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ABSTRACT

The author has developed a model for transferring and implementing educational innovations from one institution to another. The model consists of an organized set of variables whose precedence relationships were determined by statistical analysis of collected data. A questionnaire was sent to a sample of prospective consumers of educational technology. Using their responses to the questionnaire, several forms of multivariate statistical analysis were used to determine which factors were important to consumers. These factors were then used for the design of a data collection form for innovation developers, and the foundation for the design of a data management system. (Author/CH)

TRANSFERABILITY AND IMPLEMENTATION OF EDUCATIONAL TECHNOLOGY

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Abstract

Prior to this document very little work had been done in the field of transferring and implementing educational innovations from one institution to another. Most of the work which had been done previously approached the problem from the innovation developer's point of view. This paper adopts the opposite, that is the consumer's, point of view.

A questionnaire was sent to a sample of prospective consumers. Using their responses to the questionnaire, several forms of multivariate statistical analysis were used to determine which factors were important to them. These factors were then used for (1) the design of a data collection form for innovation developers, and (2) the foundation for the design of a data base for a data management system.

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CHAPTER I

INTRODUCTION

Purpose of This Thesis

The purpose of this thesis is the derivation of a model which will be used in four distinct, yet closely related, ways. It should be noted here, however, that the term "model" is not being used in its normally accepted sense. The "model" is not a mathematical model, which predicts, given a set of inputs, a normal response plus or minus an error term. Instead the "model" is an organized set of variables whose precedence relationships were determined by the statistical analysis of collected data.

The first use of the model was for the design of data collection forms to be used specifically for research in education. One of the major problems in all research today is the recognition of what data are important early enough in the project, such that those data are not lost. One solution to this problem is to collect and save all the data possible. Then, at the end of the project, all the data, important and unimportant, must be carefully analyzed and separated. Another, possibly better, solution is to determine ahead of time what items of data will be important and capture only those items.

The second and third uses of the model are related to the consumer. The prospective consumer will be able to use the model, first, for evaluation of an educational innovation and, second, for determination of necessary changes, if any, required to transfer and implement this innovation at his or

her educational institution. A consumer must be wary of making two types of mistakes. Assume he has been given data upon which to make his evaluation, and the data are not what he was interested in. Then the first error would be to reject an innovation when it was a very good one. The second error would be to accept an innovation which was not good. These two errors are similar to Type I and Type II errors in statistical hypothesis testing. (27) Use of this model will hopefully minimize the possibility of these two types of errors, since derivation of the model depends upon prospective consumer inputs.

The fourth use of the model is for the foundation of a data base which will be used in conjunction with a management information system. This management information system will present, quickly and efficiently, the information which the consumer needs to employ to make his evaluation. A listing of the program and an example output are included in Appendix H.

The four previously mentioned uses of the model are closely related to one main goal. That goal is to maximize the probability that worthwhile educational innovations will be accepted and used by other institutions. To meet that goal, the necessary information must first be collected and then disseminated to the prospective consumer in an orderly fashion.

The Organization of the Thesis

The introduction to and organization of the thesis are presented in Chapter I. Chapter II presents a review of literature pertaining to the

transferring and implementation of educational innovations. Chapter III presents the hypothesized model along with a discussion of methods for collection of data. The analysis of the data and analytical techniques are presented in Chapter IV. The results and conclusions, along with suggestions for extensions and recommendations for further research, are provided in Chapter V.

CHAPTER II

LITERATURE REVIEW

Introduction

This chapter presents a short summary of the work which has been done in the past regarding educational innovations and their adoption or implementation by an educational institution. It presents several important considerations such as the necessary steps in and obstacles to change in institutions. The important concept of innovation is defined in this chapter also. Finally, a practical approach is presented, using the model mentioned in Chapter I, along with a discussion of its merit.

The Problem

The first step in this type of endeavor is a complete and concise definition of the problem. Basically, it is a problem in marketing, specifically customer acceptance. Given that a company has developed a new product for a very specific market, what factors will determine the acceptance or rejection of the product by the customers, and which of these factors are most important? In our case the new product is an educational innovation and the customers are educational institutions. From the customer's viewpoint, the problem is slightly different. The problem is how to efficiently and effectively evaluate the new product, minimizing the probability of making the two types of errors mentioned in Chapter I. Both problems are related, however. The common point of both problems is "What are the factors?"

What Is An Innovation?

Miles (25, 26) defines an innovation as "a deliberate, novel, specific change which is thought to be more efficacious in accomplishing the goals of a system." He goes on to define a system as "a bounded collection of interdependent parts, devoted to the accomplishment of some goal or goals, with the parts maintained in a steady state in relation to each other and the environment by means of (1) standard modes of operation, and (2) feedbacks from the environment about the consequences of systems actions."

This definition of a system seems to fit an educational system very well. The interdependent parts are the different colleges, departments, and teachers. The goal of all three parts is to provide an opportunity for education in the best manner possible. The interdependency of the parts is very obvious. The environment would be the student body. The steady state relationship between the parts and the environment is the hierarchy of the educational system which goes from student up to administrator. Feedback from the environment comes in several forms. One form which was popular in the late 1960's was protest. A second type is the teacher evaluation forms which are administered at the end of each semester. Other types of feedback are student comments and student interviews. These often are used after a new type of course is taught or after a new method of teaching an old course is used.

Educational innovations range from new textbooks to entirely new courses. Often, the development of a new course is made possible by advances in other areas such as computer technology. For example, a course in pipeline

design or structure of bridges might be developed in which the student "draws" the pipeline or bridge on a graphics terminal using a light pen. Also, development of new courses is made possible when costs of new technology become feasible. The previously mentioned course in pipeline design could have been developed ten years ago but the cost of the equipment would have made it infeasible. Many innovations are not complete courses, but instead are computer-based supports which are used in conjunction with existing courses to help the student learn the material better and eliminate student and faculty tedium. For example, a course in statistics might have a computer-based support package which aids the student in discovering vital facts about different types of distributions simply by displaying those distributions and asking the student leading questions. This development would be enhanced by the fact that the cost for computer "line time" has decreased drastically in the past few years. Another type of innovation might be to take an existing course taught by the traditional means and change the teaching strategy such that the course becomes self-paced. These are only three of the many possible innovations in educational technology.

Steps in Change

What steps are necessary for change in general? Cooper (10) says that traditional curriculum change involves:

1) evaluation of the current program
2) review of research literature for better materials
3) development of a revised course of study and materials

4) acquisition of materials and equipment

5) in-service training

6) introduction and feedback.

This is fine for development of an innovation for oneself only. However, what if development was intended for widespread dissemination? Steps 1 through 3 would be appropriate for the developer of the innovation. If a step 3.5 were inserted for evaluation of an innovation developed elsewhere, then steps 3.5 through 6 might be appropriate for a consumer.

Gallaher (14) defines a "culture change cycle" in three stages:

1) innovation: the process whereby a new element of culture is made available

2) dissemination: the process whereby an innovation comes to be shared

3) integration: the process whereby an innovation becomes mutually adjusted to the other elements of the system.

Process 1 has to do with the developer of the innovation exclusively. Process 3 has to do mainly with the consumer. However, Process 2 has to do with both the innovator and the consumer, and the important question becomes how to make that interface a success for both parties.

