coded 1 if the tape or Quiz was used by the student, 0 if it was not. Total Lecture attendance (I_{11}), total SAS attendance (I_{31}), total Lecture tape use (I_{42}) and total Practice Quiz Use (I_{52}), variables represent the sum of the respective components. Missing values were again maintained in standard SPSS convention.

The Lab tape-time variables, I_{53} through I_{68}, representing the amount of time each student spent using each Lab tape were computed from Carrel Laboratory records. To use a Lab tape each student would check a tape out through a lab attendant. When finished, the student would check the tape back in. The Lab attendant would note the times of tape check-out and check-in. Often students would use the same

tape on several occasions. When the Lab tape records were transcribed and coded at the end of the course check-out and check-in times were altered to reflect any multiple tape uses by students. The data was then key punched, sorted in case order, visually inspected for errors, entered into a raw data computer file, and processed with a SPSS variable generating program. This program produced Lab tape times, in hours and fractions of hours, for each student and Lab tape. This tape time data was then entered into the SPSS Master file with the usual validity and case order checks.

The weekly Quizzes and Final Exam were processed in the same manner as the Pretest. Each computer answer sheet was checked and corrected and submitted to the MSU Scoring Office, the test summaries were examined for anomalous data and the tests rescored if necessary. The computer card decks were sorted in case order, with blank cards inserted for those students who missed the test, and entered as a raw data computer file. The test data was then entered into the SPSS Master file with validity and case order checks. Bad or improperly sequenced data was purged, corrected and reentered.

The last three items on each quiz (usually questions 31, 32, and 33) and on the final exam, requested information on the methods and manner of study for that test. The values of these variables were assigned to elements I_{70} through I_{99} of the I matrix. Likewise, total scores on each of the quizzes were assigned to elements I_{100} to I_{108}.

At this point the Master file contained about 900 variables. All the test items from the nine quizzes and the final exam which were not related to the Ecosystem concepts delineated in the content analysis discussed in Chapter 3 (see Table 3.8) were purged from the Master

file (excluding I_{70} through I_{99}). The remaining test items constituted the IR vector for each student, and as was done with the Pretest items, each test item was then transformed to the IP vector format; 1 was assigned to IP_i for a correct response, 0 for an incorrect. Each student's $\overline{IP}$ consisted of 97 variables each having a value of 0 or 1, reflecting the performance on Ecosystem related test items.

The Master file now contained a relatively error free, fundamental data set describing each student with variables suitable for the first step in the regression analysis.

5.1 Regression Analysis 1

The main hypothesis of this modeling process maintains that everything a student experiences prior to answering a question influences that answer. Most of the student's previous experiences other than the instructional ones must be assumed to be insignificant in order to model the learning experience. The variables developed for the study are assumed to have at least a potential effect on the outcomes of instruction, as measured in the performance variables.

The intention of this process is to search for those variables that play a large role in reflecting student performance, incorporate them in the model and test the model for accurate predictions using another set (winter term) of data.

In the first stage of analysis each Ecology related test item (represented as a variable with a value of 0 or 1 in $\overline{IP}$) was regressed against all variables representing possible effects as hypothesized in the model. Using the SPSS Multiple Regression routine (Nie et al, 1975) each test item (IP_i) was regressed against the entire B Matrix, those elements of the I Matrix which represented instructional events or

actions which had occurred previous to the test including the item (a test item from Quiz 5 would not be regressed against the total score on Quiz 7 or the length of time Lab Tape 17, as it would not be used until the eighth or ninth week), and all other ecology concept related test items aggregated to tentative[1] K Matrix elements, from previous quizzes in the course. Due to the large amount of core storage necessary for the Multiple Regression routine each test item was regressed against the relevant set of independent variables divided into groups of about 70. This required six or more regression runs for each element of the IP Matrix at this stage of the analysis. The limitations introduced into the model by this necessity are discussed in the last section of this chapter.

From the output of the six or more initial regression runs a set of up to 70 significant independent variables was developed. These were the variables which contributed the greatest amounts to the explained variance of the dependent variable, the test item, on each of the initial regressions. It was also required that the "overall F" value of the regression at the point of the significant variables addition be at least 1.0. Table 5.4 shows a set of Regression Summary

---

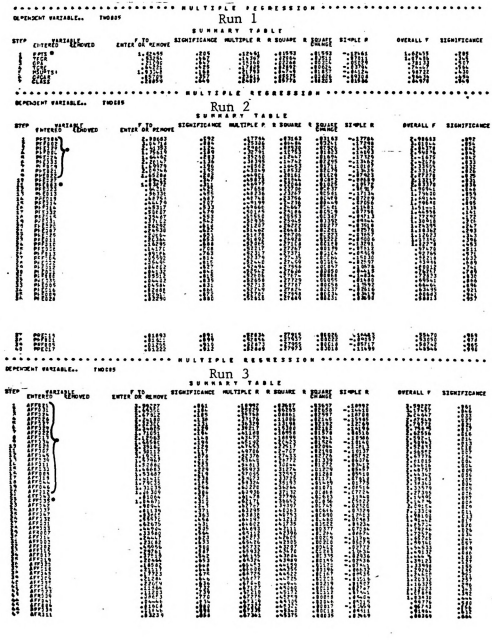
[1] The test items from the previous quizzes which were related to ecology concepts, as shown in Table 3.9, were aggregated using the following formula;

$$K_i = \frac{\Sigma \, IP_\delta}{N}$$

as defined in section 4.2. This was a tentative aggregation because missing data was scattered throughout the variable set.

TABLE 5.4

PHASE ONE REGRESSION SUMMARY TABLES
FOR A SAMPLE TEST ITEM



*"Significant" Variables for Phase Two Regression Analysis.

TABLE 5.4 cont'd.

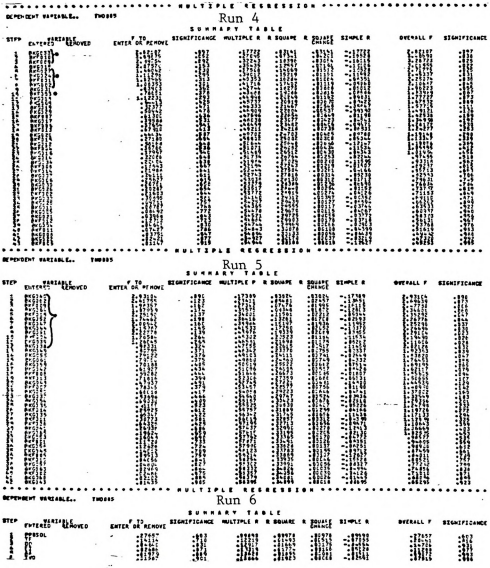
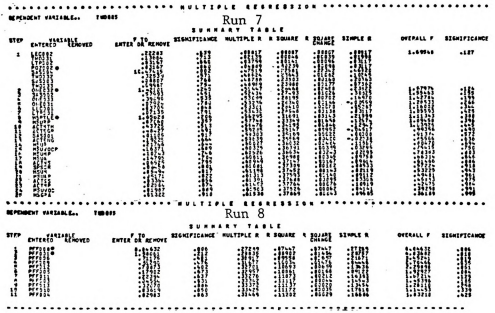


TABLE 5.4 cont'd.



PFF008 = KO801, PFF001 = KO101

ables from the initial regression runs for a sample test (IP_i)
the group of significant independent variables that were developed
n the inspection of these runs.

This process was repeated for each test item or each element in
IP vector.

Regression Analysis 2

The second phase of the regression analysis consisted of regressing
h test item or $\overline{IP}$ element against the appropriate set of significant
iables. The Multiple Regression routine was again used with each
up of approximately 70 variables. From each regression run the act-
and regression "predicted" values of the test item were output for
h student case to a separate file. The regression predicted values
e then rounded off to 0 or 1 using the standard criterion, and a set
residuals (equal to the actual minus the predicted) generated. The
ber of residuals with a value equal to a plus or minus 1 for a test
m was the error rate for 105 cases (or approximately the percentage
or rate). Tables 5.5 and 5.6 show, respectively the Summary Tables
en of a sample test item against a "significant"* set of independent
iables and the resulting residuals.

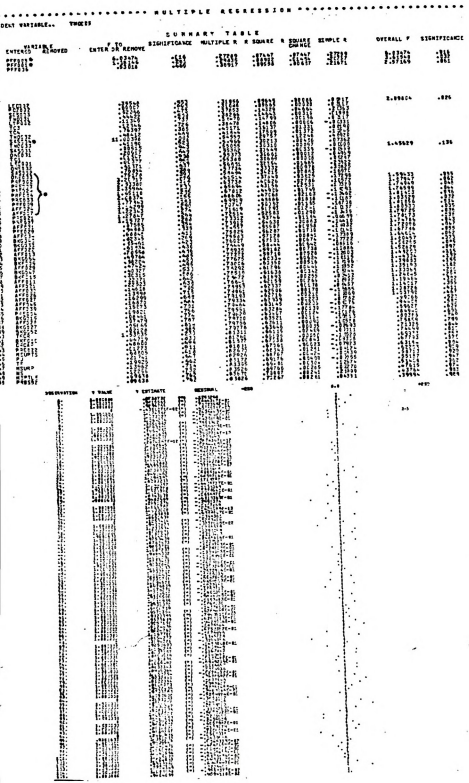
If the second phase regression resulted in an error rate of ten
cent or more, the set of significant independent variables and the
vious phase one regressions were reexamined and the set of signifi-
t variables refined. For over ninety percent of the test items it
not necessary to reexamine the significant variables. No more
n one iteration of this process was required for any test item to

---

gnificant" is not used in the statistical sense here. What is
ended is that the variables labeled as significant hold the promise
being useful in the prediction of performance through the applica-
n of the model.

TABLE 5.5

PHASE TWO SUMMARY TABLE
FOR A SAMPLE TEST ITEM



"Significant" Variables for Phase Three Regression Analysis

are

the
in

TE

Tw

TABLE 5.6

RESIDUAL ERROR RATE FOR THREE SAMPLE TEST ITEMS

Below the actual and the rounded regression estimated responses are shown as 0 or 1,

0 = incorrect responses to the test item; 1 = correct.

The error is computed by subtracting the estimate from the actual; the number +1s and -1s in the error summaries, indicate the number of incorrect estimates

TEST ITEM ACCURACY OF ESTIMATION					
Two 5	CODE	ABSOLUTE FREQ.	RELATIVE FREQ. (PCT.)	ADJUSTED FREQ. (PCT.)	CUM FREQ. (PCT.)
Actual Response	0	9	8.6	9.2	9.2
	1.0000000	89	84.8	90.8	100.0
	-9.0000000	7	8.7	Missing	
	Total	105	100.0	100.0	
	CODE	ABSOLUTE FREQ.	RELATIVE FREQ. (PCT.)	ADJUSTED FREQ. (PCT.)	CUM FREQ. (PCT.)
Regression Estimate	0	9	8.6	9.2	9.2
	1.0000000	89	84.8	90.8	100.0
	-9.0000000	7	6.7	Missing	
	Total	105	100.0	100.0	
	CODE	ABSOLUTE FREQ.	RELATIVE FREQ. (PCT.)	ADJUSTED FREQ. (PCT.)	CUM FREQ. (PCT.)
Error:*	0	98	93.3	100.0	100.0
	-9.	7	6.7	Missing	
	Total	105	100.0	100.0	
Based on:	Valid Cases	98	Missing Cases 7		

*0 Estimation Errors = 0%

TABLE 5.6 (Continued)

RESIDUAL ERROR RATE FOR THREE SAMPLE TEST ITEMS

TEST ITEM	ACCURACY OF ESTIMATION				
Two 4	CODE	ABSOLUTE FREQ.	RELATIVE FREQ. (PCT.)	ADJUSTED FREQ. (PCT.)	CUM. FREQ. (PCT.)
	0	29	27.8	29.9	29.9
Actual Response	1.0000000	68	64.8	70.1	100.0
	-9.0000000	8	7.6	Missing	
	Total	105	100.0	100.0	
	CODE	ABSOLUTE FREQ.	RELATIVE FREQ. (PCT.)	ADJUSTED FREQ. (PCT.)	CUM. FREQ. (PCT.)
	0	25	23.8	25.8	25.8
Estimate Regrssion	1.0000000	72	68.6	74.2	100.0
	-9.0000000	8	7.6	Missing	
	Total	105	100.0	100.0	
	CODE	ABSOLUTE FREQ.	RELATIVE FREQ. (PCT.)	ADJUSTED FREQ. (PCT.)	CUM FREQ. (PCT.)
	-1.	4	3.8	4.1	4.1
Error:*	0	93	88.6	95.9	100.0
	-9	8	7.6	Missing	
	Total	105	100.0	100.0	
Based on: Valid Cases		97	Missing Cases		

*4 Estimation Errors = 4.1%

RE

TEST

Five

Ac
Re

Re
Ea

*

TABLE 5.6 (Continued)

RESIDUAL ERROR RATE FOR THREE SAMPLE TEST ITEMS

TEST ITEM	ACCURACY OF ESTIMATION				
Five 4	CODE	ABSOLUTE FREQ.	RELATIVE FREQ. (PCT.)	ADJUSTED FREQ. (PCT.)	CUM. FREQ. (PCT.)
	0	43	41.0	46.2	46.2
Actual Response	1.0000000	50	47.5	53.8	100.0
	-9.0000000	12	11.4	Missing	
	Total	105	100.0	100.0	
	CODE	ABSOLUTE FREQ.	RELATIVE FREQ. (PCT.)	ADJUSTED FREQ. (PCT.)	CUM. FREQ. (PCT.)
	0	41	39.0	44.1	44.1
Regression Estimate	1.0000000	52	49.5	55.9	100.0
	-9.0000000	12	11.4	Missing	
	Total	105	100.0	100.0	
	CODE	ABSOLUTE FREQ.	RELATIVE FREQ. (PCT.)	ADJUSTED FREQ. (PCT.)	CUM. FREQ. (PCT.)
	-1.	5	4.8	5.4	5.4
Error:*	0	85	81.0	91.4	96.8
	1.	3	2.9	3.2	100.0
	-9.	12	11.4	Missing	
	Total	105	100.0	100.0	
Based on:	Valid Cases	93	Missing Cases	12	

*8 Estimation Errors = 8.6%

produc

of the

5.3 I

secon

K M

as de

Maste

in or

cases

varia

Regre

vari

case

Matr

the

cont

2 In

beg

aga

rec

Bec

Mas

th

re

fi

co

roduce an error rate of ten percent or less.

This second phase of the regression analysis was repeated for each f the items in the IP vector.

.3 Regression Analysis 3

After each test item had been successfully processed through the econd regression analysis phase, the test items were aggregated into Matrix elements using the following equation:

$$K_i = \frac{\Sigma\ IP_\delta}{N}$$

s defined in section 4.3. Before this was done, however, the SPSS aster file was altered somewhat to aid computation. Up to this point, n order to use as much of the available information as possible, any ases with missing values for a variable had had the mean value of that ariable substituted for the missing value (using Option 20 of the SPSS egression routine). Before summing and normalizing the IP vector ariables using the above expression, the mean values of any missing se variables were substituted throughout the entire file. The trix elements were then generated[2] using the above expression and e concept-test item relationships outlined in Chapter 3. Table 5.7 ntains the mean, standard deviation and rage of each K_i.

---

n the two previous phases of regression analysis the K elements had een updated on a "weekly" basis, and test items regressed, in part, gainst prior K elements. This was a tentative arrangement used to educe the total number of variables stored in the SPSS Master file. ecause of the large number of variables necessary for analysis the aster file was maintained as a SPSS Archive file. The reduction in he number of variables necessary for analysis in the third phase of egression, allowed the Master file to be stored as a "regular" SPSS ile with about 490 variables, which made the computer analysis onsiderably easier.

TABLE 5.7

K MATRIX ELEMENTS AND DEFINITIONS FOR FALL TERM 1977

	i	VARIABLE NOTATION	COMPONENT TEST ITEMS K_i =	MEAN	RANGE	STANDARD DEVIATION
Week One	1	K0101	Σ Quiz One 1, 6, 9, 21	0.498	0.0-1.000	0.229
	2	K0201	Σ Quiz One 1, 4, 6, 8	0.358	0.0-0.750	0.185
	3	K0301	Σ Quiz One 3, 4, 6	0.278	0.0-0.667	0.202
	4	K0401	Σ Quiz One 4, 5, 6, 8, 9	0.555	0.0-0.800	0.147
	5	K0501	Σ Quiz One 4, 8	0.451	0.0-1.000	0.225
	6	K0601	Σ Quiz One 4, 7, 8	0.422	0.0-1.000	0.235
	7	N.D.				
	8	K0801	Σ Quiz One 3, 7, 9, 18	0.667	0.0-1.000	0.248
	9	K0901	Σ Quiz One 8	0.824	0.0-1.000	0.378
	10	K1001	Σ Quiz One 9	0.804	0.0-1.000	0.393
	11	K1101	Σ Quiz One 6, 18	0.451	0.0-1.000	0.225
	12	K1201	Σ Quiz One 18, 19	0.554	0.0-1.000	0.268
	13	N.D.				
	14 through 44		Set Equal to Pretest Item Groupings			
Week Two	1	K0102	K0101	0.498	0.0-1.000	0.229
	2	K0202	K0201	0.358	0.0-0.750	0.185
	3	K0302	K0301	0.278	0.0-0.667	0.202
	4	K0402	K0401	0.555	0.0-0.800	0.147
	5	K0502	K0501	0.451	0.0-1.000	0.225
	6	K0602	K0601	0.422	0.0-1.000	0.235
	7	N.D.				
	8	K0802	K0801 +Σ Quiz Two 1, 2, 4, 5	0.732	0.375-1.000	0.173
	9	K0902	K0901 + Quiz Two 6	0.784	0.0-1.000	0.282
	10	K1002	K1001 +Σ Quiz Two 1, 4, 5	0.787	0.250-1.000	0.206
	11	K1102	K1101	0.451	0.0-1.000	0.225
	12	K1202	K1201	0.554	0.0-1.000	0.268

TABLE 5.7 (Continued)

	i	VARIABLE NOTATION	COMPONENT TEST ITEMS K_i =	MEAN	RANGE	STANDARD DEVIATION
Week Two	13	N.D.				
	14	K1402	Quiz Two 6	0.745	0.0-1.000	0.229
	15 through 44 Set Equal to Pretest Item Groupings					
Week Three	1	K0103	K0102	0.498	0.0-1.000	0.229
	2	K0203	K0202	0.358	0.0-0.750	0.185
	3	K0303	K0302 + ΣQuiz Three 5, 7	0.395	0.0-0.800	0.217
	4	K0403	K0402	0.555	0.0-0.800	0.147
	5	K0503	K0502	0.451	0.0-1.000	0.225
	6	K0603	K0602	0.422	0.0-1.000	0.235
	7	N.D.				
	8	K0803	K0802 + Quiz Three 1	0.732	0.375-1.000	0.173
	9	K0903	K0902 + ΣQuiz Three 1, 2	0.784	0.0-1.000	0.282
	10	K1003	K1002	0.787	0.250-1.000	0.206
	11	K1103	K1102	0.451	0.0-1.000	0.225
	12	K1203	K1202	0.554	0.0-1.000	0.268
	13	N.D.				
	14	K1403	K1402 + Quiz Three 1	0.635	0.0-1.000	0.350
	15	K1503	Quiz Three 8	0.848	0.0-1.000	0.350
	16	K1603	Quiz Three 19	0.818	0.0-1.000	0.376
	17	N.D.				
	18	K1803	Quiz Three 27	0.798	0.0-1.000	0.392
	19 through 44 Set Equal to Pretest Item Groupings					
Week Four	1	K0104	K0103	0.498	0.0-1.000	0.229
	2	K0204	K0203	0.358	0.0-0.750	0.185
	3	K0304	K0303 + Quiz Four 2	0.454	0.0-0.833	0.192
	4	K0404	K0403 + Quiz Four 2	0.587	0.167-0.833	0.147
	5	K0504	K0503 +Σ Quiz Four 1, 2	0.610	0.0-1.000	0.200
	6	K0604	K0603	0.422	0.0-1.000	0.235
	7	N.D.				

TABLE 5.7 (Continued)

	i	VARIABLE NOTATION	COMPONENT TEST ITEMS K_i =	MEAN	RANGE	STANDARD DEVIATION
Week Four	8	K0804	K0803	0.732	0.375-1.000	0.173
	9	K0904	K0904 + Quiz Four 2	0.724	0.200-1.000	0.206
	10	K1004	K1003	0.787	0.250-1.000	0.206
	11	K1104	K1103	0.451	0.0-1.000	0.225
	12	K1204	K1203	0.554	0.0-1.000	0.268
	13	N.D.				
	14	K1404	K1403	0.635	0.0-1.000	0.350
	15	K1504	K1503	0.848	0.0-1.000	0.350
	16	K1604	K1603 + Quiz Four 27	0.830	0.0-1.000	0.268
	17	N.D.				
	18	K1804	K1803	0.798	0.0-1.000	0.392
	19	through 44 Set Equal to Pretest Item Groupings				
Week Five	1	K0105	K0104	0.498	0.0-1.000	0.229
	2	K0205	K0204	0.358	0.0-0.750	0.185
	3	K0305	K0304	0.454	0.0-0.833	0.192
	4	K0405	K0404	0.587	0.167-0.833	0.147
	5	K0505	K0504	0.610	0.0-1.000	0.200
	6	K0605	K0604	0.422	0.0-1.000	0.235
	7	N.D.				
	8	K0805	K0804 +Σ Quiz Five 2, 4	0.719	0.364-1.000	0.162
	9	K0905	K0904 + Quiz Five 2	0.768	0.167-1.000	0.177
	10	K1005	K1004 +Σ Quiz Five 4,10	0.711	0.333-1.000	0.206
	11	K1105	K1104	0.451	0.0-1.000	0.225
	12	K1205	K1204	0.554	0.0-1.000	0.268
	13	N.D.				
	14	K1405	K1404 Σ Quiz Five 5, 12	0.672	0.250-1.000	0.240
	15	K1505	K1504 Quiz Five 10	0.715	0.0-1.000	0.283
	16	K1605	K1604	0.830	0.0-1.000	0.268
	17	N.D.	——	——	——	——

TABLE 5.7 (Continued)

	i	VARIABLE NOTATION	COMPONENT TEST ITEMS K_i =	MEAN	RANGE	STANDARD DEVIATION
Week Five	18	K1805	K1804	0.798	0.0-1.000	0.392
	19	K1905	ΣQuiz 1, 5	0.715	0.0-1.000	0.297
	20	K2005	ΣQuiz 2, 4, 10	0.703	0.333-1.000	0.242
	22	through 44 Set Equal to Pretest Groupings				
Week Six	1	K0106	K0105 + Quiz Six 26	0.578	0.180-1.000	0.189
	2	K0206	K0205	0.358	0.0-0.750	0.185
	3	K0306	K0305	0.454	0.0-0.833	0.192
	4	K0406	K0405 + Quiz Six 29	0.609	0.143-0.857	0.145
	5	K0506	K0505	0.610	0.0-1.000	0.200
	6	K0606	K0605 Quiz Six 30	0.543	0.0-1.000	0.192
	7	N.D.				
	8	K0806	K0805	0.719	0.364-1.000	0.162
	9	K0906	K0905	0.768	0.167-1.000	0.177
	10	K1006	K1005	0.711	0.333-1.000	0.206
	11	K1106	K1105	0.451	0.0-1.000	0.225
	12	K1206	K1205	0.554	0.0-1.000	0.268
	13	N.D.				
	14	K1406	K1405	0.672	0.250-1.000	0.240
	15	K1506	K1505	0.715	0.0-1.000	0.283
	16	K1606	K1605	0.830	0.0-1.000	0.268
	17	N.D.				
	18	K1806	K1805	0.798	0.0-1.000	0.392
	19	K1906	K1905	0.715	0.0-1.000	0.297
	20	K2006	K2005	0.703	0.333-1.000	0.242
	21	N.D.				
	22	K2206	Quiz Six 26	0.899	0.0-1.000	0.279

TABLE 5.7 (Continued)

	i	VARIABLE NOTATION	COMPONENT TEST ITEMS K_i =	MEAN	RANGE	STANDARD DEVIATION
	23 through 44 Set Equal to Pretest Groupings					
Week Seven	1	K0107	K0106	0.578	0.180-1.000	0.189
	2	K0207	K0206	0.358	0.0-0.750	0.185
	3	K0307	K0306	0.454	0.0-0.833	0.192
	4	K0407	K0406 + Quiz Seven 24	0.649	0.125-0.875	0.137
	5	K0507	K0506	0.610	0.0-1.000	0.200
	6	K0607	K0606	0.543	0.0-1.000	0.192
	7	N.D.				
	8	K0807	$\overline{\text{K0806}}$	$\overline{0.719}$	$\overline{0.364}$-1.000	$\overline{0.162}$
	9	K0907	K0906	0.768	0.167-1.000	0.177
	10	K1007	K1006	0.711	0.333-1.000	0.206
	11	K1107	K1106	0.451	0.0-1.000	0.225
	12	K1207	K1206	0.554	0.0-1.000	0.268
	13	N.D.				
	14	K1407	$\overline{\text{K1406}}$	$\overline{0.672}$	$\overline{0.250}$-1.000	$\overline{0.240}$
	15	K1507	K1506	0.714	0.0-1.000	0.283
	16	K1607	K1606 + Quiz Seven 25	0.865	0.333-1.000	0.190
	17	N.D.				
	18	K1807	$\overline{\text{K1806}}$	$\overline{0.798}$	$\overline{0.0}$-1.000	$\overline{0.392}$
	19	K1907	K1906	0.715	0.0-1.000	0.297
	20	K2007	K2006	0.703	0.333-1.000	0.242
	21	N.D.				
	22	K2207	$\overline{\text{K2206}}$	$\overline{0.899}$	$\overline{0.0}$-1.000	$\overline{0.279}$
	23	K2307	Quiz Seven 24	0.925	0.0-1.000	0.249
	24	K2407	Quiz Seven 27	0.720	0.0-1.000	0.424
	25 through 44 Set Equal to Pretest Groupings					

TABLE 5.7 (Continued)

	i	VARIABLE NOTATION	COMPONENT TEST ITEMS K_i =	MEAN	RANGE	STANDARD DEVIATION
Week Eight	1	K0108	K0107	0.578	0.180-1.000	0.189
	2	K0208	K0207	0.358	0.0-0.750	0.185
	3	K0308	K0307 + Quiz Nine 10	0.484	0.0-0.857	0.193
	4	K0408	K0407	0.649	0.125-0.875	0.137
	5	K0508	K0507 + Quiz Nine 28	0.659	0.0-1.000	0.185
	6	K0608	K0607	0.543	0.0-1.000	0.192
	7	N.D.				
	8	K0808	$\overline{\text{K0807}}$ + Quiz Nine 9	$\overline{0.704}$	$\overline{0.333}$-1.000	$\overline{0.161}$
	9	K0908	K0907 Σ + Quiz None 10, 19	0.778	0.375-1.000	0.147
	10	K1008	K1007	0.711	-.333-1.000	0.206
	11	K1108	K1107	0.451	0.0-1.000	0.225
	12	K1208	K1207	0.554	0.0-1.000	0.268
	13	N.D.				
	14	K1408	$\overline{\text{K1407}}$	$\overline{0.672}$	$\overline{0.250}$-1.000	$\overline{0.240}$
	15	K1508	K1507 + Σ Quiz Nine 8, 10	0.624	0.0-1.000	0.238
	16	K1608	K1607 + Quiz Nine 10	0.815	0.250-1.000	0.181
	17	N.D.				
	18	K1808	$\overline{\text{K1807}}$	$\overline{0.798}$	$\overline{0.0}$-1.000	$\overline{0.392}$
	19	K1908	K1907 + Quiz Nine 19	0.796	0.0-1.000	0.220
	20	K2008	K2007	0.703	0.333-1.000	0.242
	21	N.D.				
	22	K2208	$\overline{\text{K2207}}$	$\overline{0.899}$	$\overline{0.0}$-1.000	$\overline{0.279}$
	23	K2308	K2307 + Σ Quiz Nine 14,15,16,17, 19,24,25	0.832	0.375-1.000	0.118
	24	K2408	K2407	0.720	0.0-1.000	0.424
	25	K2508	Quiz Nine 2	0.913	0.0-1.000	0.265
	26	K2608	Quiz Nine 10	0.663	0.0-1.000	0.445
	27	K2708	Σ Quiz Nine 12,13,20 21,23	0.663	0.200-1.000	0.209
	28	K2808	Quiz Nine 17	0.902	0.0-1.000	0.279

TABLE 5.7 (Continued)

	i	VARIABLE NOTATION	COMPONENT TEST ITEMS K_i =	MEAN	RANGE	STANDARD DEVIATION
Week Eight	29	K2908	Σ Quiz Nine 20, 21	0.766	0.0-1.000	0.264
	30	K3008	Quiz Nine 22	0.500	0.0-1.000	0.470
	31	K3108	Quiz Nine 23	0.543	0.0-1.000	0.468
	32	K3208	Quiz Nine 24	0.946	0.0-1.000	0.213
	33	K3308	Quiz Nine 28	0.857	0.0-1.000	0.327
34 through 44 Set Equal to Pretest Groupings						
Week Nine	1	K0109	K0108	0.518	0.180-1.000	0.189
	2	K0209	K0208 + Σ Quiz Ten 20, 21	0.495	0.0-0.833	0.173
	3	K0309	K0308	0.484	0.0-0.857	0.193
	4	K0409	K0408	0.649	0.125-0.875	0.137
	5	K0509	K0508	0.659	0.0-1.000	0.185
	6	K0609	K0608	0.543	0.0-1.000	0.192
	7	N.D.				
	8	K0809	$\overline{K0808}$	$\overline{0.704}$	$\overline{0.333}$-1.000	$\overline{0.161}$
	9	K0909	K0908 + Quiz Ten 23	0.788	0.444-1.000	0.135
	10	K1009	K1008	0.711	0.333-1.000	0.206
	11	K1109	K1108	0.451	0.0-1.000	0.225
	12	K1209	K1208	0.554	0.0-1.000	0.268
	13	N.D.				
	14	K1409	$\overline{K1408}$	$\overline{0.672}$	$\overline{0.250}$-1.000	$\overline{0.240}$
	15	K1509	K1508	0.624	0.0-1.000	0.238
	16	K1609	K1608	0.815	0.250-1.000	0.181
	17	N.D.				
	18	K1808	$\overline{K1808}$	$\overline{0.798}$	$\overline{0.0}$-1.000	$\overline{0.392}$
	19	K1909	K1908	0.796	0.0-1.000	0.220
	20	K2009	K2008	0.703	0.333-1.000	0.242
	21	N.D.				
	22	K2209	$\overline{K2208}$	$\overline{0.899}$	$\overline{0.0}$-1.000	$\overline{0.279}$
	23	K2309	K2308 + Σ Quiz Ten 13, 20	0.826	0.400-1.000	0.118

TABLE 5.7 (Continued)

	i	VARIABLE NOTATION	COMPONENT TEST ITEMS K_i =	MEAN	RANGE	STANDARD DEVIATION
Week Nine	24	K2409	K2408	0.720	0.0-1.000	0.424
	25	K2509	K2508 + Σ Quiz Ten 12, 14	0.887	0.333-1.000	0.175
	26	K2609	K2608	0.663	0.0-1.000	0.445
	27	K2709	K2708	0.663	0.200-1.000	0.209
	28	K2809	K2808	0.902	0.0-1.000	0.279
	29	K2909	K2908	0.766	0.0-1.000	0.264
	30	K3009	K3008	0.500	0.0-1.000	0.470
	31	K3109	K3108 + Quiz Ten 19	0.656	0.0-1.000	0.286
	32	K3209	K3208 + Σ Quiz Ten 1,2,4,12,14, 19	0.805	0.564-1.000	0.143
	33	K3309	K3308	0.857	0.0-1.000	0.327
	34	K3409	Σ Quiz Ten 1, 14	0.901	0.500-1.000	0.186
	35	K3509	Quiz Ten 1	0.956	0.0-1.000	0.192
	36	K3609	Quiz Ten 2	0.560	0.0-1.000	0.464
	37	K3709	Quiz Ten 18	0.648	0.0-1.000	0.447
	38	K3809	Quiz Ten 4	0.659	0.0-1.000	0.443
	39	K3909	Σ Quiz Ten 5, 9, 19	0.824	0.0-1.000	0.218
	40	K4009	Σ Quiz Ten 6,7,10,14, 15,16,18	0.824	0.571-1.000	0.137
	41	K4109	Quiz Ten 11	0.901	0.0-1.000	0.279
	42	K4209	Quiz Ten 13	0.769	0.0-1.000	0.394
	43	K4309	Quiz Ten 19	0.769	0.0-1.000	0.394
	44	K4409	Quiz Ten 21	0.703	0.0-1.000	0.427
Week Ten	1	K0110	K0109	0.578	0.180-1.000	0.189
	2	K0210	K0209	0.495	0.0-0.833	0.173
	3	K0310	K0309 + Final 52	0.517	0.0-0.875	0.188
	4	K0410	K0409	0.649	0.125-0.875	0.137
	5	K0510	K0509	0.659	0.0-1.000	0.185

TABLE 5.7 (Continued)

	i	VARIABLE NOTATION	COMPONENT TEST ITEMS K_i =	MEAN	RANGE	STANDARD DEVIATION
Week Ten	6	K0610	K0609 + Final 52	0.585	0.0-1.000	0.188
	7	N.D.				
	8	K0810	$\overline{\text{K0809}}$ + Σ Final 2,4,18,33	$\overline{0.705}$	$\overline{0.250}$-1.000	$\overline{0.147}$
	9	K0910	K0909 + Σ Final 15,23,24	0.771	0.333-1.000	0.136
	10	K1010	K1009 + Final 52	0.717	0.286-1.000	0.203
	11	K1110	K1109	0.451	0.0-1.000	0.225
	12	K1210	K1209	0.554	0.0-1.000	0.268
	13	N.D.				
	14	K1410	$\overline{\text{K1409}}$ + Σ Final 4,18,33	$\overline{0.662}$	$\overline{0.143}$-1.000	$\overline{0.198}$
	15	K1510	K1509 + Final 49	0.655	0.200-1.000	0.212
	16	K1610	K1609 + Σ Final 9,45	0.835	0.333-1.000	0.145
	17	N.D.				
	18	K1810	$\overline{\text{K1809}}$	$\overline{0.798}$	$\overline{0.0}$-1.000	$\overline{0.392}$
	19	K1910	K1909 + Final 24	0.698	0.0-1.000	0.222
	20	K2010	K2009 + Σ Final 33,43	0.582	0.200-1.000	0.218
	21	N.D.				
	22	K2210	$\overline{\text{K2209}}$ + Final 48	$\overline{0.908}$	$\overline{0.0}$-1.000	$\overline{0.197}$
	23	K2310	K2309 + Σ Final 12,15,23, 24,25	0.783	0.400-1.000	0.114
	24	K2410	K2409	0.770	0.0-1.000	0.424
	25	K2510	K2509	0.887	0.333-1.000	0.175
	26	K2610	K2609	0.663	0.0-1.000	0.445
	27	K2710	K2709 + Σ Final 9,25,36,44	0.707	0.222-1.000	0.162
	28	K2810	K2809	0.902	0.0-1.000	0.279
	29	K2910	K2909 + Final 36	0.695	0.0-1.000	0.241
	30	K3010	K3009	0.500	0.0-1.000	0.470
	31	K3110	K3109	0.656	0.0-1.000	0.286
	32	K3210	K3209 + Σ Final 11,12	0.782	0.444-1.000	0.141
	33	K3310	K3309	0.857	0.0-1.000	0.327
	34	K3410	K3409 + Final 11	0.892	0.333-1.000	0.181

TABLE 5.7 (Continued)

	i	VARIABLE NOTATION	COMPONENT TEST ITEMS K_i =	MEAN	RANGE	STANDARD DEVIATION
Week Ten	35	K3510	K3509	0.956	0.0-1.000	0.192
	36	K3610	K3609 + Final 28	0.739	0.0-1.000	0.267
	37	K3710	K3709 + Final 28	0.782	0.0-1.000	0.274
	38	K3810	K3809	0.659	0.0-1.000	0.443
	39	K3910	K3909 + Σ Final 12,37,57,58	0.777	0.286-1.000	0.175
	40	K4010	K4009 + Σ Final 11,28,37,46 57,58	0.839	0.538-1.000	0.114
	41	K4110	K4109 + Final 11	0.888	0.0-1.000	0.211
	42	K4210	K4209 + Final 12	0.645	0.0-1.000	0.307
	43	K4310	K4309 + Final 28	0.843	0.0-1.000	0.241
	44	K4410	K4409	0.703	0.0-1.000	0.427
PRETEST GROUPINGS						
Week 0	1	K0100	N.D.			
	2	K0200	Σ Pretest 18,28	$\overline{0.432}$	$\overline{0.0-1.000}$	$\overline{0.351}$
	3	K0300	Pretest 23	0.261	0.0-1.000	0.413
	4	K0400	Σ Pretest 5,23	0.360	0.0-1.000	0.329
	5	K0500	N.D.			
	6	K0600	Pretest 23	$\overline{0.261}$	$\overline{0.0-1.000}$	$\overline{0.413}$
	7	N.D.	___			
	8	K0800	Pretest 3	$\overline{0.691}$	$\overline{0.0-1.000}$	$\overline{0.439}$
	9	K0900	Σ Pretest 19,20,25,30	0.409	0.0-0.750	0.206
	10	K1000	N.D.	___	___	___
	11	K1100	N.D.	___	___	___
	12	K1200	N.D.	___	___	___
	13	N.D.	___	$\overline{0.691}$	$\overline{0.0-1.000}$	$\overline{0.439}$
	14	K1400	Pretest 3			
	15	K1500	N.D.	$\overline{0.536}$	$\overline{0.0-1.000}$	$\overline{0.355}$
	16	K1600	Σ Pretest 7,27	___	___	___
	17	N.D.	___			

TABLE 5.7 (Continued)

	i	VARIABLE NOTATION	COMPONENT TEST ITEMS K_i =	MEAN	RANGE	STANDARD DEVIATION
Week 0	18	K1800	N.D.			
	19	K1900	Σ Pretest 20,30	0.361	0.0-1.000	0.244
	20	K2000	Pretest 32	0.253	0.0-1.000	0.415
	21	N.D.		—	—	—
	22	K2200	N.D.			
	23	K2300	Σ Pretest 5,9,17,19,20,21,25,30	0.495	0.125-0.875	0.179
	24	K2400	N.D.	—	—	—
	25	K2500	N.D.	—	—	—
	26	K2600	N.D.			
	27	K2700	Σ Pretest 7,15,24	0.299	0.0-1.000	0.232
	28	K2800	Pretest 26	0.884	0.0-1.000	0.306
	29	K2900	Pretest 15	0.054	0.0-1.000	0.213
	30	K3000	Σ Pretest 22,29	0.197	0.0-1.000	0.296
	31	K3100	N.D.			
	32	K3200	Σ Pretest 4,16,17,20	0.473	0.0-1.000	0.236
	33	K3300	N.D.			
	34	K3400	Pretest 16	0.688	0.0-1.000	0.445
	35	K3500	N.D.	—	—	—
	36	K3600	N.D.	—	—	—
	37	K3700	N.D.	—	—	—
	38	K3800	N.D.			
	39	K3900	Pretest 17	0.453	0.0-1.000	0.476
	40	K4000	N.D.			
	41	K4100	Pretest 16	0.688	0.0-1.000	0.445
	42	K4200	Pretest 17	0.453	0.0-1.000	0.476
	43	K4300	N.D.	—	—	—
	44	K4400	N.D.	—	—	—

were

sing

in th

used

is a

the

case

and

valu

equa

(K_1

run

err

var

1,

sec

eac

sig

wh

th

va

of

si

ma

The set of variables describing the students for Winter term 1978 were also added to the SPSS Master file at this juncture. The processing of this data into model variables was identical to that described in the first sections of this chapter. The winter term data was not used to develop the model, but rather to test and validate it. That is after the model was developed from the Fall date, it was applied to the Winter data and the predicted and actual performance scores compared.

The Master file was once again subjected to a data validity and case order check and the final irregularities sorted out. The third and final set of regression routines were then run on this missing-value-free Master file (omitting the Winter data from the regression equation development).

Starting with the first K Matrix element for the first week (K_1 = K0101) the significant set of variables for the last regression run of each of the component test items of K_1 resulting in a residual error rate of 10% or less were aggregated into a group of independent variables. For instance, the component test items for K0101 were items , 6, 9, and 21 from Quiz One (from Table 5.7). From inspection of the second phase regression runs (each with an error rate less than 10%), each test item was seen to be correlationally related to ten or eleven significant independent variables. As before, only those variables which contributed significantly to the explanation of the variance in the test items were selected. For K0101 there were 42 such independent variables. The K Matrix element was then regressed against the set of significant variables. This final regression produced the regression coefficients β, λ, μ and the constant α which relate concept mastery to background, instructional behavior and prior knowledge.

This process was completed for each element in B not equal to 0, for week one. The process was then repeated for weeks two through ten (the final exam). Simultaneous with the final regression runs, the model was applied to the variables within the Winter term, although the regression coefficients were not based on the 75 cases in the Winter file. Thus, the final coefficients of the model were developed and the validity of applying the model to an independent set of data were measured concurrently.

Table 5.8 shows the output from a sample phase 3 regression run. The resultant equation relating K_{10} (K1002, week 2) to the model variables is;

$$K_{10}' - 0.041\ B_{39} - 0.030\ B_{43} - 0.121\ B_{63} + 0.053\ B_{69}$$
$$- 0.104\ B_{79} + 0.193\ B_{81} - 0.062\ B_{85} + 0.084\ B_{87}$$
$$- 0.037\ B_{88} - 0.034\ B_{104} + 0.045\ B_{109} + 0.056\ B_{137}$$
$$- 0.063\ B_{153} - 0.046\ B_{158} - 0.135\ I_{54} + 0.136\ K_1$$
$$+ 0.257\ K_{10} + 0.6047$$

corresponding to

$$K_{10}' = \beta_{1039}\ B_{39} + \beta_{1043}\ B_{43} + \beta_{1063}\ B_{63} + \beta_{1069}\ B_{69}$$
$$+ \beta_{1079}\ B_{79} + \beta_{1081}\ B_{81} + \beta_{1085}\ B_{85} + \beta_{1087}\ B_{87}$$
$$+ \beta_{1088}\ B_{88} + \beta_{1081}\ B_{81} + \beta_{1085}\ B_{85} + \beta_{1087}\ B_{87}$$
$$+ \beta_{10\ 153}\ B_{153} + \beta_{10\ 158}\ B_{158} + \lambda_{10\ 54}\ I_{54} + \mu_{10\ 1}\ K_1$$
$$+ \mu_{10\ 10}\ K_{10} + \alpha_{10}$$

from section 4.4

Figure 5.2 shows a plot of the residuals computed for the actual value of K1002 minus the regression estimated (from the above equations)

TABLE 5.8
PHASE THREE REGRESSION
FOR A SAMPLE TEST ITEM

K-1002

```
* * * *
```

value

Winte

of Kl

For t

5.4

desc

The

and

Thi

thi

in

is

th

ab

in

pr

value for K1002. Figure 5.3 shows the same plot for K1002 from the Winter, validation data. For the Fall data about 65% of the variance of K1002 was accounted for by the variables used in the regression. For the Winter term the same variables accounted for about 23%.

5.4 Limitations

There are a number of important limitations on the processes described in sections 5.0 through 5.3:

--The use of number of independent variables much larger than the number of cases;

--The arbitrariness in the procedure for selecting the variables to be entered in each group and the arbitrariness of running such groups against the dependent variables through multiple regression in "waves";

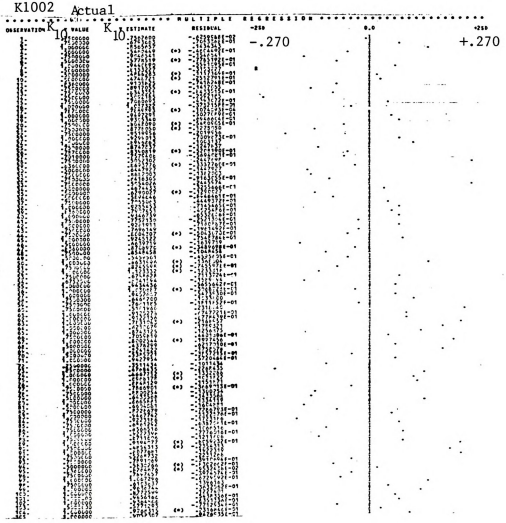
--The effects of substituting mean values for missing values; and

--The problems inherent in using regression analysis for predicting dichotomous variables.

The number of independent variables

The use of more independent than dependent variables is an obvious and intentional violation of standard multiple regression requirements. This breach of procedure may be defended by recalling that the intent of this process was to locate and identify variables that may prove useful in predicting performance. This use of the multiple regression routine is similar to using a very large guage mess screen to sort gravel; only the largest chunks of stone are identified. In our case only the variables which stand out as potential predictors are identified. Subtle interactions and properties of the variables are not picked up in this process. Likewise, among groups of variables that are intercorrelated,

FIGURE 5.2
SAMPLE PHASE THREE REGRESSION RESIDUALS
FOR FALL TERM DATA BASE

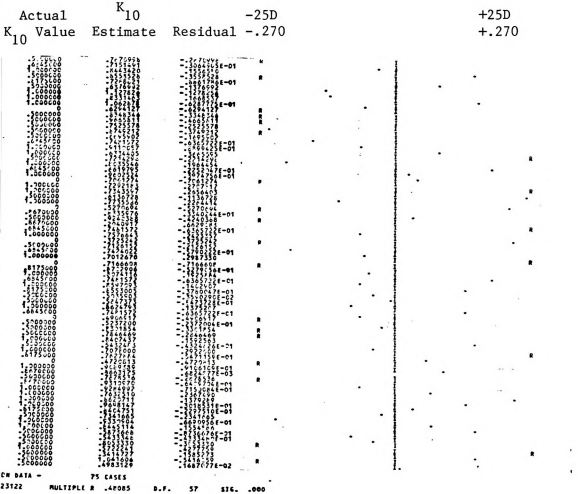


Act

K_{10} V

EXTRAPOLATION BA
N SQUARE .23122

FIGURE 5.3
SAMPLE PHASE THREE REGRESSION RESIDUALS
FOR VALIDATION (WINTER TERM) DATA BASE



only th

depende

"signif

Arbitra

As

be regr

restric

Under r

indepen

such c

ticall

the ph

ables

possib

sent a

howeve

ables

larger

Altho

and i

that

inter

the v

sion

"sign

fabr

more

deve

only those few variables accounting for the largest share of the dependent variable's variance are identified and sorted into the "significant" set.