Obstacles to Change

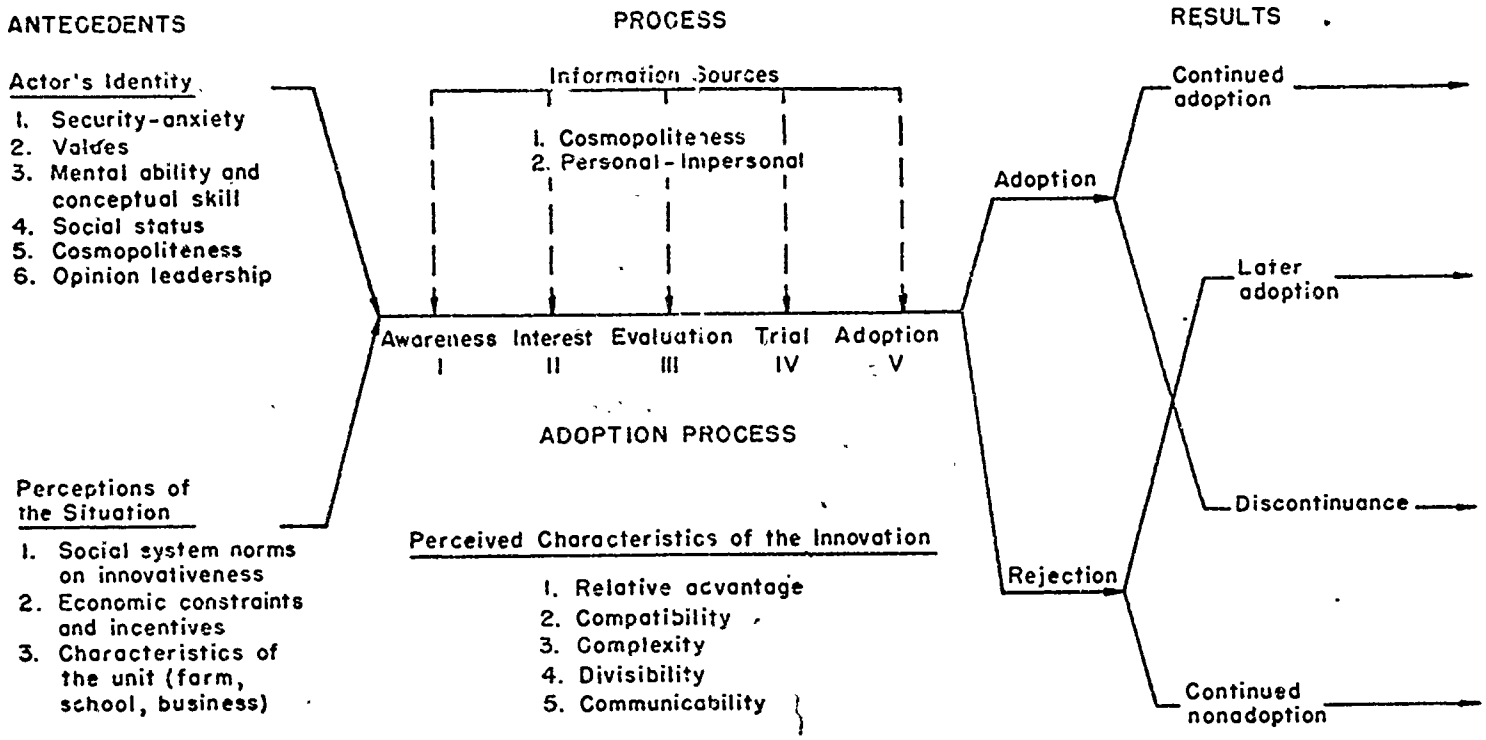
Carlson (6), Wiley (32), and McAndrew (24) seem to adopt a similar attitude in dealing with the subject of obstacles to change. That is, they put the

blame for non-adoption on the consumer. Their prevalent attitude is that if the consumer did not accept an innovation then he or she is at fault and would not recognize a good innovation regardless of its merit. This might be correct in a small percentage of the cases, but surely not in general.

Jenks (18) presents a fairly good model of a system and an innovation. (See Figure 1.) He then used regression analysis on the antecedent to try and discover the factors relating to adoption or non-adoption of an innovation. This is a highly commendable effort but it attacks the problem from the wrong end. The "Actor's Identity" factors that he identified relate to the consumer and not the innovation. It seems that he is also trying to put the blame for non-adoption on the consumer. Perhaps people who feel this way also think they shouid go out and change the consumer to fit their innovation, which is not a very feasible approach.

No one mentions that the fault could lie with the developers of the innovation. Could it be that the consumer rejects an innovation because he or she was not given the information upon which to make a sound judgement regarding the merits of the innovation? Or, if the consumer was given information might it have been the wrong information, which in turn caused the consumer to reject the innovation? This idea about information definitely has to be considered a main factor or cause of acceptance or rejectance of an innovation.

Another obstacle to change might be the lack of necessary physical facilities. Closely related to this is the problem of budget. Can the consumer's institution afford to acquire the necessary equipment? If not, surely he or she will reject the innovation no matter how good it is or is not. A third obstacle


ANTECEDENTS
PROCESS
RESULTS
Actor's Identity
1. Security-anxiety
2. Valdes
3. Mental ability and conceptual skill
4. Social status
5. Cosmopoliteness
6. Opinion leadership
Information Sources
1. Cosmopoliteness
2. Personal-Impersonal
Awareness I
Interest II
Evaluation III
Trial IV
Adoption V
ADOPTION PROCESS
Adoption
Rejection
Continued adoption
Later adoption
Discontinuance
Continued nonadoption
Perceptions of the Situation
1. Social system norms on innovativeness
2. Economic constraints and incentives
3. Characteristics of the unit (farm, school, business)
Perceived Characteristics of the Innovation
1. Relative advantage
2. Compatibility
3. Complexity
4. Divisibility
5. Communicability

might be that the administration is tied to traditional methods of teaching and is highly skeptical of innovations. This in turn would indicate that the financing necessary for the innovation would be difficult to get, thereby causing rejection. Jenks (17) hints at the three above factors in his model under the heading "Perceptions of the Situation." These three factors nevertheless, cannot be influenced by anyone outside the consumer's institution and, therefore, are not important to the developer of an innovation.

Diffusion

Carlson (6) says "diffusion literature is as sophisticated and as well-developed as any other areas of scientific study to which educators have given their attention." This is probably not completely correct because the literature concerning diffusion and the relationship between the supplier and the consumer seems to bear no real relationship to the practical problems of getting an innovation diffused or spread out. This would imply that the opportunity for much more research in this area exists.

Practical Approach

The only practical way to approach the problem is from the consumer's point of view. If the developer of an innovation anticipates the consumer's every need and can answer most questions that he might ask concerning an innovation he will stand a much greater chance to "sell" his product.

Miles (25) lists five questions for a consumer to ask himself:

1) What is the innovation?

2) What changes are necessary for adoption?

3) What equipment and materials will be needed?

4) How much and what type of in-service training is required?

5) What are the mechanisms for evaluation and feedback?

These are important questions which must be answered prior to adoption of the innovation.

Lippitt (20) also proposes some necessary steps for resource adoption:

1) A review of alternatives by appropriate decision makers.

2) Study validity of resources used in developmental stages.

3) Set up a plan to test alternatives and feasibility.

4) Analyze needs for in-service training and adoption.

Butts (5) comes closer to identifying many of the important requirements for change than anyone else:

1) Setting of the school must be receptive to change

2) Essential materials and facilities

3) Adequate time and guidance for planning and analysis

4) In-service training

5) Users' meeting

6) Materials budget

7) In-service training time

8) Mailing list for revision and changes

9) Sufficient rewards for the implementor.

Summary

In summary, most of the literature available was disappointing. Much of it sounded good superficially such as Cooper's "Initiating Educational Change," only to be vague and without any suggestions for practical application. Only a few people such as Lippitt (20, 21), Miles (25, 26), Butts (5), and Jenks (18) deal with any of the practical considerations which have to be made in transferring and implementing an educational innovation. It seems obvious that the consumer's point of view should be taken into account if the implementation of the innovation is to be a success.

CHAPTER III

THE EXPERIMENT

Introduction

It was determined that, to identify those variables or those factors which were important to both the developers and the consumers of innovations, an experiment must be set up and carried out. The first step was to have some developers of innovations, along with the author, hypothesize a set of variables for the model. The developers chosen were the members of the Implementation Model Committee of Project C-BE.* Each of the hypothesized variables fell into one of five major categories. Those categories were:

1) Nature of the Course
2) Resource Requirements
3) Benefits on a Comparative Basis
4) Commitment of Supplier and Consumer
5) Implementation Procedures.

The ordering of the categories is not meant to indicate any order of importance. Next a questionnaire was formulated using the hypothesized variables as a foundation. The questionnaire was then sent to random faculty and administrators all over the country to gauge their reactions. I am now going to discuss the five categories.

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Nature of the Course

This category was thought to be important because it contains many of the details regarding the innovation. Five main variables suggested under this category were:

1) objectives of the course
2) description of the course
3) detailed course outline
4) student prerequisites
5) history of the course.

These variables all deal with a specific course. This is because very few innovations are general enough to be used with any course, unless the innovation is something like a new teaching method, such as self-paced instruction, or a computer-based record keeping system.

The variable "objectives of the course" includes ideas such as grade level of the course and the level of the material presented in the course. It would be important to know whether the course was intended to be taught as a remedial course, an undergraduate course or a graduate course. Closely related to grade level is the level of the material. The level of material signifies whether the course was meant to give the students an introduction to the material or a deeper understanding of material to which they had been previously exposed. Also included under this variable is the important consideration of whether the objectives of the course can be modified to meet someone else's needs. A consumer from the discipline of psychology might need a graduate level statistics

course and might be able to use one developed for engineering students if the objectives could be modified slightly.

The variable "description of the course" takes into account the important ideas of course content, teaching method, pedagogical strategy, availability of special materials, and reference materials. Reference materials let the consumer know which books were used for texts and outside references. Content of the course tells the consumer how much material and, in particular, which ideas and concepts were covered in the texts and the references. It also indicates in how much detail the material was covered. The availability of special materials has to do with the developer furnishing materials such as computer programs and instructions for their use. The term "special" materials implies that the materials are not commercially available. It was also deemed important to know what the pedagogical strategy or teaching method was. A course taught by the self-paced method can be quite different from the same course taught by the more traditional approach of in-class lectures.

The third variable was "detailed course outline." This is important in case there is some inherent advantage to teaching material in a specific order. Some concepts may need to be taught first as a background for other concepts taught later. This might enhance the ability of the student to understand the material.

The fourth variable was "student prerequisites." Depending on the level of the course, it may be to the student's advantage to have had background in other areas. Sometimes this background may be recommended and other

times it might be required. Also, the prerequisites may be used to limit the size of the class, if that is important.

The fifth variable was "history of the course." Included in this variable are ideas such as overall evaluation of the course, evaluation procedures, publications, and student feedback. The consumer might very well want to know how the course was evaluated and why it was evaluated a certain way. If the consumer wanted a descriptive account of the course and was unable to visit the institution of the developer, then he might read any publications which had come about due to the course. Student evaluation of the course would probably be of interest to the prospective consumer also.

Also, implicitly included in the five variables mentioned previously, is the notion of whether the values of the variables can be modified. This is important in the same way as it was discussed under "objectives of the course."

Resource Requirements

Included in this category, five variables were identified. They are:

1) faculty and staff requirements
2) physical plant requirements
3) budget requirements
4) material requirements
5) computing requirements.

Once again, no precedence relationships are intended by the ordering of the variables.

The first variable was "faculty and staff requirements." The importance of this variable would not only be in costs but also in faculty manpower requirements. A school might be looking for a course which could be taught by an instructor or a teaching assistant instead of a professor due to a shortage of faculty. It would also be important to know whether these requirements were rigid or flexible.

The next variable is "physical plant requirements." A consumer would certainly want to know how many students the course was designed for in order to more efficiently plan the use of classrooms. It would also be imperative to know whether the course required a specialized lab or not. Some consumers might be interested in the course if the lab could be modified or eliminated.

The variable "budget requirements" is of obvious importance to the consumer. What school has an unlimited budget to use as they see fit? Included in this topic are expenditures for special materials or equipment such as teletypes or graphics terminals. Other expenditures are for faculty relief time, graders, and proctors. Another expenditure could be for computer time used by students. The total cost of implementation is also an important, one-time only expenditure.

"Material requirements" is the same variable as the previously mentioned "availability of special materials." Many variables such as this one overlap into several categories.

The last variable in this category is "computer requirements." This is important only if the innovation depends heavily on the computer. If the course is taught on the computer, such as the earlier mentioned pipeline design

course, the computer resources will be very important. It may mean that the consumer will have to buy or rent additional hardware to supplement any existing hardware that his institution already has. This would certainly be an important consideration. This variable includes areas such as the amount of computing time required per student per semester. Also special materials produced on a certain type of computer may not be easily transferred to another type of computer.

Benefits on a Comparative Basis

The "benefits on a comparative basis" will be an area about which a prospective consumer will be particularly concerned. The benefits are divided into three main areas or variables. They are:

1) benefits to the student
2) benefits to the teacher
3) benefits to the institution.

Probably no innovation will have all the hereafter mentioned benefits but every innovation should have a few of them.

There are several ways a student may benefit from the use of an innovation. The first benefit would be to learn and remember more material. The innovation may increase teaching efficiency such that more material is covered more effectively than another method of teaching. Thus, the students' learning effectiveness and retention of knowledge would be enhanced. Another benefit might be less time required of the student by the course. A course using a self-paced method of instructing makes it possible for a student to cover

material at his own pace. Thus, most students would need to spend less time on easy concepts. Another benefit would be a saving of money. For example, if a certain innovation made it possible to eliminate a lab for a course taught by traditional methods, the student would save the cost of the lab fee and the time usually spent in lab each week. A final benefit might be the elimination of student tedium. In a traditionally taught statistics course, the student might be required to draw hundreds of numbers from a table of random digits to demonstrate a theorem about the binomial or the normal distribution. This is a very tedious procedure which could be eliminated by a different course which had a computer-based support for generating random numbers, calculating means and calculating standard deviations.

There are also several ways a teacher could benefit from an innovation. Overt benefits might be relief of tedium and increased innovation time. Covert benefits could be teacher satisfaction and increased prestige. The innovation may increase teaching efficiency and thus increase both the teacher's satisfaction and the student/teacher time in meaningful contact. This new method may give the teacher more free time which could be used for (1) development of new courses, (2) enrichment of materials, and (3) enrichment of teaching. The last benefit could be relief of tedium. For an example, go back to the statistics example mentioned in student benefits. Using the traditional method of teaching, much of the teacher's time is spent working examples for students. This is tedious and often non-productive work. A computer-based support package which generated and worked example problems for students via a time-

sharing terminal could relieve the faculty members of tedium and see to the individual student's needs more effectively. This is not intended to belittle example problems, for they play an important role in the students' understanding of statistics. However, some students may need two examples to grasp a concept, while other students may need ten examples to grasp the same concept.

The benefits to the institution may be reduced costs, increased faculty morale, and increased student morale. The various ways that costs may be reduced were mentioned previously under budget requirements. However, in the case of computer-based innovation, often the costs may be increased instead of decreased. This increased cost would need to be balanced or outweighed by student benefits and teacher benefits. Closely related to these student benefits and teacher benefits are increased student morale and increased faculty morale. One problem dealing with institutional benefits is the lack of a means for objective evaluation of the benefits.

Commitment of Supplier and Consumer

This major category is based on two different parts. The commitment of the supplier to the consumer is in essence a "guarantee" such as a consumer might receive with any new product. The commitment of the consumer to the supplier is of a more indirect nature. Often a supplier will give away samples either free or at a reduced cost. This is for aid in the evaluation of the supplier's product and often carries some stipulations to insure a fair evaluation. This is similar to the commitment of the customer to the supplier.

The commitment of the supplier entails areas such as special materials, free consultation for special problems, aid in in-service training, and mechanisms for feedforward. The special materials aspect was discussed previously. Free consultation might be in the areas of debugging computer programs or implementation of the program on a different type of computer. Aid in in-service training covers instruction in use of special materials. The mechanism for feedforward is to inform users of potential problems and minor and major revisions or improvements.

The commitment of the consumer includes four different areas. These are (1) evaluation and feedback, (2) time, (3) manpower, and (4) budget. The evaluation and feedback are very important. The supplier will want to know about any potential problems such as computer programming errors. The supplier will want to be insured of the consumer carrying out a fair evaluation, and he will want to be informed of the results of that evaluation. The commitment of time is closely related to the evaluation. The evaluation must not be done until at least a fair amount of time has been devoted to the trial of the innovation. Also, it would be expected that the consumer would budget a fair amount of manpower to the trial of the innovation to give the innovation a better chance of success. The same argument holds for the budget commitment as for the manpower commitment.

Implementation Procedures

The last category is implementation procedures. It is not as important for the consumer's evaluation of the innovation as it is for the period

between evaluation and trial. Two variables suggested here were a Pert network and a time-sequencing chart. These would depict the tasks necessary to implement the innovation along with a suggested order for carrying out the tasks. Some of those tasks could be in-service training, student orientation, securing the classroom, and securing the financing.

The Questionnaire

After the variables or factors were hypothesized, a sample of one hundred and fifty-four administrators and faculty was chosen. They were chosen from forty-nine states, and their institutions ranged in size from junior colleges to major universities. A questionnaire was then formulated and sent to each. The questionnaire was for a dual purpose. First, it was to gauge the administrators' and faculty members' opinions and attitudes about the hypothesized variables. The second purpose was to allow the administrators and faculty members to add any variables which they felt had been omitted.

The questionnaire contained fifty-two items and a page for comments. It also contained two pages for biographical information, information about Project C-BE, and information about the purpose of the questionnaire. For each of the fifty-two items there was a rating scale of Very Important, Important, or Less Important to be checked. Less Important was used to avoid the negative connotation of Unimportant.

A total of fifty-eight (37.6%) questionnaires was returned. Of those, thirty-seven (63.9%) were returned completed, seven (12.0%) were returned unanswered, seven (12.0%) were returned unopened, five (8.6%) were

returned with missing data, and two (3.4%) were returned too late to be used in the analysis.

The data were then transcribed to computer cards and weighted, with a rating of Very Important having a weight of three, a rating of Important having a weight of two, and a rating of Less Important having a weight of one.

The five questionnaires with missing data were not used in the analysis. The reason was that to give an unanswered question a score of zero was unfair since that would imply that the question was below Less Important. This may have been what the person intended, but on the other hand he or she simply may not have understood the question.

The questionnaire, along with the cover letter is presented in Appendix A. Also included is a listing of each respondent's answers and a percentage distribution of answers for each question.

CHAPTER IV

ANALYSIS, RESULTS, AND CONCLUSIONS

Introduction

Five methods of statistical analysis were used to analyze the data once it had been scored and transcribed to cards. Those were:

1) Hierarchical Cluster Analysis
2) Non-Hierarchical Cluster Analysis
3) Discriminant Analysis
4) A computer program called Testat
5) Analysis by inspection.

The analysis of the data was for determining which factors or variables were foremost in the prospective consumers' minds. The results of the analysis were then used in the design of a data collection form for developers of innovations.

Hierarchical Cluster Analysis

Most hierarchical clustering techniques are "one of three general types" (4). Those three types are:

1) linkage methods
2) centroid methods
3) error sum of squares methods.

This type of hierarchical cluster analysis used in this study was the Ward Sum of Squares Method.