Arbitrary group selection and regression runs

As mentioned earlier the largest group of variables which could be regressed against a dependent variable was about 70. This is a restriction imposed by the size and capabilities of the computer used. Under normal circumstances with an N of about one hundred, seventy independent variables would be a reasonable and adequate number. Under such circumstances the investigator would be searching for a statistically significant set of variables which best describe and reflect the phenomenon measured in the dependent variable. This set of variables would have the smallest intercorrelation within itself of all the possible groups of variables, thereby allowing each variable to represent as much independent information as possible. In this study, however, it was not the intention to find such an optimal set of variables but rather to identify a useful set of variables within a much larger set of variables potentially related to the learning process. Although background variables were grouped together in sets of seventy, and instructional variables were grouped the same, it is recognized that many variables in different groups were interrelated, and those interrelationships were never exposed by this method. Obviously, if the variables were grouped differently and passed through the regression routine we would have gotten different "answers" in terms of the significant" variables. However, the method used does allow us to fabricate a crude model which can be tested and further refined through more standard and statistically acceptable methods. If the variables developed for the model in this crude procedure allow predictions to

be made

that a

potenti

Substit

It

cases w

or depen

small

missin

number

study

larges

the va

more t

appare

indepe

more

varia

ues d

ships

deter

the e

be mo

Predi

disc

a va

base

be made which approach reality (even if distantly), then we may assume that a refined version will produce even more useful results, and the potential usefulness of this type of modeling will have been demonstrated.

Substituting mean values for missing values.

It is standard practice in regression computations to delete any cases where there is one or more missing value for any of the independent or dependent variables. In a large data set each case may have a small fraction of the variable inventory missing, deleting cases with missing values from the regression analysis would quickly shrink the number of cases and limit the usefulness of such a regression. In this study means were substituted for missing values in order to include the largest possible N in each regression analysis. This slightly reduces the variance of each independent or dependent variable and each appears more tightly clustered around its mean value. This tends to reduce the apparent variation in the dependent variable accounted for through the independent variables and thus the resultant analysis may be said to be more conservative. Although missing data was not widespread in the variables used in this study, the use of means in place of missing values does not noticably affect our search for the "strong" relationships among variables. Again, if it was the intention of this study to determine the statistical significance of the relations among variables, the effect of substituting the mean for missing values would have to be more carefully considered.

Predicting dichotomous variables.

In section 5.2, the second phase of the regression analysis was discussed. Here regression equations were essentially used to predict value of 0 or 1 (incorrect or correct response, for each test item based on the independent variables respectively). The proper use of

the regres

continuou

variable.

would nul

and relat

ever, in

statistic

possible

mous vari

relations

e regression equation assumes that the variables involved are
ntinuous, but here the equation was used to predict a dichotomous
riable. This practice violating a basic regression assumption
uld nullify any conclusions concerning the statistical significance
d relationships of the dependent and independent variables. How-
er, in this study no conclusions were being drawn concerning the
atistical significance of the relationships between variables, only
ssible relationships were being sought. The prediction of dichoto-
us variables was used only as a crude tool to search for variable
lationships.

6.0 I

ure de

in the

and

ground

knowle

fit o

tion

Appen

coeff

iable

varia

in pa

"beta

here

the

dard

is a

the

ated

CHAPTER 6

RESULTS AND ANALYSIS

.0 Introduction

The results of the regression modeling and validation proced-
re described previously are presented in this chapter. For each element
n the K matrix generated during the weekly testing routine the β , λ ,
nd μ coefficients (and the α constants) relating the K_i to the back-
round variables (B), the instruction variables (I), and previous
nowledge (K), are presented. Statistics describing the goodness of
it of the model to both the base (Fall '77) term data and the valida-
ion (Winter '78) term data are also provided.

The coefficients β, λ, μ and α are tabulated in the tables in
ppendix E in two forms. Each is presented first as an untransformed
oefficient which is to be multiplied directly by the appropriate var-
able in the model. Secondly, the coefficient computed on standardized
ariable values rather than on original unstandardized values is given
n parenthesis. The second coefficient is usually referred to as a
eta weight" (Nie et al., 1975) but this convention will be dropped
re in favor of the term 'coefficient weight' to avoid confusion with
e β coefficients. Since the coefficient weights are based on stan-
rdized variable values, the relative size of each coefficient weight
a measure of the relative effect of each independent variable on
e dependent variable (Nie et al, 1975). The constants (α's) associ-
ed with the coefficient weights are all equal to zero.

T

viousl

table

an ind

the co

6.1 W

were i

readi

ing t

tion

and K

model

(or

is mu

whic

digi

to t

two

for

Week

the

Eco

pra

det

Table 6.1 summarizes the tested ecosystem concept coverage previously presented in Table 3.10. An inspection of this coverage table and the coefficient weights of each of the variables provides an indication of the relative correlational importance of each of the course components modeled.

6.1 Week One

During the first week of class the basic concepts of Ecosystems were introduced in the lecture and reinforced in the SAS and textbook readings. The practice quiz also contained a number of items pertaining to Ecosystems concepts. The first quiz contained enough information to construct the mastery or performance variables K_1 through K_6, and K_8 through K_{12}. The coefficients relating these indices to other model components are contained in Table E.1.

In Table E.1 each coefficient is referenced by a β , λ , or μ (or α for the constants), the acronym of the independent variable it is multiplied by in the model, and the dependent or K_i variable to which it contributes. The K_i variables are referenced with a four digit code, K0301 for example, where the first two digits (03) refer to the element of K matrix and C matrix represented, and the second two digits (01) to the week represented (for the example K0301, K_3 for week 1 is represented).

Week One Instructional Variables

From Table E.1 it appears that student attendance at lecture and the second SAS are major contributors to the successful mastery of the Ecosystem concepts C_1 through C_6, and C_8 through C_{12}. Use of the practice quiz did not generally improve performance and may have detracted.

TABLE 6.1

TESTED ECOSYSTEM CONCEPT COVERAGE

C_i	Concept	Lecture 1	2	3	4	5	6	7	8	9	10	SAS 1	2	3	4	5	6	7	8	9	10	Tape Lab 1	2	3	4	5	6	7	8	9	10	Textbook 1	2	3	4	5	6	7	8	9	10	Practice Quiz 1	2	3	4	5	6	7	8	9	10
1.	Organism	X										X	X	X	X	X					X		X	X	X	X					X	X					X		X			X	X		X		X				X
2.	Ecosystem	X	X	X					X	X			X							X				X			X												X										X	
3.	Matter Cycle	X	X	X						X			X											X		X				X	X			X						X									X	
4.	Producer	X	X	X	X	X	X		X	X		X	X				X	X	X	X	X		X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5.	Consumer	X	X	X	X	X	X		X	X		X	X		X					X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6.	Decomposer	X	X	X	X				X	X			X				X			X					X		X			X	X	X					X			X			X		X		X			X	X
7.	Not Defined																																																		
8.	Organic Molecule	X	X	X	X	X	X			X				X			X			X				X	X		X						X		X		X		X	X			X	X	X	X	X	X		X	
9.	Energy Flow	X	X	X	X	X	X	X		X			X	X			X							X		X	X			X			X	X	X		X	X		X	X	X	X	X	X	X				X	X
10.	Inorganic Molecule/Matter	X	X	X	X	X	X			X				X			X							X	X		X						X	X	X		X		X	X			X	X	X	X	X	X		X	
11.	Nutrient																																X											X							
12.	Metabolism						X					X													X		X																								
13.	Not Defined																																																		
14.	Energy Storage		X	X																						X							X	X									X				X	X			
15.	Photosynthesis		X	X						X				X										X						X			X	X										X	X	X	X				
16.	Physical Environment		X				X		X					X			X	X	X	X	X			X	X	X	X	X		X	X	X			X	X	X	X	X	X		X	X	X	X	X		X		X	X
17.	Not Defined																																																		
18.	Habitat																							X				X													X							X			
19.	Efficiency		X			X				X														X																X						X					
20.	Respiration		X			X						X			X	X									X	X	X								X									X	X	X				X	
21.	Not Defined																																																		
22.	Mutualism																													X							X			X										X	
23.	Food Chain/Web			X						X														X						X	X				X	X				X										X	X
24.	Life Cycle													X			X							X			X	X				X									X									X
25.	Behavior								X							X			X							X				X						X			X		X	X								X	X
26.	Biotic Environment																			X	X																														
27.	Succession									X										X										X										X										X	
28.	Predation																													X										X											X
29.	Biome																													X										X										X	
30.	Niche																																								X									X	
31.	Community	X																												X										X										X	
32.	Population	X																												X	X	X								X	X	X									X
33.	Dispersal																																																		X
34.	Density																														X	X									X										X
35.	Territory								X																															X											
36.	Birth/Death Rate																															X									X										X
37.																																																			

TABLE 6.1 , cont.

TESTED ECOSYSTEM CONCEPT COVERAGE

Concept	Week	Lecture 1 2 3 4 5 6 7 8 9 10	SAS 1 2 3 4 5 6 7 8 9 10	Tape Lab 1 2 3 4 5 6 7 8 9 10	Textbook 1 2 3 4 5 6 7 8 9 10	Practice Quiz 1 2 3 4 5 6 7 8 9 10
38. Age Distribution						
39. Carrying Capacity				X		X
40. Population Growth/Stability				X	X	X
41. Density Dep./Indep. Factors			X	X		X
42. Population Interactions		X		X		X
43. Equilibrium		X X		X	X X	X X
44. Biomagnification				X		X

Population Interactions: Parasitism, Symbiosis, Competition, Commensalism

BACK

also
sequ
Fres
and
ment
on t
they
take
BS 2
clas
The
impo
the
to
to
tio
may
tiv
GOO

th
th
pr

BACKGROUND AND PRIOR KNOWLEDGE

A prior understanding of the concept of population (C_{32}) may also have benefited students, as well as the knowledge of food chain sequence (B_{19}), and the definition of an ecosystem (B_{28}). Those Freshmen and Sophomore students (B_5) with a few transfer credits (B_3) and good previous course performance (B_6) did better on these K elements than did others in the course. The students that performed well on these K indices also tended to do poorly in High School Biology if they took it, tended to take more College Chemistry, were required to take MSU remedial Math course 081 but not 082, were not repeating BS 202, and reported to find lab work helpful but not the studying of class notes. (B_{123}, B_{135}, B_{139}, B_{156}, B_{161}, and B_{171}, respectively). The successful student also reported a tendency not to "freeze" on important exams (B_{63}), a confidence that it is not necessary to know the type of exam questions beforehand (B_{80}), that it was not necessary to work with others on course work (B_{100}), that it is generally unwise to follow the majority (B_{107}, B_{108}) and that it best to answer a question based on how you feel it should be answered (B_{94}). These students may be characterized as prepared, methodical, unimaginative, conservative and conscious of the opinions of others (B_{116}).

GOODNESS OF FIT AND EXTRAPOLATION

Table 6.2 contains a summary describing the goodness of fit of the model's regression-based equations to the base term (Fall '77) and the validation term data. The following parameters are included to provide an indication of the goodness of fit:

Multiple R - the multiple regression coefficient between the set of independent variables and the dependent variable.

R^2 - proportion of the total variation in the dependent variable explained by the combined linear influence of the independent variables.

Sig. - an approximate significance level for the resulting multiple regression equation.

Adjust. R^2 - adjusted R^2, a more conservative estimate of the fraction of variance of the dependent variable explained; based on the equation

Adjust. $R^2 = R^2 - \frac{K-1}{N-K} (I-R^2)$ where N = number of cases and, K = number of coefficients + constants in the regression equation.

R^{2*} & Sig. - will be explained under week 2.

Number of Variables - number of independent variables in the regression equation, not including the constant.

Std. Dev. Resid. - Standard Deviation of the residual, where the residual is equal to the difference between the actual value of the dependent variable and the regression estimate.

For the K elements generated within the first quiz it was possible to explain 51 to 64 percent of the variance using 18 to 29 independent model variables. When these equations were applied to the validation term's data only one dependent variable, K_1, was estimated with a significance level equal to or less than 0.10. The reason for this poor fit was the lack of any close similarity during the first few class weeks between the validation (Winter '78) term and the base (Fall '77) term. However, the two versions of the course converge toward a common ground as the weeks proceed.

TABLE 6.2

TABLE 6.2

WEEK 1 REGRESSION EQUATIONS GOODNESS OF FIT
AND EXTRAPOLATION

	FALL TERM N = 105							EXTRAPOLATION - WINTER TERM N = 75					
	Multiple R	R^2	Sig.	Adjust R^2	Std. Dev. Resid.	R^{2*}	Sig.	Multiple R	R^2	Sig.	R^{2*}	Sig.*	Number of Variable
K0101	.798	.637	.001	.504	.161	NA	NA	.242	.059	.10	NA	NA	26
K0201	.738	.545	.001	.409	.142	NA	NA	NS	NS	NS	NA	NA	18
K0301	.720	.518	.001	.405	.156	NA	NA	NS	NS	NS	NA	NA	18
K0401	.804	.646	.001	.500	.104	NA	NA	NS	NS	NS	NA	NA	26
K0501	.757	.574	.001	.473	.163	NA	NA	NS	NS	NS	NA	NA	17
K0601	.797	.635	.001	.508	.164	NA	NA	NS	NS	NS	NA	NA	23
K0801	.716	.513	.001	.387	.194	NA	NA	NS	NS	NS	NA	NA	19
K0901	.775	.601	.001	.478	.273	NA	NA	NS	NS	NS	NA	NA	21
K1001	.711	.505	.001	.386	.308	NA	NA	NS	NS	NS	NA	NA	18
K1101	.777	.604	.001	.391	.175	NA	NA	NA	NA	NA	NA	NA	29
K1201	.781	.611	.001	.412	.205	NA	NA	NA	NA	NA	NA	NA	28

NS - Not significant

NA - Not applicable

6.2

trat

inte

cept

phys

eff

exp

ist

Eco

K_{lo}

anc

flo

the

oth

WEI

th

an

co

th

be

Th

Pr

a

w

6.2 Week Two

During the second week of class the course content was concentrated on the basic chemical and physical processes underlying biological interactions in ecology. In the lecture some of the basic ecosystem concepts were reviewed and the concepts of energy storage (both chemical and physical), photosynthesis and respiration processes, and equilibrium and efficiency were introduced. The SAS, Tape Lab, and textbook readings expanded these topics and introduced some of the basic concpts of chemistry. The Practice Quiz contained items covering only several of the Ecosystem concepts.

The second weekly quiz contained items which allowed K_8, K_9, and K_{10} to be updated and a new value to be computed for K_{14}. Thus, performances on the concepts of organic and inorganic molecules (C_8, C_{10}) energy flow (C_9) and energy storage (C_{14}) were measurable. Table E.2 contains the coefficients relating these indices (K_8, K_9, K_{10}, and K_{14}) to the other model components.

WEEK TWO INSTRUCTIONAL VARIABLES AND PRIOR KNOWLEDGE

Of the instructional sessions of the second week, only the time in the third tape lab (I_{54}) appears to significantly correlate with performance on the ecosystem concepts. None of the other instructional sessions correlate significantly with the performance indices. Those students that did not do well on ecology items on the Pretest (B_{18}, B_{29}) tended to be more successful than those who did on the second week's K elements. The students whose K values indicated a high degree of mastery after the second week had done well at recognizing a definition of behavior on the Pretest (B_{21}), but had scored poorly on several Pretest items requiring a sophisticated interpretation of experimental data (B_{24}, B_{33}). Likewise previous mastery of the concepts of inorganic molecule and

nutri

secon

was n

BACKG

that

mathe

(B_{14}

a ho

pref

stud

long

resc

dis

did

wor

tem

"pc

ca

te

GO

th

we

e

a

t

nutrient (K1001 and K1101) contributed to successful performance the second week, while previous mastery of the concept of metabolism (K1201) was negatively correlated with success on the second week's K elements.

BACKGROUND

Correlations with items from the Background Questionnaire indicate that the successful students (on week two K elements) took more advanced mathematics in high school (B_{136}), had a positive attitude toward science (B_{149}), had generally a higher self-reported GPA (B_{153}), reported having a hobby involving plants or animals (B_{158}), and indicated that they preferred a general, broad view of biology in the course (B_{183}). These students were generally weak in writing skills, did not expect to spend long hours studying outside class, found textbooks but not films or other resource materials helpful in science courses, and did not prefer to discuss course materials with friends (B_{198}).

In the affective sphere, the successful students reported that they did not "freeze" (B_{63}) or feel excessively nervous on exams (B_{67}), or worry about how well they did after the exam was over (B_{69}). They also tended to prefer taking exams over writing papers (B_{70}), but dislike "pop" or surprise quizzes (B_{79}). Overall, they may be characterized as calm and confident in their ability to perform on tests (B_{83}, B_{87}), testwise and independent of peer pressure in academic matters.

GOODNESS OF FIT AND EXTRAPOLATION

Table 6.3 contains goodness of fit and extrapolation parameters for the week two regression equations. For the three K elements updated from week one (K0802, K0902, and K1002), 65 to 84 percent of the variance was explainable with 15 to 21 independent model variables. The R^{2*} and the associated "sig" (significance level) indicate the approximate proportion of the variance in the dependent variable accounted for by the

TABLE 6.3

TABLE 6.3

WEEK 2 REGRESSION EQUATIONS GOODNESS OF FIT
AND EXTRAPOLATION

	FALL TERM							EXTRAPOLATION - WINTER TERM					
	Multiple R	R^2	Sig.	Adjust R^2	Std. Dev. Resid.	R^{2*}	Sig.	Multiple R	R^2	Sig.	R^{2*}	* Sig.	Number of Variable
K0102	-	-	-	-	-	-	-	-	-	-	-	-	-
K0202	-	-	-	-	-	-	-	-	-	-	-	-	-
K0302	-	-	-	-	-	-	-	-	-	-	-	-	-
K0402	-	-	-	-	-	-	-	-	-	-	-	-	-
K0502	-	-	-	-	-	-	-	-	-	-	-	-	-
K0602	-	-	-	-	-	-	-	-	-	-	-	-	-
K0802	.916	.838	.001	.792	.079	.684	.001	.568	.323	.001	.093	.15	21
K0902	.846	.715	.001	.664	.164	.412	.001	.771	.594	.001	NS	NS	15
K1002	.804	.647	.001	.570	.135	.577	.001	.481	.231	.001	.195	.01	17
K1102	-	-	-	-	-	-	-	-	-	-	-	-	-
K1202	-	-	-	-	-	-	-	-	-	-	-	-	-
K1402	.697	.486	.001	.401	.328	NA	NA	NA	NA	NA	NA	NA	14

independent variables excluding the previous value of K_i. For example, from Table 5.7, K0802 is equal to K0801 plus Quiz items Two 1, 2, 4, and 5. Thus, K0802 is highly correlated with K0801. From Table 6.3, about 84% of the variance of K-802 is explained by the 14 variables including K0801, in the regression equation shown in Table E.2. If K0801 is excluded from this regression equation, about 68% (R^{2*}) the variance of K0802 is explained by the variables remaining in the equation. The significance level, 0.001, remains relatively unchanged. Similarly 41 and 58% of the variance is explained for K0902 and K1002, respectively by unrelated variables. Note also that the standard deviations of the residuals have decreased from the previous week's values. This indicates an improvement of the "fit" of the equations to the data.

For the Winter term extrapolation data about 32, 59, and 23 percent of the variation in the K0802, K0902, and K1002 variables, respectively. No data was available to calculate a K1402 for this term. For the three variables, most of the variance is explained by the previously calculated variables, K0801, K0901, and K1001, with 10 to 20 percent explained by the remaining variables.

6.3

eco
The
and
cyc
ite
the
and
the
and
sio
Tab
WEI

wer
(I
th
wi
ot
PR

wh
ex
(I
wa
s
t
a

6.3 Week Three

Energy, its production, capture and movement through the ecosystem were the main topics of the third week's instructional sessions. The basics of the Ecosystem concepts were again reviewed (C_1 through C_{10}) and the concepts of food chain or web (C_{23}), habitat (C_{18}) and life cycle (C_{24}) were introduced. The practice quiz covered most of these items. The quiz given at the end of week three contained items allowing the K elements K_3, K_8, K_9, and K_{14} to be updated (K0303, K0803, K0903, and K1403, respectively). Additionally, K elements measuring mastery on the concepts of photosynthesis (K1503), the physical environment (K1603) and habitat (K1803) were also generated from the test data. The regression generated coefficients for these elements of K are presented in Table E.3.

WEEK THREE INSTRUCTIONAL VARIABLES

The students who performed successfully on the week three K measures were characterized as those who did not spend much time in Tape Lab 4 (I_{55}) but had done well on the previous quiz (I_{101}). Attendances during the first lecture (I_1) and the second SAS (I_{13}) are positively correlated with success on some of the K elements and negatively correlated with others.

PRIOR KNOWLEDGE

In the area of previous knowledge the successful students were those who knew the basics of ecology on the pretest (B_{18}, B_{30}, B_{41}) and had expanded that knowledge during the first three weeks of the course (K0101, K0201, K0401, K0802, K0902, and K1402). A negative correlation was found with the mastery of the concept of metabolism (K1201). These students were generally those who began the course with a good grasp of the concepts of biology and ecology and an ability to interpret graphs and experiments (B_{57}).

BAC

cor

few

rea

tiv

one

wea

sid

hel

ial

not

co

ot

st

qu

GO

th

th

th

is

K

a

v

K

o

BACKGROUND

In background, only a few characteristics proved to be significant correlationally. The successful students tended to have taken no or few college physics courses (B_{131}), were not required to take the remedial reading course ATL 101B (B_{148}), and indicated that they prefer quantitative discussions, as with mathematical derivations, over more qualitative ones. As in the previous week's discussion these students were generally weak in writing skills, did not expect to spend long hours studying outside of class, found textbooks but not other resource materials or film helpful in science courses, and did not prefer to discuss course materials with friends (B_{198}).

Significant correlations with Affective Questionnaire items were not found in any pattern. Variables B_{61}, B_{67}, B_{81}, and B_{99} are positively correlated with some of the K elements, and negatively correlated with others. The only straight forward result here is that the successful students for week 3 tended to feel that they should not answer test questions based on the way they feel.

GOODNESS OF FIT AND EXTRAPOLATION

The goodness of fit parameters for the equations developed with the third week's data are contained in Table 6.4. About 72 to 95 percent of the variation of those K elements with information stretching back into the first and second weeks of the course was explained using 15 to 19 independent variables. Removing this prior information (K0301, K0802, K0902 and K1402), about 29 to 70 percent of the variation was explainable with the remaining variables. Forty-two to forty-six percent of the variation in the K elements appearing for the first time (K_{15}, K_{16}, and K_{18}) was explained using 14 to 16 independent variables. Extrapolation of these equations to the winter term generally produced a better fit

TABLE 6.4

TABLE 6.4

WEEK 3 REGRESSION EQUATIONS GOODNESS OF FIT
AND EXTRAPOLATION

	FALL TERM N = 105					EXTRAPOLATION - WINTER TERM N = 75							
	Multiple R	R^2	Sig.	Adjust R^2	Std. Dev. Resid.	R^{2*}	Sig.	Multiple R	R^2	Sig.	R^{2*}	Sig. *	Number of Variable
K0103	-	-	-	-	-	-	-	-	-	-	-	-	-
K0203	-	-	-	-	-	-	-	-	-	-	-	-	-
K0303	.870	.757	.001	.670	.125	.588	.001	.823	.677	.001	.059	.08	19
K0404	-	-	-	-	-	-	-	-	-	-	-	-	-
K0503	-	-	-	-	-	-	-	-	-	-	-	-	-
K0603	-	-	-	-	-	-	-	-	-	-	-	-	-
K0803	.972	.945	.001	.934	.045	.521	.001	.987	.974	.001	MS	MS	15
K0903	.851	.724	.001	.665	.130	.700	.001	.845	.713	.001	.409	.001	16
K1003	-	-	-	-	-	-	-	-	-	-	-	-	-
K1103	-	-	-	-	-	-	-	-	-	-	-	-	-
K1203	-	-	-	-	-	-	-	-	-	-	-	-	-
K1403	.857	.735	.001	.678	.199	.289	.03	NA	NA	NA	NA	NA	17
K1503	.681	.463	.001	.353	.281	NA	NA	NA	NA	NA	NA	NA	15
K1603	.648	.420	.001	.322	.310	NA	NA	NA	NA	NA	NA	NA	14
K1803	.672	.452	.001	.341	.318	NA	NA	NA	NA	NA	NA	NA	16

than

to ni

measu

able

and

cant

able

probi

and

the

than seen in the week two extrapolation parameters. Sixty-eight to ninety-seven percent of the variation in the dependent variables measured (K0303, K0803, and K0903) was possible using all the available information. However, when the antecedent K values (K0301, K0802, and K0902) are removed from the equations only K0903 shows a significant amount of the variance (41%) accounted for by the remaining variables. The poor extrapolation for this week and the fourth week is probably due to a problem during the winter term resulting in the third and fourth weekly quizzes being combined into a single shorter quiz given the fourth week. This undoubtedly confounds the data.

6.4 Week Four

Instruction during the fourth week of class was concentrated on the internal structure and function of consumer organisms. Several ecosystem concepts were reviewed, but very little new added to the previous instructional delineation of ecosystem. The concept of equilibrium was reintroduced within the concepts of structure and function of the living organism and the parallels drawn between the organism and the ecosystem. The practice quiz contained a number of ecosystem concepts.

Table E.4 contains the model coefficients for the K elements measured within the fourth quiz. K elements K_3, K_4, K_5, K_9, and K_{16} were updated with the new data (to K0304, K0404, K0504, K0904, and K1064, respectively.) No new elements were added.

WEEK FOUR INSTRUCTIONAL VARIABLES

Some distinct trends begin to emerge during the fourth week which characterize the students showing a high level of mastery of the ecosystem concepts measured. Such students tended to spend less time than others on Tape Lab 8 (I_{59}) and more time and effort carefully reading the assigned textbook readings (I_{80}). These students also reported spending more time outside class studying course materials (I_{72}, I_{81}), and reported that they found resource books and magazines very helpful in science courses.

BACKGROUND AND PRIOR KNOWLEDGE

The successful students of week 4 also tended to know something about ecology before entering the course (B_{15}), but performed poorly on the pretest on several items testing general biological knowledge (B_{16}, B_{23}, and B_{37}). These students generally were not required to take a remedial math (B_{138}) course and described themselves as

conservative in some measures (B_{98}). They generally had taken high school biology and received a high grade, were minoring in elementary education science, and reported having an activity-oriented science program in their own elementary school experience. Although they reported having a positive attitude toward science, they had little interest in it and were not intending to devote much time to it in their own elementary classrooms (B_{191}).

GOODNESS OF FIT AND EXTRAPOLATION

Table 6.5 contains the goodness of fit and extrapolation parameters for the equations developed from the week four data. The variation accounted for in the five independent variables (K0304, K0404, K0504, K0904, K1604) ranges from 73 to 93 percent using 13 to 16 dependent variables. Eliminating K0303, K0401, K0501, and K1603 from the respective calculations, the amount of variance accounted for by the remaining variables ranges from 29 to 63 percent. Note again that the standard deviations of the residuals have decreased over the previous weeks indicating an increasingly better fit to the equations to the data.

When applied to the winter term data, 77 to 97 percent of the dependent variable's variation is accounted for by the independent variables in the equations, with the exception of the equation for K1604 which did not produce a significant result. After removing prior K measures (K0303, K0401, K0501, and K0903), very little of the variation is accounted for by the dependent variables. This may again be the result of the permutation in weeks three and four of the winter term.

TABLE 6.5

WEEK 4 REGRESSION EQUATIONS GOODNESS OF FIT
AND EXTRAPOLATION

	FALL TERM N = 105							EXTRAPOLATION - WINTER TERM N = 75					
	Multiple R	R^2	Sig.	Adjust R^2	Std. Dev. Resid.	R^{2*}	Sig.	Multiple R	R^2	Sig.	R^{2*}	* Sig.	Number of Variable
K0104	-	-	-	-	-	-	-	-	-	-	-	-	-
K0204	-	-	-	-	-	-	-	-	-	-	-	-	-
K0304	.965	.930	.001	.917	.055	.286	.009	.976	.953	.001	NS	NS	15
K0404	.936	.876	.001	.854	.056	.337	.002	.988	.976	.001	NS	NS	13
K0504	.856	.732	.001	.677	.113	.631	.001	.876	.767	.001	.110	.02	16
K0604	-	-	-	-	-	-	-	-	-	-	-	-	-
K0804	-	-	-	-	-	-	-	-	-	-	-	-	-
K0904	.958	.917	.001	.901	.065	.390	.001	.878	.770	.001	NS	NS	14
K1004	-	-	-	-	-	-	-	-	-	-	-	-	-
K1104	-	-	-	-	-	-	-	-	-	-	-	-	-
K1204	-	-	-	-	-	-	-	-	-	-	-	-	-
K1404	-	-	-	-	-	-	-	-	-	-	-	-	-
K1504	-	-	-	-	-	-	-	-	-	-	-	-	-
K1604	.881	.775	.001	.737	.137	.313	.002	NS	NS	NS	NS	NS	14
K1804	-	-	-	-	-	-	-	-	-	-	-	-	-

6.5 Week Five

During the fifth week of class, instruction in BS 202 continued to be concentrated on the structure and function of organisms, with the emphasis on respiration in animals. Although no new Ecosystem concepts were introduced, the emphasis on respiration expanded the general concepts associated with the flow of energy in the ecosystem. In addition to this coverage in the lecture and SASs, a number of ecosystem concepts were reviewed or expanded in the Tape Labs and textbook readings. The Practice Quiz contained items covering nine of the Ecosystem concepts.

The fifth weekly quiz contained items which allowed K_8, K_9, K_{10}, K_{14}, and K_{15} to be updated (to K0805, K0905, K1005, K1405, and K1505, respectively). Two new performance measures K_{19} and K_{20} (K1905 and K2005) were also generated from the data. Table E.5 contains the coefficients relating these K elements to the model's independent variables.

WEEK FIVE INSTRUCTIONAL VARIABLES

The pattern which began to emerge from the week four data continues to become clearer in the week five results. The students who demonstrated mastery of a number of the week five K elements tended to be those who attended lecture regularly, especially the third and fifth lectures (I_3 and I_5), attended SAS9 (I_{20}) and scored well on the previous week's quiz (I_{103}). These students also reported that they spend a large amount of time studying outside of class (I_{72} and I_{81}) and that they carefully read and reread the textbook assignment (I_{80}).

PRIOR KNOWLEDGE

In terms of prior knowledge, the successful students tended not to know the definition of a population on the Pretest (B_{14}), but did know

something about energy relationships in ecology (B_{41}). Success on the week five elements was correlated positively with previous mastery measures on the concepts of matter cycle (K0304), consumers (K0504), organic molecule (K0803), and negatively with mastery of the concepts of ecosystem (K0201), decomposer (K0601), and especially negatively with photosynthesis (K1503). Both positive and negative correlations were found with the concepts of energy flow (K0904), inorganic molecule (K1002) and energy storage (K1403).

BACKGROUND

The successful students on week five K elements tended to report that they do not let emotion interfere with performance during a test (B_{66}), do not become confused with increased study or during a test (B_{68}), do not feel uneasy before a test is returned (B_{78}), do not feel that changing an answer during a test is to their disadvantage (B_{92}), and do not view themselves as conservative in certain areas (B_{98}). These students also indicated that they would only be satisfied with a high grade in the course (B_{152}). For some K elements, the successful students reported that they did not find the memorization of concepts helpful, but for other K elements the students reported that they preferred memorization (B_{175}). These students also indicated that they had a positive attitude toward science but low achievement in math, found textbooks helpful in studying but not reviewing exams, and intended to devote a large amount of their own elementary classroom's time to science (B_{188}).

GOODNESS OF FIT AND EXTRAPOLATION

The parameters describing the goodness of fit and extrapolation for the week five regression equations are presented in Table 6.6. The proportion of variance explained for the dependent variables with prior K measurements (K0805, K0905, K1005, K1405, and K1505) ranged

TABLE 6.6

TABLE 6.6

WEEK 5 REGRESSION EQUATIONS GOODNESS OF FIT AND EXTRAPOLATION

	FALL TERM N = 105							EXTRAPOLATION - WINTER TERM N = 75					
	Multiple R	R^2	Sig.	Adjust R^2	Std. Dev. Resid.	R^{2*}	Sig.	Multiple R	R^2	Sig.	R^{2*}	Sig. *	Number of Variable
K0105	-	-	-	-	-	-	-	-	-	-	-	-	-
K0205	-	-	-	-	-	-	-	-	-	-	-	-	-
K0305	-	-	-	-	-	-	-	-	-	-	-	-	-
K0405	-	-	-	-	-	-	-	-	-	-	-	-	-
K0505	-	-	-	-	-	-	-	-	-	-	-	-	-
K0605	-	-	-	-	-	-	-	-	-	-	-	-	-
K0805	.978	.956	.001	.950	.036	.798	.001	.756	.572	.001	.279	.001	13
K0905	.998	.995	.001	.994	.013	.393	.001	.931	.867	.001	.456	.001	14
K1005	.896	.803	.001	.771	.099	.637	.001	.689	.475	.001	.425	.001	14
K1105	-	-	-	-	-	-	-	-	-	-	-	-	-
K1205	-	-	-	-	-	-	-	-	-	-	-	-	-
K1405	.846	.715	.001	.682	.135	.425	.001	.210	.044	.10	.104	.02	10
K1505	.790	.625	.001	.554	.189	.384	.001	NS	NS	NS	NS	NS	15
K1605	-	-	-	-	-	-	-	-	-	-	-	-	-
K1805	-	-	-	-	-	-	-	-	-	-	-	-	-
K1905	.747	.557	.001	.444	.222	NA	NA	NA	NA	NA	NA	NA	20
K2005	.717	.514	.001	.397	.188	NA	NA	NA	NA	NA	NA	NA	18

from 62 to 99 percent. Removing this prior data (K0803, K0904, K1002, K1403, and K1503) reduces the amount of variation explained by the remaining independent variables to between 38 and 80 percent. Ten to fifteen independent variables were used in the full equations. For the newly calculated K elements (K1905 and K2005), 51 to 56 percent of the variance was accounted for by 18 to 20 independent variables. Extrapolating the equations into the validation term's data resulted in 48 to 87 percent of the variation being explained for those variables with a lengthy prior history (K0805, K0905, and K1005). Removing this prior information reduced the amount of variance accounted for by the independent variables to between 28 and 46 percent. Extrapolation of the equations for the remaining week five variables produced few significant results.

6.6 Week Six

The major instructional thrust for the sixth week of the course was in reproduction. Most ecosystem concepts were only touched on briefly in the lecture and SAS. Here some emphasis was placed on metabolism and the flow of energy at the molecular level. A number of ecosystem concepts were briefly reviewed or expanded upon in the Tape Labs and textbook readings. Thirteen ecosystem concepts were covered on the practice quiz.

The quiz given at the end of the sixth week contained items relevant to only four ecosystem concepts. Data was available to update elements K_1, K_4, and K_6 (to K0106, K0406, and K0606) and generate on initial value for K_{22} (K2206). Table E.6 contains the model coefficients for these four K elements.

WEEK SIX INSTRUCTIONAL VARIABLES AND PRIOR KNOWLEDGE

This week's data provided little information on the students' mastery of the ecosystem concepts contained in C , or correlational information on relevant model variables. About all that can be gleaned from Table E.6 is that the students who demonstrated a mastery of the week six K elements were more likely to have attended SAS II (I_{22}), but not to have used the Practice Quiz for week five (I_{47}). These students had demonstrated a prior understanding or mastery of the concepts of metabolism (K1201) and photosynthesis (K1505), but success on the week six K elements were negatively correlated with mastery of the concepts of energy storage (K1405) and, particularly strong with physical environment (K1604).

BACKGROUND

From the Background Questionnaire, these successful students tended to report that they had or intended to take a course in geology,

earth science, astronomy, or space science (B_{144}), were not in elementary education with a science major (B_{145}), and were not required to take the remedial reading course ATL 101 (B_{148}). These students tended to have had no previous ecology courses, but several math courses beyond the remedial, had a positive attitude towards science and expected a high grade in the course. They reported that they found textbooks and films helpful in learning but not lectures or lab work (B_{189}).

Similar to previous weeks they also reported that they did not become confused when intensely studying for or taking an exam (B_{68}), did not think about unanswered questions during an exam (B_{84}), and felt that it was adequate to go through an exam once, then quickly check their answers (B_{87}). Generally, they are described as calm and controlled when prepared, testwise, conservative and somewhat independent of friends or peers (B_{119}).

GOODNESS OF FIT AND EXTRAPOLATION

Table 6.7 contains the parameters describing the goodness of fit of the regression equations developed using week six data and the extrapolation of these equations to the winter term data. Ninety-three to ninety-eight percent of the variation in the dependent variables with prior history (K0106, K0406, and K0606) was accounted for using 10 to 14 independent model variables, but only 14 to 39 percent of the same variance was accounted for by the same sets of variables when the prior data (K0101, K0404, and K0601) was removed from the equations. About 70 percent of the variation in the newly computed K element (K2206) was accounted for by 13 variables. Little significance was found when the prior data was removed from the equations for K0101, K0404, and K0601.

TABLE 6.7

TABLE 6.7

WEEK 6 REGRESSION EQUATIONS GOODNESS OF FIT AND EXTRAPOLATION

	FALL TERM N = 105					EXTRAPOLATION - WINTER TERM N = 75							
	Multiple R	R^2	Sig.	Adjust R^2	Std. Dev. Resid.	R^{2*}	Sig.	Multiple R	R^2	Sig.	R^{2*}	Sig.*	Number of Variable
K0106	.978	.956	.001	.948	.043	.144	.22	.896	.804	.001	NS	NS	14
K0206	-	-	-	-	-	-	-	-	-	-	-	-	-
K0306	-	-	-	-	-	-	-	-	-	-	-	-	-
K0406	.961	.924	.001	.913	.043	.263	.006	.870	.757	.001	.045	.10	12
K0506	-	-	-	-	-	-	-	-	-	-	-	-	-
K0606	.963	.927	.001	.917	.055	.394	.001	.752	.565	.001	.089	.02	10
K0806	-	-	-	-	-	-	-	-	-	-	-	-	-
K0906	-	-	-	-	-	-	-	-	-	-	-	-	-
K1006	-	-	-	-	-	-	-	-	-	-	-	-	-
K1106	-	-	-	-	-	-	-	-	-	-	-	-	-
K1206	-	-	-	-	-	-	-	-	-	-	-	-	-
K1406	-	-	-	-	-	-	-	-	-	-	-	-	-
K1506	-	-	-	-	-	-	-	-	-	-	-	-	-
K1606	-	-	-	-	-	-	-	-	-	-	-	-	-
K1806	-	-	-	-	-	-	-	-	-	-	-	-	-
K1906	-	-	-	-	-	-	-	-	-	-	-	-	-
K2006	-	-	-	-	-	-	-	-	-	-	-	-	-
K2206	.697	.485	.001	.407	.215	NA	NA	NA	NA	NA	NA	NA	13

6.7

plac

sper

cept

text

cept

the

com

inf

The

are

WEB

The

use

tir

of

le

a

bu

no

an

ag

(I

(I

6.7 Week Seven

During the seventh week of the course the main emphasis was placed on animal reproduction and development. Very little time was spent in lecture or SAS on Ecosystem concepts. Any mention of the concepts was in the nature of a short, passing review. The Tape Labs and textbook readings did, however, review and elaborate on ecosystem concepts, and the Practice Quiz did include a number of related items.

The quiz given at the end of the seventh week contained data for the update of two K elements, K0407 and K1607, and for the initial computation of elements K2307 and K2407. This did not provide much information on student progress in the mastery of ecosystem concepts. The regression equations developed for these four independent variables are contained in Table E.7.

WEEK SEVEN INSTRUCTIONAL VARIABLES PRIOR KNOWLEDGE, AND BACKGROUND

An examination of Table E.7 produces several generalizations. The successful students on the week seven K elements tended not to have used the lecture tape for the seventh lecture (I_{38}) and not spent much time on Tape Lab 13 (I_{64}). They did demonstrate some prior knowledge of animal behavior on the Pretest (B_{20}) but had few or no previous college biology courses. Previous to the seventh week they had demonstrated a mastery of the concepts of ecosystem (K0201) and decomposer (K0606) but not efficiency (K1905). They also tended to agree that it is best not to always let the majority make a decision (B_{108}). Both positive and negative correlations occurred with the item concerning the advantage of thinking about the manner in which exam questions are answered (B_{83}) and the previous mastery of the concept of inorganic molecule (K1006).

GOODNESS OF FIT AND EXTRAPOLATION

Table 6.8 contains the parameters measuring the goodness of fit of the regression equations generated using Fall term data and the extrapolation of those equations to winter data. For the two K elements with previous history, K0407 and K1607, 95 to 98 percent of the variation was accounted for with 10 to 13 independent model variables. Removing that previous history reduced the percentage variation accounted for to 26 to 44 percent. About 68 percent of the variation in the new variables K2307 and K2407 was accounted for by 12 to 13 independent variables. Extrapolating the relevant equations to the winter data resulted in an accounting of 73 to 99 percent of K0407 and K1607. The results after removal of the prior information on each variable were not significant.

6.8 Week Eight

The general topics covered during the next week of class were concerned primarily with animal nervous systems and behavior. Several ecosystem concepts were reviewed and the ecological ramifications of behavior and territoriality introduced. The week was abbreviated by the Thanksgiving holiday and no quiz was given.

TABLE 6.8

WEEK 7 REGRESSION EQUATIONS GOODNESS OF FIT AND EXTRAPOLATION

	FALL TERM N = 105							EXTRAPOLATION - WINTER TERM N = 75					
	Multiple R	R^2	Sig.	Adjust R^2	Std. Dev. Resid.	R^{2*}	Sig.	Multiple R	R^2	Sig.	R^{2*}	* Sig.	Number of Variable
K0107	-	-	-	-	-	-	-	-	-	-	-	-	-
K0207	-	-	-	-	-	-	-	-	-	-	-	-	-
K0307	-	-	-	-	-	-	-	-	-	-	-	-	-
K0407	.984	.968	.001	.963	.026	.439	.001	.997	.994	.001	NS	NS	10
K0507	-	-	-	-	-	-	-	-	-	-	-	-	-
K0607	-	-	-	-	-	-	-	-	-	-	-	-	-
K0807	-	-	-	-	-	-	-	-	-	-	-	-	-
K0907	-	-	-	-	-	-	-	-	-	-	-	-	-
K1007	-	-	-	-	-	-	-	-	-	-	-	-	-
K1107	-	-	-	-	-	-	-	-	-	-	-	-	-
K1207	-	-	-	-	-	-	-	-	-	-	-	-	-
K1407	-	-	-	-	-	-	-	-	-	-	-	-	-
K1507	-	-	-	-	-	-	-	-	-	-	-	-	-
K1607	.946	.894	.001	.878	.066	.255	.009	.733	.538	.001	NS	NS	13
K1807	-	-	-	-	-	-	-	-	-	-	-	-	-
K1907	-	-	-	-	-	-	-	-	-	-	-	-	-
K2007	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 6.8

TABLE 6.8

WEEK 7 REGRESSION EQUATIONS GOODNESS OF FIT AND EXTRAPOLATION

	FALL TERM N = 105					EXTRAPOLATION - WINTER TERM N = 75							
	Multiple R	R^2	Sig.	Adjust R^2	Std. Dev. Resid.	R^{2*}	Sig.	Multiple R	R^2	Sig.	R^{2*}	Sig.*	Number of Variable
K2207	-	-	-	-	-	-	-	-	-	-	-	-	-
K2307	.687	.412	.001	.386	.195	NA	NA	NA	NA	NA	NA	NA	12
K2407	.684	.468	.001	.388	.332	NA	NA	NA	NA	NA	NA	NA	13
K2507	-	-	-	-	-	-	-	-	-	-	-	-	-

6.9 Week Nine

Ecology was the main topic of the instructional sessions conducted during the ninth week of the course. In the lecture emphasis was placed on the concepts related to the cycling of matter and the flow of energy in the ecosystem. The concepts of producer, consumer, decomposer, energy source, organic and inorganic molecules, energy, photosynthesis, efficiency, food web or chain, symbiosis and succession were all expanded upon and tied together under the rubric of the internal functioning of the ecosystem. This expansion and unifying theme was carried through the SASs, Tape Labs, and textbook readings. The Tape Labs and textbook readings also introduced and expanded upon the concepts of biomass, mutualism, competition, predation, saprophyte, biome, evolution, trophic level, climax, diversity, and eutrophication. The Practice Quiz contained items covering twenty-eight ecosystem concepts.