Hierarchical Cluster Analysis is a classification technique which optimizes an objective function. At each stage two clusters are combined. The optimization of the objective function determines which two clusters to combine. Ward's method minimizes the error sum of squares. All hierarchical methods join the two "most similar" clusters at each stage. The only difference is the definition of "most similar." The two "most similar" clusters of Ward's methods will be the two clusters which contribute the least to the total within group error sum of squares.

It is necessary at this point to define several quantities which will be used in the mathematical treatment of our discussion. Bullock defines the following quantities in Section 3.3:

x_{ijk} = score on the i^{th} of n variables for the j^{th} of m_k data units in the k^{th} of h clusters

$$\bar{x}_{ik} = \sum_{j=1}^{M_k} \frac{x_{ijk}}{M_k}$$

= mean on the i^{th} variable for data units in the k^{th} cluster

$$E_k = \sum_{i=1}^{n} \sum_{j=1}^{M_k} (X_{ijk} - \bar{X}_{ik})^2$$

= error sum of squares for cluster k; sum of Euclidean distances from each data point in cluster k to the centroid of ciuster k; within group squared deviation about the mean for cluster k.

$$E = \sum_{k=1}^{n} E_k$$

= total within group error sum of squares for the collection of clusters.

The similarity between two clusters p and q is defined as:

$$\Delta E_{pq} = \frac{M_p M_q}{M_p M_q} \sum_{i=1}^{h} (\bar{X}_{ip} - \bar{X}_{iq})^2$$

The most similar clusters are the two clusters which yield the smallest ΔE. Bullock says "an important characteristic to notice" about this formula is that ΔE_{pq} is proportional to the squared Euclidean distance between the centroids of clusters p and q. This is to be expected since $\bar{x}_{ip}$ and $\bar{x}_{iq}$ are the values of the l^{th} variable of the centroids in clusters p and q respectively, and $\sum_{j=1}^{n} (\bar{X}_{ip}-\bar{X}_{iq})^2$ is the formula for squared Euclidean distance.

Non-Hierarchical Cluster Analysis

Non-Hierarchical Cluster Analysis is another multi-variate classification technique. The four main methods of non-hierarchical cluster analysis are Forgy's method, Jancey's method, MacQueen's k-means method, and Convergent k-means method. The method used was Forgy's method.

Forgy's method allows two alternative types of input. The data may be divided initially into hypothesized clusters or a selection of seedpoints may be input. The method used was the latter. Bullock gives a good treatment of the different methods for choosing seedpoints in Section 4.1.

This method is a two phase method. The first phase consists of assigning each data unit to a cluster with the closest seedpoint. The basis for determining closeness is the squared Euclidean distance of each data unit from the respective seedpoint. Phase two consists of calculating the new centroid for each cluster and then reassigning the data points to new clusters whose seedpoints are the previously calculated centroid. Phase two also keeps track of the number of data units which change each time. The clustering is completed when no data units change clusters.

The main disadvantage of non-hierarchical cluster analysis is the pre-supposition of the number of clusters. Another disadvantage is the necessity for either choosing seedpoints or dividing the data into clusters a priori. One big advantage, however, is that relatively few computations are required, even for large sets of data. Example output of Forgy's method is given in Appendix E.

Discriminant Analysis

Discriminant Analysis, according to Anderson (2), is a multivariate statistical method which yields a "linear function which has the greatest variance between samples relative to the variance within samples."

Cooley and Lohnes (8) say Discriminant Analysis is a "procedure for estimating the position of an individual on a line that best separates classes or groups. The position is determined by a linear function of the score." Multiple discriminant functions are computed as vectors associated with the latent roots of the "determinantal equation"

$$[\, W/T - \lambda I \,] = 0$$

where I is the identity matrix and W is the pooled within groups deviation score cross-products matrix. A is the among-groups cross-products of deviations of group from grand means weighted by group sizes. The matrix A is given by T-W where T is the total sample deviation score cross-products matrix.

The elements of A, W, and T are given by the following:

$$W_{ij} = \sum_{k=1}^{g} \left[\sum_{n=1}^{N_g} (X_{ikn} - \bar{X}_{ik})\,(X_{jkn} - \bar{X}_{jk}) \right]$$

$$T_{ij} = \sum_{n=1}^{n} (X_{in} - \bar{X}_i)'(X_{jn} - \bar{X}_j)$$

$$A_{ij} = \sum_{k=1}^{g} N_g(\bar{X}_{ik} - \bar{X}_i)\,(\bar{X}_{jk} - \bar{X}_j)$$

where g = number of groups

N_g = number of subjects in group g

N = total number of subjects

i and j range from 1 to p, where

p = number of variables.

Assumptions

Several hypotheses about the data were made prior to the analysis of the data. The main hypothesis was that a "perfect" item would be one that had a mean score of 3.0 and a standard deviation of 0. The word item will be used here synonymously with the word variable since each item of the questionnaire dealt with one variable only. Thus a response to an item would be interpreted as a response to a certain variable. This brings up the second hypothesis, which was that an important variable would invoke a "strong" response (i.e., Very Important) regardless of whether the item had a positive or negative connotation regarding the variable. For example, consider the following statements which give opposite connotations:

1) The student has shown a marked increase in retention of knowledge using this new method.

2) The student does not seem to retain knowledge as well with the new method as he did with the old method.

The assumption says that either statement would invoke a "strong" response, and this response would be directly related to retention of knowledge by the student, not to the positive or negative connotation of the statement.

Analysis of the Data

The first method of analysis used was the computer program called Testat. This is one of a set of behavioral science computer programs written by Donald J. Veldman (30). This program Testat calculates the Pearson Correlation Coefficient (27) for each item versus the entire questionnaire, and also the Pearson Correlation Coefficient for each item versus the subgroup in which the item was contained. However, using these two correlation coefficients, it was impossible to determine which items were "good" and which were "bad." Some items with high means and low sigmas had low correlation coefficients also, while others with comparable means and sigmas had high correlation coefficients. The program also calculated means and standard deviations for each item and the percentage distribution of responses to each item. It also calculated a consistency coefficient for each subgroup and for the total questionnaire. The formula for this consistency coefficient is

$$\alpha = \frac{k}{k-1} \left[\frac{\sigma_T^2 - \sum^{h} \sigma_I^2}{\sigma_T^2} \right]$$

where k = number of items in the scale

I = item

T = Total (or Subscale Total)

Cronbach (9) says that the consistency coefficient measures the homogeneity of a questionnaire and that "in a homogenous test, the items measure the same thing." He goes on to say that many feel that alpha is a

conservative estimate or lower bound on the coefficient of precision or reliability coefficient. However, he also says that "it is doubtful if testers have any practical need for a coefficient of precision." This is probably true in our case. The questionnaire was not intended to be homogeneous, for each question was set up to elicit a response on one individual item or variable. It is very likely that a person would have opposite feelings about two different variables such as student retention of knowledge and the textbook required. It seems that this coefficient would be more applicable to a questionnaire which has "correct" and "incorrect" answers such as a test, rather than to a questionnaire set up to measure opinion.

The next method of analysis used was one-dimensional Hierarchical Cluster Analysis. The one variable used was the mean. It seemed that this was the important variable since the sigmas only ranged from 0.43 to 0.88. This is fairly small so that the tendency was to ignore the standard deviation. This was an error which was later realized and corrected. Since there were fifty-two data points, The Hierarchical Cluster Analysis started with fifty-two clusters and merged until it had only one cluster. The next step was to take the merge list and determine the order in which the clusters all merged and, therefore, what data points were in each cluster as they merged. This helped determine the natural breakpoints of the data -- that is, the points at which the data tend to separate into the groups which are most homogeneous. Figure 2 shows the ordered data and the way in which the clusters merged from five clusters down into two clusters. The breakpoints for the five clusters are at points that are fairly easy to recognize since the difference in the mean above the breakpoint

and the mean below the breakpoint is greater than the difference between any two adjacent means in each cluster, excluding the last data point (question 11). The input and output for the Hierarchical Cluster Analysis program are shown in Appendix D.

The next step was to do Non-Hierarchical Cluster Analysis to confirm the results of the Hierarchical Clustering. First, the clustering was done on one variable, the mean, into five clusters, using seedpoints from the five clusters which had been determined by Hierarchical Cluster Analysis. The results were the same and came as no surprise, since the assumption of five clusters had been made and the seedpoints were drawn from those five clusters. Sometimes, Hierarchical Cluster Analysis will yield erroneous results due to a phenomenon known as "linking." Then one-dimensional Non-Hierarchical Analysis into two clusters was done and once again the results were the same. The seedpoints were from the two clusters which Hierarchical Analysis had given. There was a tendency at this point to classify the items in the first cluster as Important and the items in the second cluster as Unimportant since the items in the second cluster had means below 1.90. However, this would have been very incorrect, as will be seen later.

Next, two-dimensional Non-Hierarchical Cluster Analysis on the fifty-two data points was tried using both the mean and the sigma as variables. There was no change in the results in either the five clusters or the two clusters. This tended to reinforce the erroneous hypothesis that the sigma was unimportant. The results should have been expected, however, since the magnitude of

the means was from three to five times as large as that of the sigmas. Table 1 is a list of the questions, their means and their standard deviations.