The eighth quiz, given at the end of the ninth week contained information which allowed eight of the K elements to be updated and initial values for nine new K elements to be computed (K0308, K0508, K0808, K0908, K1508, K1608, K1908, K2308, and K2508, K2608, K2708, K2808, K2908, K3008, K3108, K3208, K3308, respectively). Table E.8 contains the model coefficients developed for these seventeen variables.

PRIOR KNOWLEDGE

An inspection of Table E.8 indicates that most of the relevant independent variables in the regression equations are related to prior knowledge of the ecosystems concepts. The students successful on the K elements developed from the eighth quiz tended not to be familiar with some elements of ecology on the pretest (B_{25}), but in succeeding weeks had mastered the concepts of ecosystem (K0201), matter cycle

(K0304), organic molecule (K0805), photosynthesis (K1505), physical environment (K1607), and mutualism (K2206). They tended to perform poorly on the concepts of habitat (K1803) and energy storage (K1405). Negative correlations with performance on the latter concept were particularly pervasive. Both positive and negative correlations were found with the previous mastery of the concepts of consumer (K0504), energy flow (K0905), nutrient (K1101), metabolism (K1201), efficiency (K1905), and respiration (K2005).

WEEK NINE INSTRUCTIONAL AND BACKGROUND VARIABLES

The successful students also tended to make use of the tape of lecture 9 (I_{40}). Both positive and negative correlations were found between the independent K elements and attendance at lecture 6 (I_6) AND SAS 17 (I_{28}). These students also reported that they expected to spend many hours studying outside class (B_{154}), did not use the ideas from one exam question to answer another (B_{93}), believed that it was not always best to follow the majority (B_{107}), and found that their families approved of their chosen careers (B_{106}). Both positive and negative correlations were found with a reported belief that thinking about the grade a person will receive in a course interferes with studying (B_{72}) for that course. These students also tended to report a high biology grade in high school, were required to take a remedial writing course, and a high college GPA, had a negative attitude toward science and seldom read about biology or any science topics (B_{197}).

GOODNESS OF FIT AND EXTRAPOLATION

Table 6.9 contains the parameters describing the goodness of fit of the equations in Table E.8 to the Fall term data, and to the Winter term extrapolation data. For the dependent variables with prior information (K0308, K0508, K0808, K0908, K1508, K1608, K1908, and K2308)

TABLE 6.9

WEEK 9 REGRESSION EQUATIONS GOODNESS OF FIT AND EXTRAPOLATION

	FALL TERM N = 105							EXTRAPOLATION - WINTER TERM N = 75					
	Multiple R	R^2	Sig.	Adjust R^2	Std. Dev. Resid.	R^{2*}	Sig.	Multiple R	R^2	Sig.	R^{2*}	Sig.*	Number of Variable
K0108	–	–	–	–	–	–	–	–	–	–	–	–	–
K0208	–	–	–	–	–	–	–	–	–	–	–	–	–
K0308	.972	.945	.001	.938	.048	.430	.001	.579	.335	.001	.258	.001	11
K0408	–	–	–	–	–	–	–	–	–	–	–	–	–
K0508	.966	.934	.001	.922	.052	.376	.001	.577	.333	.001	NS	NS	14
K0608	–	–	–	–	–	–	–	–	–	–	–	–	–
K0808	.984	.969	.001	.963	.031	.755	.001	.908	.824	.001	.519	.001	14
K0908	.958	.918	.001	.896	.047	.725	.001	.834	.696	.001	.311	.001	20
K1008	–	–	–	–	–	–	–	–	–	–	–	–	–
K1108	–	–	–	–	–	–	–	–	–	–	–	–	–
K1208	–	–	–	–	–	–	–	–	–	–	–	–	–
K1408	–	–	–	–	–	–	–	–	–	–	–	–	–
K1508	.856	.732	.001	.672	.136	.446	.001	.534	.285	.001	NS	NS	18
K1608	.905	.820	.001	.790	.083	.329	.001	.622	.386	.001	NS	NS	14
K1808	–	–	–	–	–	–	–	–	–	–	–	–	–
K1908	.985	.970	.001	.961	.043	.321	.06	NS	NS	NS	NS	NS	20
K2008	–	–	–	–	–	–	–	–	–	–	–	–	–

TABLE 6.9 (cont'd)

WEEK 9 REGRESSION EQUATIONS GOODNESS OF FIT AND EXTRAPOLATION

	FALL TERM N = 105					EXTRAPOLATION - WINTER TERM N = 75							
	Multiple R	R^2	Sig.	Adjust R^2	Std. Dev. Resid.	R^{2*}	Sig.	Multiple R	R^2	Sig.	R^{2*}	Sig.*	Number of Variable
K2208	-	-	-	-	-	-	-	-	-	-	-	-	-
K2308	.802	.643	.001	.502	.083	.619	.001	.237	.056	.09	.059	.08	21
K2408	-	-	-	-	-	-	-	-	-	-	-	-	-
K2508	.679	.462	.001	.364	.211	NA	NA	NA	NA	NA	NA	NA	15
K2608	.715	.511	.001	.423	.338	NA	NA	NA	NA	NA	NA	NA	15
K2708	.736	.541	.001	.442	.156	NA	NA	NS	NS	NS	NA	NA	15
K2808	.588	.346	.001	.271	.239	NA	NA	NA	NA	NA	NA	NA	10
K2908	.756	.571	.001	.437	.198	NA	NA	NS	NS	NS	NA	NA	21
K3008	.759	.576	.001	.500	.333	NA	NA	NA	NA	NA	NA	NA	15
K3108	.602	.363	.001	.251	.405	NA	NA	NA	NA	NA	NA	NA	14
K3208	.728	.530	.001	.454	.158	NA	NA	NS	NS	NS	NA	NA	13
K3308	.735	.541	.001	.451	.242	NA	NA	NA	NA	NA	NA	NA	16

80 to 90 percent of the variation was explainable with 11 to 21 independent model variables. Removing the prior K variables (K0304, K0504, K0805, K0905, K1505, K1607, K1905 and K2307) from the regression equations results in a reduction of the explained variance to 32 to 62 percent. For the new K variables (K2508 to K3308) 35 to 54 percent of the variation is explainable using 13 to 21 independent model variables.

Extrapolating the quiz eight equations to the Winter term data resulted in a reduction of the explained variance. A range of about 6 to 82 percent of the variance within the dependent K variables is explainable using the full sets of independent variables mentioned in the previous paragraph. Removing the prior K variables as discussed above, reduces these percentages. Note, however, that 26 to 52 percent of the variation in K0308, K0808, and K0908 is still accounted for by the remaining independent variables. This indicates that much of the model is transferable from term to term.

6.10 Week Ten

The main emphasis of the instructional sessions of the final week of class was on the flow of energy through the ecosystem and population ecology. This served to unify most of the ecosystem concepts presented previously in the term. The lecture was devoted mainly to the introduction of the few remaining uncovered ecosystem concepts and to a complete and thorough review of the total ecosystem concept. This review was accomplished by interrelating all of the ecosystem concepts through the concepts of the flow of energy and the cycle of matter. The SASs, Tape Labs, and textbook readings all contributed to this final summary and review. Twenty-two items relating to ecosystems concepts were included on the Practice Quiz.

The ninth quiz given at the end of the tenth week contained items which allowed for the update of six K elements and the computation of initial K elements for eleven concepts (K0209, K0909, K2309, K2509, K3109, K3209 and K3409 to K4409, respectively). Table E.9 contains the regression equations for these K elements developed from the Fall term data.

WEEK TEN INSTRUCTIONAL VARIABLES

A pattern similar to that observed in the previous weeks emerges from the inspection of Table E.9. Students performing well on the K elements tended to have a lower attendance at lectures 7 and 10 (I_7, I_{10}) but higher in SAS 19. They also tended to use practice quiz nine but not ten (I_{50}, I_{51}), spent more time on Tape Lab 18 (I_{69}) and scored higher on the previous quiz (I_{107}).

PRIOR KNOWLEDGE

In terms of prior knowledge, the students demonstrating some mastery of the K elements for this week tended to understand the

rudiments of biological organization (B_{11}) on the pretest, as well as something about the definition of a niche (B_{39}), but not a practical example of the concept (B_{32}). Neither did they tend to understand the concept of food chain (B_{42}) or the relationship between respiration and photosynthesis in green plants (B_{43}). Positive correlations were found between the previous mastery of the concepts of ecosystem (K0201), niche (K3008) and community (K3108) and performance on the week 10 K elements. A negative correlation was found between the previous performance on the concept of biotic environment (K2608) and these K elements. Both positive and negative correlations were found between the week ten K variables and prior knowledge of the concepts of energy flow in the biosphere (B_{35}), metabolism (K1201), energy storage (K1405), life cycle (K2407), behavior (K2508) and population).

BACKGROUND

In terms of the Background and Affective questionnaire items, the students demonstrating some mastery on the week ten K elements tended to report that they had not taken the Physical Science Course for elementary education majors (B_{130}), did find resource books and magazines helpful in learning for science courses (B_{168}) but not films (B_{163}). They also reported that thoughts of doing poorly interfered with their test performance (B_{74}), that they did not count on friends for help in preparing for an exam (B_{81}) and that it was unwise to skip around on an exam to answer all the easy questions first (B_{88}).

Table 6.10 contains a summary of the parameters describing the goodness of fit and extrapolation for the regression equations developed from the week 10 data. For those K elements with prior information it was possible to account for between 83 and 98 percent of the variance using 12 to 22 independent model variables. Removing this prior

TABLE 6.10

WEEK 10 REGRESSION EQUATIONS GOODNESS OF FIT AND EXTRAPOLATION

	FALL TERM N = 105					EXTRAPOLATION - WINTER TERM N = 75						
	Multiple R	R^2	Sig.	Adjust R^2	Std. Dev. Resid.	R^{2*}	Sig.	Multiple R	R^2	Sig.	R^{2*}	Sig. *	Number of Variable
K0109	–	–	–	–	–	–	–	–	–	–	–	–	–
K0209	.941	.885	.001	.854	.066	.452	.001	.394	.115	.003	.101	.05	20
K0309	–	–	–	–	–	–	–	–	–	–	–	–	–
K0409	–	–	–	–	–	–	–	–	–	–	–	–	–
K0509	–	–	–	–	–	–	–	–	–	–	–	–	–
K0609	–	–	–	–	–	–	–	–	–	–	–	–	–
K0809	–	–	–	–	–	–	–	–	–	–	–	–	–
K0909	.978	.956	.001	.949	.030	.403	.001	.945	.892	.001	.124	.004	12
K1009	–	–	–	–	–	–	–	–	–	–	–	–	–
K1109	–	–	–	–	–	–	–	–	–	–	–	–	–
K1209	–	–	–	–	–	–	–	–	–	–	–	–	–
K1409	–	–	–	–	–	–	–	–	–	–	–	–	–
K1509	–	–	–	–	–	–	–	–	–	–	–	–	–
K1609	–	–	–	–	–	–	–	–	–	–	–	–	–
K1809	–	–	–	–	–	–	–	–	–	–	–	–	–
K1909	–	–	–	–	–	–	–	–	–	–	–	–	–
K2009	–	–	–	–	–	–	–	–	–	–	–	–	–

TABLE 6.10 (Con't.)

WEEK 10 REGRESSION EQUATIONS GOODNESS OF FIT AND EXTRAPOLATION

	FALL TERM N = 105							EXTRAPOLATION - WINTER TERM N = 75					
	Multiple R	R^2	Sig.	Adjust R^2	Std. Dev. Resid.	R^{2*}	Sig.	Multiple R	R^2	Sig.	R^{2*}	Sig.*	Number of Variable
K2209	-	-	-	-	-	-	-	-	-	-	-	-	-
K2209	-	-	-	-	-	-	-	-	-	-	-	-	-
K2309	.965	.931	.001	.912	.035	.475	.001	.878	.771	.001	.092	.05	20
K2409	-	-	-	-	-	-	-	-	-	-	-	-	-
K2509	.848	.719	.001	.633	.106	.578	.001	NA	NA	NA	NA	NA	22
K2609	-	-	-	-	-	-	-	-	-	-	-	-	-
K2709	-	-	-	-	-	-	-	-	-	-	-	-	-
K2809	-	-	-	-	-	-	-	-	-	-	-	-	-
K2909	-	-	-	-	-	-	-	-	-	-	-	-	-
K3009	-	-	-	-	-	-	-	-	-	-	-	-	-
K3109	.860	.739	.001	.683	.161	.259	.09	NA	NA	NA	NA	NA	16
K3209	.835	.698	.001	.564	.094	.683	.001	NS	NS	NS	NS	NS	27
K3309	-	-	-	-	-	-	-	-	-	-	-	-	-
K3409	.633	.401	.001	.305	.155	NA	NA	NS	NS	NS	NA	NA	13
K3509	.691	.478	.001	.381	.151	NA	NA	NA	NA	NA	NA	NA	14
K3609	.606	.367	.001	.294	.390	NA	NA	NA	NA	NA	NA	NA	10
K3709	.628	.394	.001	.286	.378	NA	NA	NA	NA	NA	NA	NA	14

TABLE 6.10 (Con't.)

WEEK 10 REGRESSION EQUATIONS GOODNESS OF FIT AND EXTRAPOLATION

	FALL TERM N = 105							EXTRAPOLATION - WINTER TERM N = 75					
	Multiple R	R^2	Sig.	Adjust R^2	Std. Dev. Resid.	R^{2*}	Sig.	Multiple R	R^2	Sig.	R^{2*}	Sig. *	Number of Variable
K3809	.750	.562	.001	.470	.323	NA	NA	NA	NA	NA	NA	NA	16
K3909	.745	.555	.001	.414	.167	NA	NA	NS	NS	NS	NA	NA	21
K4009	.794	.631	.001	.459	.101	NA	NA	.250	.063	.086	NA	NA	28
K4109	.804	.647	.001	.558	.186	NA	NA	NA	NA	NA	NA	NA	19
K4209	.783	.613	.001	.542	.267	NA	NA	NA	NA	NA	NA	NA	15
K4309	.699	.489	.001	.373	.311	NA	NA	NA	NA	NA	NA	NA	16
K4409	.745	.555	.001	.473	.310	NA	NA	NA	NA	NA	NA	NA	15

nformation (K0201, K0908, K2308, K2508, K3108, K3208) reduced the mount of the variance accounted for by the remaining independent ariables to between 26 and 63 percent. Extrapolation of these equaions onto the winter term data produced mixed results; from almost 0 o 89 percent of the variation accounted for with all the prior infor- ation, to 0 to 12 percent with the prior information removed. For he newly generated K elements (K3409 to K4409) between 37 and 64 per- ent of the variance was accounted for by between 10 and 28 variables. one of these equations were successfully extrapolated into the winter erm data.

.11 Final

The last set of model coefficients were based on those ecosystem concepts covered by items contained on the Final Exam (see Table 3.9). These test items contained the information necessary for the computational update of twenty-three ecosystem concept performance indices: K0310, K0610, K0810, K0910, K1010, K1410, K1510, K1610, K1910, K2010, K2210, K2310, K2710, K2910, K3210, K3410, K3610, K3710, K3910, K4010, K4110, K4210 and K4310. The coefficients relating these K elements to the model variables are shown in Table E.10.

PRIOR KNOWLEDGE

From Table E.10, the student successful on the final K elements may be characterized as having a prior knowledge of the (macro) flow of energy in the ecosystem (B_{35}, B_{41}), the definition of ecology (B_{18}), and relationships in the physical environment (B_{37}), but did not understand the flow of energy at the molecular level (B_{13}) or the concept of plant respiration (B_{42}). Both positive and negative correlations were found between the K elements and a pretest item testing the interpretation of an experiment (B_{23}), as well as general understanding of ecology (B_{51}). Throughout the term these students also demonstrated a mastery of the concepts of organism (K0106), matter cycle (K0308), organic molecule (K0808), inorganic molecule (K1005), photosynthesis (K1508), food chain or web (K2309), predation (K2808) and population growth/stability (K4009).

ACKGROUND

In terms of background the successful student may have been a ansfer student (B_{155}) but transferred few credits to MSU (B_3), tended have a positive attitude toward science (B_{149}) and, had little or no

previous college biology courses (B_{125}). These students also indicated that they felt that the study of class notes was very helpful in a science course (B_{171}) but that studying and discussing course material was not helpful. Both positive and negative correlations were found between K elements and the expectation of a high grade in the course.

From the Affective Questionnaire, the successful students tended to report that they become confused on tests or with intense study (B_{68}), that students should think how they are answering questions on a test (B_{85}) and look for helpful ideas for answering some questions on a test in other questions (B_{93}), that every word in a test question is important and, that it was not necessary to look over the entire test before starting (B_{89}). These students also reported that they enjoyed working with students who get good grades in class (B_{99}), but didn't need the encouragement of friends when they met with failure (B_{101}). These students may be characterized overall as fearing exams, somewhat dependent on friends and family for support, with a tendency to work well with others and very conservative (B_{117}).

INSTRUCTIONAL VARIABLES

It appears that the most successful of these students tended to attend the eighth lecture (I_8) (a week when attendance was low because of a holiday), and the second and ninth SASs (I_{13}, I_{20}). They used the fifth practice quiz (I_{47}) but not the first lecture tape (I_{32}), and tended to have retaken each of the nine practice quizzes in preparation for the final (I_{97}). These students also scored high on the second quiz (I_{101}).

GOODNESS OF FIT AND EXTRAPOLATION

Table 6.11 contains the parameters describing the goodness of fit and extrapolation of the model equations developed using the data from

FINAL REGRESSION EQUATIONS GOODNESS OF FIT
AND EXTRAPOLATION

	FALL TERM N = 105							EXTRAPOLATION - WINTER TERM N = 75					
	Multiple R	R^2	Sig.	Adjust R^2	Std. Dev. Resid.	R^{2*}	Sig.	Multiple R	R^2	Sig.	R^{2*}	Sig.*	Number of Variable
K0110	-	-	-	-	-	-	-	-	-	-	-	-	-
K0210	-	-	-	-	-	-	-	-	-	-	-	-	-
K0310	.987	.977	.001	.970	.032	.478	.001	.870	.756	.001	.051	.11	21
K0410	-	-	-	-	-	-	-	-	-	-	-	-	-
K0510	-	-	-	-	-	-	-	-	-	-	-	-	-
K0610	.972	.944	.001	.025	.051	.455	.003	.796	.633	.001	.138	.01	22
K0810	.984	.968	.001	.953	.032	.847	.001	.856	.733	.001	.472	.001	26
K0910	.977	.955	.001	.927	.037	.652	.001	.856	.733	.001	.107	.04	35
K1010	.985	.970	.001	.960	.041	.580	.001	.769	.591	.001	.280	.001	21
K1110	-	-	-	-	-	-	-	-	-	-	-	-	-
K1210	-	-	-	-	-	-	-	-	-	-	-	-	-
K1410	.968	.938	.001	.900	.062	.640	.001	.816	.666	.001	.044	.2	32
K1510	.978	.956	.001	.938	.053	.369	.061	.663	.440	.001	NS	NS	26
K1610	.970	.940	.001	.902	.046	.566	.003	.803	.645	.001	NS	NS	34
K1810	-	-	-	-	-	-	-	-	-	-	-	-	-
K1910	.949	.901	.001	.865	.082	.490	.001	.713	.509	.001	.143	.01	23
K2010	.960	.921	.001	.878	.076	.549	.001	.519	.270	.001	NS	NS	30

TABLE 6.11 (Con't.)

FINAL REGRESSION EQUATIONS GOODNESS OF FIT AND EXTRAPOLATION

	FALL TERM N = 105					EXTRAPOLATION - WINTER TERM N = 75						
	Multiple R	R^2	Sig.	Adjust R^2	Std. Dev. Resid.	R^{2*}	Sig.	Multiple R	R^2	Sig.	R^{2*}	* Sig.	Number of Variable
K2210	.920	.846	.001	.808	.086	.573	.001	NA	NA	NA	NA	NA	18
K2310	.955	.911	.001	.866	.042	.731	.001	.824	.679	.001	.054	.111	30
K2410	–	–	–	–	–	–	–	–	–	–	–	–	–
K2510	–	–	–	–	–	–	–	–	–	–	–	–	–
K2610	–	–	–	–	–	–	–	–	–	–	–	–	–
K2710	.954	.910	.001	.862	.060	.759	.001	.558	.312	.001	NS	NS	32
K2810	–	–	–	–	–	–	–	–	–	–	–	–	–
K2910	.929	.863	.001	.862	.060	.759	.001	.558	.312	.001	NS	NS	24
K3010	–	–	–	–	–	–	–	–	–	–	–	–	–
K3110	–	–	–	–	–	–	–	–	–	–	–	–	–
K3210	.958	.919	.001	.883	.048	.520	.001	.862	.743	.001	.040	.16	27
K3310	–	–	–	–	–	–	–	–	–	–	–	–	–
K3410	.945	.892	.001	.851	.070	.592	.001	.921	.848	.001	NS	NS	25
K3510	–	–	–	–	–	–	–	–	–	–	–	–	–
K3610	.950	.903	.001	.874	.095	.320	.08	NA	NA	NA	NA	NA	21
K3710	.952	.906	.001	.876	.096	.399	.01	NA	NA	NA	NA	NA	22
K3810	–	–	–	–	–	–	–	–	–	–	–	–	–

TABLE 6.11 (Con't.)

FINAL REGRESSION EQUATIONS GOODNESS OF FIT AND EXTRAPOLATION

	FALL TERM N = 105							EXTRAPOLATION - WINTER TERM N = 75					
	Multiple R	R^2	Sig.	Adjust R^2	Std. Dev. Resid.	R^{2*}	Sig.	Multiple R	R^2	Sig.	R^{2*}	Sig.*	Number of Variable
K3910	.906	.821	.001	.737	.090	.565	.001	.712	.507	.001	NS	NS	28
K4010	.954	.910	.001	.857	.043	.668	.001	.757	.573	.001	.084	.05	29
K4110	.906	.822	.001	.753	.105	.534	.001	NA	NA	NA	NA	NA	25
K4210	.859	.738	.001	.658	.179	.498	.001	NA	NA	NA	NA	NA	22
K4310	.941	.885	.001	.847	.094	.398	.01	NA	NA	NA	NA	NA	23
K4410	-	-	-	-	-	-	-	-	-	-	-	-	-

the fall term final exam. The twenty-three K elements calculated from the final exam items are all updates of previously developed K elements. When all the previous information is included, 74 to 98 percent of the variation in these elemtns is accounted for using 18 to 35 dependent model variables. Removing the previous information (K0308, K0606, K0808, K0909, K1005, K1405, K1508, K1608, K1908, K2005, K2206, K2309, K2708, K2908, K3209, K3409, K3609, K3709, K3909, K4009, K4109, K4209, and K4309) it is possible to account for 32 to 85 percent of the variation in the independent variables using the remaining dependent variables in each regression equation. This tends to be an improvement over the fit of previous week's equations. Note also that the standard deviations of the residuals have grown significantly smaller for the final version than they were in the early weeks of the course.

When the final equations were extrapolated to the winter term data, a fairly good fit was obtained using all the prior information in most cases. Thirty-one to eighty-five percent of the variation in the independent K elements is accounted for by the extrapolated equations where data was available to apply the extrapolation. Removing the prior information on each K element, reduces the goodness of fit considerably.

6.12 Summary

A summary of the goodness of fit of the final version of the course model to the Fall term data and extrapolation to the Winter data is provided in Table 6.12 For each K element the parameters describing the fit to the base and extrapolation term data are given. The number of times the equation was updated based on new weekly data throughout the course, and the last time the element was updated are also provided. This latter parameter is equal to the last two digits of the four digit "K" code used throughout this chapter (if the equation was updated based on week 3 this parameter is equal to 3; if based on the final it is equal to 10, etc.).

For eighteen of the forty K elements it was possible to account for over 90 percent of the variation using an average of 26 independent variables. For twenty-eight of the dependent K elements it was possible to account for over 70 percent of the variation using about the same number of independent model variables. Those K variables with the greatest amount of variation accounted for were also those for which there was sufficient information available from the weekly tests to provide a number of updatings throughout the term. For those variables which were based on information contained in only one weekly test, the amount of variation accounted for by the independent variables was proportionately less; about thirty-five to sixty percent of the dependent variable's variation.

The large proportion of accountable variance is slightly deceptive because in those instances where the K element was updated from one week to the next, the value of K element is based on a running sum. The K element for one week is equal to the sum of the previous week's K element adjusted for the number of contributing test items plus the values of

TABLE 6.12

GOODNESS OF FIT AND EXTRAPOLATION SUMMARY

			FALL TERM N = 105							EXTRAPOLATION-WINTER TERM N = 75					
K_i	Number of Weekly Updates[1]	Last Calculated Element[2]	Multiple R	R^2	Sig.	Adjust R^2	Std. Dev. Resid.	R^{2*}	Sig.	Multiple R	R^2	Sig.	R^{2*}	Sig.	Number of variables in the last calculated regression equation
K_1	2	6	.978	.956	.001	.948	.043	.144	.22	.896	.804	.001	NS	NS	14
K_2	2	9	.941	.885	.001	.854	.066	.452	.001	.394	.115	.003	.101	.05	20
K_3	5	10	.987	.977	.001	.970	.032	.478	.001	.870	.756	.001	.051	.11	21
K_4	4	7	.984	.968	.001	.963	.026	.439	.001	.997	.994	.001	NS	NS	10
K_5	3	8	.966	.934	.001	.922	.052	.376	.001	.577	.333	.001	NS	NS	14
K_6	3	10	.972	.944	.001	.925	.051	.455	.003	.796	.633	.001	.138	.01	22
K_8	6	10	.984	.968	.001	.953	.032	.847	.001	.856	.733	.001	.472	.001	26
K_9	8	10	.977	.955	.001	.927	.037	.652	.001	.856	.733	.001	.107	.04	35
K_{10}	4	10	.985	.970	.001	.960	.041	.580	.001	.769	.591	.001	.280	.001	21
K_{11}	1	1	.777	.604	.001	.391	.175	NA	NA	NA	NA	NA	NA	NA	29
K_{12}	1	1	.781	.611	.001	.412	.205	NA	NA	NA	NA	NA	NA	NA	28
K_{14}	4	10	.968	.938	.001	.900	.062	.640	.001	.816	.666	.001	.044	.2	32
K_{15}	4	10	.978	.956	.001	.938	.053	.369	.061	.663	.440	.001	NS	NS	26
K_{16}	5	10	.970	.940	.001	.902	.046	.566	.003	.803	.645	.001	NS	NS	34
K_{18}	1	3	.672	.452	.001	.341	.318	NA	NA	NA	NA	NA	NA	NA	16
K_{19}	3	10	.949	.901	.001	.865	.082	.490	.001	.713	.509	.001	.143	.01	23
K_{20}	2	10	.960	.921	.001	.878	.076	.549	.001	.519	.270	.001	NS	NS	30
K_{22}	2	10	.920	.846	.001	.808	.086	.573	.001	NA	NA	NA	NA	NA	18
K_{23}	4	10	.955	.911	.001	.866	.042	.731	.001	.824	.679	.001	.054	.111	30
K_{24}	1	7	.684	.468	.001	.388	.332	NA	NA	NA	NA	NA	NA	NA	13

[1] The number of weekly recalculations of the K element, excluding the Pretest.

[2] The last occurrence of the weekly recalculation; equal to the last two digits (CD) of the KABCD code.

TABLE 6.12 (Con't.)

GOODNESS OF FIT AND EXTRAPOLATION SUMMARY

			FALL TERM N = 105						EXTRAPOLATION-WINTER TERM N = 75					
K_i	Number of Weekly Updates[1]	Last Calculated Element[2]	Multiple R	R^2	Sig.	Adjunt R^2	Std. Dev. Resid.	R^{2*}	Sig.	Multiple R	R^2	Sig.	R^{2*}	Sig. *	Number of variables in the last calculated regression equation
K_{25}	2	9	.848	.719	.001	.633	.106	.578	.001	NA	NA	NA	NA	NA	22
K_{26}	1	8	.715	.511	.001	.423	.338	NA	NA	NA	NA	NA	NA	NA	15
K_{27}	2	10	.954	.910	.001	.862	.060	.759	.001	.558	.312	.001	NS	NS	32
K_{28}	1	8	.588	.346	.001	.271	.239	NA	NA	NA	NA	NA	NA	NA	10
K_{29}	2	10	.929	.863	.001	.816	.103	.451	.003	.877	.769	.00	NS	NS	24
K_{30}	1	8	.759	.576	.001	.500	.333	NA	NA	NA	NA	NA	NA	NA	15
K_{31}	2	9	.860	.739	.001	.683	.161	.259	.09	NA	NA	NA	NA	NA	16
K_{32}	3	10	.958	.919	.001	.883	.048	.520	.001	.862	.743	.001	.040	.16	27
K_{33}	1	8	.735	.541	.001	.451	.242	NA	NA	NA	NA	NA	NA	NA	16
K_{34}	2	10	.945	.892	.001	.851	.070	.592	.001	.921	.848	.001	NS	NS	25
K_{35}	1	9	.691	.478	.001	.381	.151	NA	NA	NA	NA	NA	NA	NA	14
K_{36}	2	10	.950	.903	.001	.874	.095	.320	.08	NA	NA	NA	NA	NA	21
K_{37}	2	10	.952	.906	.001	.876	.096	.399	.01	NA	NA	NA	NA	NA	22
K_{38}	1	9	.750	.562	.001	.470	.323	NA	NA	NA	NA	NA	NA	NA	16
K_{39}	2	10	.906	.821	.001	.737	.090	.565	.001	.712	.507	.001	NS	NS	28
K_{40}	2	10	.954	.910	.001	.857	.043	.668	.001	.757	.573	.001	.084	.05	29
K_{41}	2	10	.906	.822	.001	.753	.105	.534	.001	NA	NA	NA	NA	NA	25
K_{42}	2	10	.859	.738	.001	.658	.179	.498	.001	NA	NA	NA	NA	NA	22
K_{43}	2	10	.941	.885	.001	.847	.094	.398	.01	NA	NA	NA	NA	NA	23
K_{44}	1	9	.745	.555	.001	.473	.310	NA	NA	NA	NA	NA	NA	NA	15

[1] The number of weekly recalculations of the K element, excluding the Pretest.

[2] The last occurrence of the weekly recalculation; equal to the last two digits (CD) of the KABCD code.

new test items divided by the total number of test items involved to normalize the variable. The K element is directly related computationally to the previous week's K element and thus correlated. The R^{2*} column in Table 6.12 contains the proportion of variance accounted for by the independent variables in each regression equation excluding the previous K element for each entry. Here, for the majority of K elements, the accountable variation falls into the 40 to 60 percent range. Since it is not realistic to entirely eliminate the effects of specific previous knowledge any more than it is to color the interpretation of the results by a deliberate computational bias, the amount of variation in the K elements accounted for by the independent model variables probably lies somewhere above the R^{2*} values and below the R^2 values for Fall term. The mean value for $R^2 + R^{2*}/2$ is .654[1], indicating that for Fall term on the average about 65 percent of the variation in concept mastery is accounted for by variables representing cognitive and affective background and instructional behavior. Recall that Bloom estimated that up to 65 percent of school achievement may be accounted for by cognitive and affective entry characteristics.

Looking at the parameters describing the extrapolation of the model to the Winter term data in Table 6.12, the same pattern as described above is again apparent. Of the twenty-one K elements which the model could be applied to, 70 percent or more of the variance was accounted for by the independent model variables for eight K elements; and 50 percent

---

1) for those values or R^{2*} listed as NA no previous K elements were available to drop from the regression equations; for the mean calculated above R^{2*} was set equal to R^2.

or more for 16. Removing the previous week's K elements from the equations decreases the accountable variation precipitously. Only two entries in the R^{2*} column represent accountable variations over 20 percent. The mean value for $R^2 + R^{2*}/2$ for the extrapolation term is .337, indicating that on the average the model developed on Fall data accounted for about 34 percent of the variation in the relevant mastery variables collected Winter term.

BS 202 was not taught by the same instructor Winter term as Fall term, nor was the course taught and organized in exactly the same manner. Presumably, if the course had been taught in precisely the same manner both terms, the model equations developed from the Fall term data would have fit the Winter data much better than demonstrated in this study. However, the approximately "34% fit" of the model to the Winter data does provide evidence supporting the contention that the routine within a course and its effect on learning may be modeled, and that modeling has some validity across terms.

6.13 Synopsis

Tables 6.13, 6.14 and 6.15 contain a summary of the major relationships between model variables. Table 6.13 contains the major relationships between the background variables (B) and (K). A "1+" in the table indicates that for one of the weeks a positive model relationship was indicated between a B element and a K element ($K \propto +B$). Likewise a "1-" indicates a negative relationship. A "1±" or other combinations indicates that both positive and negative relationships occurred during differnt weeks (only those relationships with coefficient weights equal to or greater than 0.050 are shown in Tables 6.13, 6.14 and 6.15) An inspection of Table 6.13 shows that most of the first 209 background variables were

related to concept item performance--that is, item performance was related to previous performance in college (B_1 - B_{10}), prior knowledge (B_{11} - B_{60}) (although the pretest factors contributed little), affective characteristics (B_{61} - B_{116}), and many items of miscellaneous background (B_{117} - B_{209}). College entry level tests, such as the ACT and SAT (B_{210}-B_{236}) did not play a useful role in the model.

Table 6.14 contains the relationships between the instructional variables (K) and the concept knowledge indices (I) in the same format as Table 6.13. Here it is obvious that some instructional variables play a larger role than others. For instance, attendance during the first lecture (I_1) and the second small assembly session (I_{13}) appear to have a significant influence on many of the fist ten ecosystem concepts presented (K_1 - K_{10}). Other I elements such as the use of practice quiz 9 (I_{50}) appear to have a greater effect on the mastery of latter concepts.

Table 6.15 contains the relationships between concept performance (K') and prior concept performance (K) in the same fashion as used in Tables 6.13 and 6.14. Note here that the strong relationships shown along the diagonal (top left to bottom right) indicates the expected relationships between current learning and previous knowledge. The many off-diagonal positive and negative correlational occurances indicates the relationsips between inter-connected concepts.

TABLE 6.13

Frequency of Correlational Occurrences:
Background Variables, (B)
vs. Concept Knowledge Indices (K)

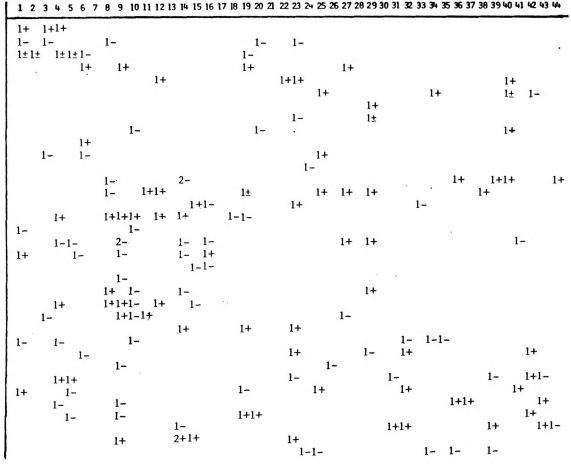


TABLE 6.13 (cont.)

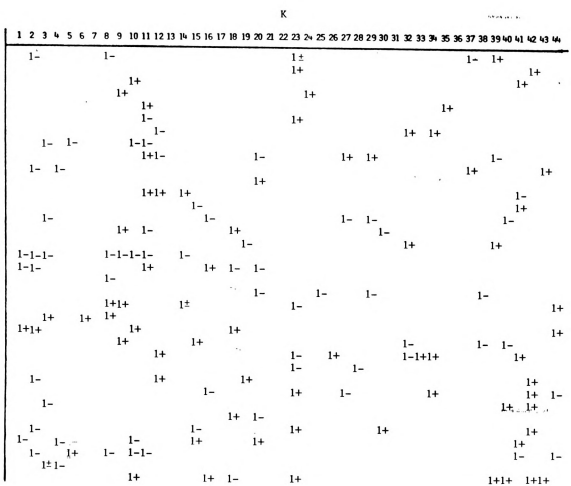


TABLE 6.13 (cont.)

K

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
83			1+						1+					1+																														
84																						1−																					
85																								1−												1+						1−	
86				1+														1+																									
87	1+									1+					1+							1−									1−1−											1−	
88																														1+						1+1+							1+
89												1−							1+																				1+				
90															1−			1−				1−												1−			1+1+						
91															1+																									1−1−			
92					1+		1+													1+			1−	1−																			
93																1+							1+		1+															1−		1−	
94	1+		1−1−					1−												1−											1+												
95																																		1−									
96								1+1+1+						1+																														
97																	1+																			1−		1−1−1+				
98										1−1+1+				1−1+					1−																								
99			1−											1+								1−																					
100				1−				1−	1−										1+											1+												
104																														1−													
102								1−																											1+							
106																1−																										
105								1−							1+																					1−	1−						
106															1+1+										1+																		
107				1+				1−1+		1−1−					1+1+										1−1+											1+					1+		
108			1+1+						1+													1−																				1−	
109			1+					1+	1+																																		
111																			1+																								
112																								1+										1+									
113																						1−														1−1−						
115														1−																					1−						1−		
116				1+1+					1+		1−			1−					1+			1−																					
117					1+										1−																											1±		
118																																											
119																						1+																					
121																																											

TABLE 6.13 (cont.)

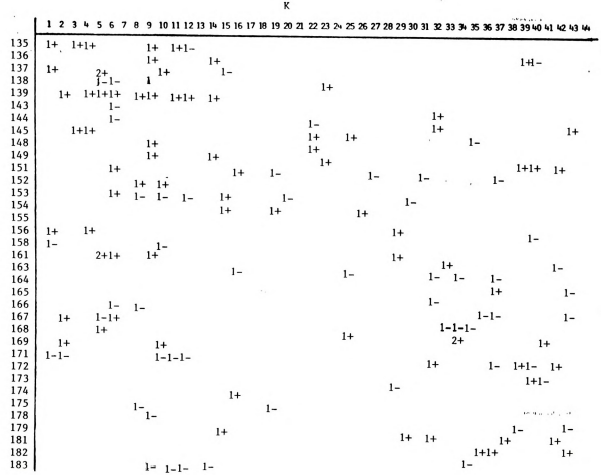


TABLE 6.13 (cont.)

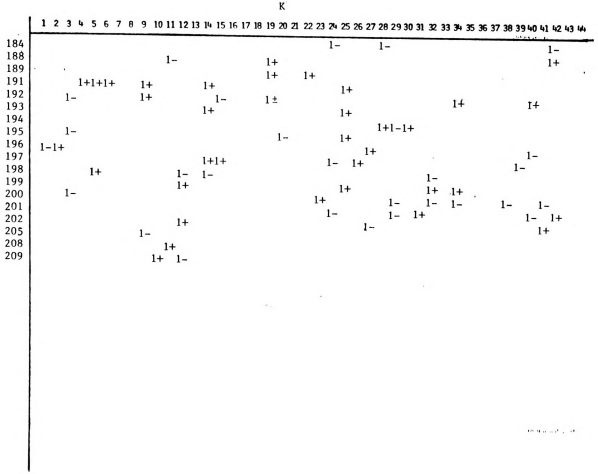


TABLE 6.14
Frequency of Correlational Occurrences:
Instructional Variables (I) vs Concept Knowledge Indices (K)

K

I	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
1	1+		1+	1+	1+			1+																		1+																		
2															1-																														
4																																	1-		1-						1-1-			
5																			1+																	1+					1+			
6																									1-1-		1-		1-1-															
7																					1-							1-						1-				1-1+					
8																					1+																						
9																					1-1-					1+																	
10																					1-					1-		1-										2-			2-		
11																																												
12																										1+																		
13	1+		1+	1+	1+	1+		1+							1+																									1+			
15							1+	1+																																				
17																																						1+						
20																																												
22																			1+			1+																						
23			1+																							1-	1-																	
24															1+																														
25																																	1-	1+										
27																									1-			1+			1-					1-		1+						
28																			1+						1+						1-		1-										
29																																												
30																						1+									1+												
31																																					1+1+						
32					1-																							1+															
34																1-																					1-						
35																																					1-						
38														1-								1-1-			1-	1-																	
39																																	1+					1+					
40														1+											1+	1+	1+																	
41														1-																														
42																																												
47															1+						1+																					1+		
48																					1-																						1+	
49																																	1+										

TABLE 6.14 (cont.)

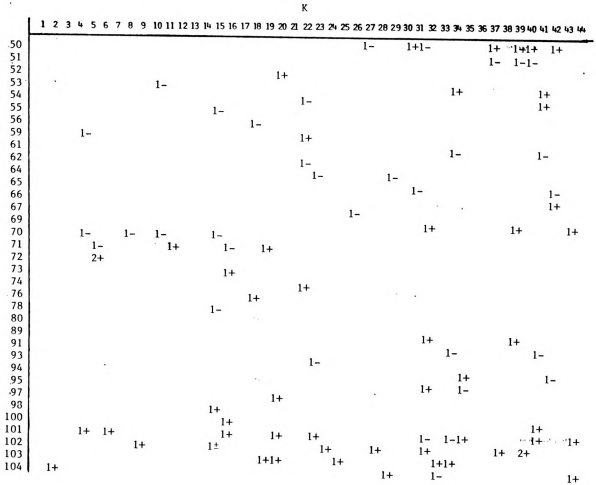


TABLE 6.14 (cont.)

K

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
105																									1+						1+														
106																																													
107																																1+				1+	1+			1+				
108																													1+																

TABLE 6.15

Frequency of Correlational Occurrences:
Concept Performance (K') vs Prior Performance (K)

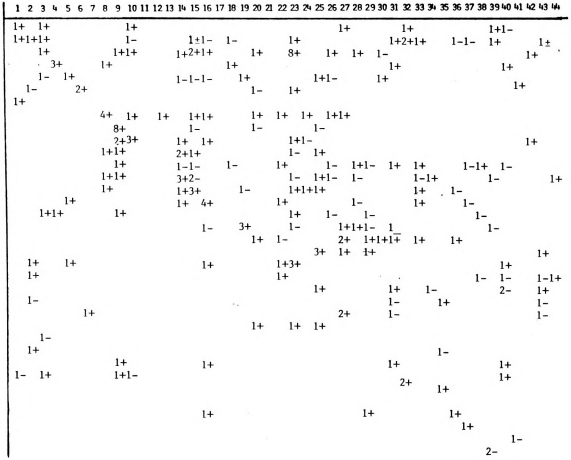
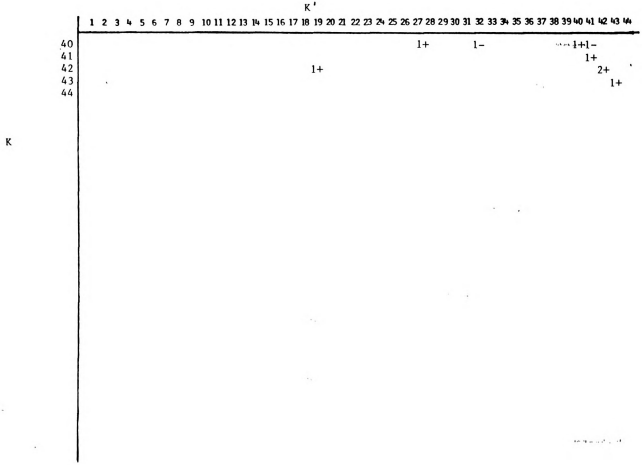


TABLE 6.15 (cont.)



CHAPTER 7

APPLICATIONS -AN EXAMPLE

There are a number of situations in which a course model of the type developed in this study might be applied. If a course was offered and taught regularly by the same instructor in a manner and with a syllabus unvarying from term to term a model of this type could be developed and implemented as a quality control monitor and feedback mechanism. Regular processing of the information collected on the students through the model would produce predictions on probable student performance in the course, much in the same manner as the model "predicted" student performance in the Winter term for the current study. The instructor on a regular basis throughout the term could suggest possible corrective remediation for those students which were predicted to have difficulty with certain aspects of the course. The model in this situation would serve as an instrument to improve course efficiency and productivity.

Another possible use of a model of this type is in the formulation and investigation of research questions. The model provides a conceptual structure which will fit any type of complex, sequential instruction. Given that a large number of variables are involved in the processes and phenomena in question, the modeling methodology provides a method for isolating those variables strongly related to the dependent variables under study. Once these "strong" components are isolated, the more subtle interactions may be investigated and isolated with further experimentation and standard statistical techniques.

To demonstrate the usefulness of the modeling scheme, a combination of the two previous suggestions was undertaken using the BS 202 course model developed in this study. This demonstration employs the model both in a variation of the "quality control" feedback mechanism and as a "first stage" investigatory tool.

As mentioned earlier, one of the perennial problems in BS 202 is the large number of students in the course who do not achieve the level of mastery of biological science desirable for elementary teachers, although they do receive a passing grade. Many components have been added to the course over the years it has been taught to improve student performance. Still there are students that perform at a level inadequate for their intended profession.

A possible new approach to this problem would be to divide the incoming student class into groups based on specific individual academic inadequacies or instructional behaviors and modify or supplement the instruction given each group to improve student performance. It might be possible to isolate members of the class that are poor readers, for instance, and provide the group with instruction which minimizes the effect of reading on performance in the course. Another group might be found which has poor study skills. These individuals might be provided with supplemental instruction to improve their study of biological science. Unfortunately, previous attempts at the identification of such groups have met with little success.

The BS 202 course model is based on a large amount of information on student behavior and background. If definite and meaningful student groups exist within the class, it is probable that this information contains parameters useful in identifying those groups. It is also possible that those variables which consistently appear as the "strong" correlates

in the regression model detailed in Chapter 6 and Appendix E are related to the grouping parameters. If such was the case, then by using these variables groups within the class could be identified and characterized. Furthermore, if these variables were all measured within the first week or two of the term, then the groups could be identified in time to apply modified, supplemental, or remedial instruction for the remainder of the term and perhaps improve student performance.