Discriminant Analysis was used next. The reason for using this technique is that is was reasonable to assume that there were two classes of questions, Important and Unimportant. Discriminant Analysis is a good method of dividing data when there are two distinct classes. Two variables, mean and sigma, were used again. This analysis yielded some rather unusual information. Regardless of the breakpoint chosen for the two classes, the program was able to formulate a discriminant function which divided the data into those two classes with very few, if any, misclassifications. Seeking an explanation, the non-hierarchical clustering results were examined again. The examination of the five clusters revealed that the size of the clusters was almost the same, about ten, and also the total range of the means in each cluster was about the same, which was 0.21. A standard histogram of the number in each class versus the total range of each class (See Figure 3) showed the means to be uniformly distributed. Therefore, arbitrary breakpoints could be chosen anywhere and a discrimination between the two classes could still be made. Example input and output for Discriminant Analysis is given in Appendix F.

At this point it was realized that the tendency to divide the questions into the two classes mentioned previously was not valid based on the information that was available so far. So a more thorough analysis of the data was begun. Once again, a list of the questions, their means and their sigmas, which had been ordered on the means from high to low, was examined. To this list for each item, the percentage distribution of responses was added. This percentage distribution

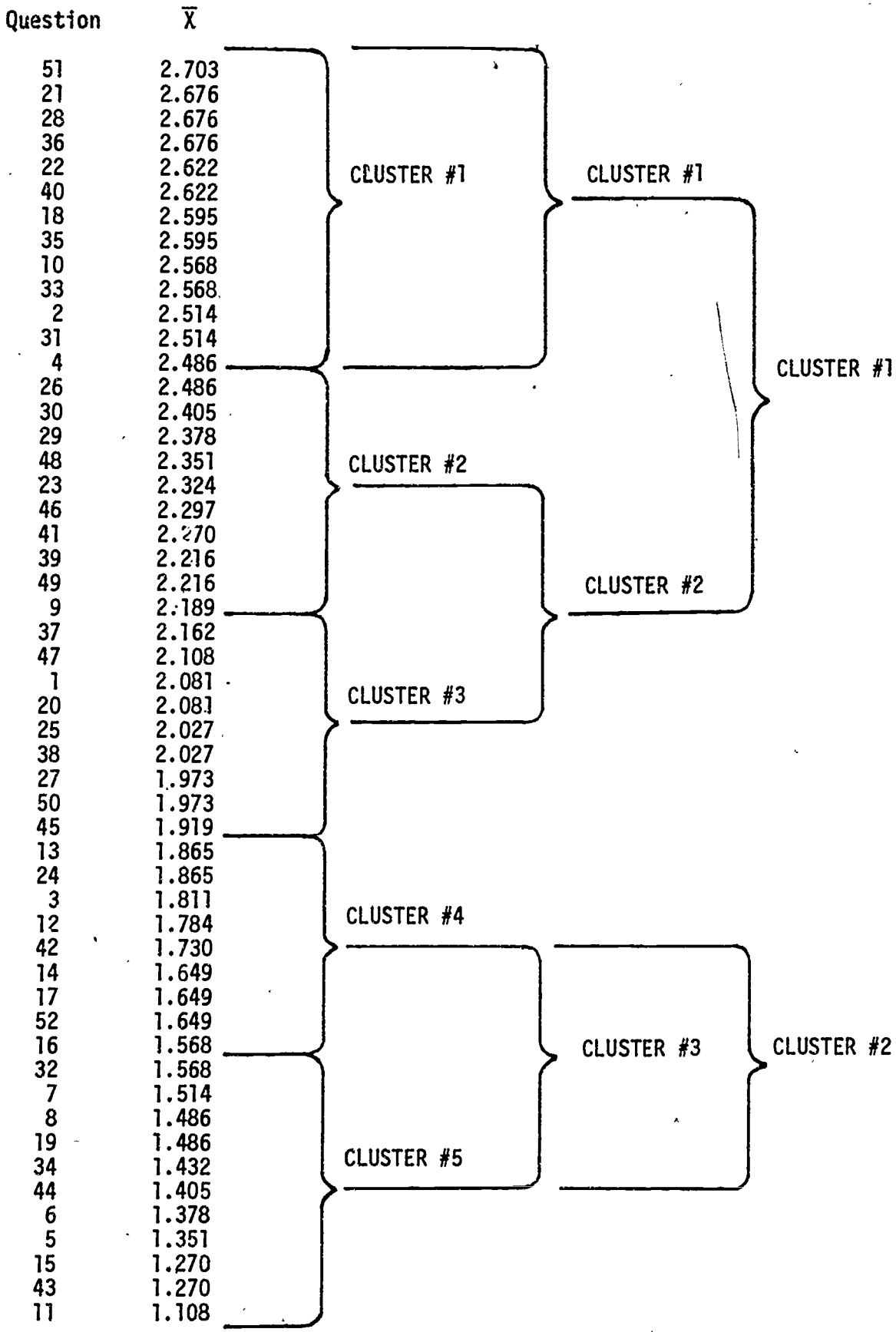


Figure 2. Hierarchical Clusters

QUESTION	$\bar{X}$	σ
51	2.71	.56
21	2.69	.47
18	2.64	.58
36	2.64	.62
22	2.63	.49
28	2.62	.54
10	2.60	.54
40	2.60	.59
35	2.57	.67
31	2.55	.50
33	2.55	.71
2	2.52	.51
4	2.50	.59
26	2.50	.63
30	2.40	.59
48	2.38	.58
23	2.33	.72
29	2.31	.75
41	2.29	.71
46	2.29	.64
49	2.26	.63
39	2.24	.58
9	2.19	.63
1	2.12	.77
37	2.10	.82
47	2.10	.69
20	2.07	.64
38	2.02	.78
27	2.00	.70
25	1.98	.64
45	1.98	.75
50	1.95	.78
13	1.85	.76
24	1.81	.71
3	1.79	.65
12	1.76	.70
42	1.71	.71
14	1.67	.87
52	1.64	.81
17	1.62	.66
16	1.60	.70
32	1.60	.70
7	1.48	.74
8	1.48	.67
19	1.48	.55
34	1.40	.63
44	1.38	.58
5	1.36	.58
6	1.33	.57
43	1.29	.46
15	1.26	.45
11	1.10	.43

Table 1. Questions, Means, Sigmas

was obtained from the previously mentioned Testat Analysis. Table 2 shows this list. Several things were immediately apparent. First, the sigmas, as listed, seemed to be distributed from low to high to low. Secondly, there was a definite correspondence between the sigmas and the percentage distribution trends. At the top of the list, the percentage distribution was skewed very definitely to the right. At the bottom of the list the percentage distribution was skewed very definitely to the left. Finally, in the middle of the list, the percentage distribution approached a uniform distribution which accounted for the larger variances. Therefore, even thought the sigmas were small, they undoubtedly contained some valuable information. The prior feeling that a mean of two or greater indicated a good or important item, was incorrect. For example, an item whose distribution of answers was five for Very Important, twenty-seven for Important, and five for Less Important would have a mean of 2.000 and a sigma of 0.528. Another item whose distribution of answers was twelve for Very Important, thirteen for Important, and twelve for Less Important would have a mean of 2.000 and a sigma of 0.8185. It is easily seen, although the means are equal and the standard deviations differ by only .29 that the first item is a much better indicator than the second item. Thus, it became apparent that some of the items with high variance or "poor" distribution should be lowered on the list.

It was decided to use the percentage distribution numbers as variables also. To give all five variables equal status, the data was normalized (0,1). This was done by computing a mean and a standard deviation for each column. Then using the formula $\frac{\bar{X} - u}{\sigma}$ one comes up with the transformed data of Table 3.