What was done here to illustrate an application of the model was to search through those variables which appeared as strong correlates with the dependent performance variables and choose from among them those which were collected early in the time schedule of the course. Using this subset of variables strongly related to performance students were sorted into several groups based on similarities in the values of the variables used. The students assigned to each group were then very similar to one another on many of these characteristics measured by variables available early in the term. Dissimilarities on these characteristics were apparent between groups. At that point, the complete variable profiles of the students in each group were analyzed for similarities. While the variables used to initially group students reflected characteristics measured early in the course, this analysis of the entire profile provided more information on and insight into the nature of each group. Thus students were first grouped according to characteristics measurable early in the learning process, then student information reflecting characteristics measured throughout the entire course process were examined and analyzed. This analysis of the total information available on each student produced broad group profiles and suggestions or hypotheses on how the learning performance of each group could be improved or supplemented.

An inspection of the tables containing the model coefficients in Appendix E confirms that there are indeed a number of variables which appear as strong correlates with the performance indices throughout the term. There are at least forty-two such strong variables which are available within the first two weeks of the term. These forty-two variables are listed in Table 7.1 with a description of the general grouping parameters to which each contributes. These variables reflect previous academic performance, prior knowledge of biology, testwiseness, test anxiety, attitudes, expectations, and learning preferences. The last three variables indicate instructional behavior and performance.

To locate the meaningful student groups the forty-two variables were used as grouping variables in the Veldman (1967) Hierarchial Grouping Analysis computer program (HGROUP) located on the University of Michigan computer and available through the MERIT Network. This program groups N cases in N-1 to 2 groups through an algorithm which assigns cases to groups in an attempt to maximize the average intergroup distance while minimizing the average intragroup distance. The HGROUP program deals with profile similarity and groups cases based on a minimal increase in within-group variation at each step. Table 7.2 contains the HGROUP clustering of 94 students from the Fall term, beginning with the formation of twelve groups from thirteen. Eleven students were not included in the grouping analysis because of the unusually large amount of missing data in these students' profiles, thereby decreasing N from 105 to 94. Student cases in Table 7.2 are represented by a one to three digit code followed by a "C". Table 7.2 does not provide any information on the first eighty grouping steps; from 93 groups to 13 groups. Starting with the twelfth grouping, the most similar groups are combined forming 11, 10, 9, etc., groups. Each absorption of one group by another increases

TABLE 7.1

GROUPING VARIABLES

VARIABLE	ACRONYM	GENERAL GROUPING PARAMETER
B_3	TRCR	Transfer Credits
B_6	MSUPTS	Previous Academic Performance
B_{18}	PRE008	General Knowledge, Ecology
B_{19}	PRE009	Specific Knowledge, Ecology
B_{23}	PRE013	Knowledge and Application, Biology
B_{28}	PRE018	General Knowledge, Ecology
B_{35}	PRE025	Specific Knowledge, Ecology
B_{41}	PRE031	General Knowledge, Ecology
B_{42}	PRE032	General Knowledge, Biology
B_{63}	AFF003	Test Anxiety
B_{67}	AFF007	Test Anxiety
B_{68}	AFF008	Test Anxiety
B_{71}	AFF011	Test Anxiety
B_{74}	AFF014	Test Anxiety
B_{81}	AFF021	Test Wiseness
B_{85}	AFF025	Test Wiseness
B_{87}	AFF027	Test Wiseness
B_{89}	AFF029	Test Wiseness
B_{90}	AFF030	Test Wiseness
B_{92}	AFF032	Test Wiseness
B_{93}	AFF033	Test Wiseness
B_{94}	AFF034	Test Wiseness
B_{98}	AFF038	Peer Orientation
B_{107}	AFF047	Peer Orientation
B_{108}	AFF048	Peer Orientation
B_{123}	BKG004	Biology Background
B_{125}	BKG006	Biology Background
B_{126}	BKG007	Attitude Toward Biology
B_{131}	BKG012	Science Background
B_{135}	BKG016	Science Background
B_{138}	BKG019	Mathematics Background

TABLE 7.1 (Continued)

VARIABLE	ACRONYM	GENERAL GROUPING PARAMETER
B_{149}	BKG030	Attitude Toward Science
B_{151}	BKG032	Expectations in Course
B_{152}	BKG033	Expectations in Course
B_{153}	BKG034	Previous Academic Performance
B_{161}	BKG042	Learning Profile
B_{168}	BKG049	Learning Profile
B_{171}	BKG052	Learning Profile
B_{175}	BKG056	Learning Profile
I_{1}	LEC001	Lecture Attendance
I_{70}	ONE031	Practice Quiz Usage
I_{101}	Q2	Performance on Quiz Two

TABLE 7.2
HIERARCHICAL GROUPING ANALYSIS OUTPUT
(VELDMAN'S H GROUP)

```
12 GROUPS AFTER COMBINING G  6 (N= 16) AND G 42 (N=  3). ERROR =   75.8000
G  1 (N= 4)   1C   53C   67C   89C
G  2 (N= 25)  2C    5C    6C   14C   15C   30C   47C   43C   44C   45C   46C   60C   62C
              66C   71C   76C   77C   78C   81C   91C   94C  100C  102C  103C  104C
G  4 (N=  3)  5C   87C   96C
G  6 (N= 17)  7C   14C   23C   24C   25C   31C   36C   38C   4CC   48C   50C   52C   55C
              74C   92C   93C  105C
G  7 (N= 11)  8C   22C   34C   42C   59C   64C   68C   86C   91C  101C
G  8 (N=  5)  9C   19C   29C   56C   70C
G  9 (N= 11)  10C  11C   26C   27C   28C   69C   75C   83C   84C   97C   99C
G 11 (N=  4)  12C  37C   57C   70C
G 16 (N=  4)  19C  67C   85C   88C
G 17 (N=  5)  20C  49C   72C   79C   82C
G 18 (N=  4)  21C  32C   61C   65C
G 31 (N=  2)  35C  58C

11 GROUPS AFTER COMBINING G  9 (N= 11) AND G 17 (N=  5). ERROR =   82.3746
G  1 (N= 4)   1C   53C   67C   89C
G  2 (N= 25)  2C    5C    6C   14C   15C   30C   47C   43C   44C   45C   46C   60C   62C
              66C   71C   76C   77C   78C   81C   90C   94C  100C  102C  103C  104C
G  4 (N=  3)  5C   87C   96C
G  6 (N= 17)  7C   14C   23C   24C   25C   31C   36C   38C   4CC   48C   50C   52C   55C
              74C   92C   93C  105C
G  7 (N= 10)  8C   22C   34C   42C   59C   64C   68C   86C   91C  101C
G  8 (N=  5)  9C   19C   29C   56C   70C
G  9 (N= 16)  10C  11C   20C   26C   27C   28C   49C   69C   73C   75C   79C   82C   83C
              84C   97C   99C
G 11 (N=  4)  12C  37C   57C   70C
G 16 (N=  4)  19C  67C   85C   88C
G 18 (N=  4)  21C  32C   61C   65C
G 31 (N=  2)  35C  58C

10 GROUPS AFTER COMBINING G  2 (N= 25) AND G  7 (N= 10). ERROR =   84.3652
G  1 (N= 4)   1C   53C   67C   89C
G  2 (N= 35)  2C    5C    6C   8C    14C   15C   22C   30C   34C   41C   42C   43C   44C
              45C   46C   59C   60C   62C   64C   68C   69C   71C   76C   77C   78C   81C
              86C   90C   91C   94C  100C  101C  102C  103C  104C
G  4 (N=  3)  5C   87C   96C
G  6 (N= 17)  7C   14C   23C   24C   25C   31C   36C   38C   40C   48C   50C   52C   55C
              74C   92C   93C  105C
G  8 (N=  5)  9C   19C   29C   56C   70C
G  9 (N= 16)  10C  11C   20C   26C   27C   28C   49C   69C   73C   75C   79C   82C   83C
              84C   97C   99C
G 11 (N=  4)  12C  37C   57C   70C
G 16 (N=  4)  19C  67C   85C   88C
G 18 (N=  4)  21C  32C   61C   65C
G 31 (N=  2)  35C  58C

 9 GROUPS AFTER COMBINING G  9 (N= 16) AND G 11 (N=  4). ERROR =   85.0164
G  1 (N= 4)   1C   53C   67C   89C
G  2 (N= 35)  2C    3C    6C    8C    14C   15C   22C   30C   34C   41C   42C   43C   44C
              45C   46C   59C   60C   62C   64C   68C   69C   71C   76C   77C   78C   81C
              86C   90C   91C   94C  100C  101C  102C  103C  104C
G  4 (N=  3)  5C   87C   96C
G  6 (N= 17)  7C   14C   23C   24C   25C   31C   36C   38C   40C   48C   50C   52C   55C
              74C   92C   93C  105C
G  8 (N=  5)  9C   19C   29C   56C   70C
G  9 (N= 20)  10C  11C   12C   20C   24C   26C   27C   28C   37C   49C   57C   69C   70C   73C
              75C   79C   82C   83C   84C   97C   99C
G 16 (N=  4)  19C  67C   85C   88C
G 18 (N=  4)  21C  32C   61C   65C
G 31 (N=  2)  35C  58C

 8 GROUPS AFTER COMBINING G  1 (N=  4) AND G  4 (N=  3). ERROR =   93.3180
G  1 (N= 7)   1C    5C   53C   67C   87C   89C   96C
G  2 (N= 35)  2C    3C    6C    8C    14C   15C   22C   30C   34C   41C   42C   43C   44C
              45C   46C   59C   60C   62C   64C   68C   69C   71C   76C   77C   78C   81C
              86C   90C   91C   94C  100C  101C  102C  103C  104C
G  6 (N= 17)  7C   14C   23C   24C   25C   31C   36C   38C   40C   48C   50C   52C   55C
              74C   92C   93C  105C
G  8 (N=  5)  9C   19C   29C   56C   70C
G  9 (N= 20)  10C  11C   12C   20C   24C   26C   27C   28C   37C   49C   57C   69C   70C   73C
              75C   79C   82C   83C   84C   97C   99C
G 16 (N=  4)  19C  67C   85C   88C
G 18 (N=  4)  21C  32C   61C   65C
G 31 (N=  2)  35C  58C

 7 GROUPS AFTER COMBINING G  2 (N= 35) AND G  8 (N=  5). ERROR =  107.8966
G  1 (N= 7)   1C    5C   53C   67C   87C   89C   96C
G  2 (N= 40)  2C    3C    6C    8C    9C    14C   15C   19C   22C   29C   30C   34C   41C
              42C   43C   44C   45C   46C   56C   59C   60C   62C   64C   66C   68C   71C
              76C   77C   78C   80C   81C   86C   90C   91C   94C  100C  101C  102C  103C
              104C
G  6 (N= 17)  7C   14C   23C   24C   25C   31C   36C   38C   40C   48C   50C   52C   55C
              74C   92C   93C  105C
G  9 (N= 20)  10C  11C   12C   20C   26C   27C   28C   37C   49C   57C   69C   70C   73C
              75C   79C   82C   83C   84C   97C   99C
G 16 (N=  4)  19C  67C   85C   88C
G 18 (N=  4)  21C  32C   61C   65C
G 31 (N=  2)  35C  58C
```

ΔE

6.6

2.0

0.6

8.3

14.6

8.5

TABLE 7.2 cont'd.

```
 6 GROUPS AFTER COMBINING G  2 (N= 40) AND G  6 (N= 17). ERROR =  116.3689
G  1 (N=  7)    1C    5C    53C   67C   87C   89C   96C
G  2 (N= 57)    2C    3C    6C    7C    8C    9C   14C   15C   16C   18C   22C   23C   24C
                25C   29C   3CC   31C   34C   36C   38C   40C   41C   42C   43C   44C   45C
                46C   48C   50C   52C   55C   56C   59C   60C   62C   64C   66C   68C   71C
                74C   76C   77C   78C   80C   81C   86C   90C   91C   92C   93C   94C   100C
                101C  102C  103C  104C  105C
G  9 (N= 20)    10C   11C   12C   20C   26C   27C   29C   37C   49C   57C   69C   7CC   73C
                75C   79C   82C   83C   84C   97C   99C
G 16 (N=  4)    19C   63C   85C   88C
G 18 (N=  4)    21C   32C   61C   65C                                                        6.0
G 31 (N=  2)    35C   58C

 5 GROUPS AFTER COMBINING G  9 (N= 20) AND G 18 (N=  4). ERROR =  122.3687
G  1 (N=  7)    1C    5C    53C   67C   87C   89C   96C
G  2 (N= 57)    2C    3C    6C    7C    8C    9C   14C   15C   16C   18C   22C   23C   24C
                25C   29C   3CC   31C   34C   36C   38C   40C   41C   42C   43C   44C   45C
                46C   48C   50C   52C   55C   56C   59C   60C   62C   64C   66C   68C   71C
                74C   76C   77C   78C   80C   81C   86C   90C   91C   92C   93C   94C   100C
                101C  102C  103C  104C  105C
G  9 (N= 24)    10C   11C   12C   20C   21C   26C   27C   28C   32C   37C   49C   57C   61C
                65C   69C   7CC   73C   75C   79C   82C   83C   84C   97C   99C                4.0
G 16 (N=  4)    19C   63C   85C   88C
G 31 (N=  2)    35C   58C

 4 GROUPS AFTER COMBINING G  2 (N= 57) AND G 16 (N=  4). ERROR =  126.3512
G  1 (N=  7)    1C    5C    53C   67C   87C   89C   96C
G  2 (N= 61)    2C    3C    6C    7C    8C    9C   14C   15C   16C   18C   19C   22C   23C
                24C   25C   29C   3CC   31C   34C   36C   38C   40C   41C   42C   43C   44C
                45C   46C   48C   50C   52C   55C   56C   59C   60C   62C   63C   64C   66C
                68C   71C   74C   76C   77C   78C   80C   81C   85C   86C   88C   9 C   91C
                92C   93C   94C   100C  101C  102C  103C  104C  105C
G  9 (N= 24)    10C   11C   12C   20C   21C   26C   27C   28C   32C   37C   49C   57C   61C
                65C   69C   7CC   73C   75C   79C   82C   83C   84C   97C   99C                4.5
G 31 (N=  2)    35C   58C

 3 GROUPS AFTER COMBINING G  2 (N= 61) AND G 31 (N=  2). ERROR =  136.9125
G  1 (N=  7)    1C    5C    53C   67C   87C   89C   96C
G  2 (N= 63)    2C    3C    6C    7C    8C    9C   14C   15C   16C   18C   19C   22C   23C
                24C   25C   29C   3JC   31C   34C   36C   38C   40C   41C   42C   43C
                45C   46C   48C   50C   52C   55C   56C   59C   60C   62C   63C
                64C   66C   68C   71C   74C   76C   77C   78C   80C   81C   85C   86C
                88C   9 C   91C   92C   93C   94C   100C  101C  102C  103C  104C  105C
G  9 (N= 24)    10C   11C   12C   20C   21C   26C   27C   28C   32C   37C   49C   57C   61C  11.0
                65C   69C   7CC   73C   75C   79C   82C   83C   84C   97C   99C

 2 GROUPS AFTER COMBINING G  1 (N=  7) AND G  2 (N= 63). ERROR =  141.9141
G  1 (N=  7)    1C    2C    3C    5C    6C    7C    8C    9C   14C   15C   16C   18C   19C
                22C   23C   24C   25C   29C   3CC   31C   34C   35C   36C   38C   40C   41C
                42C   43C   44C   45C   46C   48C   50C   52C   53C   55C   56C   58C   59C
                60C   62C   63C   64C   66C   67C   68C   71C   74C   76C   77C   78C   80C
                81C   85C   86C   87C   88C   89C   90C   91C   92C   93C   94C   96C   100C
                101C  102C  103C  104C  105C
G  9 (N= 24)    10C   11C   12C   20C   21C   26C   27C   28C   32C   37C   49C   57C   61C
                65C   69C   7CC   73C   75C   79C   82C   83C   84C   97C   99C

END OF FILE ON *MSOURCE* CAUSES A RETURN TO MTS.
EXECUTION TERMINATED   21:17:04  T=1.623  BC=0        $.97

$SIG
```

the total within-group error. Notice that the largest absolute increase in error (Δ E) for these grouping steps occurs when 8 groups are combined to form 7 groups. For the purposes here, it is assumed that the 8 groups represent an "optimal" aggregation of individuals on the forty-two grouping variables. Thus, the grouping analysis has prodiced eitht groups of students with maximized intragroup similarities. Tables 7.3 and 7.4 contain the group profiles across the forty-two grouping variables.

After the development of the eight distinct groups the entire array of background, instructional and performance data contained within the B, I, and K matrices was examined for within-group similarities and between-group differences. A number of similarities within each group was found as well as many between-group differences. The fact that students within each group are similar not only on the grouping variables but also on many other variables as well indicates that the groupings are in some sense legitimate, and may provide a clue to improved instruction in the course. The next section contains a profile of each group based on the examination of the entire store of model information. The group profiles are presented as general descriptors or characteristics of the group as a whole which are based on the tendencies of the students in the group on a large number of variables.

The suggestions for group performance improvement presented at the end of each profile discussion are based both on group tendencies and a comparison of the more successful students in each group with the less successful ones. Such suggestions are of course hypotheses in need of testing through future studies.

TABLE 7.3
VALUES OF GROUPING VARIABLES B_{18} THROUGH I_{70}
BY GROUP NUMBERS

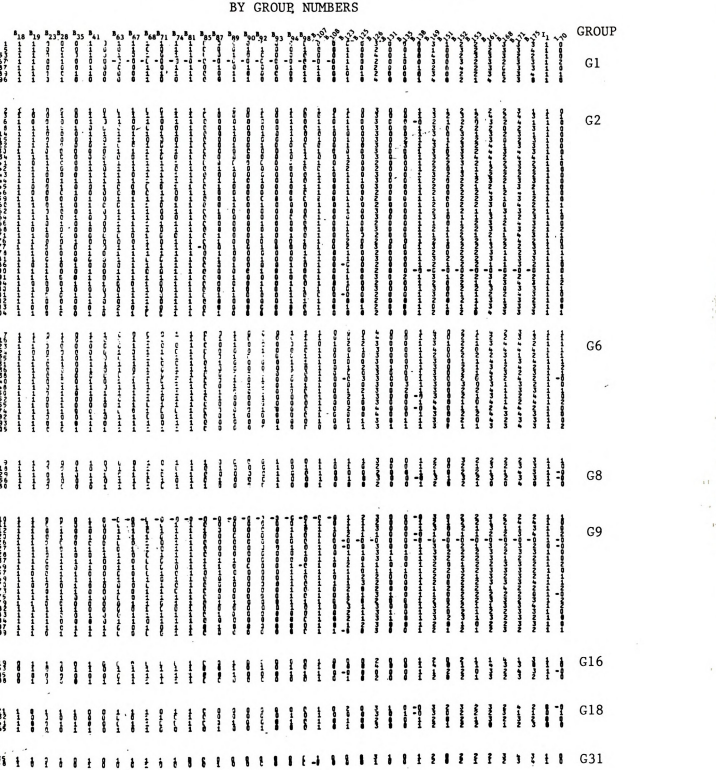


TABLE 7.4

VALUES OF GROUPING VARIABLES B_3, B_6, I_{101}

BY GROUP NUMBER

STUDENT CASE NUMBER	B_3	B_6	I_{101}	GROUP NUMBER
1	40	3045	20	
5	12	2005	24	
53	0	715	20	G1
67	0	1925	25	
87	0	1735	23	
89	0	1865	26	
96	0	3365	24	
2	6	1245	23	
3	0	1780	22	
6	6	1915	21	
8	8	910	18	
14	0	2575	23	
15	0	930	18	
22	0	1430	21	G2
30	0	2880	13	
34	0	755	19	
41	0	1650	17	
42	0	2670	24	
43	0	2375	21	
44	0	4100	22	
45	0	2570	27	
46	0	2235	18	
59	0	1105	16	
60	14	2430	24	
62	0	2360	25	
64	0	2825	22	
66	90	1725	20	
68	0	2055	20	
71	0	2910	19	
76	0	1905	24	
77	36	3085	18	
78	0	2070	20	
81	0	4450	17	
86	63	1540	22	
90	0	1995	19	
91	0	2380	24	
94	0	2690	16	
100	0	2285	22	
101	34	1750	25	
102	0	2195	25	
103	0	0	11	
104	0	1565	25	

TABLE 7.4 (Continued)

STUDENT CASE NUMBER	B_3	B_6	I_{101}	GROUP NUMBER
7	0	1375	25	
16	0	0	22	
23	0	0	23	
24	63	970	22	
25	0	1165	22	
31	0	2595	27	
36	0	0	19	
38	0	2805	23	G6
40	0	0	26	
48	0	2805	27	
50	83	1450	25	
52	0	0	21	
55	2	1905	24	
74	0	1295	21	
92	0	1340	24	
93	0	0	25	
105	8	4710	28	
9	0	3190	17	
18	0	2735	25	
29	76	1315	--	G8
56	0	0	25	
80	0	2485	22	
10	93	1140	17	
11	92	750	--	
12	0	0	23	
20	93	0	19	
26	78	1020	--	
27	92	190	14	
28	87	835	24	
37	0	1855	22	
49	0	4555	20	
57	47	410	14	G9
69	88	340	25	
70	95	0	23	
73	9	2065	20	
75	0	1065	20	
79	96	285	21	
82	87	565	23	
83	93	190	22	
84	0	0	14	
97	93	390	20	
99	90	1600	23	
19	0	2455	27	
63	0	4470	24	G16
85	0	0	21	
88	0	4080	27	
21	0	3365	25	
32	0	0	17	G18
61	0	2740	26	
65	0	2395	21	
35	0	3290	10	G31
58	47	980	21	

Group Profiles and Hypotheses for Instructional Improvement

Group G1

Group G1 was composed of seven individuals Fall term 1977. They appear to have entered the University with the intention of pursuing a scientific or technical major, but for some reason, probably the lack of quantitative skills, changed major to a curriculum requiring BS 202. Generally, they had a neutral or positive attitude toward science, aimed at a high grade in the course but expected to be satisfied with an average grade. They had taken some college physics or chemistry, received an A or B in high school biology, found lab work and class notes helpful in their studies and considered memorization important. Initially most knew some superficial aspects of biology, but little of the details. They tended to be anxious about test taking and having enough time to complete the tests, and generally not testwise or clever at playing the testing game. The individuals in this group tended to be somewhat conscious of and dependent on peer opinions and decisions. The students with the higher GPAs in the group were more conservative than those students in the group with low GPAs. They attended nearly all the SAS sessions, and usually used the lecture tapes to make up for missed lectures. On the continuum of dull to bright students, this group as a whole tends toward the dull end.

There are a number of possibilities for improving the performance of those students characteristic of this group:

1. Encourage the use of the lecture tapes to make up for missed lectures.
2. Encourage the use of the practice quiz in preparation for the weekly quiz.

3. Attention and remediation needs to be directed toward the poor study and critical reading skills characteristic of this group.
4. Some effort should be expended to correct the tendency of individuals in this group to try to memorize everything taught in the course.
5. These individuals need to be actively kept involved in the course and encouraged to spend considerable time and effort in preparation.
6. Some of the individuals in this group do not benefit much from anything they try to improve their performance. Perhaps those individuals in this group with low GPAs need individual tutoring.

(It should be remembered that each of the above suggestions is a hypothesis in need of testing. Each hypothesis is suggested through the data collected and analyzed, but not proven. Additional studies are needed to pursue these and all of the following suggestions or hypotheses.)

Groups G2 and G31

Group G31 appears to be an irregular artifact, and so was merged with Group G2 for the purpose of analysis. Group G2 was composed of thirty-seven individuals, roughly one-third of the students in the course Fall term.

Into this group falls the conscientious and the bored, the easily discouraged and the undaunted. It is a group with little regularity beyond a tendency to be irregular in study habits and instructional behavior. In general, the group was rather deficient in background knowledge of biology although most took High School Biology with a grade of

A, B, or C. They tended to be non-science oriented with almost no background of college biology, physics, or chemistry. Although most reported a neutral or mildly positive attitude toward biology, many indicated a negative attitude toward science in general. The group was generally not test anxious, but was moderately testwise and fairly independent of group pressure; although the worst performace was given by the most conservative of the group. The group has a GPA range of mid 2.0s to mid 3.0s, with the grade in the course related proportionately to GPA. Most aimed for a high course grade but indicated they would be satisfied with a 3.0 to 4.0. The poorer students in the group tended to be the worst judges of their own potential. Resource magazines and books were viewed as helpful in a science course, but not as much as lab, classnotes and memorization. The score these students received on the problem solving test (PRBSOL) may indicate the potential performance in the course. The Myers-Briggs test scores for this group indicated that most of the G2 students had profiles characteristic of elementary teachers, and would be expected to have little interest in technical things or abstract thinking.

Several areas for performance improvement are suggested (or hypothesized) by the information collected on these students:

1. The one, single area of major improvement for this group may be each individual's need to develop a regular, consistent, disciplined mode or habit of study. They need to spend time each week regularly reading, studying course materials, and using the practice quiz. They should avoid any tendency toward irregular study and then try to catch up before the quiz.

2. This group would also benefit from instruction in critical reading and test taking skills.

Group G6

This group was composed of seventeen individuals Fall term, mostly freshmen, sophomores, and transfer students. They tend to be a self-confident, although not overachieving, group of hardworkers who quickly adapted to the course. With one exception all the members of this group received a course grade in the 3.0 to 4.0 range. The group had a somewhat mixed background in biology, most having taken high school biology and received an A, B, or C, and over half having taken one term or more of college biology. Many may have transferred biology credit to Michigan State. The group had a generally positive attitude toward all science, including biology and intended to aim for a 4.0 in the course, but would be satisfied with a 3.0. The group had a good attitude toward lab, registering nearly perfect attendance in the small assembly sessions. They tended to use the lecture tapes to make up for missed labs, used the practice quizzes from midterm to final, spent considerable time in the tape labs and spent between 4 and 6 hours in outside study regularly each week.

The impression from this group is that they need little in the way of extra help in the course. Some possible areas of improvement are:

1. Lectures. Missed lectures tend to lower final grade. Lecture tapes should be used to make up for any lectures missed.
2. These students should try to use the practice quiz each week regularly throughout the term. They should take the practice quiz like a real test, then correct their mistakes.

3. Some of these students, especially the younger ones, need some coaching to improve their testwiseness, and confidence in their ability to take exams.

Group G8

The five individuals in this group tended to have an average GPA and little or no background in college chemistry or physics. They received an A or B in high school biology and reported a neutral or mildly positive attitude toward both biology and science in general. They tended to initially know something about the basics of biology and ecology but little about specific biological or ecological processes. They aimed high in the course, but indicated that they would be satisfied with an average grade. The group was generally mixed on test anxiety and self-confidence, and can only be considered partially testwise. They generally reported themselves to be independent and not affected by peer pressures, but the results of their Myers-Briggs assessment is contradictory, indicating that the need for encouragement and praise. They generally registered a preference for memorizing facts over other modes of study. There is also some evidence that these individuals become discouraged, and perhaps self destructively defiant, very easily and quickly.

The following are areas where an increased instructor effort might result in increased performance and better attitude in the part of these individuals:

1. These students need continual attention, encouragement, and praise throughout the term.
2. These students should be encouraged to attend the lecture and SAS regularly.
3. They should use the practice quiz each week, looking up the answer to each question as they go through it.

4. Use of the tape labs should be encouraged. Perhaps the instructor could provide more attention to these students in the individualized sessions.
5. These students need help in critical reading and with the improvement of their study skills. Many of these students try very hard, but the lack of study skills causes them to waste a great deal of time, and eventually they become discouraged and give up.

Group G9

Group G9 was composed of twenty students Fall term. This may be the group that the BS 202 instructors most clearly perceive as failures in preparation for biology teaching. This group is composed of mainly transfer students (75%) and freshmen. Although they come to the course with a GPA between 2.5 and 3.5, about one-half receive a grade of 2.0 or less; one-quarter of the group receiving a 1.5 or 1.0. No member of this group received a course grade above a 3.0. The group had a mixed background in biology. Those that took biology in high school reported a grade of B, C, or D. Although some reported taking another college biology course, performance on the pretest was mixed; most knew simple definitions, but missed the more sophisticated questions. The group reported mixed apprehension about tests, and most of the students were not particularly testwise. Many lacked self confidence, but did not tend to rely on their peers for support. The group had little science background and indicated negative to slightly positive attitudes toward biology. Over half were neutral or negative towards science in general. They all indicated that they intended to aim for a 3.0 or 4.0 in the course and would be satisfied with nothing less than a 3.0. Many were disappointed.

This might be a group to separate into a separate section where extra attention and encouragement could be provided. In addition, the following suggestions for performance improvement are provided:

1. Lecture attendance and/or use of the lecture tapes should be mandatory.
2. Use of the practice quiz should be encouraged. Perhaps the practice quiz could be administered in a "dry run" fashion in SAS, followed by discussion.
3. Minimum amounts of time spent in the tape lab should be set and mandatory.
4. Instruction in the improvement of study efficiency and critical reading should be provided to reduce wasted student effort and prevent discouragement. Included here should be the effective use of memorization.

Many of the G9 students appear to have potential, but unfortunately most of it goes unfulfilled because of poor study habits and attitude.

Group G16

There were four individuals in this group Fall term. These individuals tend to be intelligent, self confident, testwise, and independent. They had some high school biology, but little or no college science. They tended to have a neutral or positive attitude toward biology and science in general, and had high expectations for their own performance in the course. Although they had little previous knowledge of biology they were confident in their ability, and their self assessment was essentially accurate. They were clever thinkers and reasoners; INFJ or INTJs in the Myers-Briggs classification.

Although this is a high performing group, the following suggestions could possibly improve their performance:

1. These individuals should be given the opportunity to improve their test taking skills and reduce their test anxiety.
2. Increased usage of the practice quiz should be encouraged.
3. These students should be given some help to improve their use of the tape lab and prevent wasted effort.
4. The use of the straight memorization of fact should be discouraged.
5. These areas should be corrected early in the course to prevent discouragement.

Group G18

This last group was composed of four students Fall term. These individuals tended to have about an average GPA on entering the course. They took high school biology, no college biology, but took several college physics and chemistry courses. With this science background they generally had a neutral or positive attitude toward biology and science in general. They tended to know something about ecology, were able to generalize about the relationships of matter and energy, but apparently had forgotten many biology facts. They aimed for a high grade in the course but were willing to settle for an average grade. They were moderately confident in their abilities to take tests and were generally independent.

Concentration in the following areas for these students would probably improve their performance in the course:

1. They should attempt to attend all of the lectures.
2. Use of the practice quiz as a "dry run" before the real quiz may improve their performance.

3. They should study six or more hours outside class regularly each week.
4. Some effort should be made to help decrease these students' test anxiety, improve their study skills, including the deemphasis of memorization, and improve their test taking skills. This will help decrease their frustration with the course.

Summary

This is as far as the grouping analysis can be taken with the information and procedures of this study. The next step is to administer the instruments containing the forty-two grouping variables to a new, fresh BS 202 class and divide the class into tentative groups based on the responses. Table 7.5 contains the operational[1] variable values on which to base such groupings. The experimenter may also wish to add additional items or instruments, such as the Myers Briggs or the Cognitive Style Mapping, to further aid in student differentiation and group assignment. One possible research design would then have the groups each split randomly into experimental and control groups. The control groups would then be merged and received the standard BS 202 instructional package. The experimental groups would receive various treatments based on the hypotheses proposed earlier in this chapter to improve instructional performance. Such instructional treatments would include, but not necessarily be limited to; instruction in the improvement of study skills,

---

[1] These are the operational values of variable; for the pretest items an "0" indicates an incorrect response, a "1" a correct response. For the Affective and Background Questionnaire items (B_{63} to B_{175}) the responses are shown as a number from 0 through 4, indicating a student response of 1 through 5. The 0-4 is an artifact of machine scoring.

TABLE 7.5

		GROUPS						
Variable	Acronym	G1	G2	G6	G8	G9	G16	G18
B_3	TRCR	0-40	0-10	0-85	0-75	0-100	0	0
B_6	MSUPTS	700-3400	900-3100	0-2000	0-3200	0-2000	0-4500	0-3400
B_{18}	PRE008	1	1	1	1	1	0	0
B_{19}	PRE009	1		1	1	1		0
B_{23}	PRE013	0		0	0			
B_{28}	PRE018						0	
B_{35}	PRE025	0	0	0				
B_{41}	PRE031							
B_{42}	PRE032	0				0		0
B_{63}	AFF003							
B_{67}	AFF007							
B_{68}	AFF008		1					1
B_{71}	AFF011							
B_{74}	AFF014		1			1		
B_{81}	AFF021	1	1	1	1	1	1	1
B_{85}	AFF025	0	0	0		0	0	0
B_{87}	AFF027			0			0	
B_{89}	AFF029				0	0		
B_{90}	AFF030		0	0	0	0	0	0
B_{92}	AFF032				0	0		
B_{93}	AFF033	0	0	0	1	0	0	0
B_{94}	AFF034			0	0			

TABLE 7.5 (Continued)

		GROUPS						
Variable	Acronym	G1	G2	G6	G8	G9	G16	G18
B_{98}	AFF038					0		0
B_{107}	AFF047		1	1	1	1	0	1
B_{108}	AFF048	0	0	0		0	0	0
B_{123}	BKG004	0,1	0,1,2	0,1,2	0,1	-0,1,2,3		0,1,2
B_{125}	BKG006	0,1	0		0,1		0	0
B_{126}	BKG007	2,3,4	2,3	3,4	2,3	1,2,3		2,3
B_{131}	BKG012	0	0	0,1	0		0	0,1
B_{135}	BKG016	0,1	0		0	0	0	0,1
B_{138}	BKG019	0,1	-0,1	-0,1	-0,1	-0,1	1	-0,1
B_{149}	BKG030		1,2,3,4	2,3,4	1,2,3	1,2,3		2,3
B_{151}	BKG032	0,1	0,1,2	0,1	0,1	0,1,2	0,1,2	0,1,2
B_{152}	BKG033	2,3,4		1,2	2,3	2.3	0,1,2	2,3
B_{153}	BKG034	1,2,3	0,1,2	0,1,2	1,2	1,2	0,1	1,2
B_{161}	BKG042	2,3,4	1,2,3,4	2,3,4		1,2,3	1,2,3,4	
B_{168}	BKG049		0,1,2,3	1,2,3,4		1,2,3	1,2,3,4	1,2,3,4
B_{171}	BKG052	2,3	2,3,4	2,3,4	2,3,4	2,3	1,2,3,4	1,2,3,4
B_{175}	BKG056		2,3,4	1,2,3		2,3,4		1,2,3,4
I_1	LEC001	1	1	1	1	1	1	0
I_{70}	ONE031						0,1	
I_{101}	Q2	20-26	11-27	19-28	17-25	0-23	21-27	17-26

critical reading in the sciences, improvement of test taking skills, individual tutoring, development of consistent, disciplined study, additional course instructional sessions and mandatory attendance. Additional instructional treatments may also be instituted as the investigation uncovers further intragroup problems and shortcomings.

In summary, then, what has been demonstrated is the possible development of a tool for improving student performance in the course. When perfected, the grouping mechanism would channel students through different "tracts" of the course designed to remediate or minimize student weaknesses, and capitalize on student strengths. This grouping mechanism would be based on the results of the experimentation and investigations following the leads presented in the model study. These leads and suggestions for grouping presented in the current study were a direct result of viewing and modeling the course as a system of sequential events and processes. Such a view establishes some order to the chaos of the reality.

CHAPTER 8

SUMMARY, EVALUATION, RECOMMENDATIONS AND CONCLUSIONS

In this study a very simple application of systems approach and modeling has been applied to the instructional system of a college biological science course. In this abstract conceptualization students were viewed as entities passing through the instructional processes of the course, and the changes in their knowledge of a subset of the content taught in the course, measured through their test performance, was considered to be the product of the course. Ecology, a main component of modern biology, was used as the subset of content on which student performance was monitored. Each component of the course was viewed as an instructional session contributing to the students' knowledge of ecology. The effects of the instructional sessions were aggregated on a weekly basis and related through the model to student performance on ecological concepts based on items from the weekly quiz. Student concept performance was also related through the model to a large array of background information collected at the beginning of the course. The model was successively applied and updated weekly throughout the ten week schedule of the course.

At the beginning of the study it was necessary to establish a reference frame for the content. To do this a content analysis of the concept of "Ecosystem" was conducted to the depth necessary and appropriate for an Ecology course for college biology majors. An analysis of the Ecosystem content taught in BS 202 was then conducted. When

comparing the two analyses it was apparent that although the version of "Ecosystem" taught in BS 202 is less sophisticated than the reference version, it is comprehensive, and probably represents all that is digestible in ten weeks by non-science, elementary education majors. From an analysis of the content of the weekly tests and final exam it appears that not all of the concepts were tested for and that very few were tested for repeatedly throughout the term. This lack of comprehensive and repeated testing of key concepts reduced the efficacy and usefulness of the modeling process. The scarcity of repeated measures on performance indices also makes it difficult to generalize the model for other terms.

One of the basic intents of the model building process is that the final product will organize information in such a manner to make previously unrecognized relationships recognizable. For this study, a large amount of information was collected on students' backgrounds and instructional behaviors. The approximately 900 variables reflecting this information were then processed through a series of multiple regression procedures from which the final model equations emerged. The relatively small number of students involved in the study (N = 105) and the regression "filtering" process identified variables with strong correlational relationships to the performance indices. Those variables in the final version may be assumed to be important background parameters or components of the course. Conversely, however, if a variable did not turn out to be a strong correlate, it cannot be dismissed as unimportant or irrelevant to the course. More study needs to be given to these variables. Perhaps another "layer" of modeling may produce additional information about the course.

The modeling process employed in this study required very close attention to the details of the initial data processing. The process

detailed in Chapter 5 for removing errors and developing clean, consistent data sets is absolutely necessary anytime a modeling process of this sort is undertaken. Without this very close attention to details the results of this study, as modest as they may be, would never have emerged.

For the Fall term, 1977, it was found that the variables representing student background and instructional behavior (from B and I , respectively) accounted for about 65 percent, on the average, of the variation in the performance or mastery variables. Extrapolating the model to the Winter 1978 term, these same variables accounted for about 34 percent of the variation in the dependent, performance variables. The latter poor fit for the Winter term is probably due to a number of changes in the course, including instructors, between the two terms. It is probalby reasonable to state that, under the assumptions and constructions of the model, about 65 percent of the variation in performance is accounted for by student background and instructional behavior (Tamir's (1976) antecedents and transactions).

Bloom, as discussed in Chapter 2, stated that up to 90 percent of the variation in school learning may be accounted for by cognitive and affective entry characteristics and quality of instruction (1977). Together, he estimated that cognitive entry behaviors and affective entry characteristics may account for up to 65 percent of the variation. This study includes cognitive and affective entry characteristics in the background variables. These variables when included with instructional behaviors, which measure something different from quality of instruction, account for about 65 percent on the average, of the variance in performance indices, a measure which is very similar to Bloom's school learning parameter. Thus, this study is somewhat in agreement with Bloom's estimates.

The model developed in this study provides a different view of a standard academic course. It also appears to be transferable across terms with some limitations. However, the largest contribution of the methodology demonstrated is not in the academic exercise of model building, but rather in the uses of such modeling as a research tool. In the present case, the combination of the modeling methodology with grouping analysis produced results which may prove useful in improving the instructional quality of the course. Further study of the legitimacy of the groupings and hypotheses suggested for performance improvement in the Chapter 7 is needed to support this contention. However, the grouping analysis based on the results of the model building process may be an important link between a research tool and classroom implementation. The systems model organized the process of teaching into a heretofore undeveloped schema. From the vast chaos of information describing this particular learning process, the model pointed to certain definite relationships which appear on first examination to be potentially very useful in restructuring the course and improving learning. If this is the case, then the concept of course modeling, hopefully using more sophisticated techniques than employed in this study, may be of some value in educational research.

In retrospect the methods employed in this study to develop the model coefficients were very cumbersome and time consuming considering the results of the effort. That is, a great deal of effort was put into the determination of the strongly correlated variables but the method of that determination, the use of multiple correlation on "waves" of variables, did not insure that all of the relationships were examined. If this study is replicated it is recommended that the number of independent variables used be significantly reduced, that the number of students

in the study group be significantly increased and that multivariate linear regression analysis replace multiple regression. The use of multivariate regression is more appropriate for use with the vectors used in the systems model than multiple regression.

This study has explored, albeit imperfectly, the application of the systems approach to instructional research. It has shown that such an application is possible and pointed to some of the advantages of viewing instruction using the conceptualization of this abstract organization. Although the model developed in this study was based on some very simple assumptions, the grouping analysis using variables identified by the model illustrated a realistic and practical utilization. It is hoped that more research efforts will develop the possibilities of this approach further.

APPENDICES

APPENDIX A

Course Description

APPENDIX A

Biological Science 202 Fall 1977

Course Syllabus

Staff: Dr. N. Jean Enochs
Mr. Charles Elzinga
Mr. John Fogl
Ms. Elaine Rybak

Texts: Keeton, William T. Elements of Biological Science, 2nd Edition; New York: Norton 1973.

Enochs, N. Jean. Biological Science 202 Study Guide. Unpublished.

Burnett, Fisher, Zim. Zoology. New York: Golden Press. 1973.

Burnett, Alexander, Zim. Botany. New York: Golden Press. 1970.

There are copies of these textbooks on reserve in the Materials Center, Room 103C McDonel Hall, which also has other Biology books and materials.

Introduction

This course is designed for the preservice elementary school teacher; however, it is open to any student who wants an introductory Biological Science course. Its purposes are to help you 1) to learn basic biological facts, concepts, and skills; 2) to think scientifically, and 3) to develop confidence in your ability to teach Biology as a science in elementary schools. It is our conviction that you, the learner, must actively learn, that teachers can only help you learn, and secondly, that your ability to ask questions and find answers, to think and to make decisions, to take responsibility for yourself is most important. Therefore, we have designed the course to allow you to develop yourself as you learn Biological Science with as much help or as little help as you need. As instructors we propose to help you by 1) suggesting what you should learn by presenting objectives; 2) designating one or more learning activities by which you may learn to fulfill the objectives; and 3) evaluating and documenting your success at learning and performing in the Biological Sciences. Your role is to learn actively, to take responsibility for your learning to the limits of your capacity. You will be able to pace yourself through an individual study session and decide to what degree you wish to pursue the subject. If you have little background in Biology, you may ask questions and repeat techniques without slowing others who may already be familiar with some of the material. If you already know the material specified to be learned you may skip over the designated learning experiences at your discretion to ask questions, investigate and go beyond the minimal levels of mastery. The individual study session is designed to give you as much individual help and time as you wish.

Course Methodology

The procedures for this quarter have evolved over a seven year period as students have tried and responded to this approach to learning. We have made significant changes in the course on the basis of student suggestions; and we

anticipate continuing the development of the course on the basis of your experience this quarter. The general description of the procedure follows:

General Assembly Session (GAS): Monday 9:10	1 hour
Small Assembly Sessions (SAS): M, W or T,T	2 hours
Individual Learning Session (ILS): M, W or T, T (or as long as you need).	2 hours
Evaluation Session (ES): Friday, 9:10	1 hour
Minimum . .	6 hours/week.

You are scheduled to attend a General Assembly Session (GAS) on Monday in which information suited to lecture rather than laboratory or discussion session is presented. The context for the weeks work will be set in this session and it will be heavily content oriented and coordinated with the assigned reading concerning the biological facts and concepts of the week. It may be used for guest lecturers on biological topics or movies, and it is the only occasion where all the students meet with the senior instructor at the same time.

The Small Assembly Session (SAS) meets in 106C McDonel Hall and brings together 22 students for group interaction with the aspects of the course that may best be learned in this manner. This session is oriented toward elementary school "sciencing" and techniques for maintaining and investigating animals, plants, and microorganisms in the classroom. In it you will become acquainted with the instructor who is personally concerned with you and your progress through the course.

From there you will move into the Individual Learning Session (ILS). You should have read over the objectives for the week and assigned readings before coming to the Learning Center to begin the learning activities which can best be done individually. You will be able to follow the programs at your own rate, with or without further explanation from the instructor and receive help on a one-to-one basis. You may spend as much or as little time in this session as you need with as much or as little assistance as you need in learning to fulfill the week's objectives and going beyond the minimal requirements to do independent activities. You should also use this time to ask the instructors questions about the lectures, assigned reading or any aspect of the course which is unclear to you. Since we anticipate the students with an average background (1 year of high school biology) will spend about 2 hours in the ILS, we strongly urge you to begin the weekly program early and to finish it another day rather than doing it all in one sitting. There will be a tally of how many students are in the Learning Center at each hour so that you may know when the slack times are and try to come then for any extra time you need. You will also find on the bulletin board a schedule showing when your SAS instructor will be on duty in the ILS.

You are also scheduled for an Evaluation Session (ES) on Friday. During this hour you will be given a quiz over the week's objectives using pictures, diagrams, objects or specimens from the GAS, SAS, ILS and assigned reading. It is anticipated that this session will be both a testing and learning situation for you. There is no mid-term examination requirement.

Attendance

Students are expected to attend all sessions: absence is considered to be serious. Absences due to ill health or death in the family are excusable and can be made up by contacting your instructor on your return. The privilege of

makeup work is not guaranteed under any other circumstance. The makeup work for the ES will require the absentee to write a 2-3 page report which demonstrates comprehension of all the objectives for the unit and/or completing requisite quizzes. The makeup work must be done within one week after permission for it has been granted. Students who miss more than two week's work during the quarter will be required to obtain written permission from Dr. Enochs before they can make up the quizzes or continue in the course.

Grading

Your grade on the course will be determined by your performance on class assignments and your score on the written tests and final examination. Self tests will be provided at intervals to allow you to see how successful your learning strategies are in relation to the stated objectives and the performance of other students in the course, in order that you may modify your strategies if necessary for you to reach your goals. You should feel free to discuss your grades with your instructor and/or with the senior instructor, Dr. Enochs. The grading scale follows:

Quizzes 1-9 (30 each)	270 points	333-370 points (90%)	= 4.0
		314-332 points (85%)	= 3.5
Final Exam	60 points	296-313 points (80%)	= 3.0
		277-295 points (75%)	= 2.5
Participation and		259-276 points (70%)	= 2.0
Assignments	40 points	240-258 points (65%)	= 1.5
		222-239 points (60%)	= 1.0
Total Points	370 points		

Your grade in the course will be determined by your performance on class assignments, participation, and your scores on the written tests and final examination.

The tests will be based on the instructional objectives and may use information, pictures, diagrams, objects and specimens from the GAS, SAS, ILS, and assigned readings.

Course Content

Elementary teachers 1) must be familiar with the basic facts, concepts, and principles of biology but that is not enough. Teachers also 2) need to be proficient in the processes of science such as observing, measuring, classifying, using numbers, predicting, inferring, communicating, hypothesizing, experimenting, and interpreting data. Teachers 3) must be skilled in handling living organisms and laboratory apparatus. Even that is not enough, teachers 4) should be curious and investigative, and have a positive attitude toward learning. This seems like an impossibly big order, but it is with these ideas in mind that we have designed this course. It is finally enough that you are fully responsible and creatively free in helping youngsters learn to be, in the 21st century.

It is our belief that you will benefit from your college career in proportion to the degree to which you are directly involved with your learning. We feel that this method will allow you direct involvement with the subject matter and at the same time give you individual attention from the instructors and encouragement to go beyond the minimal requirements. We will be interested in your reaction to this methodology, and we will be responsive to your observations and suggestions as we try to make the time spent in this course profitable to you. I encourage you to come in and talk with me when I am in the lab, during my office hours, or call and make an appointment.

Sincerely,

N. Jean Enochs

N. Jean Enochs

APPENDIX A
COURSE OUTLINE

eek	Ecological Thread	Organismal Thread	Readings*
Oct. 3-7	Introduction GAS: Organizing Biology SAS:Models of Biology Teaching ILS:Microscope SAS:Nature of Life	Invertebrates SAS:Classifying/Pond Water	K:1-4; 66-69 Z:24-39 B:18-25 Handout: Levels of Organization
Oct. 10-13	GAS:Chemical Basis of Life SAS:Physical Basis of Life ILS:Cells	ILS:Mollusks, Annelids, and Echinoderms SAS:Field Trip/Trees	K:13-31; 35-46 46-56; 62-66 Z:40-44 Handout:Chemical Basis of Life
Oct. 17-21	Producers GAS:Energy and Life SAS:Photosynthesis ILS:Producers	SAS:Arthropods SAS:Insects	K:57-62; 82-84; 95-101; 118-119; 127-137 Z:45-64 Handout:Photosynthesis
Oct. 24-28	Consumers GAS:Homeostasis 1 SAS:Consumer Anatomy 1 ILS:Consumers 1 SAS:Consumer Anatomy 2	Vertebrates SAS:Field Trip/ museum fish, amphibians, reptiles	K:31-34; 109-115; 119-126; 137-161 Z:65-81 Handout:Liver Functions
Oct.31-Nov. 4	GAS:Respiration/Control SAS:Consumers 2 ILS:Skeletal Systems	SAS:Birds SAS:Mammals	K:200-208; 226-231; 234-239 Z:82-96 Handout:Respiration
Nov. 7-11	Continuity of Life GAS:Molecular Reproduction SAS:Genetic Disorders ILS:Reproduction 1 SAS:Plant Development	SAS:Decomposers	K:279-289; 322-329; 326-341; 165-177 B:28-41
Nov. 14-18	GAS:Homeostasis 2 SAS:Animal Development ILS:Reproduction 2 SAS:Human Development	SAS:Mosses, Ferns, and Gymnosperms	K:186-196;341-346 Handout:Menstrual Cycle B:45-55; 104-105
Nov. 21-22	Interactions of Organisms GAS:Behavior/Nervous System SAS:Invertebrate Behavior SAS:Vertebrate Behavior	Thanksgiving Holiday	K:248-274

APPENDIX A

2

eek	Ecological Thread	Organismal Thread	Readings*
Nov.28- Dec. 2	GAS:Biogeochemical Cycling SAS:Water Quality ILS:Ecology I SAS:Air Quality	SAS:Flowering Plants	K:392-402; 418-425 Handout: N+C cycles B:56-63; 106-115
Dec. 5-9	GAS:Energy Flow/Population SAS:Food and Population ILS:Ecology II SAS:Planet Management	SAS:Taxonomy	K:402-418; 388-390 B:12-15 Z:4-7 Handout:Taxonomy

Final Exam: Friday, December 16, 1977, 12:45-2:45 p.m. in McDonel Kiva.

*Books for reading designated: K = Keeton, Z = Zoology, B = Botany

APPENDIX B

Background Variables

EXPERIMENTAL BACKGROUND QUESTIONNAIRE

INSTRUMENT: BACKGROUND QUESTIONNAIRE

Variable Acronym	ITEM	FALL TERM 1977 MEAN	STD.DEV.	N	WINTER TERM 1978 MEAN	STD.DEV.	N
BKG001	1. My major is: 1. elementary education. 2. social science. 3. child development. 4. special education. 5. other.	0.810	1.195	100	0.963	1.414	54
BKG002	2. I have taken: 1. no biology (botany, zoology, physiology) in high school. 2. less than one year of biology in high school. 3. one year of biology in high school. 4. two years of biology in high school. 5. more than two years of biology in high school.	1.940	0.763	100	1.667	0.869	54
BKG003	3. If you took a Biology course in High School, the textbook used was: (If you took more than one course, indicate the last textbook used). 1. Modern Biology. 2. BSCS Green. 3. BSCS Yellow. 4. BSCS Blue. 5. Interaction of Ideas and Experiments (BSCS Second Course).	0.696	1.129	69	0.700	1.119	30
BKG004	4. If you took course(s) in Biology in High School, indicate the grade that best describes your level of achievement in Biology: 1. A. 2. B. 3. C. 4. D. 5. F.	0.890	0.706	91	1.362	0.792	47
BKG005	5. I have taken: 1. No Ecology course. 2. An Ecology course in High School. 3. An Ecology course in College.	0.350	0.716	100	0.370	0.760	54
BKG006	6. I have taken: 1. no college biology (botany, zoology, physiology) courses. 2. one quarter of college biology. 3. two quarters of college biology. 4. a year of college biology prior to this course. 5. more than a year of college biology prior to this course.	0.400	0.739	100	0.321	0.644	53

Variable Acronym	ITEM	FALL TERM 1977 MEAN	STD.DEV.	N	WINTER TERM 1978 MEAN	STD.DEV.	N
BKG007	7. Which of the following most accurately describes your attitude toward biological science? 1. very negative. 2. negative. 3. neutral. 4. positive. 5. very positive.	2.560	0.756	100	2.189	0.962	53
BKG008	8. At MSU I have taken: 1. less than one year of Natural Science. 2. one year of Natural Science. 3. a waiver (by examination) of the Natural Science sequence. 4. a waiver (by course substitution) of the Natural Science sequence. 5. no Natural Science course.	1.750	1.258	100	1.500	1.306	52
BKG009	9. Have you taken a course in high school physics? 1. Yes. 2. No.	0.790	0.409	100	0.849	0.361	53
BKG010	10. If yes, the grade that I received was: 1. 4.0. 2. 3.5. 3. 3.0. 4. 2.0 or 2.5. 5. Below 2.0.	1.226	1.283	31	1.273	1.348	11
BKG011	11. At MSU I have: 1. not taken Physical Science 203. 2. have taken Physical Science 203. 3. have waived Physical Science 203 by examination. 4. have waived Physical Science 203 by course substitution. 5. currently enrolled in Physical Science 203.	0.457	1.074	94	0.667	1.291	51
BKG012	12. I have taken: 1. A college physics course other than PHS 203. 2. two college physics courses other than PHS 203. 3. more than two college physics courses other than PHS 203.	0	0	10	0.600	0.548	5
BKG013	13. If you have taken college physics courses other than PHS 203, indicate your level of achievement: 1. A. 2. B. 3. C. 4. D. 5. F.	1.364	0.809	11	1.286	1.113	7

Variable Acronym	ITEM	FALL TERM 1977 MEAN	STD.DEV.	N	WINTER TERM 1978 MEAN	STD.DEV.	N
BKG014	14. Have you taken a course in high school chemistry? 1. Yes. 2. No.	0.414	0.495	99	0.404	0.495	52
BKG015	15. If yes, the grade that I received was: 1. 4.0. 2. 3.5. 3. 3.0. 4. 2.0 or 2.5. 5. Below 2.0.	2.000	1.074	60	2.097	1.106	31
BKG016	16. I have taken: 1. one college chemistry course. 2. two college chemistry courses. 3. three college chemistry courses. 4. more than three college chemistry courses.	0.583	0.793	12	1.000	1.528	7
BKG017	17. The most advanced course in mathematics in High School that I have had is best described as: 1. high school algebra. 2. high school geometry. 3. high school trigonometry. 4. advanced High School mathematics or introductory college mathematics. 5. calculus.	1.480	1.086	98	1.235	1.031	51
BKG018	At HSU I have taken or am required to take the following Math courses: 18. IS 194 (Quantitative Techniques) 1. Yes. 2. No.	0.848	0.361	92	0.846	0.364	52
BKG019	19. MTH 081 1. Yes. 2. No.	0.944	0.232	89	0.863	0.348	51
BKG020	20. MTH 082 1. Yes. 2. No.	0.876	0.331	89	0.686	0.469	51
BKG021	21. MTH 102 1. Yes. 2. No.	0.908	0.291	87	0.902	0.300	51
BKG022	22. MTH 108, 109, 11 or higher level course(s) 1. Yes. 2. No.	0.648	0.480	91	0.620	0.490	50

INSTRUMENT: BACKGROUND QUESTIONNAIRE

Variable Acronym	ITEM	FALL TERM 1977 MEAN	STD.DEV.	N	WINTER TERM 1978 MEAN	STD.DEV.	N
BKG023	23. If you are a transfer student, what is the highest level math course you received transfer credit for; 1. IS 194. 2. MTH 081/103. 3. MTH 032/104. 4. MTH 102. 5. MTH 108, 109, 111, or higher.	2.727	1.306	33	2.462	0.877	13
BKG024	24. The level of achievement in my study of mathematics is best described as: 1. A. 2. B. 3. C. 4. D. 5. F.	1.260	0.837	96	1.583	0.846	48
BKG025	25. I have taken or plan to take a college course dealing with geology--earth science, astronomy, or space science. 1. Yes. 2. No.	0.500	0.503	98	0.574	0.499	54
BKG026	26. If you are working toward an Elementary Teaching Certificate, is science your major? 1. Yes. 2. No. 3. Does not apply.	1.031	0.464	98	1.057	0.497	53
BKG027	27. If you are working toward an Elementary Teaching Cenrtificate, is science your minor? 1. Yes. 2. No. 3. Does not apply.	0.969	0.549	97	0.943	0.602	53
BKG028	28. Did you take or are you required to take ATL 101A? 1. Yes. 2. No.	0.827	0.381	98	0.673	0.474	52
BKG029	29. Did you take or are you required to take ATL 101B? 1. Yes. 2. No.	0.876	0.361	96	0.846	0.364	52
BKG030	30. Which of the following most accurately describes your attitude toward science in general? 1. very negative. 2. negative. 3. neutral. 4. positive. 5. very positive.	2.434	0.835	99	2.222	0.945	54

INSTRUMENT: BACKGROUND QUESTIONNAIRE

Variable Acronym	ITEM	FALL TERM 1977 MEAN	STD.DEV.	N	WINTER TERM 1978 MEAN	STD.DEV.	N
BKG031	31. I am taking this course 1. only to fulfill a distribution or college science requirement. 2. only to fulfill a requirement for my major. 3. only to fulfill another requirement not mentioned above. 4. to fulfill a requirement but would want to take it anyway. 5. simply because I want to--it is not a requirement.	1.677	1.058	99	1.519	1.059	54
BKG032	32. The grade I will aim for in this course is: 1. 4.0. 2. 3.5. 3. 3.0. 4. 2.5. 5. 2.0.	0.485	0.747	99	0.759	1.063	54
BKG033	33. The lowest grade that would satisfy me in this course is: 1. 4.0. 2. 3.5. 3. 3.0. 4. 2.5. 5. 2.0.	2.091	0.624	99	2.407	1.019	54
BKG034	34. My overall college grade-point average is within the range 1. 3.5 - 4.0. 2. 3.0 - 3.49. 3. 2.5 - 2.99. 3. 2.0 - 2.49. 5. below 2.0.	1.455	0.718	99	1.722	0.878	54
BKG035	35. I expect to spend _____ hours per week studying for this course outside of class: 1. less than 2 hours per week. 2. 3 - 5 hours per week. 3. 6 - 8 hours per week. 4. 9 - 10 hours per week. 5. over 10 hours per week.	1.740	0.824	96	1.792	0.863	53
BKG036	36. I transferred to HSU from another school: 1. Yes. 2. No.	0.633	0.485	98	0.648	0.482	54
BKG037	37. I am repeating Biological Science 202 this term. 1. Yes. 2. No.	0.980	0.142	98	1.000	0.000	54

INSTRUMENT: BACKGROUND QUESTIONNAIRE

Variable Acronym	ITEM	FALL TERM 1977 MEAN	STD.DEV.	N	WINTER TERM 1978 MEAN	STD.DEV.	N
BKG038	38. Was the science which was taught to you in elementary school predominately student activity oriented? 1. Yes. 2. No. 3. Science was essentially absent in my elementary science experience.	0.798	0.700	99	0.942	0.725	52
BKG039	39. Do you have a hobby dealing with plants or animals? 1. Yes. 2. No.	0.525	0.502	99	0.611	0.492	54
BKG040	40. Do you read about biological topics in your free time? (including newspaper articles, Time, Newsweek science sections, Scientific American, Audubon, National Wildlife, etc.) 1. No, seldom. 2. About once a month. 3. About once a week.	0.687	0.649	99	0.630	0.681	54
BKG041	41. Do you read about other scientific or science-related topics in your free time? (including newspaper articles, Time, Newsweek, etc.) 1. No, seldom. 2. About once a month. 3. About once a week.	0.758	0.730	99	0.704	0.743	54
	Rate each of the following according to its value to you in learning concepts in past science or science-related courses. Use the following scale: 1 Not Helpful 2 Slightly Helpful 3 Somewhat Helpful 4 Very Helpful 5 Extremely Helpful						
BKG042	42. Laboratory work.	2.636	0.963	99	2.538	0.979	52
BKG043	43. Demonstrations.	2.879	0.860	99	2.846	0.872	52
BKG044	44. Films.	2.253	0.930	99	2.255	0.845	51
BKG045	45. Lectures.	2.808	0.791	99	2.404	1.015	52
BKG046	46. Recitations.	2.202	1.069	99	2.255	0.891	51
BKG047	47. Textbooks.	2.515	0.930	99	2.308	1.020	52
BKG048	48. Problem sets.	2.030	0.931	99	1.942	0.895	52
BKG049	49. Resource books, Magazines, etc.	1.990	0.985	99	1.712	0.997	52
BKG050	50. Studying for, taking, and reviewing exams.	2.808	0.922	99	2.385	1.174	52

INSTRUMENT: BACKGROUND QUESTIONNAIRE

Variable Acronym	ITEM	FALL TERM 1977 MEAN	STD.DEV.	N	WINTER TERM 1978 MEAN	STD.DEV.	N
	1 Not Helpful 2 Slightly Helpful 3 Somewhat Helpful 4 Very Helpful 5 Extremely Helpful						
BKG051	51. Studying the textbook.	2.596	0.880	99	2.423	0.915	52
BKG052	52. Studying your class notes.	2.939	0.843	99	2.712	0.825	52
BKG053	53. Studying a friend's class notes.	1.424	0.970	99	1.500	1.038	52
BKG054	54. Studying and discussing the course material with friends.	2.556	0.895	99	2.538	1.075	52
BKG055	55. Reviewing previously discussed or solved problems.	2.556	0.848	99	2.481	0.727	52
BKG056	56. Memorizing the most important concepts or topics.	2.545	0.982	99	2.385	1.105	52
BKG057	57. Memorizing as much of the material as possible.	1.667	1.097	99	1.808	1.155	52
BKG058	58. Rewriting all or parts of your notes.	1.879	1.206	99	1.942	1.162	52
BKG059	59. Relating one concept or topic to another.	3.081	0.817	99	2.750	0.883	52
BKG060	60. When anticipating and taking exams I am generally 1. so tense that I often feel sick and/or my mind goes blank. 2. sufficiently nervous that my abilities are often impaired. 3. slightly nervous such that my performance is slightly and/or occasionally impaired. 4. relaxed and unaffected by tension. 5. stimulated by the tension to perform exceptionally well.	1.949	0.747	99	2.000	0.950	52
BKG061	61. Compared with other courses I have taken, I anticipate the difficulty of this course to be: 1. very easy. 2. easy. 3. about average. 4. difficult. 5. very difficult.	2.768	0.754	99	3.019	0.641	52
BKG062	62. I anticipate that this course will be: 1. very boring. 2. boring. 3. slightly interesting. 4. interesting. 5. very interesting.	2.918	0.586	98	2.827	0.706	52

INSTRUMENT: BACKGROUND CURRENT/VOLTAGE

Variable Acronym	ITEM	FALL TERM 1977 MEAN	STD.DEV.	N	WINTER TERM 1978 MEAN	STD.DEV.	N
BKG063	63. The type of discussion which I find to be the clearest in aiding my understanding of a topic presented in a lecture or section of a textbook is: 1. Quantitative with as little description and additional discussion as possible; mathematical derivations or proofs. 2. Logical and quantitative, but with a few well reasoned examples given to illustrate the implications of the general principles and conclusions. 3. Thoroughly discussed with a great deal of qualitative illustrations drawn from common experiences, and many examples of applications to problem situations (no math).	1.531	0.522	96	1.765	0.473	51
BKG064	64. I would prefer to have the content of the course selected in the following way: 1. A broad overview of many topics at a survey level. 2. An overview of many topics, but with some depth in one or two topics. 3. An in-depth concentration on a few topics, but with some discussion of their relation to the whole subject area. 4. Concentration and exploration of several topics in greater detail and depth.	1.281	0.903	96	1.118	0.840	
BKG065	65. Which one of the following types of instruction would enable you to obtain the best understanding of a particular set of concepts? 1. General to Specific -- the concepts are first introduced at a high level of generality with reference to their association with other related concepts, and are then elaborated on until a particular set of subconcepts are understood at a desired level of depth, breadth, and detail. 2. Specific to General -- the concepts are developed by first concentrating on understanding each of a number of independent subconcepts, which are then combined to form a broad general concept.	0.302	0.634	94	0.327	0.474	52
BKG066	Answer the following questions only if you are working toward a Teaching Certificate. 66. The degree to which I anticipate deriving enjoyment out of teaching science to elementary school children is best described as: 1. very little. 2. little. 3. some. 4. much. 5. very much.	3.087	0.780	92	2.583	0.986	48
BKG067	67. The percentage of my classroom time which I anticipate devoting to teaching science is: 1. less than 5%. 2. 5 - 10%. 3. 10 - 15%. 4. 15 - 20%. 5. More than 20%.	2.444	0.823	90	2.167	1.059	48

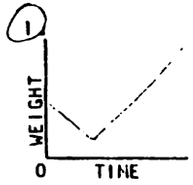
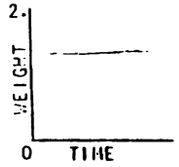
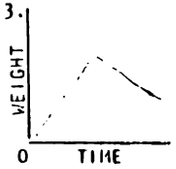
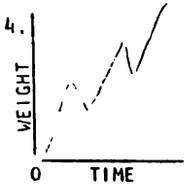
Variable Acronym	ITEM	FALL TERM 1977 MEAN	STD.DEV.	N	WINTER TERM 1978 MEAN	STD.DEV.	N
BKG068	63. Answer the following question only if you have some advance information about BS 202 from fellow students: I have heard from other students that BS 202, for students with my major is: 1. a waste of time. 3. valuable. 2. slightly valuable. 4. extremely valuable.	1.568	0.818	44	1.316	0.946	19

Variable Acronym	ITEM	FALL TERM 1977 MEAN	STD.DEV.	N	WINTER TERM 1978 MEAN	STD.DEV.	N
PRE001	1. Which of the following levels of organization includes all of the others within it? (1.) organism. 2. cell. 3. organelle. 4. molecule. 5. organ system.	0.573	0.497	96	0.667	0.424	75
PRE002	2. If you were looking at some cells through a microscope, they could definitely be identified as plant cells and not animal cells if they had 1. nuclei. 2. chromosomes. 3. vacuoles. 4. cell membranes. (5.) cell walls.	0.438	0.499	96	0.356	0.428	75
PRE003	3. The chief value to the animal body of the breakdown of glucose to carbon dioxide and water is that it 1. satisfies the body's craving for food. (2.) releases energy. 3. provides the raw materials for protein synthesis. 4. enables the body to synthesize carbohydrates. 5. contributes to the oxygen supply for entire animal kingdom.	0.691	0.464	94	0.678	0.417	75
PRE004	4. A population is a localized aggregation of 1. individuals of different species. 2. several species. 3. several communities. 4. individuals of two ecosystems. (5.) individuals of the same species.	0.667	0.474	96	0.610	0.435	75
PRE005	5. Of the following the ultimate source of most food in the typical fresh-water pond is/are the 1. microscopic green plants. 2. minute unicellular animals, 3. minnows, aquatic insects, and molluscs. 4. large water weeds. 5. bacteria and fungi.	0.458	0.501	96	0.525	0.446	75

INSTRUMENT: PRETEST

Variable Acronym	ITEM	FALL TERM 1977 MEAN	STD.DEV.	N	WINTER TERM 1978 MEAN	STD.DEV.	N
PRE006	6. Fixation of atmospheric nitrogen is accomplished by 1. a symbiotic relationship between an alga and a fungus. (2) certain bacteria living in the roots of leguminous plants. 3. leaves of green plants. 4. the roots of all higher plants. 5. all of these.	0.098	0.299	92	0.153	0.321	75
PRE007	7. The climax stage of a biotic succession (1) persists until the environment or climate changes. 2. changes rapidly from time to time. 3. is the first stage in a succession. 4. is the stage in which only plants are present. 5. varies considerably regardless of the climate.	0.473	0.502	91	0.456	0.437	75
PRE008	8. Ecology is 1. the study of evolution. 2. the study of disease. 3. the study of fossils. (4) the study of the relations of plants and animals to their environment. 5. none of the above.	0.958	0.201	96	0.917	0.249	75
PRE009	9. The sequence in a typical food chain is 1. plants-large carnivores-small carnivores-herbivores. (2) plants-herbivores-small carnivores-large carnivores. 3. large carnivores-small carnivores-herbivores-plants. 4. herbivores-plants-large carnivores-small carnivores. 5. small carnivores-large carnivores-herbivores-plants.	0.792	0.408	96	0.850	0.322	75
PRE010	Questions 10 and 11 are based on the following experiment. A lizard placed before three plates, one at a temperature of 50°C, one at a temperature of 37°C, and one at a temperature of 15°C, consistently moves to the 37°C plate. 10. This behavior is an example of (1) a response to a stimulus. 2. reasoning. 3. reflex arc. 4. anthropomorphism.	0.521	0.502	96	0.633	0.434	75

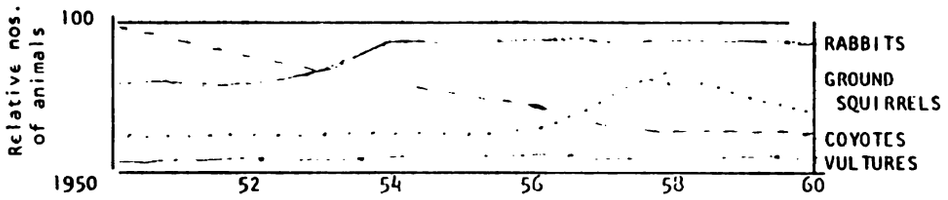
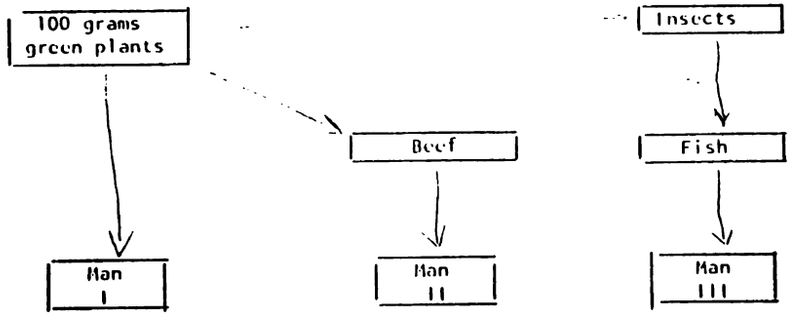
INSTRUMENT: PRETEST

Variable Acronym	ITEM	FALL TERM 1977 MEAN	STD.DEV.	N	WINTER TERM 1978 MEAN	STD.DEV.	N
PRE011	11. Many eggs from these lizards were hatched under laboratory conditions. The young lizards consistently moved to the 37°C plate. This behavior can best be called 1. social. (2.) innate. 3. learned. 4. intelligent.	0.969	0.175	96	0.917	0.249	75
PRE012	12. A certain baby loses weight because he cannot digest his mother's milk. The doctor finds something that the baby can digest and he gains weight. Which of the following graphs shows how his weight changes? (1.)  2.  3.  4. 	0.958	0.201	96	0.900	0.270	75
PRE013	13. Two well-watered geranium plants, in sealed pots, were placed under two dry bell jars, X and Y. The leaves of the plant under Jar X were coated with vaseline on both upper and lower surfaces, while those of the plant under jar Y were not coated. The two bell jars were then placed in bright sunlight for 8 hours. At the end of this time, what was the probable condition of the inside surface of the bell jars? (1.) Jar X showed more moisture than Jar Y. 2. Jar X showed less moisture than Jar Y. 3. Each jar was very moist with no noticeable difference in amount. 4. Jar X was covered with many fine droplets of vaseline. 5. None of the above.	0.219	0.416	96	0.317	0.419	75

INSTRUMENT: PRETEST

Variable Acronym	ITEM	FALL TERM 1977 MEAN	STD.DEV.	N	WINTER TERM 1978 MEAN	STD.DEV.	N
PRE014	14. An ecologist conducted an experiment to find out how many frogs lived in a pond. He could not catch all of the frogs and count them. The first day he caught 55 frogs and put a band on one of the legs of each frog. He waited a week to give the banded frogs a chance to distribute themselves evenly throughout the pond. He then caught 72 frogs, and 12 of them had bands on one leg. What could the ecologist reasonably conclude about the number of frogs in the pond? 1. There were 127 frogs in the pond. 2. There were 115 frogs in the pond. (3) There were over 300 frogs in the pond. 4. This data doesn't tell us anything about the total number of frogs in the pond.	0.292	0,457		0.317	0.419	75
PRE015	15. A biome may be best described as: 1. The functional role or position in the ecosystem. 2. A characteristic form or mode of growth. (3) A climax plant formation. 4. A local unit of population. 5. The plant life of a given period.	0.054	.0.228	92	0.119	0.289	75
PRE016	16. As population density increases 1. carrying capacity increases. 2. behavior decreases. 3. environmental resistence decreases. 4. biotic potential is reached. (5) competition increases.	0.688	0.466	96	0.600	0.441	75

INSTRUMENT: PRETEST

Variable Acronym	ITEM	FALL TERM 1977 MEAN	STD.DEV.	N	WINTER TERM 1978 MEAN	STD.DEV.	N
PRE017	Question 17 refers to this diagram.  17. The best explanation for the change in the ground squirrel population between 1958 and 1960 is that: 1. the vulture population was decreasing. 2. the coyotes were eating more rabbits. (3.) rabbits are more successful competitors for grass. 4. ground squirrels were reproducing more rapidly.	0.453	0.500	95			
PRE018	18. An Ecosystem consists of: (1.) The biotic components of a community. (2.) The biotic and abiotic components of a defined area. 3. The only area proper for the study of ecology. 4. All the species in the world. 5. Plants, animals, and microorganisms.	0.421	0.496	95	0.333	0.424	75
PRE019	three possible pathways for the energy produced by the green plants.  19. In which of the following situations would the most energy be available? (1.) I. 2. II. 3. III. 4. It is equal for all three.	0.615	0.489	96	0.550	0.448	75

INSTRUMENT: PRETEST

Variable Acronym	ITEM	FALL TERM 1977 MEAN	STD.DEV.	N	WINTER TERM 1978 MEAN	STD.DEV.	N
PRE020	20. In which situation(s) would man receive only about 10% of the original energy supplied by the producer? 1. I. 3. III. 2. II. 4. It is the same in all three.	0.083	0.278	96	0.117	0.289	75
PRE021	21. Animals at the top of a food chain 1. breed faster than those lower in the food chain. 2. are smaller than those lower in the chain. 3. are more numerous than those lower in the chain. (4.) are carnivorous.	0.621	0.488	95	0.517	0.450	75
PRE022	22. Which of the following is the niche of a grasshopper? (1.) herbivore. 2. grassland. 3. arthropoda. 4. insecta. 5. grass.	0.138	0.347	94	0.100	0.270	75
PRE023	23. Animals are not required in the carbon cycle because: 1. Green plants and decomposers produce only CO_2 while animals use up CO_2 thus causing a one way flow of carbon, not a cycle. 2. Green plants produce all the oxygen needed by decomposers while decomposers provide all the complex carbon compounds required by green plants. (3.) Decomposers and respiring plants produce all the CO_2 required by green plants which in turn produce all the oxygen (O_2) required by decomposers and respiring plants. 4. Animals are required because strict decomposers are members of the Kingdom Metazoa, which are animals. 5. None of the above.	0.261	0.442	92	0.164	0.319	75
PRE024	24. A eutrophic lake is: 1. in an early successional stage of the lake. (2.) in a late successional stage of the lake. 3. has clear, deep, water. 4. contains few but high quality fish species (i.e., trout, etc.) 5. None of the above.	0.370	0.485	92	0.333	0.414	75

INSTRUMENT: PRETEST

Variable Acronym	ITEM	FALL TERM 1977 MEAN	STD.DEV.	N	WINTER TERM 1978 MEAN	STD.DEV.	N
PRE020	20. In which situation(s) would man receive only about 10% of the original energy supplied by the producer? 1. I. 2. II. 3. III. 4. It is the same in all three.	0.083	0.278	96	0.117	0.289	75
PRE021	21. Animals at the top of a food chain 1. breed faster than those lower in the food chain. 2. are smaller than those lower in the chain. 3. are more numerous than those lower in the chain. (4.) are carnivorous.	0.621	0.488	95	0.517	0.450	75
PRE022	22. Which of the following is the niche of a grasshopper? 1. herbivore. 2. grassland. 3. arthropoda. 4. insecta. 5. grass.	0.138	0.347	94	0.100	0.270	75
PRE023	23. Animals are not <u>required</u> in the carbon cycle because: 1. Green plants and decomposers produce only CO_2 while animals use up CO_2 thus causing a one way flow of carbon, not a cycle. 2. Green plants produce all the oxygen needed by decomposers while decomposers provide all the complex carbon compounds required by green plants. (3.) Decomposers and respiring plants produce all the CO_2 required by green plants which in turn produce all the oxygen (O_2) required by decomposers and respiring plants. 4. Animals <u>are</u> required because strict decomposers are members of the Kingdom Metazoa, which are animals. 5. None of the above.	0.261	0.442	92	0.164	0.319	75
PRE024	24. A eutrophic lake is: 1. in an early successional stage of the lake. (2.) in a late successional stage of the lake. 3. has clear, deep, water. 4. contains few but high quality fish species (i.e., trout, etc.) 5. None of the above.	0.370	0.485	92	0.333	0.414	75

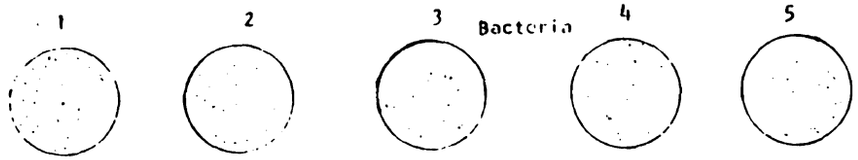
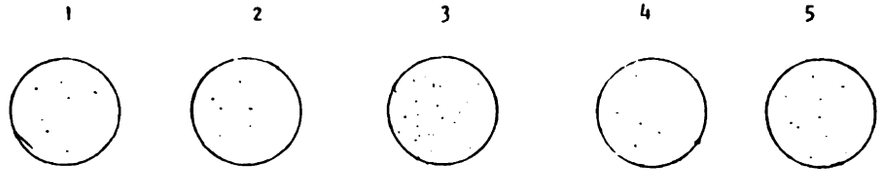
DEFENSE

Variable Acronym	ITEM	FALL TERM 1977 MEAN	STD.DEV.	N	WINTER TERM 1978 MEAN	STD.DEV.	N
PRE025	25. Which of the following statements describes energy in the biosphere? 1. a flow of energy is a characteristic of all ecosystems. 2. there is no such thing as an energy cycle. 3. energy is steadily drained from the ecosystem as it is passed along the links of a food chain. 4. an ecosystem cannot continue functioning without a constant input of energy from the outside. (5.) all of the above statements.	0.298	0.460	94	0.379	0.430	75
PRE026	26. A toad eating a grasshopper would be an example of: 1. competition. (2.) predation. 3. parasitism. 4. symbiosis. 5. scavenging.	0.884	0.322	95	0.833	0.336	75
PRE027	27. In an area with prevailing winds from west to east air moving from over an ocean and across a mountain would lose the most moisture 1. over the ocean. 2. over the beach. 3. on the eastern slope of the mountain. (4.) on the western side of the mountain. 5. none of these.	0.600	0.492	95	0.517	0.450	75
PRE028	28. Which one of the following best describes a sealed aquarium? 1. population. (2.) ecosystem. 3. biosphere. 4. organ system. 5. community.	0.442	0.499	95	0.317	0.419	75
PRE029	29. The ecological niche of a plant or animal refers to 1. the kind of environment surrounding it. 2. where one would go to look for that organism. 3. the population size of the organism in a community. (4.) the role of the organism in a community. 5. the efficiency of energy transfer in a community.	0.255	0.438	94	0.183	0.348	75

INSTRUMENT: PRETEST

Variable Acronym	ITEM	FALL TERM 1977 MEAN	FALL TERM 1977 STD.DEV.	FALL TERM 1977 N	WINTER TERM 1978 MEAN	WINTER TERM 1978 STD.DEV.	WINTER TERM 1978 N
PRE030	30. The efficiency with which food energy is passed from producers to the top trophic level in a food chain can be increased by: 1. getting the animals in the top trophic level to eat more. (2) decreasing the number of steps (trophic levels) in the food chain. 3. increasing the rate of photosynthesis. 4. increasing the number of steps in the food chain. 5. none of the preceding.	0.638	0.483	94	0.431	0.438	75
PRE031	31. Animals at the top of a pyramid of energy 1. breed faster than those lower in the food chain. 2. are smaller than those lower in the chain. 3. are more numerous than those lower in the chain. (4) are carnivorous. 5. are producers.	0.574	0.497	94	0.407	0.439	75
PRE032	32. Green plants give off carbon dioxide as a result of: 1. transpiration. 2. photosynthesis. (3) respiration. 4. manufacture of cellulose. 5. translocation.	0.253	0.437	95	0.167	0.336	75

INSTRUMENT: PRETEST

Variable Acronym	ITEM	FALL TERM 1977 MEAN	STD.DEV.	N	WINTER TERM 1978 MEAN	STD.DEV.	N
PRE033	Professor E. Colic, a biologist, conducted an experiment to determine whether four new chemicals, Crud, Smear, Yuk, and Everdie, are effective in killing household bacteria. The professor grew five identical bacteria cultures in petri dishes as shown in the diagram below.  The professor then added equal amounts of Crud and Smear to the first culture, equal amounts of Yuk and Smear to the second culture, equal amounts of Crud and Yuk to the third culture, equal amounts of Smear and Everdie to the fourth culture, and equal amounts of Everdie and Yuk to the fifth culture. The professor knew from previous experiments that the chemicals did not react with each other. He reasoned that if one or both of the chemicals added to a culture were effective, the bacteria in that culture should die. The results of the experiment twelve hours after the chemicals were added is shown in the diagram below.  						
	33. Is the chemical Yuk effective in killing bacteria? 1. Yes. (2) No. 3. Can't tell from the experiment.	0.626	0.486	91	0.627	0.432	

INSTRUMENT: PRETEST

Variable Acronym	ITEM	FALL TERM 1977 MEAN	FALL TERM 1977 STD.DEV.	FALL TERM 1977 N	WINTER TERM 1978 MEAN	WINTER TERM 1978 STD.DEV.	WINTER TERM 1978 N
PRE034	34. Is the chemical Everdie effective in killing bacteria? 1. Yes. 2. No. 3. Can't tell from the experiment.	0.769	0.424	91	0.678	0.417	75

INSTRUMENT: AFFECTIVE QUESTIONNAIRE

Variable Acronym	ITEM	FALL TERM 1977 MEAN	STD.DEV.	N	WINTER TERM 1978 MEAN	STD.DEV.	N
AFF001	1. During course examinations I find myself thinking of things unrelated to the actual course material.	0.687	0.466	99	0.545	0.503	55
AFF002	2. I get to feel very panicky when I have to take a surprise exam.	0.253	0.437	99	0.236	0.429	55
AFF003	3. I freeze up on things like intelligence tests and final exams.	0.556	0.519	98	0.519	0.504	54
AFF004	4. After taking a test I always feel I could have done better than I actually did.	0.374	0.486	99	0.418	0.498	55
AFF005	5. I have an uneasy, upset feeling before taking a final exam.	0.343	0.477	99	0.455	0.503	55
AFF006	6. When taking a test my emotional feelings do not interfere with my performance.	0.768	0.424	99	0.800	0.404	55
AFF007	7. During a course examination I frequently get so nervous that I forget facts I really know.	0.596	0.493	99	0.582	0.498	55
AFF008	8. The harder I work at taking a test or studying for one, the more confused I get.	0.747	0.437	99	0.800	0.404	55
AFF009	9. As soon as an exam is over I try to stop worrying about it, but I just can't.	0.646	0.480	99	0.800	0.404	55
AFF010	10. I would rather write a paper than take an examination for my grade in a course.	0.663	0.475	99	0.593	0.496	54
AFF011	11. I think I could do much better on tests if I could take them alone and not feel pressured by a time limit.	0.374	0.486	99	0.222	0.420	54
AFF012	12. Thinking about the grade I may get in a course interferes with my studying and my performance on tests.	0.535	0.501	99	0.455	0.503	55
AFF013	13. On exams I take the attitude, "If I don't know it now there's no point worrying about it."	0.535	0.501	99	0.618	0.490	55
AFF014	14. Thoughts of doing poorly interfere with my performance on tests.	0.707	0.457	99	0.564	0.501	55
AFF015	15. I don't study any harder for final exams than for the rest of my course work.	0.806	0.397	98	0.782	0.417	55
AFF016	16. Even when I'm well prepared for a test, I feel very anxious about it.	0.313	0.466	99	0.364	0.485	55
AFF017	17. I seldom feel the need for "cramming" before an exam.	0.735	0.444	99	0.691	0.466	55
AFF018	18. I start feeling very uneasy just before getting a test paper back.	0.243	0.477	99	0.364	0.485	55
AFF019	19. I dread courses where the professor has the habit of giving "pop" quizzes.	0.182	0.388	99	0.167	0.376	54
AFF020	20. In most cases a student does not need to know what type of questions will be on the test.	0.939	0.240	99	0.927	0.262	55
AFF021	21. The best way for a student to find out what will be on a test is to ask his friends.	0.980	0.141	99	0.964	0.189	55

INSTRUMENT: AFFECTIVE QUESTIONNAIRE

Variable Acronym	ITEM	FALL TERM 1977 MEAN	STD.DEV.	N	WINTER TERM 1978 MEAN	STD.DEV.	N
AFF022	22. Students should seek to find something of interest in any study material.	0,071	0.258	99	0.073	0.262	55
AFF023	23. It is to the student's advantage to think about how he is answering the questions on a test.	0,061	0.240	99	0.055	0.229	55
AFF024	24. A student should continue to think about unanswered questions that he has skipped on a test.	0.535	0.501	99	0.455	0.503	55
AFF025	25. When a student takes a test he should try to think how he is answering the questions on a test.	0,092	0.290	98	0.074	0.264	55
AFF026	26. If a student usually sits with his friends in class, he will be better off sitting with them during the test.	0,735	0.444	98	0.667	0.476	54
AFF027	27. Generally, it is sufficient to go through a test once and then a fast second time to check your marks.	0.283	0.453	99	0.255	0.440	55
AFF028	28. A student should answer the easiest questions first even if he has to skip around on the test.	0.384	0.489	99	0.327	0.474	55
AFF029	29. A student should look over the entire test before he starts any question.	0.333	0.474	99	0.436	0.501	55
AFF030	30. Every word in a question is important.	0.030	0.172	99	0.091	0.290	55
AFF031	31. A student should always play with the question until he has it in a form he can deal with.	0.333	0.474	99	0.333	0.476	54
AFF032	32. One generally finds that changing an answer is more often to one's disadvantage.	0,202	0.404	99	0.170	0.379	53
AFF033	33. A student should try to use ideas from other questions in the test to answer current questions.	0.061	0,240	99	0.056	0.231	54
AFF034	34. A student should answer the questions according to how he feels they should be answered.	0.384	0.489	99	0.370	0.487	54
AFF035	35. A student should try to think of the answer to a question before he looks at the choices.	0,081	0.274	99	0.109	0.315	55
AFF036	36. A student should compare the choices for an item with one another to find out what makes them different.	0.051	0.220	99	0.074	0.264	54
AFF037	37. I hesitate to ask for help from others.	0.606	0.491	99	0.519	0.504	54
AFF038	38. It's fun to try out ideas that others think are crazy.	0.255	0.438	98	0.259	0.442	54
AFF039	39. I enjoy working with students who get good marks.	0.144	0.353	97	0.222	0.420	54
AFF040	40. It's good for students to work with one another on their course work.	0,071	0.258	99	0.073	0.262	55

Variable Acronym	ITEM	FALL TERM 1977 MEAN	STD.DEV.	N	WINTER TERM 1978 MEAN	STD.DEV.	N
AFF041	41. I don't need my friend's encouragement when I meet with failure.	0.837	0.372	98	0.836	0.373	55
AFF042	42. Committee work is a waste of time.	0.857	0.352	98	0.830	0.379	53
AFF043	43. It doesn't bother me if I get a 2.5 in a course instead of a 3.5.	0.960	0.198	99	0.891	0.315	55
AFF044	44. I feel better avoiding a fight or an argument than trying to have my own way.	0.378	0.487	98	0.481	0.504	54
AFF045	45. I like to follow instructions and to do what is expected of me.	0.051	0.221	98	0.091	0.290	55
AFF046	46. My family does not like what I have chosen for my career.	0.929	0.258	99	0.981	0.136	54
AFF047	47. In class it is best to go along with the majority even when you disagree.	0.857	0.352	98	0.833	0.376	54
AFF048	48. It is not always best to have the majority make the decision.	0.111	0.316	99	0.154	0.364	52

Name _

of pr
grade
you d

sheet
on th

can v

ANALYTIC ABILITY

BIOLOGICAL SCIENCE 202:PROBLEM SOLVING

ame _____ Student Number _____

The objective of this exercise is to determine student aptitude on types problems not often encountered. Your performance will not effect your rade. Please do the best you can, but DO NOT GUESS. Leave an item black if ou do not know the correct answer.

Please fill in your name and student number on this sheet and on the IBM eet. Darken in the appropriate squares under your name and student number the IBM sheet.

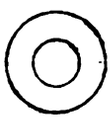
The questions are all multiple choice. Answer each question that you n without guessing by marking the appropriate box on the IBM sheet.

You may write or draw on the test pages if you wish.

PART I D

ART I **Directions**: In this part, you are to choose from five diagrams the one that illustrates the relationship among three given classes better than any of the other diagrams offered.

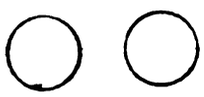
There are three possible relationships between any <u>two</u> different classes:



indicates that one class is completely contained in the other, but not vice versa.



indicates that neither class is completely contained in the other, but the two do have members in common.



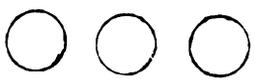
indicates that there are no members in common.

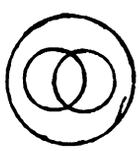
<u>Note</u>: The size of the circles does <u>not</u> indicate relative size of the classes.

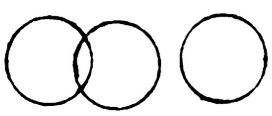
Example:

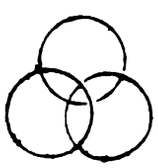
Birds, pets, trees.

(1) 

(2) 

(3) 

(4) 

(5) 

The correct answer, (4), shows that one of the classes (trees) has no members in common with the other two. (No trees are either birds or pets, and no birds or pets are trees). (4) also shows that the other two classes have some members in common, but neither is completely included in the other (some birds are pets and some pets are birds, but there are birds that are not pets and there are pets that are not birds).

The five possible choices for questions 1 through 8 are given below:

(1) 

(2) 

(3) 

(4)

(5) 

1. Nuts, pecans, forks.

2. Adult women, infants, black-haired people.

3. Fish, minnows, things that live in the water.

4. Governments, democracies, dictatorships.

5. Adult men, government officials, congressmen

6. Students, children, parents.

7. Lizards, cats, reptiles.

8. Frozen desserts, milk products, ice cream.

II. (In answering the questions below it may be useful to draw a rough diagram.)

Questions 9 and 10.