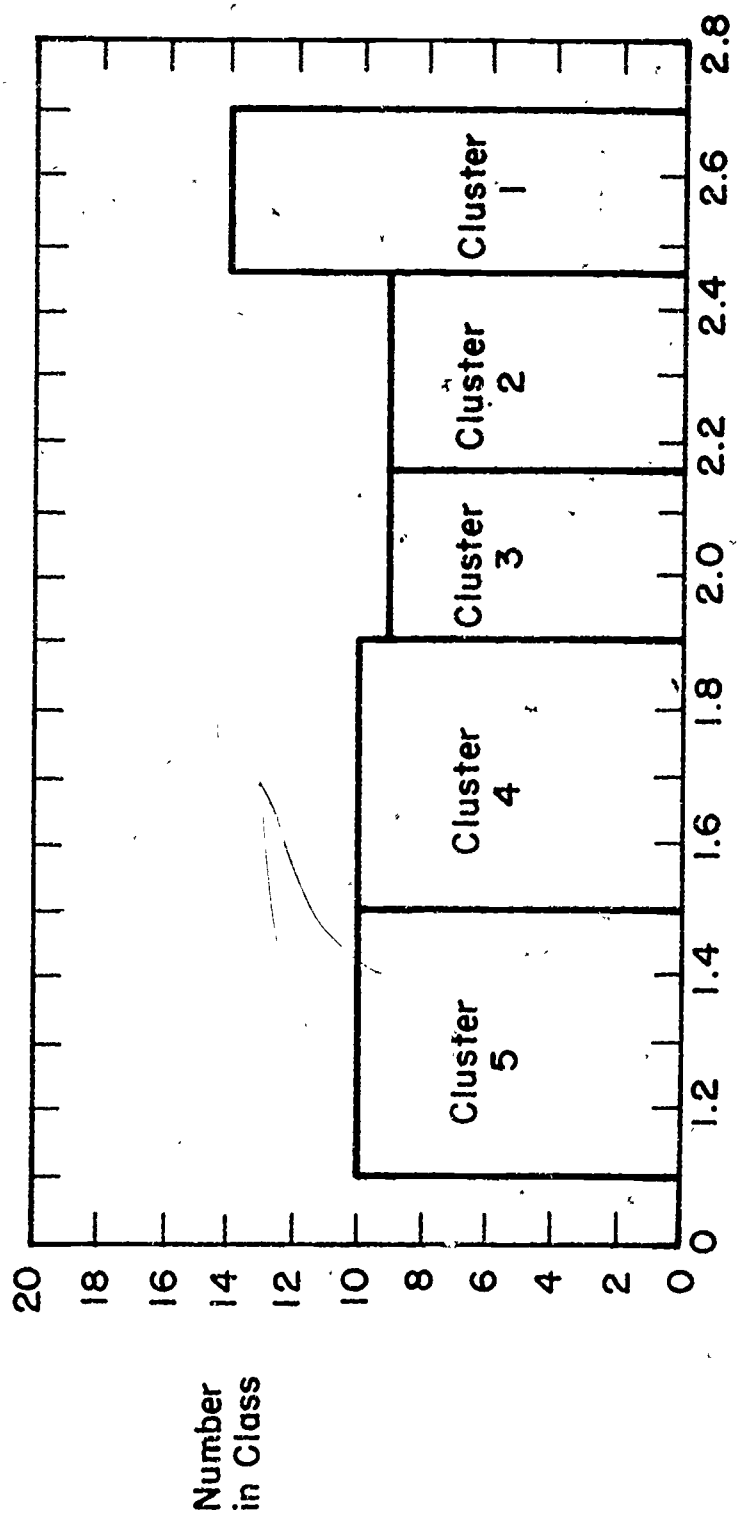


Figure 3. Histogram of Non-Hierarchical Cluster Analysis Results

Question	x	σ	LI	I	VI
51	2.703	.571	5	19	76
21	2.676	.475	0	32	68
28	2.676	.475	0	32	68
36	2.676	.580	5	22	73
22	2.622	.492	0	38	62
40	2.622	.545	3	32	65
18	2.595	.599	5	30	65
35	2.595	.644	8	24	68
10	2.568	.555	3	38	59
33	2.568	.728	14	16	70
2	2.514	.507	0	49	51
31	2.514	.507	0	49	51
4	2.486	.607	5	41	54
26	2.486	.607	5	41	54
30	2.405	.551	3	54	43
29	2.378	.721	14	35	51
48	2.351	.588	5	54	41
23	2.324	.747	16	35	49
46	2.297	.618	8	54	38
41	2.270	.693	14	46	41
39	2.216	.584	8	62	30
49	2.216	.630	11	57	32
9	2.189	.660	14	54	32
37	2.162	.800	24	35	41
47	2.108	.699	19	51	30
1	2.081	.759	24	43	32
20	2.081	.640	16	59	24
25	2.027	.645	19	59	22
38	2.027	.799	30	38	32
27	1.973	.726	27	49	24
50	1.973	.799	32	38	30
45	1.919	.759	32	43	24
13	1.865	.751	35	43	22
24	1.865	.713	32	49	19
3	1.811	.660	32	54	14
12	1.784	.712	38	46	16
42	1.730	.693	41	46	14
14	1.649	.889	62	11	27
17	1.649	.633	43	49	8
52	1.649	.824	57	22	22
16	1.568	.689	54	35	11
32	1.568	.689	54	35	11
7	1.514	.768	65	19	16
8	1.486	.692	62	27	11
19	1.486	.559	54	43	3
34	1.432	.647	65	27	5
44	1.405	.599	65	30	5
6	1.378	.594	68	27	5
5	1.351	.588	70	24	5
15	1.270	.450	73	27	0
43	1.270	.450	73	27	0
11	1.108	.458	95	0	5

Table 2. Data Not Normalized

QUESTION	$\bar{x}$	σ	LI	I	VI
51	1.436	-.673	-.936	-1.395	1.915
21	1.377	-1.586	-1.131	-.435	1.558
18	1.377	-1.586	-1.131	-.435	1.558
36	1.377	-.587	-.936	-1.173	1.781
22	1.260	-1.425	-1.131	.009	1.290
28	1.260	-.920	-1.014	-.435	1.424
10	1.202	-.406	-.936	-.582	1.424
40	1.202	.022	-.819	-1.025	1.558
35	1.143	-.825	-1.014	.009	1.156
31	1.143	.821	-.585	-1.616	1.647
33	1.026	-1.282	-1.131	.821	.799
2	1.026	-1.282	-1.131	.821	.799
4	.965	-.330	-.936	.230	.933
26	.965	-.330	-.936	.230	.933
30	.790	-.863	-1.014	1.190	.441
48	.731	.755	-.585	-.213	.799
23	.672	-.511	-.936	1.190	.352
29	.614	1.002	-.507	-.213	.709
41	.555	-.225	-.819	1.190	.218
46	.497	.488	-.585	.599	.352
49	.379	-.549	-.819	1.781	-.139
39	.379	-.111	-.702	1.412	-.050
9	.321	.174	-.585	1.190	-.050
1	.262	1.507	-.194	-.213	.352
37	.145	.545	-.390	.969	-.139
47	.087	1.116	-.194	.378	-.050
20	.087	-.016	-.507	1.559	-.407
38	-.031	.031	-.390	1.559	-.496
27	-.031	1.497	.040	.009	-.050
25	-.148	.802	-.077	.821	-.407
45	-.148	1.497	.118	.009	-.139
50	-.265	1.116	.118	.378	-.407
13	-.382	1.040	.235	.378	-.496
24	-.382	.679	.118	.821	-.630
3	-.499	.174	.118	1.190	-.854
12	-.558	.669	.352	.599	-.764
42	-.675	.488	.469	.599	-.854
14	-.851	2.354	1.289	-1.985	-.273
52	-.851	-.083	.547	.821	-1.122
17	-.851	1.735	1.094	-1.173	-.496
16	-1.026	.450	.977	-.213	-.988
32	-1.026	.450	.977	-.213	-.988
7	-1.143	1.202	1.406	-1.395	-.764
8	-1.204	.479	1.289	-.804	-.988
19	-1.204	-.787	.977	.378	-1.345
34	-1.321	.051	1.406	-.804	-1.122
44	-1.380	-.406	1.406	-.582	-1.256
5	-1.438	-.454	1.523	-.804	-1.256
6	-1.497	-.511	1.601	-1.025	-1.256
43	-1.673	-1.824	1.718	-.804	-1.479
15	-1.673	-1.824	1.718	-.804	-1.479
11	-2.024	-1.748	2.577	-2.798	-1.256

Table 3. Normalized Data

Using the five variables, Non-Hierarchical Cluster Analysis was applied to the transformed data. Using various seedpoints it consistently returned two clusters of size twenty-eight and twenty-four. Applying the same method to get three clusters, the elimination of three questions from the first cluster was made possible. The three which were eliminated had a fairly high standard deviation. This left two clusters of twenty-five and twenty-seven which were designated as Important and Unimportant. It was felt that there was more justification in this split than in the previous split of groups of thirty-two and twenty. Appendix E contains example input and output for Non-Hierarchical Cluster Analysis.

At this point it was decided to try Discriminant Analysis again, using the transformed data and five variables. The results were the same as before with one exception. Now it was possible to hypothesize a breakpoint at any place in my list, and Discriminant Analysis would provide a discriminant function and zero misclassifications.

Results and Conclusions

After examining the non-transformed data, the questions were ordered in the first cluster, on the basis of the mean, sigma and the percentage distribution, from the most important to the least important. Figure 4 gives this ordered list along with the variables contained in those twenty-five questions. The last twenty-seven questions could be ordered randomly since it would probably be more costly than it was worth to gather data related to those variables.

QUESTION	VARIABLE
21	Student retention of knowledge
28	Faculty costs per semester
51	External computer resource requirements
22	Student/Teacher time in meaningful contact
36	Special computer equipment requirements
40	Budget information
10	Availability of special materials (computer program)
2	Objectives of the course
31	Student morale
18	Student interest
35	Computer resources modification
4	Modification of content and scope of course
26	Instructor satisfaction
30	Faculty morale
33	Addition to faculty
48	Feedback mechanism
46	Commitment of supplier
29	Increased students per class
39	Cost of course
49	Feedforward mechanisms
23	Faculty tedium
41	Special materials
20	Student interest
25	Preparation time for instructor

Figure 4

Important Variables

The first ten questions of the important group, ordered as previously mentioned are the following:

The student seems to retain more knowledge when taught by the new method.