(A) It is assumed that a half tone is the smallest possible interval between notes.
(B) Note T is a half tone higher than note V.
(C) Note V is a whole tone higher than note W.
(D) Note W is a half tone lower than note X.
(E) Note X is a whole tone lower than note T.
(F) Note Y is a whole tone lower than note W.

Which of the following represents the relative order of the notes from the lowest to the highest?

(1) X Y W V T.
(2) Y W X V T.
(3) W V T Y X.
(4) Y W V T X.
(5) Y X W V T.

Which of the following statements about an additional note, Z, could NOT be true?

(1) Z is higher than T.
(2) Z is lower than Y.
(3) Z is lower than W.
(4) Z is between W and Y.
(5) Z is between W and X.

11. TI

(
(
(
(
(

12. H
a

(

13.

14.

Questions 11 and 12

(A) A red ticket is required for entrance.
(B) You can get a red ticket if you have your blue form signed by the director.
(C) The director will only sign the blue form if you surrender your yellow pass to him.
(D) If you have a green slip, you can exchange it for a yellow pass, but only if the director has signed your blue form.
(E) If you have a valid driver's license, you do not have to have your blue form signed by the director in order to get a red ticket.
(F) You can get a yellow pass on request, but only if you do not already have a green slip.

. The above procedures fail to specify

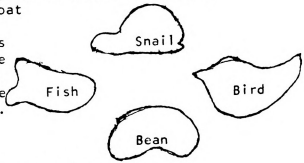
(1) whether anything besides a red ticket is required for entrance.
(2) whether you can exchange a green slip for a yellow pass.
(3) the condition under which the director will sign the blue form.
(4) how to get a red ticket if you have a yellow pass.
(5) how to bypass the requirement of having the blue form signed.

. Having which of the following makes it impossible for someone without a driver's license to enter?

(A) A signed blue form.
(B) An unsigned blue form.
(C) A yellow pass.
(D) A red ticket.
(E) A green slip.

Questions 13 and 14

This problem is about Fish, Snail, Bean, and Bird Islands. People have been traveling among these islands by boat for many years, but recently an airplane started a business. Carefully read the clues about possible plane trips. The trips may be direct or include stops and plane changes on an island. When a trip is possible it can be made in either direction between the islands.



(A) People can go by plane between Bean and Fish Islands.
(B) People cannot go by plane between Bird and Snail Islands.
(C) People can go by plane between Bean and Bird Islands.

. Can people go by plane between Fish and Bird Islands?

(1) Yes.
(2) No.
(3) Can't tell from the clues.

. Can people go by plane between Snail and Fish Islands?

(1) Yes. (2) No. (3) Can't tell from the clues.

DIRECTIONS:

1. Please

2. Write y

3. Answer

4. Check y

5. Read th
   11 com

6. Be sur

7. Return

Answers 1-

1) Sprin

2) Sprin

3) C and

4) G and

CONTROLLING VARIABLES

TIONS:

lease read and examine the first page carefully.

rite your name and student number at the top of page 2.

nswer questions 1, 2, 3 and 4, then

heck your answers with those given below.

ead the top of page 3 carefully, then answer questions 5 through
l completely.

e sure to write your name and student number at the top of page 2.

eturn your "test" during your SAS.

rs 1-4

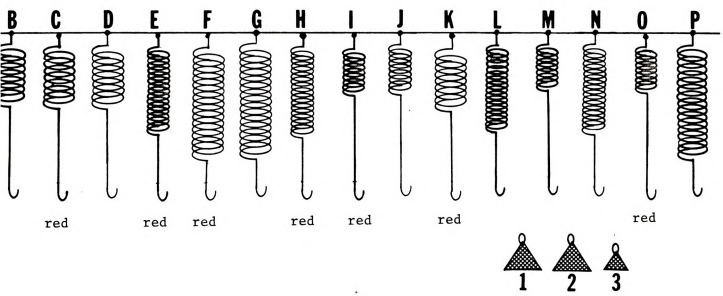
oring K: Brass, Few coils, Thin wire, Big coils

oring N is made of THIN, STEEL wire and has MANY, SMALL coils.

and I are different: They have different sized coils.

and P are the same: Same coil size, number of coils and metal.

B



There are 16 springs and three weights shown above.

Some of the springs have big coils and some have small coils. The springs with BIG coils are: A, B, C, D, F, G, K, P.

Some of the springs are made of thick wire and some are made of thin wire. The ones made of THIN wire are: D, F, G, H, J, K, N.

Some of the springs have many coils and some have only a few. The springs with MANY coils are: A, E, F, G, H, L, N, P.

Some of the springs are made of steel and some are made of brass. The STEEL springs are colored black and the BRASS springs are colored red. The brass (red) springs are: A, C, E, F, H, I, K, O.

The steel (black) springs are: B, D, G, J, L, M, N, P.

Weights number 1 and number 2 weigh the same amount. They are both heavy. Weight number 3 is lighter.

(If you have any questions please raise your hand).

on P

1)

2)

3)

4)

NAME: _____

2

Please answer the following questions. Be sure to use ALL of the information on Page 1.

1) Circle the words below which describe spring K:

Brass or Steel.

Many coils or Few coils.

Thin wire or Thick wire.

Small coils or Big coils.

2) Which of the following is TRUE about spring N? (Circle the correct choice).

a) Spring N is made of THIN, BRASS wire and has MANY, LARGE coils.
b) Spring N is made of THICK, STEEL wire and has a FEW, SMALL coils.
c) Spring N is made of THIN, STEEL wire and has MANY, SMALL coils.
d) Spring N is made of THIN, STEEL wire and has a FEW, SMALL coils.

3) How are springs C and I DIFFERENT? (Circle the correct choice).

a) They are made of different kinds of metal.
b) They are made of wire of different thicknesses.
c) They have different numbers of coils.
d) They have different sized coils.

4) How are springs G and P the SAME? (Circle the correct choice).

a) Same coil size, number of coils and wire thickness.
b) Same coil size, number of coils and metal.
c) Same metal, number of coils, and wire thickness.
d) Same metal, coil size and wire thickness.

Suppose we wanted to see whether or not the number of coils a spring has makes a difference on how far down it goes when a weight is hung on the spring.

We could test this by hanging

weight number 1 on spring A

and

weight number 2 on spring C,

and seeing which spring goes down farther:

or

we could test the same thing by hanging

weight number 2 on spring N

and

weight number 1 on spring J,

and

seeing which spring goes down farther.

Here are some tests for you to make. (Please raise your hand if you have any questions)

5) Can you make a test to see if the size of the coils makes any difference in how far a spring will go down? /Yes/ /No /

If so, the test could be made by hanging

weight number __ on spring __.

and

weight number __ on spring __.

6) Which spring could you compare to spring B to show whether the size of the coils changes the amount the springs go down?

Spring __, No spring /___/

7) Can

mad

If

and

8)

7) Can you make a test to see if the thickness of the wire that the springs are made of makes any difference in how far a spring will go down? /Yes/ /No/

If so, the test could be made by hanging

weight number __ on spring __.

and

weight number __ on spring __.

8) Which spring could you compare to Spring 0 to show whether the thickness of the wire that the springs are made of changes the amount the spring goes down?

Spring __, No spring /__/

9) Can you make a test to see if the kind of metal a spring is made of changes the amount a spring goes down? /Yes/ /No /

If so, the test could be made by hanging

weight number __ on spring __

and

weight number __ on spring __.

10) If you put weight number 1 on spring E and weight number 2 on spring J, would this be a good test to see if the metal the springs are made of affects the amount they go down?

/Yes/ /No /

11) Can you make a test to see if the weight hung on the spring changes the amount it will go down?

/Yes/ /No /

If so, the test could be made by hanging

weight number __ on spring __

and

weight number __ on spring __.

APPENDIX C

Instructional Variables

APPENDIX C

Instructional Variables

I Matrix Element	Variable Acronym	FALL TERM 1977 Mean	Std.Dev.	N.	WINTER TERM 1978 Mean	Std.Dev.	N.
I_1	LEC001	0.914	0.281	105	0.767	0.381	75
I_2	LEC002	0.876	0.331	105	0.800	0.360	75
I_3	LEC003	0.848	0.361	105	0.717	0.406	75
I_4	LEC004	0.733	0.444	105	0.733	0.398	75
I_5	LEC005	0.752	0.434	105	0.667	0.424	75
I_6	LEC006	0.733	0.444	105	0.717	0.406	75
I_7	LEC007	0.702	0.460	104	0.617	0.438	75
I_8	LEC008	0.562	0.499	105	0.683	0.284	75
I_9	LEC009	0.562	0.499	105	0.567	0.446	75
I_{10}	LEC010	0.648	0.480	105	0.583	0.444	75
I_{11}	LECATD	7.356	2.516	104	6.167	2.182	75
I_{12}	SAS001	0.990	0.098	105	0.883	0.289	75
I_{13}	SAS002	0.990	0.098	105	0.900	0.270	75
I_{14}	SAS003	0.933	0.251	105	0.900	0.270	75
I_{15}	SAS004	0.962	0.192	105	0.917	0.249	75
I_{16}	SAS005	0.962	0.192	105	0.833	0.336	75
I_{17}	SAS006	0.952	0.214	105	0.550	0.448	75
I_{18}	SAS007	0.924	0.267	105	0.800	0.360	75
I_{19}	SAS008	0.933	0.252	104	0.667	0.424	75
I_{20}	SAS009	0.893	0.310	103	0.650	0.429	75
I_{21}	SAS010	0.932	0.253	103	0.717	0.406	75
I_{22}	SAS011	0.921	0.271	101	0.650	0.429	75
I_{23}	SAS012	0.960	0.196	101	0.533	0.449	75
I_{24}	SAS013	0.950	0.218	101	0.567	0.446	75
I_{25}	SAS014	0.941	0.238	101	0.650	0.429	75
I_{26}	SAS015	0.839	0.374	31	0.600	0.282	75
I_{27}	SAS016	0.891	0.313	101	0.533	0.449	75
I_{28}	SAS017	0.921	0.271	101	0.750	0.390	75
I_{29}	SAS018	0.901	0.300	101	0.800	0.360	75
I_{30}	SAS019	0.931	0.255	101	0.617	0.438	75
I_{31}	SASATD	16.990	2.166	101	12.917	3.227	75

APPENDIX C

I Matrix Element	Variable Acronym	FALL TERM 1977 Mean	Std.Dev.	N.	WINTER TERM 1978 Mean	Std.Dev.	N.
I_{32}	LTP001	0.010	0.098	105	0.	0.	75
I_{33}	LTP002	0.010	0.098	105	0.013	0.115	75
I_{34}	LTP003	0.010	0.098	105	0.067	0.251	75
I_{35}	LTP004	0.029	0.167	105	0.040	0.197	75
I_{36}	LTP005	0.010	0.098	105	0.040	0.197	75
I_{37}	LTP006	0.019	0.137	105	0.040	0.197	75
I_{38}	LTP007	0.029	0.167	105	0.013	0.115	75
I_{39}	LTP008	0.029	0.167	105	0.033	0.103	75
I_{40}	LTP009	0.019	0.137	105	0.040	0.197	75
I_{41}	LTP010	0.010	0.098	105	0.027	0.162	75
I_{42}	LTPTOT	0.171	0.545	105	0.280	0.831	75
I_{43}	PQZ001	0.019	0.195	105	0.160	0.369	75
I_{44}	PQZ002	0.019	0.195	105	0.227	0.421	75
I_{45}	PQZ003	0	0	105	0.187	0.392	75
I_{46}	PQZ004	0.457	0.501	105	0.227	0.421	75
I_{47}	PQZ005	0.457	0.501	105	0.293	0.458	75
I_{48}	PQZ006	0.410	0.494	105	0.240	0.430	75
I_{49}	PQZ007	0.390	0.490	105	0.320	0.470	75
I_{50}	PQZ008	0.371	0.486	105	0.293	0.458	75
I_{51}	PQZ009	0.333	0.474	105	0.347	0.479	75
I_{52}	PQZTOT	2.457	2.442	105	2.293	2.958	75
I_{53}	TC1	1.003	0.271	76	0.836	0.357	75
I_{54}	TC3	0.901	0.273	89	0.807	0.501	75
I_{55}	TC4	0.833	0.363	75	1.286	0.968	75
I_{56}	TC5	0.752	0.429	83	1.189	0.497	75
I_{57}	TC6	1.371	1.018	89	0.900	0.709	75
I_{58}	TC7	0.916	0.642	85	1.190	0.510	75
I_{59}	TC8	1.353	0.642	88	0.811	0.418	75
I_{60}	TC9	0.613	0.302	81	1.222	0.465	75
I_{61}	TC10	1.320	0.445	89	0.632	0.315	75
I_{62}	TC11	0.930	0.516	89	1.275	0.915	75

APPENDIX C

I Matrix Element	Variable Acronym	FALL TERM 1977 Mean	Std.Dev.	N.	WINTER TERM 1978 Mean	Std. Dev.	N.
I_{63}	TC12	1.238	0.567	86	0.841	0.472	75
I_{64}	TC13	0.942	0.491	82	0.945	0.366	75
I_{65}	TC14	1.008	0.413	82	0.907	0.407	75
I_{66}	TC15	0.841	0.431	82	1.128	0.357	75
I_{67}	TC16	1.220	0.516	81	0.805	0.429	75
I_{68}	TC17	0.460	0.382	68	1.276	0.584	75
I_{69}	TC18	1.395	0.657	77	0.319	0.158	75
I_{70}	ONE031	.527	.701	93	0.474	0.660	75
I_{71}	ONE032	2.362	.788	94	2.333	0.577	75
I_{72}	ONE033	2.064	1.086	94	2.474	0.872	75
I_{73}	TWO031	0.805	0.689	77	0.483	0.642	75
I_{74}	TWO032	2.208	0.848	77	2.207	0.712	75
I_{75}	TWO033	2.803	1.083	76	2.509	0.932	75
I_{76}	TRE031	0.671	0.602	73	0.671	0.0	75
I_{77}	TRE032	2.164	0.834	73	2.164	0.0	75
I_{78}	TRE033	2.800	1.044	70	2.800	0.0	75
I_{79}	FOR031	0.701	0.631	87	0.536	0.735	75
I_{80}	FOR032	2.000	0.812	86	1.786	0.672	75
I_{81}	FOR033	2.741	1.014	85	2.607	1.061	75
I_{82}	FVE031	0.704	0.697	81	0.553	0.654	75
I_{83}	FVE032	2.198	0.900	81	1.894	0.598	75
I_{84}	FVE033	2.617	1.056	81	2.277	0.911	75
I_{85}	SIX031	0.789	0.754	71	0.611	0.706	75
I_{86}	SIX032	1.914	0.775	70	1.759	0.677	75
I_{87}	SIX033	2.690	0.994	71	2.151	0.860	75
I_{88}	SVN031	0.623	0.708	77	0.709	0.710	75
I_{89}	SVN032	1.974	0.843	77	1.907	0.758	75
I_{90}	SVN033	2.558	1.219	77	2.345	0.948	75
I_{91}	NIN031	0.760	0.768	75	0.706	0.703	75
I_{92}	NIN032	1.716	0.973	74	1.784	0.794	75
I_{93}	NIN033	2.493	1.132	75	2.240	0.966	75

APPENDIX C

I Matrix Element	Variable Acronym	FALL TERM 1977 Mean	Std. Dev.	N.	WINTER TERM 1978 Mean	Std. Dev.	N.
I_{94}	FIN061	0.472	0.641	89	0.556	0.585	75
I_{95}	FIN062	1.697	0.946	89	1.574	0.967	75
I_{96}	FIN063	2.135	1.140	89	1.741	1.029	75
I_{97}	FIN064	0.500	0.678	88	0.528	0.584	75
I_{98}	FIN065	1.307	0.975	88	1.907	0.826	75
I_{99}	FIN066	2.591	1.301	88	2.745	0.919	75
I_{100}	Q1	20.892	3.333	102	24.323	3.821	75
I_{101}	Q2	21.224	3.798	98	26.317	3.101	75
I_{102}	Q3	21.202	4.542	99	25.320	3.049	75
I_{103}	Q4	22.042	3.202	95	27.397	4.206	75
I_{104}	Q5	24.516	3.091	93	28.000	3.437	75
I_{105}	Q6	23.056	4.060	89	22.820	4.391	75
I_{106}	Q7	23.387	3.962	93	27.276	3.872	75
I_{107}	Q9	22.087	3.015	92	26.283	3.852	75
I_{108}	Q10	22.363	3.237	91	23.667	3.676	75

APPENDIX D

FACTOR ANALYSES

TABLE D.1

PRETEST FACTOR ANALYSIS

B Matrix Elements	Variable	Communality
B_{11} =	PRE001	.30445
B_{12} =	PRE002	.74161
B_{13} =	PRE003	.42990
B_{14} =	PRE004	.34633
B_{15} =	PRE005	.49032
B_{16} =	PRE006	.38673
B_{17} =	PRE007	.31443
B_{18} =	PRE008	.25685
B_{19} =	PRE009	.24983
B_{20} =	PRE010	.65.78
B_{21} =	PRE011	.32335
B_{22} =	PRE012	1.00227
B_{23} =	PRE013	.17973
B_{23} =	PRE014	.61759
B_{25} =	PRE015	.44553
B_{26} =	PRE016	.33886
B_{27} =	PRE017	.58876
B_{28} =	PRE018	.76886
B_{29} =	PRE019	.68459
B_{30} =	PRE020	.30051
B_{31} =	PRE021	.66861
B_{32} =	PRE022	.33987
B_{33} =	PRE023	.38825
B_{34} =	PRE024	.89144
B_{35} =	PRE025	.36339
B_{36} =	PRE026	.90180
B_{37} =	PRE027	.89388
B_{38} =	PRE028	.29826

Factor*	Eigenvalue	PCT of VAR	CUM PCT
1	2.50708	14.3	14.3
2	1.93106	11.0	25.3
3	1.57459	9.0	34.3
4	1.52678	8.7	43.0
5	1.45112	8.3	51.3
6	1.20621	6.9	58.1
7	1.15199	6.6	64.7
8	1.08548	6.2	70.9
9	.94324	5.4	76.3
10	.86626	4.9	81.2
11	.82853	4.7	85.9
12	.70668	4.0	90.0
13	.63201	3.6	93.6
14	.59487	3.4	97.0
15	.53464	3.0	100.0

Analysis: Principal Factoring** with 33 Iterations and Varimax Orthogonal Rotation.

TABLE D.1 CONTINUED

PRETEST FACTOR ANALYSIS

B Matrix Elements		Variable	Communality
B_{39}	=	PRE029	.47304
B_{40}	=	PRE030	.59189
B_{41}	=	PRE031	.59372
B_{42}	=	PRE032	.29020
B_{43}	=	PRE033	.58242
B_{44}	=	PRE034	.84169

Factor	Major Components ("Pre" test items)	Mean	Range	Standard Deviation
1	21,23,24,26,31,33,34	0.0	-2.16 to 1.19	0.899
2	1,2,3,5,17,18,30	0.0	-1.40 to 1.61	0.897
3	1,3,5,7,14,21,32	0.0	-1.85 to 1.37	0.827
4	1,7,9,12,21,24,26,27, 30,33	0.0	-5.07 to 0.97	1.014
5	2,19,20,21,24,30,32	0.0	-1.70 to 1.41	0.863
6	3,17,18,24,26,31,34	0.0	-1.72 to 1.84	0.911
7	3,5,12,23,24,26,29,30, 34	0.0	-3.25 to 1.64	0.923
8	4,5,6,8,11,16,18,21, 22,23,24,30	0.0	-2.33 to 1.20	0.806
9	2,12,17,26,27,31,34	0.0	-1.85 to 1.63	0.864
10	6,8,17,19,21,26,27	0.0	-1.66 to 1.51	0.933
11	2,3,6,14,18,21,27,28, 33	0.0	-1.46 to 1.76	0.820
12	2,9,15,17,18,23,24	0.0	-1.16 to 3.34	0.782
13	2,5,6,10,14,22,25	0.0	-1.61 to 1.17	0.821
14	12,18,21,22,25,29,31	0.0	-1.19 to 2.30	0.774
15	5,6,7,10,11,17,18, 23,24,25,30,31,32	0.0	-2.28 to 1.40	0.795

*Pretest Factors are included in B as elements B_{46} through B_{60}.

**SPSS PA2 Option

TABLE D.2

AFFECTIVE QUESTIONNAIRE FACTOR ANALYSIS

VARIABLE	COMMUNALITY
B_{61} = AFF001	.33224
B_{62} = AFF002	.58348
B_{63} = AFF003	.62353
B_{64} = AFF004	.33870
B_{65} = AFF005	.49620
B_{66} = AFF006	.29129
B_{67} = AFF007	.33136
B_{68} = AFF008	.27740
B_{69} = AFF009	.42686
B_{70} = AFF010	.34254
B_{71} = AFF011	.26843
B_{72} = AFF012	.37906
B_{73} = AFF013	.35248
B_{74} = AFF014	.54894
B_{75} = AFF015	.28740
B_{76} = AFF016	.42324
B_{77} = AFF017	.21490
B_{78} = AFF018	.51831
B_{79} = AFF019	.39920
B_{80} = AFF020	.31958
B_{82} = AFF022	.54067
B_{83} = AFF023	.58784
B_{84} = AFF024	.24068
B_{85} = AFF025	1.00699
B_{86} = AFF026	.11840
B_{87} = AFF027	.11573
B_{88} = AFF028	.44775
B_{89} = AFF029	.29973
B_{90} = AFF030	.12821
B_{91} = AFF031	.27303
B_{92} = AFF032	.29683

FACTOR*	EIGENVALUE	PCT OF VAR	CUM PCT
1	3.98067	22.7	22.7
2	2.22991	12.7	35.5
3	1.83957	10.5	46.0
4	1.62837	9.3	55.3
5	1.46467	8.4	63.6
6	1.34250	7.7	71.3
7	1.24444	7.1	78.4
8	1.10681	6.3	84.7
9	1.03649	5.9	90.7
10	.83154	4.7	95.4
11	.80332	4.6	100.0

ANALYSIS: PRINCIPAL FACTORING** WITH 10 ITERATIONS AND VARIMAX ORTHOGONAL ROTATION

TABLE D.2 (Continued)

VARIABLE	COMMUNALITY
B_{93} = AFF033	.48614
B_{94} = AFF034	.29880
B_{95} = AFF035	.22451
B_{96} = AFF036	.38471
B_{97} = AFF037	.33337
B_{98} = AFF038	.44918
B_{99} = AFF039	.44896
B_{100} = AFF040	.60531
B_{101} = AFF041	.28223
B_{102} = AFF042	.44650
B_{103} = AFF043	.27658
B_{104} = AFF044	.25514
B_{105} = AFF045	.28700
B_{106} = AFF046	.42460
B_{107} = AFF047	.25481
B_{108} = AFF048	.23745

FACTOR	MAJOR COMPONENTS (Affective Questionnaire Items, "AFF")	MEAN	RANGE	STANDARD DEVIATION
1	2,3,5,6,7,25,30,32,33,41	0.0	-1.61-2.08	0.907
2	10,20,22,25,31,33,36,42,45,46	0.0	-1.94-3.61	0.971
3	2,4,9,16,18,25,32,33,41,43,44	0.0	-1.75-1.63	0.838
4	1,4,9,25,28,34,37,39,40,42	0.0	-2.79-1.48	0.850
5	1,5,10,13,14,34,37,44,48	0.0	-2.42-1.42	0.821
6	2,7,9,24,33,34,36,39,40,43	0.0	-1.24-4.65	0.847
7	2,3,8,16,20,23,25,29,33,34,37,45,47	0.0	-2.33-1.84	0.829
8	2,3,10,14,22,23,24,25,28,31,33,35,37,40, 42,44,45	0.0	-1.74-2.01	0.840
9	3,5,22,23,25,40,41,42,45,46	0.0	-1.44-3.94	0.836
10	3,8,15,16,17,18,19,23,25,33,34,46	0.0	-1.97-2.45	0.818
11	2,5,12,14,19,33,38,40,42,46	0.0	-1.38-1.83	0.805

*Affective Factors are included

**SPSS PA2 option in B as Elements B_{109} to B_{111}

TABLE D.3

BACKGROUND QUESTIONNAIRE FACTOR ANALYSIS

B Matrix Elements	Variable	Communality
B_{121} =	BKG002	.54719
B_{123} =	BKG004	.50201
B_{124} =	BKG005	.42654
B_{125} =	BKG006	.37496
B_{126} =	BKG006	.75568
B_{128} =	BKG009	.36752
B_{130} =	BKG011	.28720
B_{131} =	BKG012	.39482
B_{133} =	BKG014	.45750
B_{135} =	BKG016	.25327
B_{136} =	BKG017	.34421
B_{137} =	BKG018	.39120
B_{138} =	BKG019	.30725
B_{139} =	BKG020	.27691
B_{140} =	BKG021	.44576
B_{141} =	BKG022	.40536
B_{143} =	BKG024	.59727
B_{144} =	BKG024	.30524
B_{145} =	BKG026	.34726
B_{146} =	BKG027	.57897
B_{147} =	BKG028	.81401
B_{148} =	BKG029	.60365
B_{149} =	BKG030	.76220
B_{150} =	BKG031	.69106
B_{151} =	BKG032	.56750
B_{152} =	BKG033	.46199
B_{153} =	BKG034	.55654
B_{154} =	BKG035	.51077
B_{155} =	BKG036	.57872
B_{156} =	BKG037	.67004

Factor*	Eigenvalue	PCT of VAR	CUM PCT
1	4.61321	15.3	15.3
2	3.66936	12.2	27.5
3	3.01920	10.0	37.5
4	2.63990	8.8	46.3
5	2.26269	7.5	53.8
6	1.97362	6.5	60.3
7	1.69051	5.6	65.9
8	1.59578	5.3	71.2
9	1.57649	5.2	76.4
10	1.55107	5.1	81.6
11	1.34883	4.5	86.1
12	1.23278	4.1	90.2
13	1.18913	3.9	94.1
14	.92674	3.1	97.2
15	.84963	2.8	100.0

Analysis: Principal Factoring** with 21 Iterations and Varimax Orthogonal Rotation

TABLE D.3 CONTINUED

B Matrix Elements	Variable	Communality
B_{157} =	BKG038	.36526
B_{158} =	BKG039	.45860
B_{159} =	BKG040	.79317
B_{160} =	BKG041	.67308
B_{161} =	BKG042	.44745
B_{162} =	BKG043	.39290
B_{163} =	BKG044	.53208
B_{164} =	BKG045	.59895
B_{165} =	BKG046	.46947
B_{166} =	BKG047	.78492
B_{167} =	BKG048	.64009
B_{168} =	BKG049	.34698
B_{169} =	BKG050	.50186
B_{170} =	BKG051	.82095
B_{171} =	BKG052	.45371
B_{172} =	BKG053	.31704
B_{173} =	BKG054	.59783
B_{174} =	BKG055	.71381
B_{175} =	BKG056	.65008
B_{176} =	BKG057	.65604
B_{177} =	BKG058	.41004
B_{178} =	BKG059	.49227
B_{179} =	BKG060	.28790
B_{180} =	BKG061	.47901
B_{181} =	BKG062	.44370
B_{182} =	BKG063	.63778
B_{183} =	BKG064	.42908
B_{184} =	BKG065	.14452
B_{185} =	BKG066	.55022
B_{186} =	BKG067	.46653

TABLE D.3 CONTINUED

Factor	Major Components (Background Questionnaire Items "BKG")	Mean	Range	Standard Deviation
1	7,22,24,30,31,32,47, 50,51,56,57,67	0.0	-2.31 to 2.03	0.923
2	5,7,22,26,33,38,41,44 45,47,51,67	0.0	-2.67 to 1.93	0.916
3	6,28,29,35,36,47,48, 51,55,56,61,67	0.0	-2.38 to 1.71	0.863
4	4,27,30,31,38,40,45, 46,47,48,50,51,52,67	0.0	-2.48 to 1.80	0.865
5	4,25,31,32,33,34,35, 44,47,51,53,63	0.0	-1.77 to 2.32	0.858
6	2,7,28,30,33,34,39, 51,55,56,57,58	0.0	-2.26 to 2.63	0.879
7	7,19,24,28,34,35,44, 48,55,56,59,60	0.0	-2.12 to 2.40	0.870
8	4,7,9,12,22,24,27,31, 34,40,41,43,45,47,51, 55,60	0.0	-2.43 to 1.85	0.843
9	5,6,17,19,21,24,25,28 29,32,33,36,40,44,45 55,57,58,60,6	0.0	-2.70 to 1.69	0.919
10	4,28,29,30,31,34,40, 41,42,48,52	0.0	-1.68 to 2.43	0.896
11	22,28,29,31,34,44,47 49,54,63	0.0	-2.69 to 1.62	0.853
12	9,24,25,28,31,34,40, 43,47,48,51,54,55,57, 63,67	0.0	-5.23 to 1.26	0.862
13	2,4,5,24,31,34,36,39, 47,48,50,51,54,55,57, 61,63,67	0.0	-2.36 to 2.27	0.861
14	5,7,17,24,26,27,32,34 35,39,44,47,48,51,54, 55,56,57,58,66	0.0	-1.88 to 2.69	0.824
15	5,7,12,19,22,24,30,34 46,55,63,64	0.0	-2.19 to 2.05	0.810

*Background Factors are included in B as Elements B_{188} through B_{202}.

**SPSS PA2 Option

APPENDIX E

Model Coefficients

TABLE E.1

MODEL COEFFICIENTS FOR WEEK 1

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K0101	K0201	K0301	K0401	K0501	
$\beta_{-,1}$	.062 (.203)		.046 (.172)	.025 (.127)		CLASS
$\beta_{-,3}$	.001 (-.193)		-.002 (-.284)			TRCR
$\beta_{-,5}$	-.005 (-.993)	-.003 (-.885)		-.003 (-.359)	-.002 (-.430)	CRERN
$\beta_{-,6}$	.0002 (1.091)	.0002 (1.129)		.0001 (.995)	.0001 (.608)	MSUPTS
$\beta_{-,13}$				.002 (.067)		PRE003
$\beta_{-,19}$	.035 (.059)					PRE009
$\beta_{-,21}$				.166 (.189)		PRE011
$\beta_{-,22}$	-.234 (-.196)					PRE012
$\beta_{-,24}$	.099 (.189)					PRE014
$\beta_{-,28}$				.083 (.268)		PRE018
$\beta_{-,30}$			-.085 (-.112)			PRE020
$\beta_{-,31}$	.042 (.085)					PRE021
$\beta_{-,32}$	-.087 (-.125)			-.072 (-.159)		PRE022
$\beta_{-,35}$			.041 (.089)	.039 (.117)		PRE025
$\beta_{-,36}$	.254 (.340)					PRE026
$\beta_{-,38}$					-.052 (-.159)	PRE028
$\beta_{-,50}$			-.066 (-.284)			PRF005
$\beta_{-,54}$		-.046 (-.214)	-.021 (-.076)	-.025 (-.149)		PRF009
$\beta_{-,61}$					.045 (.093)	AFF001
$\beta_{-,63}$	-.107 (-.242)	-.110 (-.309)	-.141 (-.364)			AFF003
$\beta_{-,64}$	-.075 (-.161)	-.052 (-.134)				AFF004
$\beta_{-,68}$			.088 (.190)			AFF008

TABLE E.1

MODEL COEFFICIENTS FOR WEEK 1

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K0101	K0201	K0301	K0401	K0501	
$\beta_{,69}$	.111 (.232)	.119 (.309)				AFF009
$\beta_{,73}$		-.068 (-.184)				AFF013
$\beta_{,77}$		.056 (-.134)				AFF017
$\beta_{,78}$	-.098 (-.204)			-.067 (-.218)		AFF018
$\beta_{,79}$					.086 (.148)	AFF019
$\beta_{,80}$		-.033 (-.043)	-.203 (-.241)	-.145 (-.237)		AFF020
$\beta_{,83}$		.112 (.145)				AFF023
$\beta_{,86}$				.054 (.163)		AFF026
$\beta_{,87}$	.064 (.127)					AFF027
$\beta_{,91}$			-.033 (-.078)			AFF031
$\beta_{,94}$	.059 (.127)		0.072 (-.174)	-.043 (-.143)		AFF034
$\beta_{,100}$				-.089 (-.157)		AFF040
$\beta_{,107}$				.049 (.118)		AFF047
$\beta_{,108}$		.072 (.123)	.086 (.134)			AFF048
$\beta_{,109}$			.040 (.181)			AFR001
$\beta_{,116}$				.017 (.099)	.059 (.220)	AFR008
$\beta_{,123}$				.039 (.187)	.047 (.147)	BKG004
$\beta_{,126}$				.023 (.120)		BKG007
$\beta_{,135}$	.070 (.174)		.052 (.146)	.059 (.230)		BKG016
$\beta_{,137}$	.123 (.193)					BKG018
$\beta_{,138}$				-.090 (-.142)	-.166 (-.171)	BKG019
$\beta_{,139}$		.149 (.267)		.089 (.200)	.197 (.291)	BKG020

TABLE E.1

MODEL COEFFICIENTS FOR WEEK 1

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K0101	K0201	K0301	K0401	K0501	
$\beta_{,145}$			.064 (.146)	.048 (.152)		BKG026
$\beta_{,156}$	.264 (.164)			.187 (.181)		BKG037
$\beta_{,158}$	-.095 (-.208)					BKG039
$\beta_{,161}$					.042 (.181)	BKG042
$\beta_{,167}$		.039 (.195)				BKG048
$\beta_{,169}$		.048 (.240)				BKG050
$\beta_{,171}$	-.042 (-.154)	-.047 (-.216)				BKG052
$\beta_{,192}$			-.053 (-.225)			BKF005
$\beta_{,196}$	-.034 (-.135)					BKF009
$\beta_{,198}$					.028 (.107)	BKF011
$\lambda_{,1}$		.101 (.153)		.119 (.228)	.230 (.288)	LEC001
$\lambda_{,13}$	.306 (.131)		.234 (.113)	.149 (.099)	.389 (.169)	SAS002
$\lambda_{,70}$				-.031 (-.150)	.028 (.090)	ONE031
$\lambda_{,71}$					-.033 (-.115)	ONE032
$\lambda_{,72}$					.032 (.153)	ONE033
$\mu_{,2}$	.099 (.179)					K0200
$\mu_{,6}$		-.063 (-.141)				K0600
$\mu_{,8}$	.074 (.143)					K0800
$\mu_{,23}$		.215 (.207)			.314 (.250)	K2300
$\mu_{,32}$	-.125 (-.130)		.272 (.318)			K3200

TABLE E.1

MODEL COEFFICIENTS FOR WEEK 1

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K0601	K0801	K0901	K1001	K1101	
$\beta_{,3}$		-.001 (-.138)				TRCR
$\beta_{,5}$	-.004 (-.752)					CRERN
$\beta_{,6}$	.0002 (.869)		.0001 (.172)			MSUPTS
$\beta_{,15}$	.096 (.195)					PRE005
$\beta_{,16}$	-.112 (-.133)					PRE006
$\beta_{,19}$		.097 (.152)			.137 (.239)	PRE009
$\beta_{,21}$		.179 (.120)		.567 (.241)		PRE011
$\beta_{,22}$				-.440 (-.215)		PRE012
$\beta_{,26}$			-.218 (-.257)			PRE016
$\beta_{,28}$		.071 (.136)	.168 (.210)			PRE018
$\beta_{,30}$				-.509 (-.344)	.120 (.142)	PRE020
$\beta_{,32}$				-.112 (-.094)		PRE022
$\beta_{,34}$			-.133 (-.160)			PRE024
$\beta_{,35}$	.100 (.184)					PRE025
$\beta_{,36}$	-.088 (-.114)					PRE026
$\beta_{,38}$			-.116 (-.146)			PRE028
$\beta_{,45}$				.023 (.232)		PRETOT
$\beta_{,47}$					.044 (.177)	PRF002
$\beta_{,48}$					-.041 (-.152)	PRF003
$\beta_{,50}$				-.143 (-.314)	-.034 (-.130)	PRF005
$\beta_{,51}$					-.040 (-.163)	PRF006
$\beta_{,57}$					.551 (.192)	PRF012

TABLE E.1

MODEL COEFFICIENTS FOR WEEK 1

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K0601	K0801	K0901	K1001	K1101	
$\beta_{,61}$			.122 (.151)		-.053 (-.110)	AFF001
$\beta_{,63}$					-.040 (-.092)	AFF003
$\beta_{,64}$					.078 (.168)	AFF004
$\beta_{,65}$		-.078 (-.150)				AFF005
$\beta_{,67}$	.060 (.127)	.090 (.179)				AFF007
$\beta_{,68}$		.074 (.130)				AFF008
$\beta_{,78}$				-.090 (-.109)		AFF018
$\beta_{,80}$					-.155 (-.165)	AFF020
$\beta_{,91}$					.048 (.102)	AFF031
$\beta_{,92}$	.108 (.185)	.079 (.129)				AFF032
$\beta_{,94}$		-.105 (-.207)			-.107 (-.232)	AFF034
$\beta_{,95}$					-.119 (-.146)	AFF035
$\beta_{,96}$		.179 (.159)		.288 (.162)		AFF036
$\beta_{,98}$					.100 (.195)	AFF038
$\beta_{,100}$		-.112 (-.116)		-.338 (-.222)	-.133 (-.153)	AFF040
$\beta_{,107}$		-.102 (-.144)			-.074 (-.115)	AFF047
$\beta_{,108}$			.139 (.116)		.088 (.123)	AFF048
$\beta_{,116}$			.106 (.236)			AFR008
$\beta_{,117}$	.053 (.188)					AFR009
$\beta_{,121}$					.030 (.103)	BKG002
$\beta_{,123}$	.066 (.198)	.066 (.187)	.070 (.130)			BKG004
$\beta_{,126}$	.080 (.256)				-.040 (-.136)	BKG007

TABLE E.1

MODEL COEFFICIENTS FOR WEEK 1

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K0601	K0801	K0901	K1001	K1101	
$\beta_{,128}$					.098 (-.169)	BKG009
$\beta_{,134}$		-.028 (-.120)				BKG015
$\beta_{,135}$			.128 (.193)		.061 (.154)	BKG016
$\beta_{,138}$	-.143 (-.141)		-.262 (-.161)			BKG019
$\beta_{,139}$	.194 (.273)	.218 (.290)	.267 (.234)		.118 (.174)	BKG020
$\beta_{,144}$	-.054 (-.116)					BKG025
$\beta_{,150}$	-.052 (.234)					BKG031
$\beta_{,152}$			-.082 (-.135)			BKG033
$\beta_{,156}$		.449 (.257)		.744 (.269)		BKG037
$\beta_{,161}$	.031 (.125)		.037 (.094)			BKG042
$\beta_{,166}$	-.053 (-.209)	-.075 (-.280)				BKG047
$\beta_{,169}$				.065 (.152)		BKG050
$\beta_{,171}$				-.083 (-.178)	-.027 (-.102)	BKG052
$\beta_{,183}$					-.048 (-.194)	BKG064
$\beta_{,188}$					-.066 (-.251)	BKF001
$\beta_{,191}$	.033 (.123)		.076 (.175)			BKF004
$\beta_{,196}$				-.392 (-.092)		BKF009
$\beta_{,198}$		-.104 (-.358)	.075 (.170)	-.143 (-.311)		BKF011
$\beta_{,205}$			-.064 (-.174)			PRBSB2
$\beta_{,208}$					.001 (.136)	EI
$\beta_{,209}$				.002 (.129)		NS
$\beta_{,217}$					.003 (.077)	MSUR

TABLE E.1

MODEL COEFFICIENTS FOR WEEK 1

Coefficients	DEPENDENT VARIABLE, K'_j					Independent Variable Acronym
	K0601	K0801	K0901	K1001	K1101	
$\lambda_{,1}$	.242 (.289)		.389 (.289)			LEC001
$\lambda_{,13}$	.255 (.106)		.663 (.171)			SAS002
$\lambda_{,32}$	.152 (.063)					LTP001
$\lambda_{,70}$		-.041 (-.115)		-.107 (-.190)		ONE031
$\lambda_{,71}$					.040 (.139)	ONE032
$\mu_{,8}$				.086 (.096)		K0800
$\mu_{,9}$			.199 (.108)			K1000
$\mu_{,23}$	.027 (.020)					K2300
$\mu_{,27}$	.166 (.163)					K2700
$\mu_{,32}$			.184 (.115)	-.204 (-.122)		K3200

TABLE E.1

MODEL COEFFICIENTS FOR WEEK 1

Coefficients	DEPENDENT VARIABLE, K'_j					Independent Variable Acronym
	K1201					
$\beta_{,8}$	.0004 (.160)					GPA
$\beta_{,19}$	.108 (.158)					PRE009
$\beta_{,21}$	.285 (.178)					PRE011
$\beta_{,28}$	.121 (.213)					PRE018
$\beta_{,49}$	-.047 (-.178)					PRF004
$\beta_{,51}$	-.063 (-.212)					PRF006
$\beta_{,57}$	.036 (.104)					PRF012
$\beta_{,71}$	.123 (.224)					AFF011
$\beta_{,73}$	.093 (.175)					AFF014
$\beta_{,89}$	-.130 (-.229)					AFF029
$\beta_{,98}$	.094 (.154)					AFF038
$\beta_{,107}$	-.273 (-.358)					AFF047
$\beta_{,116}$	-.061 (-.190)					AFR008
$\beta_{,135}$	-.055 (-.116)					BKG016
$\beta_{,139}$	.143 (.176)					BKG020
$\beta_{,153}$	.050 (-.134)					BKG034
$\beta_{,161}$	.023 (.082)					BKG042
$\beta_{,171}$	-.063 (-.198)					BKG052
$\beta_{,172}$	.022 (.081)					BKG053
$\beta_{,183}$	-.064 (-.215)					BKG064
$\beta_{,198}$	-.098 (-.314)					BKF011
$\beta_{,199}$	.036 (.117)					BKF012

TABLE E.1

MODEL COEFFICIENTS FOR WEEK 1

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K1201					
$\beta_{,202}$	.035 (.107)					BKF015
$\beta_{,205}$	-.020 (-.077)					PRBSB2
$\beta_{,209}$	-.001 (-.130)					NS
$\beta_{,210}$	.001 (.084)					TF
$\lambda_{,1}$	.120 (.126)					LEC001
$\mu_{,8}$	.068 (.112)					K0800

TABLE E.1

Model Constants
Week-1

α 1	-0.2697	α34	
α 2	0.0095	α35	
α 3	0.0331	α36	
α 4	-0.2110	α37	
α 5	-0.5500	α38	
α 6	-0.3237	α39	
α 7		α40	
α 8	0.0112	α41	
α 9	-0.1059	α42	
α10	-0.3810	α43	
α11	0.4617	α44	
α12	0.2390		
α13			
α14			
α15			
α16			
α17			
α18			
α19			
α20			
α21			
α22			
α23			
α24			
α25			
α26			
α27			
α28			
α29			
α30			
α31			
α32			
α33			

TABLE E.2

MODEL COEFFICIENTS FOR WEEK 2

Coefficients	DEPENDENT VARIABLE, K'_j					Independent Variable Acronym
	K0802	K0902	K1002	K1402		
$\beta_{,18}$		-.137 (-.093)		-.256 (-.116)		PRE008
$\beta_{,21}$	.093 (.089)	.194 (.115)		.366 (.145)		PRE011
$\beta_{,24}$		-.120 (-.185)		-.239 (-.246)		PRE014
$\beta_{,25}$	-.080 (-.099)					PRE015
$\beta_{,27}$	.040 (.109)					PRE017
$\beta_{,33}$	-.035 (-.083)					PRE023
$\beta_{,34}$	.022 (.057)					PRE024
$\beta_{,39}$	-.035 (-.085)		-.041 (-.082)			PRE029
$\beta_{,43}$	-.042 (-.111)		-.030 (-.067)			PRE033
$\beta_{,63}$	-.063 (-.189)	-.059 (-.108)	-.121 (-.306)	-.117 (-.143)		AFF003
$\beta_{,67}$		.110 (.193)		.221 (.257)		AFF007
$\beta_{,69}$	.029 (.080)		.053 (.124)			AFF009
$\beta_{,70}$		.079 (.133)		.156 (.175)		AFF010
$\beta_{,79}$	-.075 (-.167)		-.104 (-.196)			AFF019
$\beta_{,81}$			.193 (.132)			AFF021
$\beta_{,83}$		.182 (.154)		.344 (.195)		AFF023
$\beta_{,85}$			-.062 (-.087)			AFF025
$\beta_{,87}$	.034 (.088)		.084 (.185)			AFF027
$\beta_{,88}$			-.037 (-.088)			AFF028
$\beta_{,104}$			-.034 (-.081)			AFF044
$\beta_{,105}$	-.105 (-.134)					AFF045
$\beta_{,109}$	.029 (.153)		.045 (.197)			AFR001

TABLE E.2

MODEL COEFFICIENTS FOR WEEK 2

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K0802	K0902	K1002	K1402		
$\beta_{,136}$		.029 (.111)		.060 (.153)		BKG017
$\beta_{,137}$			.056 (.098)			BKG018
$\beta_{,149}$		.072 (.213)		.140 (.275)		BKG030
$\beta_{,153}$	-.043 (-.179)		-.063 (-.221)			BKG034
$\beta_{,158}$	-.027 (-.079)		-.046 (-.113)			BKG039
$\beta_{,183}$		-.035 (-.110)		-.068 (-.141)		BKG064
$\beta_{,198}$		-.029 (-.087)		-.067 (-.136)		BKF011
$\lambda_{,15}$	.141 (.156)					SAS004
$\lambda_{,54}$	-.053 (-.083)		-.135 (-.179)			TC3
$\mu_{,1}$			.136 (.152)			K0101
$\mu_{,4}$	.118 (.100)					K0401
$\mu_{,8}$	.481 (.689)					K0801
$\mu_{,9}$		.452 (.604)				K0901
$\mu_{,10}$		.079 (.109)	.257 (.492)	.159 (.148)		K1001
$\mu_{,11}$	.051 (.946)	.219 (.175)		.416 (.221)		K1101
$\mu_{,12}$	-.064 (-.098)	-.097 (-.092)		-.219 (-.138)		K1201