The actual faculty cost per semester would be greater with this new course.

What if the administration is unwilling to consider external computer resources required?

The student/teacher time in meaningful contact seems to be increased by this new method.

Special or additional computer equipment must be acquired to use this course.

There is well documented budget information at my disposal.

Special materials (i.e., computer programs) are readily available.

The objectives and nature of the course can be altered to meet our needs.

Student morale would be greater if we adopted this new course.

The student has greater interest in the subject if it is taught the new way.

There seem to be three main factors in the important group. They are student benefits, costs, and faculty benefits. The student benefits and the costs far outweigh the faculty benefits. The number of important items relating to costs is nine, and the number relating to faculty is five. Two items relate to other areas. Out of the top ten items, five relate to student benefits and five relate to costs. This is not much different from what was expected. The first

question on an administrator's mind is "Will this new method teach better?" The second thought is "How much is this going to cost?" The third question is "What benefits are there for me personally?" It is important to note that all three items are very interrelated and very important. If an innovation is not an improvement as far as student benefits are concerned, an administrator will have a difficult time justifying the additional cost necessary. And, finally, if he does not have faculty support, which comes partially from faculty benefits, the program will most likely be a failure.

Data Collection Form

The data collection form which follows was designed to give the developer of an innovation a form which is both easy to fill out and comprehensive in nature. It contains the important information for a prospective customer of an innovation.

DATA COLLECTION FORM

I. Associate Investigator(s)_____

Office address_____ Phone_____

II. The title of the course is_____

_____

III. The topic of the course is_____

_____

IV. The objectives of the course are:

A._____

B._____

C._____

D._____

V. Please attach a course outline or syllabus to this form.

VI. List all student prerequisites and indicate whether they are suggested or required.

	Suggested	Required
A._____	_____	_____
B._____	_____	_____
C._____	_____	_____
D._____	_____	_____
E._____	_____	_____

List by letter any prerequisites which could be taken care of by a remedial unit.

VII. List all required reference materials.

A. _____

B. _____

C. _____

D. _____

VIII. List all publications which exist in the open literature and describe the course.

A. _____

B. _____

C. _____

D. _____

IX. Indicate which type(s) of teaching methodology are applicable:

	Yes	No
A. Lecture type	____	____
B. Self-paced	____	____
C. In class exam(s)	____	____
D. Take home exam(s)	____	____
E. Discovery modules	____	____
F. Incentive units	____	____
G. Required labs	____	____
H. Optional labs	____	____
I. Review sessions	____	____
J. Student tutorint	____	____
K. Computer	____	____
L. Other (attach explanation)	____	____

X. The following sections dealing with faculty and staff requirements, physical plant requirements, computer resource requirements, special materials requirements, and expenditures are all dependent upon class size. Please give a relative class size to be used as a reference point.

The class size is_____.

XI. Fill in the blanks for faculty and staff requirements relative to the previously estimated class size.

A. The number of faculty needed to run this course is_____.

B. The number of proctors used is _____ and the number of hours per week per proctor is _____.

C. The number of graders necessary is _____, and the number of hours per week per grader is _____.

XII. Fill in the blanks for physical plant requirements relative to the previously mentioned class size.

A. The number of classrooms required is _____.

B. The number of labs required is _____.

C. The number of individual desks required per classroom is _____, and the number of tables per classroom is _____. The number of drawing tables per classroom is _____.

D. Visual aid equipment is required. Yes____ No____

If "yes" please specify. _____

E. Sound equipment is required. Yes____ No____

If "yes" please specify. _____

XIII. Fill in the blanks for computer-resource requirements relative to previously mentioned class size.

A. The number of teletypes required is _____.

B. The number of graphics terminals required is _____.

C. The course requires special plotting equipment. Yes___No___

If "yes" please specify._____

XIII. D. A mark sense reader is used in the course. Yes____No____

E. The average amount of computer "line" time per student is _____ minutes.

XIV. Indicate which special materials, if any, are necessary for this course.

	Yes	No
A. Computer programs The language they are written in is _____.	_____	_____
B. Slide projectors	_____	_____
C. Tape recorders or cassettes	_____	_____
D. Programmed texts	_____	_____
E. Study units	_____	_____

F. List any other special materials and an explanation.

(1)_____

(2)_____

(3)_____

XV. Fill in the amounts on all the expenditure items which (1) pertain to your project and (2) you feel you can estimate fairly. The amounts should be for a one semester breakdown unless otherwise indicated.

_____A. Estimated computer time expenditures

_____B. Faculty costs

_____C. Staff costs (teaching assts., graders, proctors)

_____D. Cost of materials

_____E. Other (explain)

_____F. Total of above items (one semester operating expenses)

XV. _____G. Computer equipment costs

_____H. In-service training costs

_____I. Other equipment costs (explain)

_____J. Printing costs

_____K. Preparation and shipping costs of materials

_____L. Other (explain)

==========

_____M. Total of above (one-time implementation costs)

XVI. Indicate which of the following method(s) of evaluation you use.

_____A. Pre-test/post-test each student before and after each module.

_____B. Post-test each student after each module.

_____C. Analyze classroom examinations for student attainment of behavioral objectives.

_____D. Other (explain)

XVII. Student Benefits - Indicate which of the benefits listed below apply to your course and which can be documented by an evaluation method listed in Section XVI.

_____A. Students learn more material.

_____B. Students retain more knowledge.

_____C. Students learn material better.

_____D. Students spend less time per week in class.

_____E. Students spend less time per week outside class.

_____F. Costs for students are reduced.

XVIII. Teacher Benefits - Give your subjective opinion of which benefits listed below apply to you due to your course.

_____A. Teacher's efficiency is improved.

_____B. Teacher's interest is heightened.

_____C. Teacher's tedium is relieved.

_____D. Teacher's free time is increased.

_____E. Other tangible benefits (explain)

_____F. Other intangible benefits (explain)

XIX. Indicate which of the following tasks need to be completed prior to the class being taught. If possible, indicate the estimated amount of time, in some appropriate unit of measurement, needed to complete the tasks.

	Yes	No	Time
In-service Training	_____	_____	_____
Secure Classroom and/or Labs	_____	_____	_____
Secure Financing	_____	_____	_____
Student Orientation	_____	_____	_____
Listing course in catalogue	_____	_____	_____
Printing of materials	_____	_____	_____
Securing computer equipment	_____	_____	_____
Order reference materials	_____	_____	_____
Securing other special equipment	_____	_____	_____
Hiring staff	_____	_____	_____
Securing student computer numbers	_____	_____	_____
Other(Explain)	_____	_____	_____
Other (Explain)	_____	_____	_____

CHAPTER V

EXTENSIONS AND RECOMMENDATIONS

Introduction

Where can one go from here? What further steps can be taken to further insure that an educational innovation will be accepted? Surely further work can be done in this area because there was virtually a void before this thesis. This is such an important area that research cannot be halted here. The opportunity exists for much more work.

Extensions and Recommendations

The most natural extension of this work would be to make the model a predictive model. This would have to be done after many projects had been accepted or turned down. One way to approach this is a survey of people who accepted projects and rejected projects. The data gathered from this survey could be analyzed by some form of statistical analysis to identify the causes of acceptance or rejection using the same variables of this model. This statistical analysis might further reduce the number of important variables and could yield coefficients for the variables. The main problem is that with twenty-five variables a large number of data points (projects rejected or accepted) would be required to insure validity of the coefficients. Another advantage might be the recognition of the interdependence of the variables. These coefficients and variables, once known, could be used by the supplier of the technological innovation to maximize the model and thus the chance of acceptability.

Another extension would be to try and determine the costs associated with gathering data for each of the variables of the model. In this way a project with a limited budget would know how to best gather data and which data was most profitable. If this extension were included in the extension mentioned previously, a coefficient might be determined for each variable such that if one know the relative value of each variable and the relative cost for obtaining data for that variable, one would know which data contributed the most to the value of the model as a whole.

I recommend that as much work as is feasibly possible be done in this area, as the quality of our education in the future depends upon what we do now. We must not let good innovations be lost because the data necessary for success was not collected. At the same time, we must have a foundation upon which to base our judgment of the merits and shortcomings of an educational innovation.