TABLE E.2

Model Constants
Week-2

α 1		α34	
α 2		α35	
α 3		α36	
α 4		α37	
α 5		α38	
α 6		α39	
α 7		α40	
α 8	0.3068	α41	
α 9	0.0122	α42	
α10	0.6047	α43	
α11		α44	
α12			
α13			
α14	-0.0236		
α15			
α16			
α17			
α18			
α19			
α20			
α21			
α22			
α23			
α24			
α25			
α26			
α27			
α28			
α29			
α30			
α31			
α32			
α33			

TABLE E.3

MODEL COEFFICIENTS FOR WEEK 3

Coefficients	DEPENDENT VARIABLE, K'_t					Independent Variable Acronym
	K0303	K0803	K0903	K1403	K1503	
$\beta_{,18}$		-.039 (-.043)		-.235 (-.129)		PRE008
$\beta_{,20}$					.080 (.110)	PRE010
$\beta_{,22}$		-.042 (-.046)	-.086 (-.073)	-.164 (-.090)		PRE012
$\beta_{,23}$		-.034 (-.078)	-.080 (-.140)	-.115 (-.130)		PRE013
$\beta_{,28}$					-.097 (-.131)	PRE018
$\beta_{,30}$		.022 (.034)	.119 (.140)			PRE020
$\beta_{,41}$		.021 (.056)		.080 (.108)		PRE031
$\beta_{,56}$		.016 (.070)				PRF011
$\beta_{,57}$			.023 (.082)	.058 (.129)		PRF012
$\beta_{,59}$					-.063 (-.138)	PRF014
$\beta_{,60}$	.041 (.150)					PRF015
$\beta_{,61}$				-.047 (-.062)		AFF001
$\beta_{,67}$		-.020 (-.056)		.082 (.115)		AFF007
$\beta_{,75}$	-.086 (-.158)					AFF015
$\beta_{,78}$	.044 (.098)					AFF018
$\beta_{,80}$	.142 (.157)					AFF020
$\beta_{,87}$					.126 (.163)	AFF027
$\beta_{,89}$	.031 (.068)					AFF029
$\beta_{,94}$	-.041 (-.092)					AFF034
$\beta_{,95}$				.113 (.088)		AFF035
$\beta_{,96}$		.050 (.063)	.116 (.113)	.268 (.169)		AFF036
$\beta_{,99}$	-.109 (-.178)				.179 (.180)	AFF039

TABLE E.3

MODEL COEFFICIENTS FOR WEEK 3

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K0303	K0803	K0903	K1403	K1503	
$\beta_{,105}$					.351 (.222)	AFF045
$\beta_{,117}$					-.117 (-.280)	AFR009
$\beta_{,123}$					-.099 (-.200)	BKG004
$\beta_{,124}$	-.039 (-.129)					BKG005
$\beta_{,130}$					-.055 (-.170)	BKG011
$\beta_{,131}$		-.034 (-.057)	-.076 (-.100)	-.120 (-.101)		BKG012
$\beta_{,139}$				.110 (.104)		BKG020
$\beta_{,148}$		.022 (.045)	.093 (.149)	.093 (.096)		BKG029
$\beta_{,155}$	.036 (.080)					BKG036
$\beta_{,177}$			-.014 (-.073)			BKG058
$\beta_{,178}$			-.033 (-.121)			BKG059
$\beta_{,182}$		-.011 (-.033)	-.038 (-.088)			BKG063
$\beta_{,195}$	-.043 (-.167)					BKF008
$\beta_{,197}$		.010 (.050)		.050 (.127)		BKF010
$\beta_{,198}$	-.024 (-.096)		-.016 (-.060)			BKF011
$\beta_{,200}$	-.029 (-.115)					BKF013
$\lambda_{,13}$		-.064 (-.036)		-.219 (-.061)		SAS002
$\lambda_{,55}$			-.053 (-.086)		-.193 (-.200)	TC4
$\lambda_{,70}$					-.104 (-.208)	ONE031
$\lambda_{,77}$	.016 (.061)					TRE032
$\lambda_{,78}$					-.067 (-.199)	TRE033
$\lambda_{,101}$					.020 (.215)	Q2

TABLE E.3

MODEL COEFFICIENTS FOR WEEK 3

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K0303	K0803	K0903	K1403	K1503	
$\mu_{,1}$	.126 (.133)		.085 (.086)			K0102
$\mu_{,2}$	.253 (.216)					K0202
$\mu_{,3}$	.592 (.551)		.062 (.055)	.272 (.157)		K0302
$\mu_{,5}$				-.158 (-.102)		K0502
$\mu_{,8}$		.945 (.938)			.426 (.211)	K0802
$\mu_{,9}$	.045 (.058)		.403 (.505)			K0902
$\mu_{,12}$					-.173 (-.133)	K1202
$\mu_{,14}$		.019 (.046)	.109 (.204)	.615 (.743)		K1402
$\mu_{,27}$	.086 (.092)					K2702
$\mu_{,29}$	-.132 (-.130)					K2902

TABLE E.3

MODEL COEFFICIENTS FOR WEEK 3

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K1603	K1803				
$\beta_{,20}$	-.099 (-.126)					PRE010
$\beta_{,21}$		-.314 (-.134)				PRE011
$\beta_{,61}$		.126 (.150)				AFF001
$\beta_{,64}$		-.158 (-.196)				AFF004
$\beta_{,69}$		.122 (.150)				AFF009
$\beta_{,76}$		.258 (.308)				AFF016
$\beta_{,81}$	.288 (.108)	-.315 (-.114)				AFF021
$\beta_{,86}$		.110 (.125)				AFF026
$\beta_{,97}$		.153 (.192)				AFF037
$\beta_{,102}$		-.139 (-.125)				AFF042
$\beta_{,104}$	-.151 (-.196)					AFF044
$\beta_{,151}$	.090 (.179)					BKG032
$\beta_{,163}$	-.044 (-.110)					BKG044
$\beta_{,174}$	.105 (.237)					BKG055
$\beta_{,192}$	-.127 (-.291)					BKF005
$\lambda_{,1}$	.117 (.087)	-.135 (-.097)				LEC001
$\lambda_{,2}$	-.177 (-.156)					LEC002
$\lambda_{,13}$	.661 (.172)					SAS002
$\lambda_{,34}$		-.527 (-.131)				LTP003
$\lambda_{,56}$		-.188 (-.206)				TC5
$\lambda_{,71}$	-.082 (-.172)					ONE032
$\lambda_{,73}$	.063 (.115)					TWO031

TABLE E.3

MODEL COEFFICIENTS FOR WEEK 3

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K1603	K1803				
$\lambda_{,76}$		.130 (.199)				TRE031
$\lambda_{,100}$	.246 (.218)					Q1
$\lambda_{,101}$	.018 (.181)					Q2
$\mu_{,2}$		-.544 (-.257)				K0202
$\mu_{,4}$		.908 (.340)				K0402
$\mu_{,12}$		-.198 (-.136)				K1202

TABLE E.3

Model Constants
Week-3

α 1		α34	
α 2		α35	
α 3	-0.0776	α36	
α 4		α37	
α 5		α38	
α 6		α39	
α 7		α40	
α 8	0.1471	α41	
α 9	0.5022	α42	
α10		α43	
α11		α44	
α12			
α13			
α14	0.6422		
α15	0.7196		
α16	-0.9258		
α17			
α18	1.1521		
α19			
α20			
α21			
α22			
α23			
α24			
α25			
α26			
α27			
α28			
α29			
α30			
α31			
α32			
α33			

TABLE E.4

MODEL COEFFICIENTS FOR WEEK 4

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K0304	K0404	K0504	K0904	K1604	
$\beta_{,15}$		.027 (.090)	.035 (.083)	.037 (.086)		PRE005
$\beta_{,16}$	-.068 (-.100)			-.067 (-.091)		PRE006
$\beta_{,23}$	-.045 (-.093)	-.041 (-.110)	-.067 (-.133)	-.058 (-.111)	-.143 (-.212)	PRE013
$\beta_{,24}$			-.116 (-.253)			PRE014
$\beta_{,28}$				-.087 (-.154)		PRE018
$\beta_{,29}$				-.070 (-.123)		PRE019
$\beta_{,37}$		-.035 (-.113)		-.035 (-.780)		PRE027
$\beta_{,46}$				.035 (.118)		PRF001
$\beta_{,50}$			-.038 (-.164)			PRF005
$\beta_{,52}$			-.020 (-.092)			PRF007
$\beta_{,90}$					-.161 (-.103)	AFF030
$\beta_{,94}$					-.050 (-.091)	AFF034
$\beta_{,98}$	.023 (.053)	.020 (.059)		.030 (.064)	.075 (.122)	AFF038
$\beta_{,123}$					-.029 (-.076)	BKG004
$\beta_{,128}$			.127 (.261)			BKG009
$\beta_{,138}$	.081 (.098)	.072 (.113)	.193 (.224)	.097 (.109)		BKG019
$\beta_{,147}$					.058 (.082)	BKG028
$\beta_{,168}$	.009 (.048)	.013 (.085)	.024 (.120)	.010 (.050)		BKG049
$\beta_{,191}$	.018 (.081)	.018 (.104)	.040 (.174)	.022 (.093)		BKF004
$\lambda_{,35}$	.036 (.032)					LTP004
$\lambda_{,46}$			-.038 (-.094)			POZ004
$\lambda_{,59}$	-.017 (-.056)	-.027 (-.116)	-.026 (-.085)	-.026 (-.082)		TC8

TABLE E.4

MODEL COEFFICIENTS FOR WEEK 4

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K0304	K0404	K0504	K0904	K1604	
$\lambda_{,72}$	.007 (.040)	.007 (.051)	.023 (.125)			ONE033
$\lambda_{,80}$				.012 (.046)	.023 (.071)	FOR032
$\lambda_{,81}$	.009 (.049)	.012 (.080)	.016 (.084)	.012 (.057)		FOR033
$\mu_{,3}$	.793 (.898)					K0303
$\mu_{,4}$	.027 (.046)	.805 (.804)				K0403
$\mu_{,5}$			.450 (.507)			K0503
$\mu_{,6}$					-.074 (-.065)	K0603
$\mu_{,9}$				.784 (.856)		K0903
$\mu_{,12}$				.101 (.101)		K1203
$\mu_{,15}$					.074 (.096)	K1503
$\mu_{,16}$	.027 (.053)	.028 (.071)	.133 (.250)	.034 (.061)	.520 (.730)	K1603
$\mu_{,18}$	.050 (.103)	.040 (.106)	.042 (.083)	.047 (.089)		K1803
$\mu_{,23}$	.025 (.023)					K2303

TABLE E.4

Model Constants
Week-4

α 1		α34	
α 2		α35	
α 3	-0.0471	α36	
α 4	-0.0043	α37	
α 5	-0.0735	α38	
α 6		α39	
α 7		α40	
α 8		α41	
α 9	-0.0201	α42	
α10		α43	
α11		α44	
α12			
α13			
α14			
α15			
α16	0.3653		
α17			
α18			
α19			
α20			
α21			
α22			
α23			
α24			
α25			
α26			
α27			
α28			
α29			
α30			
α31			
α32			
α33			

TABLE E.5

MODEL COEFFICIENTS FOR WEEK 5

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K0805	K0905	K1005	K1405	K1505	
$\beta_{,14}$	-.016 (-.045)		-.052 (-.114)			PRE004
$\beta_{,28}$		-.004 (-.011)				PRE018
$\beta_{,34}$		-.005 (-.013)				PRE024
$\beta_{,39}$				-.088 (-.151)		PRE029
$\beta_{,41}$			.041 (.094)	.101 (.198)	.094 (.157)	PRE031
$\beta_{,66}$	-.015 (-.039)		-.031 (-.063)			AFF006
$\beta_{,68}$			.041 (.088)		.094 (.145)	AFF008
$\beta_{,69}$		.006 (.016)				AFF009
$\beta_{,76}$				-.041 (-.081)		AFF016
$\beta_{,77}$					-.085 (-.133)	AFF017
$\beta_{,78}$			.027 (.063)		.062 (.105)	AFF018
$\beta_{,91}$					.076 (.128)	AFF031
$\beta_{,92}$	.020 (.050)					AFF032
$\beta_{,93}$	.033 (.048)					AFF033
$\beta_{,98}$			-.056 (-.118)		-.080 (-.124)	AFF038
$\beta_{,103}$	.028 (.034)					AFF043
$\beta_{,116}$				-.039 (-.136)		AFR008
$\beta_{,130}$	.008 (.055)					BKG011
$\beta_{,131}$		-.016 (-.026)				BKG012
$\beta_{,137}$					-.113 (-.144)	BKG018
$\beta_{,152}$	-.014 (-.053)		-.028 (-.084)			BKG033
$\beta_{,175}$	-.004 (-.025)	.003 (.019)				BKG056

TABLE E.5

MODEL COEFFICIENTS FOR WEEK 5

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K0805	K0905	K1005	K1405	K1505	
$\beta_{,177}$		-.001 (-.009)				BKG058
$\beta_{,181}$					.094 (.194)	BKG062
$\beta_{,188}$		.004 (.021)				BKF001
$\beta_{,194}$		-.003 (-.016)				BKF007
$\beta_{,199}$				.018 (.063)		BKF012
$\lambda_{,3}$	.011 (.024)					LEC003
$\lambda_{,5}$			.029 (.061)		.055 (.085)	LEC005
$\lambda_{,20}$	.028 (.054)		.059 (.089)	.054 (.069)		SAS009
$\lambda_{,60}$					-.075 (-.080)	TC9
$\lambda_{,103}$		-.001 (-.013)				Q4
$\mu_{,2}$			-.134 (-.121)		-.284 (-.186)	K0204
$\mu_{,3}$			.144 (.134)		.465 (.314)	K0304
$\mu_{,5}$		.013 (.015)				K0504
$\mu_{,6}$	-.027 (-.039)	-.013 (-.017)				K0604
$\mu_{,8}$	.878 (.946)					K0804
$\mu_{,9}$		.847 (.988)			-.185 (-.135)	K0904
$\mu_{,10}$		-.010 (-.012)	.789 (.787)			K1004
$\mu_{,11}$				.144 (.135)		K1104
$\mu_{,14}$			-.045 (-.076)	.498 (.727)	-.090 (-.111)	K1404
$\mu_{,15}$	-.017 (-.036)		-.047 (-.080)	-.054 (-.079)	.456 (.564)	K1504
$\mu_{,16}$				.130 (.145)		K1604
$\mu_{,18}$		.008 (.017)				K1804

TABLE E.5

MODEL COEFFICIENTS FOR WEEK 5

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K1905	K2005				
$\beta_{,14}$		-.117 (-.218)				PRE004
$\beta_{,19}$	.101 (.133)					PRE009
$\beta_{,31}$	.138 (.215)					PRE021
$\beta_{,36}$	-.166 (-.171)					PRE026
$\beta_{,38}$	.071 (.113)					PRE028
$\beta_{,62}$	-.105 (-.154)					AFF002
$\beta_{,66}$		-.075 (-.132)				AFF006
$\beta_{,68}$		.062 (.111)				AFF008
$\beta_{,78}$		.066 (.129)				AFF018
$\beta_{,89}$	.124 (.198)					AFF029
$\beta_{,90}$	-.198 (-.115)					AFF030
$\beta_{,92}$		.070 (.116)				AFF032
$\beta_{,98}$		-.088 (-.159)				AFF038
$\beta_{,100}$	.131 (.113)					AFF040
$\beta_{,111}$	.062 (.173)					AFR003
$\beta_{,125}$	.056 (.140)					BKG006
$\beta_{,130}$		.043 (.192)				BKG011
$\beta_{,152}$		-.070 (-.180)				BKG033
$\beta_{,153}$	.122 (.295)					BKG034
$\beta_{,175}$		-.031 (-.127)				BKG056
$\beta_{,188}$	.081 (.250)					BKF001
$\beta_{,189}$	.056 (.174)					BKF002

TABLE E.5

MODEL COEFFICIENTS FOR WEEK 5

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K1905	K2005				
$\beta_{,192}$	-.038 (-.109)					BKF005
$\lambda_{,3}$		.064 (.095)				LEC003
$\lambda_{,5}$		.056 (.101)				LEC005
$\lambda_{,20}$		.126 (.162)				SAS009
$\lambda_{,21}$	-.111 (-.094)					SAS010
$\lambda_{,58}$	-.067 (-.145)					TC7
$\lambda_{,103}$	.016 (.175)	.012 (.152)				Q4
$\mu_{,3}$		.213 (.161)				K0304
$\mu_{,5}$	.266 (.178)					K0504
$\mu_{,6}$		-.239 (-.232)				K0604
$\mu_{,8}$		.276 (.199)				K0804
$\mu_{,9}$		-.251 (-.214)				K0904
$\mu_{,15}$	-.113 (-.133)	-.068 (-.098)				K1504
$\mu_{,19}$	-.179 (-.147)					K1904

TABLE E.5

Model Constants
Week-5

α 1	
α 2	
α 3	
α 4	
α 5	
α 6	
α 7	
α 8	0.1129
α 9	0.1644
α10	0.1326
α11	
α12	
α13	
α14	0.1593
α15	0.1483
α16	
α17	
α18	
α19	0.2497
α20	0.5722
α21	
α22	
α23	
α24	
α25	
α26	
α27	
α28	
α29	
α30	
α31	
α32	
α33	
α34	
α35	
α36	
α37	
α38	
α39	
α40	
α41	
α42	
α43	
α44	

TABLE E.6

MODEL COEFFICIENTS FOR WEEK 6

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K0106	K0406	K0606	K2206		
$\beta_{,33}$			-.047 (-.101)			PRE023
$\beta_{,64}$			-.035 (-.088)			AFF004
$\beta_{,68}$	.017 (.039)			.086 (.135)		AFF008
$\beta_{,75}$			-.031 (-.064)			AFF015
$\beta_{,84}$	-.016 (-.041)			-.077 (-.138)		AFF024
$\beta_{,87}$	-.023 (-.055)			-.110 (-.179)		AFF027
$\beta_{,91}$		-.024 (-.077)				AFF031
$\beta_{,95}$		-.021 (-.039)				AFF035
$\beta_{,110}$			-.017 (-.086)			AFR002
$\beta_{,119}$	.013 (.055)			.064 (.185)		AFR011
$\beta_{,121}$		.019 (.098)				BKG002
$\beta_{,138}$		.068 (.108)				BKG019
$\beta_{,144}$	-.022 (-.058)			-.110 (-.198)		BKG025
$\beta_{,145}$	.019 (.046)			.098 (.163)		BKG026
$\beta_{,148}$	.030 (.056)			.147 (.190)		BKG029
$\beta_{,165}$		.008 (.061)				BKG046
$\beta_{,189}$	.018 (.087)			.089 (.293)		BKF002
$\beta_{,201}$			-.020 (-.087)			BKF014
$\lambda_{,22}$	.023 (.033)			.115 (.112)		SAS011
$\lambda_{,23}$		.081 (.110)				SAS012
$\lambda_{,47}$	-.016 (-.043)			-.077 (-.139)		PQZ005
$\lambda_{,81}$			.013 (.069)			FOR033

TABLE E.6

MODEL COEFFICIENTS FOR WEEK 6

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K0106	K0406	K0606	K2206		
$\lambda_{,101}$		.005 (.138)				Q2
$\lambda_{,104}$		.003 (.055)				Q5
$\mu_{,1}$	.810 (.977)					K0105
$\mu_{,4}$		.896 (.907)				K0405
$\mu_{,6}$			.786 (.962)			K0605
$\mu_{,12}$	.022 (.032)			.110 (.105)		K1205
$\mu_{,14}$		-.050 (-.083)	.057 (.071)			K1405
$\mu_{,15}$	.060 (.089)			.299 (.304)		K1505
$\mu_{,16}$	-.025 (-.035)	-.037 (-.069)	-.025 (-.035)	-.115 (-.110)		K1605
$\mu_{,18}$			.019 (.039)			K1805
$\mu_{,19}$		.023 (.048)				K1905

TABLE E.6

Model Constants
Week-6

α 1	0.0940	α34	
α 2		α35	
α 3		α36	
α 4	-0.2301	α37	
α 5		α38	
α 6	0.1940	α39	
α 7		α40	
α 8		α41	
α 9		α42	
α10		α43	
α11		α44	
α12			
α13			
α14			
α15			
α16			
α17			
α18			
α19			
α20			
α21			
α22	0.4817		
α23			
α24			
α25			
α26			
α27			
α28			
α29			
α30			
α31			
α32			
α33			

TABLE E.7

MODEL COEFFICIENTS FOR WEEK 7

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K0407	K1607	K2307	K2407		
$\beta_{,17}$				-.180 (-.198)		PRE007
$\beta_{,20}$	.020 (.069)		.163 (.313)			PRE010
$\beta_{,24}$		.044 (.102)				PRE014
$\beta_{,31}$			.136 (.253)			PRE021
$\beta_{,42}$				-.192 (-.188)		PRE032
$\beta_{,46}$				.092 (.195)		PRF001
$\beta_{,60}$		-.027 (-.112)				PRF015
$\beta_{,64}$		-.022 (-.056)				AFF004
$\beta_{,67}$			-.093 (-.184)			AFF007
$\beta_{,76}$		.029 (.071)				AFF016
$\beta_{,83}$		-.056 (-.071)		.260 (.147)		AFF023
$\beta_{,86}$		-.030 (-.071)				AFF026
$\beta_{,93}$			.206 (.198)			AFF033
$\beta_{,108}$	-.025 (-.059)		-.240 (-.303)			AFF048
$\beta_{,125}$	-.007 (-.039)		-.058 (-.173)			BKG006
$\beta_{,167}$		.009 (.046)				BKG048
$\beta_{,184}$				-.167 (-.250)		BKG065
$\beta_{,189}$		-.015 (-.073)				BKF002
$\beta_{,197}$				-.093 (-.196)		BKF010
$\beta_{,201}$				-.108 (-.209)		BKF014
$\lambda_{,6}$				-.114 (-.119)		LEC006
$\lambda_{,23}$	.015 (.021)					SAS012

TABLE E.7

MODEL COEFFICIENTS FOR WEEK 7

Coefficients	DEPENDENT VARIABLE, K'_j					Independent Variable Acronym
	K0407	K1607	K2307	K2407		
$\lambda_{,24}$		.095 (.109)				SAS013
$\lambda_{,38}$	-.041 (-.050)		-.294 (-.197)	-.454 (-.179)		LTP007
$\lambda_{,64}$			.066 (.129)			TC13
$\lambda_{,65}$	-.008 (-.025)		-.073 (-.121)			TC14
$\lambda_{,102}$				.020 (.215)		Q3
$\mu_{,2}$	.040 (.055)		.200 (.148)			K0206
$\mu_{,3}$		-.058 (-.058)				K0306
$\mu_{,4}$	.880 (.932)					K0406
$\mu_{,6}$	.026 (.036)		.351 (.271)			K0606
$\mu_{,8}$				.407 (.156)		K0806
$\mu_{,9}$		.102 (.095)				K0906
$\mu_{,10}$		.110 (.120)		-.474 (-.230)		K1006
$\mu_{,15}$				.433 (.289)		K1506
$\mu_{,16}$		.628 (.887)				K1606
$\mu_{,19}$	-.012 (-.026)		-.173 (-.206)			K1906

TABLE E.7

Model Constants
Week-7

α 1		α34	
α 2		α35	
α 3		α36	
α 4	0.0836	α37	
α 5		α38	
α 6		α39	
α 7		α40	
α 8		α41	
α 9		α42	
α10		α43	
α11		α44	
α12			
α13			
α14			
α15			
α16	0.1164		
α17			
α18			
α19			
α20			
α21			
α22			
α23	0.7302		
α24	0.2944		
α25			
α26			
α27			
α28			
α29			
α30			
α31			
α32			
α33			

TABLE E.8

MODEL COEFFICIENTS FOR WEEK 9

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K0308	K0508	K0808	K0908	K1508	
$\beta_{,20}$		-.025 (-.065)				PRE010
$\beta_{,25}$	-.063 (-.069)			-.052 (-.076)	-.178 (-.160)	PRE015
$\beta_{,27}$			.018 (.054)			PRE017
$\beta_{,66}$		-.024 (-.055)				AFF006
$\beta_{,69}$				.022 (.072)		AFF009
$\beta_{,90}$		-.070 (-.065)				AFF030
$\beta_{,93}$	.054 (.067)				.102 (.103)	AFF033
$\beta_{,106}$	.052 (.069)			.050 (.088)	.114 (.124)	AFF046
$\beta_{,107}$	.050 (.091)			.043 (.102)	.078 (.115)	AFF047
$\beta_{,146}$					.042 (.096)	BKG027
$\beta_{,148}$			-.033 (-.074)			BKG029
$\beta_{,151}$			-.012 (-.056)			BKG032
$\beta_{,154}$					.029 (.100)	BKG035
$\beta_{,161}$		.019 (.100)				BKG042
$\beta_{,167}$		-.020 (-.101)				BKG048
$\beta_{,175}$			-.010 (-.059)			BKG056
$\beta_{,177}$			.008 (.057)			BKG058
$\beta_{,179}$					.037 (.117)	BKG060
$\beta_{,183}$				-.008 (-.052)		BKG064
$\beta_{,197}$				.015 (.089)	.027 (.102)	BKF010
$\lambda_{,24}$					-.077 (-.071)	SAS013
$\lambda_{,28}$				.037 (.068)		SAS017

TABLE E.8

MODEL COEFFICIENTS FOR WEEK 9

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K0308	K0508	K0808	K0908	K1508	
$\lambda_{,40}$					.255 (.148)	LTP009
$\lambda_{,49}$		.028 (.075)				PQZ007
$\lambda_{,101}$		-.004 (-.074)				Q2
$\lambda_{,102}$					-.009 (-.169)	Q3
$\mu_{,2}$		.055 (.055)			.252 (.196)	K0207
$\mu_{,3}$	.993 (.984)			.137 (.178)	.349 (.281)	K0307
$\mu_{,5}$	-.095 (-.098)	.827 (.891)		-.076 (-.102)	-.331 (-.278)	K0507
$\mu_{,8}$	.080 (.067)		.889 (.895)	.077 (.085)		K0807
$\mu_{,9}$				.715 (.859)		K0907
$\mu_{,11}$				-.037 (-.056)	.141 (.133)	K1107
$\mu_{,12}$					.062 (.070)	K1207
$\mu_{,14}$	-.048 (-.060)	-.045 (-.058)		-.036 (-.059)	-.114 (-.115)	K1407
$\mu_{,15}$			.037 (.065)		.583 (.694)	K1507
$\mu_{,16}$		.064 (.066)				K1607
$\mu_{,18}$	-.042 (-.085)			-.046 (-.122)		K1807
$\mu_{,19}$		.055 (.089)				K1907

TABLE E.8

MODEL COEFFICIENTS FOR WEEK 9

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K1608	K1908	K2308	K2508	K2608	
$\beta_{,15}$		-.023 (-.050)				PRE005
$\beta_{,18}$		.088 (.077)				PRE008
$\beta_{,19}$				.117 (.172)		PRE009
$\beta_{,25}$	-.115 (-.136)					PRE015
$\beta_{,34}$					-.134 (-.137)	PRE024
$\beta_{,35}$			-.070 (-.258)			PRE025
$\beta_{,43}$			.037 (.143)			PRE033
$\beta_{,44}$		.031 (.055)				PRE034
$\beta_{,48}$			.019 (.135)			PRF003
$\beta_{,66}$				-.096 (-.154)		AFF006
$\beta_{,71}$			-.024 (-.101)		.111 (.121)	AFF011
$\beta_{,72}$		.033 (.076)	-.037 (-.158)			AFF012
$\beta_{,74}$			.069 (.267)			AFF014
$\beta_{,85}$				-.121 (-.133)		AFF025
$\beta_{,92}$			-.048 (-.165)	-.105 (-.160)		AFF032
$\beta_{,93}$	.099 (.131)				.416 (.224)	AFF033
$\beta_{,106}$	.098 (.139)				.321 (.186)	AFF046
$\beta_{,107}$	.086 (.167)				.285 (.226)	AFF047
$\beta_{,111}$	.015 (.069)				.084 (.159)	AFR003
$\beta_{,113}$			-.022 (-.155)			AFR005
$\beta_{,116}$			-.041 (-.292)			AFR008
$\beta_{,119}$		.019 (.070)				AFR011

TABLE E.8

MODEL COEFFICIENTS FOR WEEK 9

Coefficients	DEPENDENT VARIABLE, K'_j					Independent Variable Acronym
	K1608	K1908	K2308	K2508	K2608	
$\beta_{,126}$			.046 (.297)			BKG007
$\beta_{,138}$			.079 (.155)			BKG019
$\beta_{,154}$					.074 (.138)	BKG035
$\beta_{,183}$		-.016 (-.064)				BKG064
$\beta_{,193}$				.075 (.250)		BKF006
$\beta_{,195}$		.016 (.061)				BKF008
$\beta_{,197}$	.015 (.075)				.067 (.136)	BKF010
$\beta_{,200}$			.024 (.174)			BKF013
$\lambda_{,6}$				-.080 (-.134)		LEC006
$\lambda_{,9}$			-.044 (-.185)			LEC009
$\lambda_{,25}$		-.077 (-.083)				SAS014
$\lambda_{,27}$				-.204 (-.241)		SAS016
$\lambda_{,28}$		.085 (.105)		.178 (.182)		SAS017
$\lambda_{,40}$				.227 (.118)		LTP009
$\lambda_{,67}$	-.027 (-.076)				-.095 (-.110)	TC16
$\lambda_{,93}$		-.013 (-.069)	-.015 (-.140)			NIN033
$\lambda_{,106}$				.012 (.181)		Q6
$\mu_{,3}$	.237 (.251)		.133 (.217)		.970 (.418)	K0307
$\mu_{,5}$	-.177 (-.195)			.245 (.184)	-.649 (-.291)	K0507
$\mu_{,8}$	.114 (.103)				.556 (.203)	K0807
$\mu_{,9}$				-.355 (-.237)		K0907
$\mu_{,11}$		-.063 (-.064)	-.063 (-.120)	.295 (.250)		K1107

TABLE E.8

MODEL COEFFICIENTS FOR WEEK 9

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K1608	K1908	K2308	K2508	K2608	
$\mu_{,12}$					-.237 (-.143)	K1207
$\mu_{,14}$	-.066 (-.087)		-.128 (-.261)		-.280 (-.151)	K1407
$\mu_{,15}$			.074 (.178)	.184 (.197)		K1507
$\mu_{,16}$	.745 (.782)					K1607
$\mu_{,18}$	-.071 (-.154)	-.030 (-.053)	.046 (.152)		-.301 (-.266)	K1807
$\mu_{,19}$		.683 (.925)				K1907
$\mu_{,20}$		.048 (.053)				K2007
$\mu_{,22}$				.094 (.099)		K2207
$\mu_{,23}$			.081 (.171)			K2307

TABLE E.8

MODEL COEFFICIENTS FOR WEEK 9

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K2708	K2808	K2908	K3008	K3108	
$\beta_{,12}$			.057 (.104)			PRE002
$\beta_{,13}$			.152 (.252)			PRE003
$\beta_{,19}$	.135 (.252)		.212 (.313)			PRE009
$\beta_{,27}$			.076 (.138)			PRE017
$\beta_{,30}$	-.124 (-.157)					PRE020
$\beta_{,33}$			-.064 (-.100)			PRE023
$\beta_{,61}$				-.143 (-.142)		AFF001
$\beta_{,68}$				-.241 (-.224)		AFF008
$\beta_{,72}$		-.116 (-.208)				AFF012
$\beta_{,77}$				.271 (.255)		AFF017
$\beta_{,88}$				.249 (.259)		AFF028
$\beta_{,94}$				.094 (.097)		AFF034
$\beta_{,100}$					.247 (.136)	AFF040
$\beta_{,101}$					-.176 (-.140)	AFF041
$\beta_{,108}$			-.073 (-.087)			AFF048
$\beta_{,133}$	.118 (.280)					BKG014
$\beta_{,135}$			.042 (.090)			BKG016
$\beta_{,151}$	-.034 (-.121)				-.100 (-.159)	BKG032
$\beta_{,152}$		-.037 (-.082)		-.161 (-.214)		BKG033
$\beta_{,157}$				-.065 (-.097)		BKG038
$\beta_{,179}$				.110 (.175)		BKG060
$\beta_{,184}$		-.067 (-.152)				BKG065

TABLE E.8

MODEL COEFFICIENTS FOR WEEK 9

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K2708	K2808	K2908	K3008	K3108	
$\beta_{,194}$		.042 (.132)	-.038 (-.126)	.087 (.160)		BKF007
$\beta_{,196}$	.053 (.232)					BKF009
$\beta_{,202}$	-.055 (-.212)					BKF015
$\lambda_{,6}$				-.152 (-.144)	-.114 (-.108)	LEC006
$\lambda_{,7}$			-.105 (-.183)			LEC007
$\lambda_{,25}$					-.419 (-.212)	SAS014
$\lambda_{,27}$	.064 (.096)		.112 (.133)			SAS016
$\lambda_{,28}$				-.169 (-.098)		SAS017
$\lambda_{,38}$	-.204 (-.163)		-.540 (-.343)			LTP007
$\lambda_{,40}$	.448 (.294)		.360 (.188)			LTP009
$\lambda_{,50}$	-.094 (-.219)			.382 (.395)	-.219 (-.227)	PQZ009
$\lambda_{,64}$			-.065 (-.121)			TC13
$\lambda_{,65}$					-.219 (-.193)	TC14
$\lambda_{,90}$			-.015 (-.070)			SVN033
$\lambda_{,92}$	-.021 (-.097)					NIN032
$\lambda_{,101}$					-.020 (-.160)	Q2
$\lambda_{,102}$		.015 (.242)			.014 (.134)	Q3
$\lambda_{,104}$			.012 (.140)			Q5
$\lambda_{,105}$					.022 (.189)	Q6
$\mu_{,1}$	.187 (.169)					K0107
$\mu_{,3}$		.184 (.126)		-.406 (-.165)		K0307
$\mu_{,4}$					.578 (.169)	K0407

TABLE E.8

MODEL COEFFICIENTS FOR WEEK 9

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K2708	K2808	K2908	K3008	K3108	
$\mu_{,5}$				.634 (.269)		K0507
$\mu_{,9}$			.130 (.087)			K0907
$\mu_{,12}$		.204 (.196)	-.172 (-.175)		.318 (.182)	K1207
$\mu_{,14}$		-.334 (-.287)				K1407
$\mu_{,16}$		-.281 (-.191)				K1607
$\mu_{,18}$		.190 (.267)	-.162 (-.241)			K1807
$\mu_{,19}$			-.147 (-.166)		-.211 (-.134)	K1907
$\mu_{,20}$	.356 (.412)		.231 (.212)	.205 (.105)	.311 (.161)	K2007
$\mu_{,22}$	.089 (.119)		.281 (.297)			K2207
$\mu_{,27}$	.092 (.102)					K2707

TABLE E.8

MODEL COEFFICIENTS FOR WEEK 9

Coefficients	DEPENDENT VARIABLE, K'_j					Independent Variable Acronym
	K3208	K3308				
$\beta_{,20}$		-.135 (-.198)				PRE010
$\beta_{,49}$	.063 (.300)					PRF004
$\beta_{,66}$		-.112 (-.146)				AFF006
$\beta_{,71}$	-.101 (-.231)					AFF011
$\beta_{,90}$		-.336 (-.177)				AFF030
$\beta_{,100}$	-.146 (-.176)					AFF040
$\beta_{,143}$	.033 (.128)					BKG024
$\beta_{,144}$	.100 (.235)					BKG025
$\beta_{,161}$		.093 (.274)				BKG042
$\beta_{,165}$	-.044 (-.222)					BKG046
$\beta_{,167}$		-.085 (-.243)				BKG048
$\beta_{,198}$	-.049 (-.195)					BKF011
$\lambda_{,25}$		.216 (.157)				SAS014
$\lambda_{,28}$		-.339 (-.281)				SAS017
$\lambda_{,49}$		.165 (.247)				PQZ007
$\lambda_{,89}$	.049 (.192)					SVN032
$\lambda_{,101}$		-.023 (-.261)				Q2
$\lambda_{,103}$		.020 (.193)				Q4
$\lambda_{,104}$	-.009 (-.134)					Q5
$\mu_{,2}$	.298 (.259)	.327 (.185)				K0207
$\mu_{,5}$	.287 (.268)					K0507
$\mu_{,9}$	-.172 (-.143)					K0907

TABLE E.8

MODEL COEFFICIENTS FOR WEEK 9

Coefficients	DEPENDENT VARIABLE, K'_j					Independent Variable Acronym
	K3208	K3308				
$\mu_{,11}$	.122 (.129)					K1107
$\mu_{,12}$		.121 (.099)				K1207
$\mu_{,14}$		-.259 (-.190)				K1407
$\mu_{,15}$		.117 (.101)				K1507
$\mu_{,16}$		.237 (.138)				K1607
$\mu_{,19}$		.254 (.231)				K1907

TABLE E.9

Model Constants
Week-9

α 1		α34
α 2		α35
α 3	0.0082	α36
α 4		α37
α 5	0.1277	α38
α 6		α39
α 7		α40
α 8	0.0910	α41
α 9	0.0604	α42
α10		α43
α11		α44
α12		
α13		
α14		
α15	0.0625	
α16	0.0235	
α17		
α18		
α19	0.1921	
α20		
α21		
α22		
α23	0.5670	
α24		
α25	0.5010	
α26	0.2058	
α27	0.0794	
α28	0.8656	
α29	0.0569	
α30	0.4013	
α31	0.5087	
α32	0.9271	
α33	0.5583	

TABLE E.9

MODEL COEFFICIENTS FOR WEEK 10

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K0209	K0909	K2309	K2509	K3109	
$\beta_{,11}$	.034 (.093)			.068 (.185)		PRE001
$\beta_{,16}$				-.074 (-.119)		PRE006
$\beta_{,26}$		-.015 (-.051)				PRE016
$\beta_{,28}$		-.015 (-.052)				PRE018
$\beta_{,35}$			.020 (.073)		-.081 (-.123)	PRE025
$\beta_{,36}$				.115 (.202)		PRE026
$\beta_{,38}$			.017 (.070)			PRE028
$\beta_{,39}$					.104 (.151)	PRE029
$\beta_{,42}$				-.089 (-.211)		PRE032
$\beta_{,43}$	-.045 (-.119)		-.026 (-.100)			PRE033
$\beta_{,44}$			.032 (.108)			PRE034
$\beta_{,62}$				.052 (.131)		AFF002
$\beta_{,67}$	.028 (.081)					AFF007
$\beta_{,68}$	-.022 (-.055)					AFF008
$\beta_{,74}$	-.034 (-.089)	-.013 (-.045)				AFF014
$\beta_{,79}$	-.050 (-.112)					AFF019
$\beta_{,81}$			.090 (.108)		.333 (.164)	AFF021
$\beta_{,87}$					-.078 (-.124)	AFF027
$\beta_{,107}$				-.087 (-.176)		AFF047
$\beta_{,111}$	.019 (.091)					AFR003
$\beta_{,112}$				.033 (.160)		AFR004
$\beta_{,117}$			-.013 (-.092)			AFR009

TABLE E.9

MODEL COEFFICIENTS FOR WEEK 10

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K0209	K0909	K2309	K2509	K3109	
$\beta_{,130}$				-.024 (-.148)		BKG011
$\beta_{,143}$		.009 (.055)				BKG024
$\beta_{,145}$				.054 (.144)		BKG026
$\beta_{,152}$				-.023 (-.083)		BKG033
$\beta_{,161}$			.008 (.069)			BKG042
$\beta_{,163}$				-.031 (-.163)		BKG044
$\beta_{,164}$					-.032 (-.088)	BKG045
$\beta_{,168}$				.040 (.223)		BKG049
$\beta_{,178}$					-.032 (-.090)	BKG059
$\beta_{,188}$			.011 (.086)			BKF001
$\beta_{,191}$				.027 (.135)		BKF004
$\beta_{,195}$				.040 (.192)		BKF008
$\beta_{,196}$	.021 (.112)					BKF009
$\beta_{,199}$				.070 (.345)		BKF012
$\beta_{,201}$					.060 (.173)	BKF014
$\lambda_{,7}$	-.024 (-.054)		-.027 (-.104)			LEC007
$\lambda_{,10}$					-.053 (-.089)	LEC010
$\lambda_{,28}$	.048 (.075)		.033 (.075)			SAS017
$\lambda_{,29}$	-.031 (-.053)					SAS018
$\lambda_{,30}$		.021 (.041)				SAS019
$\lambda_{,40}$	.108 (.086)					LTP009
$\lambda_{,41}$					.215 (.073)	LTP010

TABLE E.9

MODEL COEFFICIENTS FOR WEEK 10

Coefficients	DEPENDENT VARIABLE, K'_j					Independent Variable Acronym
	K0209	K0909	K2309	K2509	K3109	
$\lambda_{,50}$			.023 (.093)			POZ009
$\lambda_{,66}$			.016 (.060)			TC15
$\lambda_{,94}$					-.040 (-.090)	FIN061
$\lambda_{,103}$				.009 (.157)		Q4
$\lambda_{,104}$	.010 (.175)					Q5
$\lambda_{,107}$				-.005 (-.095)		Q9
$\mu_{,2}$	.776 (.829)				.188 (.121)	K0208
$\mu_{,3}$			.064 (.105)			K0308
$\mu_{,9}$		.870 (.949)				K0908
$\mu_{,12}$				-.055 (-.084)		K1208
$\mu_{,14}$		.030 (.054)		.084 (.115)		K1408
$\mu_{,22}$				.065 (.104)		K2208
$\mu_{,23}$			.876 (.876)			K2308
$\mu_{,24}$	.069 (.170)		.024 (.086)		-.052 (-.077)	K2408
$\mu_{,25}$				.325 (.493)	.130 (.120)	K2508
$\mu_{,26}$	-.039 (-.101)				-.067 (-.104)	K2608
$\mu_{,27}$					-.152 (-.111)	K2708
$\mu_{,28}$				.069 (.110)		K2808
$\mu_{,30}$	.050 (.135)					K3008
$\mu_{,31}$					.522 (.854)	K3108
$\mu_{,32}$	-.051 (-.063)					K3208

TABLE E.9

MODEL COEFFICIENTS FOR WEEK 10

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K3209	K3409	K3509	K3609	K3709	
$\beta_{,11}$		.065 (.165)				PRE001
$\beta_{,32}$	-.067 (-.153)	-.070 (-.123)	-.115 (-.197)			PRE022
$\beta_{,36}$	.084 (.180)					PRE026
$\beta_{,39}$	.077 (.223)					PRE029
$\beta_{,42}$		-.054 (-.120)		-.166 (-.148)		PRE032
$\beta_{,43}$					-.211 (-.214)	PRE033
$\beta_{,47}$				.086 (.166)		PRT002
$\beta_{,62}$	.033 (.100)					AFF002
$\beta_{,70}$	-.040 (-.132)		.088 (.218)			AFF010
$\beta_{,73}$			.077 (.200)			AFF013
$\beta_{,85}$				.274 (.171)		AFF025
$\beta_{,87}$	-.066 (-.208)					AFF027
$\beta_{,88}$				.140 (.147)	.181 (.198)	AFF028
$\beta_{,90}$					.405 (.156)	AFF030
$\beta_{,95}$			-.096 (-.137)			AFF035
$\beta_{,97}$					-.172 (-.189)	AFF037
$\beta_{,102}$	.070 (.172)			.257 (.195)		AFF042
$\beta_{,105}$				-.404 (-.192)		AFF045
$\beta_{,107}$					.170 (.134)	AFF047
$\beta_{,112}$		.059 (.269)				AFR004
$\beta_{,130}$	-.012 (-.087)	-.033 (-.188)	-.042 (-.237)			BKG011
$\beta_{,134}$	-.012 (-.093)					BKG015

TABLE E.9

MODEL COEFFICIENTS FOR WEEK 10

Coefficients	DEPENDENT VARIABLE, K'_j					Independent Variable Acronym
	K3209	K3409	K3509	K3609	K3709	
$\beta_{,145}$			-.092 (-.222)			BKG026
$\beta_{,162}$					-.093 (-.179)	BKG043
$\beta_{,163}$	-.020 (-.129)	-.035 (-.176)				BKG044
$\beta_{,164}$					.112 (.198)	BKG045
$\beta_{,167}$		-.061 (-.304)	-.049 (-.238)			BKG048
$\beta_{,168}$		.054 (.285)				BKG049
$\beta_{,171}$					-.131 (-.248)	BKG052
$\beta_{,179}$	.051 (.265)					BKG060
$\beta_{,182}$			-.082 (-.223)			BKG063
$\beta_{,191}$		.049 (.227)				BKF004
$\beta_{,195}$	-.015 (-.090)					BKF008
$\beta_{,199}$	.020 (.121)	.048 (.223)				BKF012
$\beta_{,200}$	-.039 (-.237)					BKF013
$\lambda_{,7}$			-.056 (-.134)			LEC007
$\lambda_{,27}$	-.054 (-.118)					SAS016
$\lambda_{,30}$	.079 (.141)					SAS019
$\lambda_{,50}$					.263 (.286)	PQZ009
$\lambda_{,51}$					-.366 (-.388)	PQZ010
$\lambda_{,69}$	.039 (.179)					TC18
$\lambda_{,94}$			.047 (.159)			FIN061
$\lambda_{,95}$	.018 (.118)		-.036 (-.180)			FIN062
$\lambda_{,103}$	.006 (.133)					Q4

TABLE E.9

MODEL COEFFICIENTS FOR WEEK 10

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K3209	K3409	K3509	K3609	K3709	
$\lambda_{,107}$	.008 (.178)			.031 (.203)	.044 (.298)	Q9
$\mu_{,2}$	.180 (.234)					K0208
$\mu_{,5}$	-.099 (-.129)					K0508
$\mu_{,8}$				.496 (.172)		K0808
$\mu_{,11}$					.244 (.123)	K1108
$\mu_{,12}$	.128 (.240)				-.509 (-.305)	K1208
$\mu_{,14}$		.135 (.174)				K1408
$\mu_{,15}$	-.174 (-.291)			-.514 (-.263)		K1508
$\mu_{,16}$					-.345 (-.140)	K1608
$\mu_{,19}$	.068 (.104)					K1908
$\mu_{,20}$	.100 (.169)			.374 (.195)		K2008
$\mu_{,25}$		-.088 (-.125)				K2508
$\mu_{,26}$			.067 (.155)			K2608
$\mu_{,30}$			-.070 (-.171)			K3008
$\mu_{,31}$		.037 (-.171)				K3108
$\mu_{,32}$	.126 (.189)					K3208
$\mu_{,33}$			.118 (.202)			K3308

TABLE E. 9

MODEL COEFFICIENTS FOR WEEK 10

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K3809	K3909	K4009	K4109	K4209	
$\beta_{,11}$			.039 (.136)		-.186 (-.224)	PRE001
$\beta_{,14}$			.037 (.121)			PRE004
$\beta_{,19}$	.164 (.144)					PRE009
$\beta_{,35}$		-.059 (-.118)			.167 (.184)	PRE025
$\beta_{,38}$					.146 (.176)	PRE028
$\beta_{,39}$		.072 (.137)				PRE029
$\beta_{,43}$		.076 (.158)				PRE033
$\beta_{,44}$					.164 (.164)	PRE034
$\beta_{,57}$				-.113 (-.316)		PRF012
$\beta_{,59}$				.061 (.169)		PRF014
$\beta_{,60}$			-.019 (-.111)			PRF015
$\beta_{,62}$		.087 (.174)				AFF002
$\beta_{,70}$	-.203 (-.218)					AFF010
$\beta_{,74}$					.181 (.210)	AFF014
$\beta_{,75}$			.045 (.132)			AFF015
$\beta_{,78}$				.102 (.175)		AFF018
$\beta_{,79}$				-.131 (-.182)		AFF019
$\beta_{,81}$		.349 (.226)	.215 (.222)		.548 (.196)	AFF021
$\beta_{,88}$			.062 (.220)			AFF028
$\beta_{,89}$		.117 (.255)				AFF029
$\beta_{,90}$	.359 (.140)					AFF030
$\beta_{,97}$			-.032 (-.116)	-.067 (-.118)		AFF037

TABLE E.9

MODEL COEFFICIENTS FOR WEEK 10

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K3809	K3909	K4009	K4109	K4209	
$\beta_{,104}$	-.124 (-.137)					AFF044
$\beta_{,108}$		-.152 (-.220)				AFF048
$\beta_{,117}$					-.127 (-.269)	AFR009
$\beta_{,118}$		.026 (.096)				AFR010
$\beta_{,127}$				.030 (.133)		BKG008
$\beta_{,128}$			.053 (.159)			BKG009
$\beta_{,134}$	-.060 (-.144)					BKG015
$\beta_{,136}$		.020 (.101)				BKG017
$\beta_{,149}$			.025 (.155)			BKG030
$\beta_{,163}$		-.053 (-.226)				BKG044
$\beta_{,168}$			.009 (.062)			BKG049
$\beta_{,171}$			-.037 (-.229)			BKG052
$\beta_{,172}$					-.042 (-.145)	BKG053
$\beta_{,178}$		-.050 (-.186)				BKG059
$\beta_{,179}$	.076 (.129)					BKG060
$\beta_{,184}$					-.092 (-.148)	BKG065
$\beta_{,188}$					.133 (.312)	BKF001
$\beta_{,191}$			.022 (.140)			BKF004
$\beta_{,196}$			-.019 (-.129)			BKF009
$\beta_{,200}$	-.142 (-.276)					BKF013
$\beta_{,201}$			-.021 (-.125)			BKF014
$\beta_{,202}$				.069 (.200)		BKF015

TABLE E.9

MODEL COEFFICIENTS FOR WEEK 10

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K3809	K3909	K4009	K4109	K4209	
$\lambda_{,7}$		-.078 (-.165)		-.089 (-.146)		LEC007
$\lambda_{,9}$				-.093 (-.165)		LEC009
$\lambda_{,10}$	.112 (.121)	-.065 (-.144)			-.105 (-.128)	LEC010
$\lambda_{,27}$	-.247 (-.175)			.094 (.105)		SAS016
$\lambda_{,29}$			.056 (.121)			SAS018
$\lambda_{,30}$	.347 (.200)	.195 (.228)				SAS019
$\lambda_{,50}$		.208 (.462)	.089 (.315)		.196 (.241)	PQZ009
$\lambda_{,51}$		-.198 (-.429)	-.072 (-.247)			PQZ010
$\lambda_{,66}$					.151 (.165)	TC15
$\lambda_{,69}$	.059 (.088)	.058 (.174)				TC18
$\lambda_{,89}$		.053 (.204)				SVN032
$\lambda_{,100}$				.021 (.253)		Q1
$\lambda_{,102}$	.029 (.298)		.011 (.366)			Q3
$\lambda_{,107}$			.005 (.107)			Q9
$\mu_{,1}$			-.108 (-.149)			K0108
$\mu_{,2}$		.151 (.128)				K0208
$\mu_{,3}$					.276 (.135)	K0308
$\mu_{,5}$				.304 (.202)		K0508
$\mu_{,6}$				-.236 (-.163)		K0608
$\mu_{,12}$	.278 (.168)		-.181 (-.353)			K1208
$\mu_{,14}$		-.092 (-.102)				K1408
$\mu_{,18}$	-.219 (-.194)					K1808

TABLE E. 9

MODEL COEFFICIENTS FOR WEEK 10

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K3809	K3909	K4009	K4109	K4209	
$\mu_{,19}$				.178 (.140)		K1908
$\mu_{,24}$	-.144 (-.137)		-.060 (-.184)			K2408
$\mu_{,25}$			-.064 (-.124)	.198 (.187)		K2508
$\mu_{,28}$					.121 (.086)	K2808
$\mu_{,30}$	.090 (.095)					K3008
$\mu_{,31}$			.086 (.292)	-.083 (-.139)		K3108
$\mu_{,32}$			.089 (.138)	-.255 (-.195)		K3208
$\mu_{,39}$		-.080 (-.175)				K3908
$\mu_{,41}$				.051 (.081)		K4108
$\mu_{,42}$					.115 (.138)	K4208

TABLE E.9

MODEL COEFFICIENTS FOR WEEK 10

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K4309	K4409				
$\beta_{,35}$	-.141 (-.156)					PRE025
$\beta_{,39}$	.215 (.226)	-.222 (-.215)				PRE029
$\beta_{,67}$		.088 (.101)				AFF007
$\beta_{,69}$		.090 (.101)				AFF009
$\beta_{,74}$		-.216 (-.232)				AFF014
$\beta_{,79}$		-.210 (-.191)				AFF019
$\beta_{,81}$	.670 (.240)					AFF021
$\beta_{,87}$	-.156 (-.179)					AFF027
$\beta_{,88}$		.100 (.114)				AFF028
$\beta_{,108}$		-.199 (-.147)				AFF048
$\beta_{,144}$	.184 (.234)					BKG025
$\beta_{,164}$	-.074 (-.148)					BKG045
$\beta_{,178}$	-.072 (-.150)					BKG059
$\beta_{,196}$		.038 (.081)				BKF009
$\beta_{,201}$	.095 (.199)					BKF014
$\lambda_{,10}$	-.113 (-.137)					LEC010
$\lambda_{,69}$		.101 (.155)				TC18
$\lambda_{,94}$	-.068 (-.110)					FIN061
$\lambda_{,101}$		.024 (.217)				Q2
$\lambda_{,104}$		.015 (.105)				Q5
$\mu_{,2}$	.413 (.194)					K0208
$\mu_{,14}$		.183 (.103)				K1408

TABLE E.9

MODEL COEFFICIENTS FOR WEEK 10

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K4309	K4409				
$\mu_{,22}$	.193 (.136)					K2208
$\mu_{,24}$	-.132 (-.142)	.144 (.143)				K2408
$\mu_{,25}$	.177 (.119)					K2508
$\mu_{,26}$	-.137 (-.155)	-.186 (-.193)				K2608
$\mu_{,27}$	-.193 (-.103)					K2708
$\mu_{,30}$		.143 (.157)				K3008

TABLE E.9

Model Constants
Week-10

α 1		α34	0.9674
α 2	-0.0115	α35	1.1872
α 3		α36	-0.6598
α 4		α37	0.4990
α 5		α38	-0.1238
α 6		α39	0.3961
α 7		α40	0.2527
α 8		α41	0.3839
α 9	0.0938	α42	-0.4269
α10		α43	0.4179
α11		α44	0.3664
α12			
α13			
α14			
α15			
α16			
α17			
α18			
α19			
α20			
α21			
α22			
α23	-0.1148		
α24			
α25	0.3219		
α26			
α27			
α28			
α29			
α30			
α31	0.3012		
α32	0.0425		
α33			

TABLE E.10

MODEL COEFFICIENTS FOR WEEK - FINAL

Coefficients	DEPENDENT VARIABLE, K'_j					Independent Variable Acronym
	K0310	K0610	K0810	K0910	K1010	
$\beta_{,8}$				.00009 (.071)		GPA
$\beta_{,13}$				-.028 (-.091)		PRE003
$\beta_{,14}$		.024 (.057)				PRE004
$\beta_{,19}$				.029 (.084)		PRE009
$\beta_{,22}$			.049 (.064)			PRE012
$\beta_{,27}$			.020 (.064)			PRE017
$\beta_{,35}$				.019 (.060)		PRE025
$\beta_{,41}$	.020 (.051)	.029 (.073)		.031 (.107)		PRE031
$\beta_{,51}$			-.009 (-.058)			PRF006
$\beta_{,67}$				.022 (.081)		AFF007
$\beta_{,68}$				-.020 (-.063)		AFF008
$\beta_{,71}$				.014 (.051)		AFF011
$\beta_{,93}$				-.050 (-.089)		AFF033
$\beta_{,94}$				-.021 (-.077)		AFF034
$\beta_{,98}$			.018 (.053)			AFF038
$\beta_{,103}$				-.048 (-.071)		AFF043
$\beta_{,113}$				-.008 (-.050)		AFR005
$\beta_{,117}$	-.011 (-.050)	-.019 (-.086)		-.008 (-.052)		AFR009
$\beta_{,121}$				-.010 (-.058)		BKG002
$\beta_{,124}$			.012 (.060)			BKG005
$\beta_{,131}$				-.031 (-.068)		BKG012
$\beta_{,143}$	-.014 (-.064)	-.023 (-.103)			-.021 (-.085)	BKG024

TABLE E.10

MODEL COEFFICIENTS FOR WEEK - FINAL

Coefficients	DEPENDENT VARIABLE, K'_j					Independent Variable Acronym
	K0310	K0610	K0810	K0910	K1010	
$\beta_{,151}$	.021 (.085)	.035 (.138)		-.013 (-.070)		BKG032
$\beta_{,153}$	-.019 (-.073)	-.029 (-.110)			-.017 (-.060)	BKG034
$\beta_{,155}$	-.020 (-.052)	-.031 (-.080)			-.021 (-.051)	BKG036
$\beta_{,167}$	.014 (.071)	.022 (.109)			.018 (.084)	BKG048
$\beta_{,171}$				.012 (.077)		BKG052
$\beta_{,175}$			-.016 (-.107)			BKG056
$\beta_{,192}$				.025 (.159)		BKF005
$\lambda_{,12}$				.089 (.064)		SAS001
$\lambda_{,13}$				.090 (.065)		SAS002
$\lambda_{,14}$			.022 (.038)			SAS003
$\lambda_{,15}$			.071 (.093)	.102 (.144)		SAS004
$\lambda_{,20}$				.030 (.069)		SAS009
$\lambda_{,25}$	-.045 (-.057)	-.069 (-.087)			-.045 (-.053)	SAS014
$\lambda_{,28}$	.042 (.060)	.057 (.082)		-.042 (-.085)	.042 (.056)	SAS017
$\lambda_{,32}$	-.116 (-.060)	-.189 (-.098)				LTP001
$\lambda_{,47}$			-.017 (-.058)			PQZ005
$\lambda_{,71}$				.010 (.060)		ONE032
$\lambda_{,76}$			.014 (.059)			TRE031
$\lambda_{,101}$	.003 (.066)	.005 (.104)			.003 (.057)	Q2
$\lambda_{,102}$				.003 (.106)		Q3
$\mu_{,1}$	.053 (.053)	.091 (.091)				K0109
$\mu_{,3}$	.885 (.910)					K0309

TABLE E.10

MODEL COEFFICIENTS FOR WEEK - FINAL

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K0310	K0610	K0810	K0910	K1010	
$\mu_{,6}$		.830 (.848)				K0609
$\mu_{,8}$			.657 (.721)			K0809
$\mu_{,9}$				.776 (.772)		K0909
$\mu_{,10}$			.051 (.072)		.867 (.881)	K1009
$\mu_{,14}$			.075 (.123)			K1409
$\mu_{,15}$			.063 (.102)			K1509
$\mu_{,28}$				.024 (.049)		K2809
$\mu_{,29}$	-.038 (-.053)	-.059 (-.083)			-.045 (-.058)	K2909
$\mu_{,36}$			.016 (.052)			K3609
$\mu_{,40}$				.076 (.077)		K4009
$\mu_{,44}$		-.027 (-.060)				K4409

TABLE E.10

MODEL COEFFICIENTS FOR WEEK - FINAL

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K1410	K1510	K1610	K1910	K2010	
$\beta_{,1}$			.008 (.043)			CLASS
$\beta_{,3}$	-.0003 (-.051)	-.0004 (-.068)			-.0007 (-.116)	TRCR
$\beta_{,5}$				-.001 (-.301)		CRERN
$\beta_{,6}$				.00007 (.389)		MSUPTS
$\beta_{,13}$				-.042 (-.083)		PRE003
$\beta_{,18}$		-.064 (-.058)				PRE008
$\beta_{,19}$				.067 (.118)		PRE009
$\beta_{,25}$					-.052 (-.051)	PRE015
$\beta_{,27}$	.049 (.119)					PRE017
$\beta_{,29}$					-.029 (-.062)	PRE019
$\beta_{,31}$	.049 (.115)					PRE021
$\beta_{,33}$			.025 (.072)			PRE023
$\beta_{,35}$	.041 (.090)				.047 (.094)	PRE025
$\beta_{,37}$			.024 (.076)			PRE027
$\beta_{,38}$					.066 (.143)	PRE028
$\beta_{,40}$	-.035 (-.080)	.040 (.086)				PRE030
$\beta_{,42}$	-.028 (-.059)				-.032 (-.061)	PRE032
$\beta_{,45}$			-.003 (-.082)			PRETOT
$\beta_{,51}$					-.031 (-.128)	PRF006
$\beta_{,55}$					.037 (.158)	PRF010
$\beta_{,62}$					.034 (.068)	AFF002
$\beta_{,64}$			.032 (.106)			AFF004

TABLE E.10

MODEL COEFFICIENTS FOR WEEK - FINAL

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K1410	K1510	K1610	K1910	K2010	
$\beta_{,66}$					-.038 (-.074)	AFF006
$\beta_{,71}$				.025 (.055)		AFF011
$\beta_{,73}$				.045 (.103)		AFF013
$\beta_{,74}$			-.038 (-.119)		-.039 (-.082)	AFF014
$\beta_{,76}$		.026 (.056)	.014 (.044)		-.055 (-.117)	AFF016
$\beta_{,77}$		-.030 (-.063)				AFF017
$\beta_{,79}$		-.041 (-.074)				AFF019
$\beta_{,83}$			-.032 (-.053)			AFF023
$\beta_{,85}$		.036 (.050)			-.039 (-.051)	AFF025
$\beta_{,87}$		.026 (.056)				AFF027
$\beta_{,89}$	.021 (.051)					AFF029
$\beta_{,90}$				-.095 (-.073)		AFF030
$\beta_{,93}$			-.048 (-.079)	-.072 (-.078)		AFF033
$\beta_{,94}$				-.059 (-.131)		AFF034
$\beta_{,98}$	.029 (.064)					AFF038
$\beta_{,106}$		.064 (.077)				AFF046
$\beta_{,108}$			.052 (.073)			AFF048
$\beta_{,115}$	-.032 (-.133)					AFR007
$\beta_{,116}$					.047 (.182)	AFR008
$\beta_{,119}$			-.017 (-.094)			AFR011
$\beta_{,124}$	.018 (.064)					BKG005
$\beta_{,128}$				.050 (.092)		BKG009

TABLE E.10

MODEL COEFFICIENTS FOR WEEK - FINAL

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K1410	K1510	K1610	K1910	K2010	
$\beta_{,131}$					.072 (.097)	BKG012
$\beta_{,135}$			-.014 (-.055)			BKG016
$\beta_{,140}$		.062 (.085)				BKG021
$\beta_{,149}$	.017 (.072)					BKG030
$\beta_{,151}$				-.052 (-.174)		BKG032
$\beta_{,154}$					.014 (.054)	BKG035
$\beta_{,155}$		-.026 (-.060)				BKG036
$\beta_{,161}$			.008 (.055)			BKG042
$\beta_{,173}$		.012 (.050)				BKG054
$\beta_{,178}$			-.010 (-.058)			BKG059
$\beta_{,189}$		-.012 (-.052)				BKF002
$\beta_{,190}$			.008 (.050)			BKF003
$\beta_{,191}$	.023 (.102)				.019 (.075)	BKF004
$\beta_{,192}$				.040 (.156)		BKF005
$\beta_{,193}$	-.030 (-.135)		.009 (.056)			BKF006
$\beta_{,194}$					-.022 (-.089)	BKF007
$\beta_{,195}$					-.031 (-.120)	BKF008
$\lambda_{,7}$					-.037 (-.078)	LEC007
$\lambda_{,8}$	.022 (.056)	-.033 (-.078)				LEC008
$\lambda_{,11}$	-.004 (-.055)					LECATD
$\lambda_{,14}$	.042 (.053)					SAS003
$\lambda_{,15}$	.094 (.092)					SAS004

TABLE E.10

MODEL COEFFICIENTS FOR WEEK - FINAL

Coefficients	DEPENDENT VARIABLE, K'_j					Independent Variable Acronym
	K1410	K1510	K1610	K1910	K2010	
$\lambda_{,20}$				.053 (.074)		SAS009
$\lambda_{,24}$		.088 (.090)				SAS013
$\lambda_{,32}$			-.121 (-.081)			LTP001
$\lambda_{,33}$			-.123 (-.083)			LTP002
$\lambda_{,38}$		-.127 (-.100)				LTP007
$\lambda_{,39}$		.122 (.096)				LTP008
$\lambda_{,41}$		-.225 (-.103)				LTP010
$\lambda_{,42}$	.028 (.077)		.017 (.064)			LTPTOT
$\lambda_{,47}$			.040 (.138)			PQZ005
$\lambda_{,52}$					.012 (.138)	PQZTOT
$\lambda_{,58}$			-.012 (-.051)			TC7
$\lambda_{,62}$		-.022 (-.053)				TC11
$\lambda_{,65}$	.032 (.066)					TC14
$\lambda_{,66}$			.024 (-.071)			TC15
$\lambda_{,68}$			-.019 (-.050)			TC17
$\lambda_{,70}$			.012 (.058)			ONE031
$\lambda_{,71}$			-.014 (-.076)	.031 (.111)		ONE032
$\lambda_{,76}$	.015 (.046)					TRE031
$\lambda_{,90}$					-.011 (-.060)	SVN033
$\lambda_{,96}$	-.013 (-.075)					FIN063
$\lambda_{,97}$	.021 (.072)		.011 (.051)		.047 (.145)	FIN064
$\lambda_{,98}$	.021 (.106)					FIN065

TABLE E.10

MODEL COEFFICIENTS FOR WEEK - FINAL

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K1410	K1510	K1610	K1910	K2010	
$\lambda_{,100}$					-.006 (-.085)	Q1
$\lambda_{,101}$					.006 (.111)	Q2
$\lambda_{,102}$				.003 (.061)		Q3
$\lambda_{,106}$	-.004 (-.089)					Q7
$\mu_{,2}$			-.113 (-.134)			K0209
$\mu_{,11}$					.079 (.081)	K1109
$\mu_{,14}$	.647 (.784)					K1409
$\mu_{,15}$	.121 (.146)	.789 (.884)	.044 (.072)			K1509
$\mu_{,16}$	.080 (.073)		.681 (.847)			K1609
$\mu_{,18}$				-.054 (-.095)		K1809
$\mu_{,19}$			.056 (.084)	.801 (.793)		K1909
$\mu_{,20}$					.669 (.743)	K2009
$\mu_{,23}$			.149 (.121)			K2309
$\mu_{,27}$				-.056 (-.053)		K2709
$\mu_{,28}$					.088 (.112)	K2809
$\mu_{,31}$			.065 (.129)			K3109
$\mu_{,36}$			.034 (.110)			K3609
$\mu_{,40}$				.138 (.086)		K4009
$\mu_{,42}$				.083 (.157)		K4209

TABLE E.10

MODEL COEFFICIENTS FOR WEEK - FINAL

Coefficients	DEPENDENT VARIABLE, K'_j					Independent Variable Acronym
	K2210	K2310	K2710	K2910	K3210	
$\beta_{,3}$		-.0004 (-.115)				TRCR
$\beta_{,6}$			.00001 (.107)			MSUPTS
$\beta_{,8}$	.0002 (.115)	.0001 (.105)				GPA
$\beta_{,13}$		-.029 (-.110)	-.034 (-.092)	-.057 (-.104)		PRE003
$\beta_{,15}$				-.035 (-.070)		PRE005
$\beta_{,18}$		.037 (.063)				PRE008
$\beta_{,23}$			.047 (.115)	.095 (.157)	-.024 (-.067)	PRE013
$\beta_{,29}$			.025 (.072)			PRE019
$\beta_{,30}$	-.072 (-.097)					PRE020
$\beta_{,33}$		.040 (.147)			.043 (.126)	PRE023
$\beta_{,35}$		.020 (.076)				PRE025
$\beta_{,36}$	.039 (.061)					PRE026
$\beta_{,41}$		.025 (.103)				PRE031
$\beta_{,45}$			-.003 (-.069)			PRETOT
$\beta_{,49}$					.012 (.085)	PRF004
$\beta_{,51}$			.026 (.147)	.037 (.138)		PRF006
$\beta_{,59}$			-.030 (-.145)	-.069 (-.222)		PRF014
$\beta_{,66}$				-.097 (-.171)		AFF006
$\beta_{,68}$	.055 (.122)	-.030 (-.116)			-.031 (-.094)	AFF008
$\beta_{,69}$			-.017 (-.050)			AFF009
$\beta_{,73}$		.017 (.073)				AFF013
$\beta_{,74}$			-.052 (-.146)	-.063 (-.120)		AFF014

TABLE E.10

MODEL COEFFICIENTS FOR WEEK - FINAL

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K2210	K2310	K2710	K2910	K3210	
$\beta_{,77}$		.029 (.112)			.022 (.069)	AFF017
$\beta_{,90}$	-.132 (-.115)					AFF030
$\beta_{,93}$		-.044 (-.093)			-.053 (-.090)	AFF033
$\beta_{,99}$		-.033 (-.103)			-.038 (-.095)	AFF039
$\beta_{,107}$					.030 (.074)	AFF047
$\beta_{,112}$			.014 (.076)			AFR004
$\beta_{,123}$			-.010 (-.045)			BKG004
$\beta_{,125}$					-.017 (-.091)	BKG006
$\beta_{,126}$		.011 (.070)				BKG007
$\beta_{,128}$		.024 (.087)				BKG009
$\beta_{,131}$			-.037 (-.067)			BKG012
$\beta_{,139}$					.024 (.055)	BKG020
$\beta_{,149}$	.022 (.095)	.014 (.102)			.015 (.086)	BKG030
$\beta_{,155}$				.050 (.100)		BKG036
$\beta_{,161}$				.045 (.180)		BKG042
$\beta_{,166}$	-.031 (-.148)					BKG047
$\beta_{,171}$		.013 (.095)			.020 (.118)	BKG052
$\beta_{,173}$				-.042 (-.157)		BKG054
$\beta_{,179}$					.011 (.057)	BKG060
$\beta_{,200}$				-.068 (-.244)		BKF013
$\beta_{,201}$				-.031 (-.108)		BKF014
$\lambda_{,1}$			.069 (.121)			LEC001

TABLE E.10

MODEL COEFFICIENTS FOR WEEK - FINAL

Coefficients	DEPENDENT VARIABLE, K'_j					Independent Variable Acronym
	K2210	K2310	K2710	K2910	K3210	
$\lambda_{,4}$					-.039 (-.121)	LEC004
$\lambda_{,6}$			-.038 (-.104)			LEC006
$\lambda_{,8}$		.041 (.179)				LEC008
$\lambda_{,9}$	-.063 (-.159)		.045 (.139)			LEC009
$\lambda_{,10}$			-.063 (-.185)	-.054 (-.107)		LEC010
$\lambda_{,11}$		-.009 (-.188)				LECATD
$\lambda_{,12}$			.176 (.106)			SAS001
$\lambda_{,13}$		.097 (.083)				SAS002
$\lambda_{,17}$		.035 (.066)	.043 (.057)			SAS006
$\lambda_{,20}$		.027 (.075)			.033 (.073)	SAS009
$\lambda_{,23}$			-.097 (-.117)	-.190 (-.154)		SAS012
$\lambda_{,30}$	.092 (.119)					SAS019
$\lambda_{,31}$				.011 (.102)		SASATD
$\lambda_{,35}$			-.091 (-.094)	-.083 (-.058)		LTP004
$\lambda_{,38}$		.039 (.058)				LTP007
$\lambda_{,39}$					.092 (.108)	LTP008
$\lambda_{,48}$	-.059 (-.147)					PQZ006
$\lambda_{,53}$					.048 (.092)	TC1
$\lambda_{,54}$	-.114 (-.157)					TC3
$\lambda_{,59}$	.048 (.156)					TC8
$\lambda_{,61}$					-.018 (-.056)	TC10
$\lambda_{,62}$	-.068 (-.179)					TC11

TABLE E.10

MODEL COEFFICIENTS FOR WEEK - FINAL

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K2210	K2310	K2710	K2910	K3210	
$\lambda_{,65}$					-.021 (-.061)	TC14
$\lambda_{,70}$			.017 (.073)			ONE031
$\lambda_{,74}$	.026 (.111)					TWO032
$\lambda_{,91}$					-.012 (-.066)	NIN031
$\lambda_{,101}$		.003 (.109)	.004 (.096)			Q2
$\lambda_{,105}$					.002 (.053)	Q6
$\lambda_{,107}$				.007 (.084)		Q9
$\lambda_{,108}$				.012 (.164)		Q10
$\mu_{,1}$					.083 (.121)	K0109
$\mu_{,8}$	.314 (.257)	.042 (.060)	.107 (.107)			K0809
$\mu_{,9}$				-.159 (-.089)		K0909
$\mu_{,10}$		.063 (.115)				K1009
$\mu_{,14}$			-.049 (-.072)	-.064 (-.064)		K1409
$\mu_{,19}$			.075 (.102)			K1909
$\mu_{,20}$	-.117 (-.144)		.077 (.115)			K2009
$\mu_{,22}$	.462 (.654)		.041 (.070)			K2209
$\mu_{,23}$	.253 (.151)	.586 (.608)	.089 (.065)			K2309
$\mu_{,27}$			.522 (.674)			K2709
$\mu_{,28}$		.041 (.101)				K2809
$\mu_{,29}$				.711 (.778)		K2909
$\mu_{,32}$					.787 (.794)	K3209
$\mu_{,36}$				-.060 (-.115)		K3609

TABLE E.10

MODEL COEFFICIENTS FOR WEEK - FINAL

Coefficients	DEPENDENT VARIABLE, K'_j					Independent Variable Acronym
	K2210	K2310	K2710	K2910	K3210	
$\mu_{,40}$			.119 (.101)	.132 (.075)	-.106 (-.103)	K4009

TABLE E.10

MODEL COEFFICIENTS FOR WEEK - FINAL

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K3410	K3610	K3710	K3910	K4010	
$\beta_{,8}$					.0002 (.181)	GPA
$\beta_{,11}$					-.028 (-.117)	PRE001
$\beta_{,18}$		.139 (.100)	.122 (.086)	.127 (.140)	.064 (.108)	PRE008
$\beta_{,23}$	-.035 (-.076)					PRE013
$\beta_{,36}$	.052 (.088)					PRE026
$\beta_{,37}$		.085 (.150)	.084 (.144)		.021 (.086)	PRE027
$\beta_{,42}$					-.045 (-.165)	PRE032
$\beta_{,49}$	.024 (.133)					PRF004
$\beta_{,51}$				-.020 (-.102)		PRF006
$\beta_{,54}$		.029 (.094)	.032 (.102)			PRF009
$\beta_{,56}$		.020 (.062)	.018 (.054)			PRF011
$\beta_{,61}$				-.039 (-.103)	-.043 (-.174)	AFF001
$\beta_{,70}$					.024 (.100)	AFF010
$\beta_{,71}$	.047 (.125)					AFF011
$\beta_{,72}$	-.022 (-.062)					AFF012
$\beta_{,85}$		-.089 (-.097)	-.086 (-.091)			AFF025
$\beta_{,89}$	.034 (.090)					AFF029
$\beta_{,91}$				-.050 (-.134)	-.027 (-.111)	AFF031
$\beta_{,93}$				-.124 (-.170)		AFF033
$\beta_{,94}$				.022 (.062)	.018 (.078)	AFF034
$\beta_{,99}$	-.028 (-.054)					AFF039
$\beta_{,101}$	.026 (.053)	-.069 (-.097)	-.056 (-.076)			AFF041

TABLE E.10

MODEL COEFFICIENTS FOR WEEK - FINAL

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K3410	K3610	K3710	K3910	K4010	
$\beta_{,105}$		.113 (.094)	.122 (.098)			AFF045
$\beta_{,107}$				.063 (.126)		AFF047
$\beta_{,108}$	.037 (.065)					AFF048
$\beta_{,113}$		-.037 (-.112)	-.035 (-.104)			AFF005
$\beta_{,115}$	-.035 (-.161)					AFR007
$\beta_{,125}$		-.030 (-.084)		-.057 (-.243)	-.010 (-.068)	BKG006
$\beta_{,126}$		.020 (.058)	.024 (.066)			BKG007
$\beta_{,131}$					-.042 (-.109)	BKG012
$\beta_{,136}$					-.016 (-.157)	BKG017
$\beta_{,141}$					-.016 (-.069)	BKG022
$\beta_{,149}$				.053 (.254)		BKG030
$\beta_{,151}$				-.030 (-.130)		BKG032
$\beta_{,153}$				-.024 (-.097)		BKG034
$\beta_{,154}$					.011 (.077)	BKG035
$\beta_{,156}$					-.081 (-.101)	BKG037
$\beta_{,160}$				-.019 (-.079)		BKG041
$\beta_{,166}$		-.029 (-.102)	-.032 (-.108)			BKG047
$\beta_{,168}$	.026 (.144)					BKG049
$\beta_{,171}$				.024 (.115)		BKG052
$\beta_{,172}$					.016 (.138)	BKG053
$\beta_{,173}$		-.024 (-.080)	-.021 (-.068)			BKG054
$\beta_{,179}$	.023 (.095)					BKG060

TABLE E.10

MODEL COEFFICIENTS FOR WEEK - FINAL

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K3410	K3610	K3710	K3910	K4010	
$\beta_{,181}$		.062 (.137)	.057 (.122)		.012 (.060)	BKG062
$\beta_{,192}$					-.012 (-.093)	BKF005
$\beta_{,197}$				-.043 (-.219)	-.013 (-.098)	BKF010
$\beta_{,200}$	-.022 (-.106)					BKF013
$\lambda_{,1}$		.056 (.059)	.053 (.055)			LEC001
$\lambda_{,4}$	-.056 (-.137)				-.028 (-.110)	LEC004
$\lambda_{,5}$	.061 (.147)					LEC005
$\lambda_{,7}$					.042 (.170)	LEC007
$\lambda_{,8}$				.028 (.081)		LEC008
$\lambda_{,10}$				-.046 (-.127)		LEC010
$\lambda_{,13}$	.168 (.091)			-.157 (-.088)		SAS002
$\lambda_{,17}$				.085 (.104)		SAS006
$\lambda_{,20}$	.037 (.064)					SAS009
$\lambda_{,23}$				.064 (.071)	.059 (.102)	SAS012
$\lambda_{,30}$		-.063 (-.060)	-.051 (-.048)			SAS019
$\lambda_{,32}$				-.233 (-.130)		LTP001
$\lambda_{,35}$				.118 (.113)		LTP004
$\lambda_{,39}$					.084 (.123)	LTP008
$\lambda_{,47}$		.049 (.092)	.047 (.086)			PQZ005
$\lambda_{,53}$	.067 (.100)					TC1
$\lambda_{,54}$	.065 (.098)					TC3
$\lambda_{,61}$	-.041 (-.102)					TC10

TABLE E.10

MODEL COEFFICIENTS FOR WEEK - FINAL

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K3410	K3610	K3710	K3910	K4010	
$\lambda_{,81}$				.015 (.084)		FOR033
$\lambda_{,87}$		.019 (.072)	.018 (.066)			SIX033
$\lambda_{,91}$	-.024 (-.103)					NIN031
$\lambda_{,97}$		.021 (.052)	.022 (.054)	.036 (.140)		FIN064
$\lambda_{,101}$	.006 (.117)					Q2
$\lambda_{,102}$					.003 (.100)	Q3
$\lambda_{,105}$				.004 (.091)		Q6
$\mu_{,1}$				.100 (.108)		K0109
$\mu_{,2}$		-.102 (-.125)	-.207 (-.131)			K0209
$\mu_{,3}$		.096 (.069)	.127 (.090)			K0309
$\mu_{,4}$				.077 (.060)	.117 (.140)	K0409
$\mu_{,19}$				-.081 (-.102)		K1909
$\mu_{,23}$					.131 (.136)	K2309
$\mu_{,25}$					-.068 (-.104)	K2509
$\mu_{,34}$	.683 (.704)					K3409
$\mu_{,36}$		.516 (.898)				K3609
$\mu_{,37}$			.515 (.840)			K3709
$\mu_{,39}$				.462 (.578)		K3909
$\mu_{,40}$	-.131 (-.099)				.540 (.651)	K4009

TABLE E.10

MODEL COEFFICIENTS FOR WEEK - FINAL

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K4110	K4210	K4310			
$\beta_{,18}$			.136 (.108)			PRE008
$\beta_{,23}$	-.055 (-.104)					PRE013
$\beta_{,33}$		.140 (.188)				PRE023
$\beta_{,36}$	.078 (.114)					PRE026
$\beta_{,37}$			.082 (.160)			PRE027
$\beta_{,49}$	.034 (.165)					PRF004
$\beta_{,54}$			.030 (.106)			PRF009
$\beta_{,56}$			.018 (.062)			PRF011
$\beta_{,68}$		-.108 (-.153)				AFF008
$\beta_{,71}$	.067 (.156)					AFF011
$\beta_{,72}$	-.035 (-.083)					AFF012
$\beta_{,73}$		.084 (.137)				AFF013
$\beta_{,75}$		.082 (.106)				AFF015
$\beta_{,77}$		.114 (.164)				AFF017
$\beta_{,85}$			-.087 (-.105)			AFF025
$\beta_{,89}$	.052 (.118)					AFF029
$\beta_{,92}$		.075 (.099)				AFF032
$\beta_{,93}$		-.249 (-.195)				AFF033
$\beta_{,97}$		.076 (.122)				AFF037
$\beta_{,99}$	-.044 (-.073)					AFF039
$\beta_{,101}$	.041 (.073)		-.067 (-.104)			AFF041
$\beta_{,105}$			.121 (.111)			AFF045

TABLE E.10

MODEL COEFFICIENTS FOR WEEK - FINAL

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K4110	K4210	K4310			
$\beta_{,107}$		.088 (.101)				AFF047
$\beta_{,108}$	.058 (.087)					AFF048
$\beta_{,113}$			-.033 (-.112)			AFR005
$\beta_{,115}$	-.052 (-.204)					AFR007
$\beta_{,117}$		.052 (.142)				AFR009
$\beta_{,125}$		-.032 (-.076)	-.030 (-.091)			BKG006
$\beta_{,126}$			.024 (.076)			BKG007
$\beta_{,143}$		-.209 (-.078)				BKG024
$\beta_{,149}$		.079 (.216)				BKG030
$\beta_{,161}$		-.039 (-.123)				BKG042
$\beta_{,166}$			-.031 (-.119)			BKG047
$\beta_{,168}$	.039 (.184)					BKG049
$\beta_{,171}$		.082 (.224)				BKG052
$\beta_{,173}$			-.023 (-.087)			BKG054
$\beta_{,179}$	.036 (.126)					BKG060
$\beta_{,181}$			.059 (.144)			BKG062
$\beta_{,192}$	-.012 (-.050)					BKF005
$\beta_{,200}$	-.033 (-.136)					BKF013
$\lambda_{,1}$			.054 (.063)			LEC001
$\lambda_{,4}$	-.087 (-.183)					LEC004
$\lambda_{,5}$	.092 (.189)					LEC005
$\lambda_{,8}$		.050 (.080)				LEC008

TABLE E.10

MODEL COEFFICIENTS FOR WEEK - FINAL

Coefficients	DEPENDENT VARIABLE, K'_i					Independent Variable Acronym
	K4110	K4210	K4310			
$\lambda_{,13}$	.247 (.115)					SAS002
$\lambda_{,20}$	.059 (.087)					SAS009
$\lambda_{,30}$			-.049 (-.052)			SAS019
$\lambda_{,42}$		.078 (.139)				LTPTOT
$\lambda_{,47}$			.050 (.104)			PQZ005
$\lambda_{,53}$	.100 (.128)					TC1
$\lambda_{,54}$	.101 (.131)					TC3
$\lambda_{,61}$	-.064 (-.136)					TC10
$\lambda_{,65}$		-.105 (-.141)				TCI4[illegible]
$\lambda_{,87}$			.018 (.075)			SIX033
$\lambda_{,91}$	-.037 (-.134)					NIN031
$\lambda_{,97}$			.020 (.056			FIN064
$\lambda_{,101}$	.009 (.156)					Q2
$\lambda_{,105}$		.007 (.091)				Q6
$\mu_{,2}$			-.182 (-.130)			K0209
$\mu_{,3}$			.081 (.065)			K0309
$\mu_{,10}$		.255 (.171)				K1009
$\mu_{,38}$		-.088 (-.128)				K3809
$\mu_{,40}$	-.189 (-.123)					K4009
$\mu_{,41}$	.486 (.645)					K4109
$\mu_{,42}$		.491 (.630)				K4209
$\mu_{,43}$			.479 (.781)			K4309

TABLE E.10

Model Constants
Week-Final

α 1		α34	-0.1661
α 2		α35	
α 3	0.0621	α36	0.2098
α 4		α37	0.1810
α 5		α38	
α 6	0.1040	α39	-0.0158
α 7		α40	0.1127
α 8	0.0166	α41	-0.2230
α 9	-0.3240	α42	-0.5041
α10	0.0930	α43	0.2203
α11		α44	
α12			
α13			
α14	-0.0851		
α15	0.0040		
α16	0.1385		
α17			
α18			
α19	-0.3150		
α20	0.0030		
α21			
α22	0.0692		
α23	-0.2232		
α24			
α25			
α26			
α27	-0.1424		
α28			
α29	-0.0518		
α30			
α31			
α32	0.0019		
α33			

LIST OF REFERENCES

REFERENCES

Abkin, M. H. Policy Making for Economic Development: A System Simulation Model of the Agricultural Economy of Southern Nigeria. Ph.D. Thesis, Michigan State University, 1965.

Alexander, T. R; Burnett, R. W,; Zim, H. S. Botany, Golden Press, N.Y., 1970.

Anonymous. Computer Models and Application of the Sterile - Male Technique. Proceedings of a panel organized by the Joint FAO/ IAEA Division of Atomic Energy in Food and Agriculture, Vienna, December 1971, International Atomic Energy Agency, Vienna, 1973.

Arnold, G. W. and deWit, C. T. (Eds.). Critical Evaluation of Systems Analysis in Ecosystems Research and Management, Wageningen, Center for Agricultural Publishing and Documentation, 1976.

Bloom, B. S. Human Characteristics and School Learning, McGraw-Hill, 1976.

Brandenburg, R. A Task - Content Analysis of an Introductory Entomology Curriculum. Presented at the National Association for Research in Science Teaching, Annual Meeting, April 23-25, 1976, San Francisco, California.

Burnett, R. W.; Fisher, H. I.; Zim, H.S. Zoology: An Introduction to the Animal Kingdom, Golden Press, N.Y., 1973.

Carrol, J. B. A Model of School Learning. Teachers College Record, 1963, 64, 723-733.

Ellis, Jack B. The Description and Analysis of Socio-Economic Systems by Physical Systems Techniques. Ph.D. Thesis, Michigan State University, 1965.

Enochs, N. J. "Biology Preparation for Prospective Elementary Teachers". Proceedings of the Conference Marking the Twentieth Anniversary of the Science and Mathematics Teaching Center, SMTC, Michigan State University, 1977. (R. Brandenburg and J. J. Gallagher, Eds.)

Forrester, J. W. Principles of Systems. Wright-Allen Press, Cambridge, Massachusetts (a).

Forrester, J. W. World Dynamics. Wright-Allen Press, Cambridge, Massachusetts (b).

Haefele, D. Systems and Modeling: Self-Renewal Approaches to Teacher Education. The American Association of Colleges for Teacher Education, December 1971.

Keeton, William T. Elements of Biological Science. Second Edition. W. W. Norton and Co., Inc., 1973.

Kuhn, Thomas S. The Structure of Scientific Revolutions. Second Edition (International Encyclopedia of Unified Science, Vol. 2, No. 2) University of Chicago, 1970.

Laszlo, Ervin. Introduction to Systems Philosophy Toward a New Paradigm of Contemporary Thought. Harper and Row, 1972.

LeBaron, W. Systems Analysis and Learning Systems in the Development of Elementary Teacher Education Models, October 1969, National Center for Educational Research and Development, U.S. Department of Health, Education, and Welfare, Office of Education, U.S. Government Printing Office (Supt. of Documents) Catalog No. FS 5.258:58035.

Levin, Simon A. (Ed.) Ecosystem Analysis and Prediction. Proceedings of a SIAM-SIMS Conference, 1974, Society for Industrial and Applied Mathematics, 1975.

Manetsch, T. J., Park, G.L. Systems Analysis and Simulation with Applications to Economic and Social Systems, Part I. Methodology and Linear Systems Fundamentals. Department of Electrical Engineering and Systems Science, Michigan State University, August 1974 (a).

Manetsch, T. J., Park, G.L. Systems Analysis and Simulation with Applications to Economic and Social Systems, Part II. Department of Electrical Engineering and Systems Science, Michigan State University, November 1974 (b).

May, Robert M. Stability and Complexity in Model Ecosystems. Princeton, University Press, 1974.

Meadows, D. L. The Limits to Growth. Universe Books, New York, 1972.

Nie, Norman H.; Hull, C. Hadlai; Jenkins, Jean G.; Steinbrenner, Karin; Bent, Dale H. SPSS Statistical Package for the Social Sciences, Second Edition, 1975, McGraw-Hill.

Novick, M. R., Jackson, P.H. Statistical Methods for Educational and Psychological Research. McGraw-Hill, 1974.

Odum, Eugene P. Fundamentals of Ecology, Third Edition. W. B. Saunders Company, 1971.

Patten, B.C. Systems Analysis and Simulation in Ecology, Vol. II, Academic Press.

Pugh, A. L. Dynamics User's Manual, 2nd Edition, The MIT Press, 1966.

Silvern, L. C. Systems Analysis and Synthesis Applied Quantitatively to Create an Instructional System, Education and Training Consultants Co., Los Angeles, California, 1965.

Silvern, L. C. Systems Analysis and Synthesis Applied to Occupational Instruction in Secondary Schools, Education and Training Consultants Co., Los Angeles, California, 1967.

Smith, Edward L. Techniques for Instructional Design, presented at American Educational Research Association Annual Meeting, April 16, 1974.

Smith, Edward L. Methods for Content Analysis, Science and Mathematics Teaching Center, Michigan State University, April 18, 1975.

Tamir, P. Private Communication, 1976.

Tamir, Pinchas; Gallagher, James J.; and Brandenburg, Richard. The Use of Bloom's Theory of School Learning as a Framework for Case Studies of Specific Courses. Unpublished, Science and Mathematics Teaching Center, Michigan State University, 1977.

Tanner, C. K. Designs for Educational Planning. D. C. Heath and Company, 1971.

Thompson, R. B. A Systems Approach to Instruction. Linnet Books, 1971.

Veldman, Donald J. Fortran Programming for the Behavioral Sciences. Holt Rinehart and Winston, 1967.

Weber, W. H. Socioeconomic Methods in Educational Analysis. Teachers College Press, 1975.