APPENDIX A

Hypothesized Model

Hypothesized Model

I. Nature of Course

A. Course Objective

B. Course Description

1. Course Content and Scope

2. Teaching Method and Pedagogical Approach

3. Teaching Materials Available

4. Reference Materials

a. In Class Texts

b. Outside References

C. Detailed Course Outline

D. Student Prerequisites

E. History

1. Previous Accomplishments

2. Overall Evaluation

3. Publications

II. Benefits on a Comparative Basis

A. Student Benefits

1. Learning Efficiency

a. Cost to Student per Semester

b. Time Required per Week

(1) In Class

(2) Outside Class

c. Amount of Material Covered

d. Retention of Knowledge

2. Student Interest

a. Relief of Tedium

b. Student Preferences

B. Faculty Benefits

1. Teacher Efficiency

a. Student/Teacher time in meaningful contact

b. Relief of Tedium

c. Instructor Satisfaction and Rewards

2. Increase Time out of Classroom

a. For Enrichment of Materials

b. For Enrichment of Teaching

c. For Course Development

C. Institutional Benefits

1. Institution Efficiency

a. Cost to Institution

(1) Faculty Costs per Semester

(2) Materials Costs per Semester

(3) Computer Costs per Semester

(4) Total Cost of Implementation

2. Faculty Morale

3. Student Morale

III. Resource Requirements

A. Faculty

B. Computer

1. Type

2. Time

3. Capability

C. Physical Plant

D. Budget

E. Materials for Teaching

IV. Commitment

A. Supplier of Course

1. Materials Available

2. Consultation Available

3. Aid in In-Service Training

4. Mechanisms for Feedback

5. Mechanisms for Feedforward

B. Institution Commitment

1. Manpower

2. Money

3. Time

C. Faculty Commitment

V. Implementation Procedures

A. Pert Chart Plan for Change

B. Time-sequencing Chart for Tasks

Appendix B

Questionnaire

THE UNIVERSITY OF TEXAS AT AUSTIN
Project C-BE
Computer-Based Science and Engineering Education
413 Engineering Laboratory Building
AUSTIN, TEXAS 78712

DIRECTORS:
Dr. John J. Allan III
Dr. J. J. Lagowski

Dear Sirs:

I should like to introduce Project C-BE, a computer-based education project sponsored by NSF, at the University of Texas at Austin. This is a project for developing new computer aided curricula and computer-based supports for existing curricula. The enclosed literature provides additional information on Project C-BE.

Various manifestations of computing are used to enhance both the teachers' ability to teach and the students' ability to learn. At present, a wide variety of courses in the Colleges of Engineering, Natural Sciences, Social and Behavioral Sciences and Humanities at The University of Texas are supplemented, on the undergraduate level, by using computer-based methods.

We are presently engaged in research regarding the inter-university and inter-college transferability and implementation of these innovative teaching techniques. Our purpose in conducting this research project is to determine (1) what information is essential for transferability and implementation of newly developed courses, and (2) what information is required by users in other institutions to assure success in the transfer and utilization processes.

Therefore, we are asking you or your designated representative to fill out the attached questionnaire, and to return it by June 15, 1973, to assist us in our research.

A copy of the final report will be furnished to you if you will check the box at the right of your name on the questionnaire. Thank you for assistance in this matter; we will look forward to an early and favorable reply.

If you have any questions, please call me at (512) 471-3061, or my secretary Charlotte Pollard at (512) 471-4191.

Sincerely,

Randy Whitehead

Randy Whitehead

RW:jl

PROJECT C-BE

Project C-BE is a four-year project with a $1.3 million NSF budget which began in January, 1972. The effort is also receiving sizeable contributions from The University of Texas at Austin. The goal is to study the effects of computer-based instruction at a typical large university.

Under the co-direction of Dr. John J. Allan, Associate Professor of Mechanical Engineering, and Dr. J. J. Lagowski, Professor of Chemistry, the Project is the first coordinated, massive assault using computer-based techniques ever attempted at one university. Professors in many fields, including such areas as various fields of engineering, chemistry, psychology, mathematics, physics, zoology, economics, home economics, architecture, and biology are participating in the experiment. In addition to the approximately three dozen professors, 48 teaching assistants and 3,000 students in the five colleges will participate between January, 1972, and January, 1976.

Today, the typical professor is being swamped by ever-increasing numbers of students, and yet the students are very much in need of individualized instruction. With the use of the computer as a supplement to course material, the teacher can give the students much more individualized instruction, because he will have more time to actually interact with the students. Computer-based instructional techniques will assist the instructor in teaching large classes material which is more and more sophisticated. The computer is being used in both lecture and laboratory situations.

In order to make the above changes a reality, Project C-BE must accomplish four goals which the National Science Foundation has set. First, the Project must identify common concepts that apply to many areas of computer-based education. Second, methods of evaluating the economic and teaching effectiveness of using the computer as a basis for higher education also must be developed. Third, an administrator considering initiating computer-based techniques in his institution must know the pedagogical and financial investment his school would have to make. And, the fourth goal is to point out what must be present before computer-based materials can be transferred easily from one institution to another.

GOALS OF THE PROJECT

Listed below are the four (4) objectives of our research as NSF views the effort.

I. IDENTIFY COMPUTER-BASED CONCEPTS THAT ARE COMMON AMONG DISCIPLINES

With reference to reactive terminals, computer graphics, laboratory data acquisition, large-scale quizzing, and large-audience interactive lecture supplements--identify what concepts are common among the several disciplines.

II. DEVELOP EVALUATION PROCEDURES FOR THIS TYPE EFFORT

Develop procedures for evaluating the pedagogical and economic effectiveness and potential of computer-based techniques at the module, course, department, college, university, and national levels.

III. IDENTIFY THE ELEMENTS OF TRANSFERABILITY

Identify the elements that are critical to transferring successful educational packages and techniques from one institution to another.

IV. DEVELOP AN IMPLEMENTATION MODEL

Develop an implementation model so that administrators of institutions potentially using these techniques may view these techniques from the standpoints of investment, operating expense, comparative effectiveness, lead time, required attitude, etc.

BIOGRAPHICAL DATA

Copy of Report Yes No

1. Name _____

2. Position _____

3. Institution _____

4. Teaching Experience _____ years

5. Does your institution have computing facilities or access to computing facilities?

YES _____ NO _____

If yes, please briefly describe the facilities and/or arrangements for use.

BIOGRAPHICAL DATA (Continued)

6. If the answer to #5 is no, do you anticipate the acquisition of facilities in the next 2 years?

YES _____ NO _____

If not, the remainder of this questionnaire doesn't actually apply to your institution, but we appreciate your cooperation and request that you return the questionnaire as is.

7. Does your computing system have time-sharing capabilities? _____

If not, could time-sharing capabilities be added to your present system? _____

8. Does your institution or department use any courses utilizing the computer as a teaching aid, such as CAI (computer aided instruction)?

_____

If so, please briefly describe each course and use of the computer.

QUESTIONNAIRE

Assume that you have been given all of the information necessary to judge the merit of one of our computer-aided courses. Then, one at a time, assume the following statements are your conclusions, and rank them according to whether they would be (1) very important, (2) important, or (3) less important, in your consideration of transferring this project to your institution.

1. The objectives of the new course coincide with the objectives of a current course.

2. The objectives and nature of the course can be altered to meet our needs.

3. The content and scope coincides with a present course.

4. The content and scope can be modified to meet our needs.

5. The teaching method is similar to our methods.

6. The pedagogical strategy is markedly different from ours.

7. This innovation is a complete and self-contained course.

8. This innovation is only of a supportive nature.

9. This supportive innovation may be modified to support one of our present courses.

10. Special materials (i.e., computer programs) are readily available.

11. The text required is not the one used now.

12. The outside references are not available in our library and must be specially purchased.

13. The student prerequisites are fairly rigid.

14. Adoption of this new course will cause some other courses to be eliminated due to duplication.

QUESTIONNAIRE (Continued)

15. Another school(s) is already implementing the same course.

16. The time per week required of each student in class is less.

17. The time required per week by each student outside class is more.

18. The student has greater interest in the subject if it is taught the new way.

19. Not all students will like the new method.

20. More students like the new course than the old course.

21. The student seems to retain more knowledge when taught by the new method.

22. The student/teacher time in meaningful contact seems to be increased by this new method.

23. This new method seems to relieve faculty tedium.

24. The time required per week of each teacher for in-class teaching is less.

25. The outside preparation time per week for a teacher is more.

26. The instructor satisfaction while using this new method seems to be heightened.

27. The instructor rewards are intangible, and I might have a hard time locating an instructor interested in teaching the course.

28. The actual faculty costs per semester would be greater with this new course.

29. With the new method we will be able to teach more students per semester per section.

30. Faculty morale would be greater if we adopted this course.

31. Student morale would be greater if we adopted this new course.

32. This type of course will give added prestige to our department (college).

33. The adoption of this new course would necessitate the hiring of additional faculty members.

QUESTIONNAIRE (Continued)

34. The course could be taught by a graduate student instead of a faculty member.

35. Our computer(s) would require modification to handle this type of teaching aide.

36. Special or additional computer equipment must be acquired to use this course.

37. This new course would require additional classroom space.

38. A special classroom would have to be set aside for laboratory use.

39. The additonal cost involved does not justify one course, but we could split the cost by adopting three or four new, similar courses.

40. There is well documented budget information at my disposal.

41. All materials necessary are available for no royalty.

42. This course will have to be taught at least two semesters to get a fair evaluation.

43. All the faculty may not favor adoption.

44. A small amount of time is required for student orientatation to the course.

45. The teacher of this class must be given relief time to orient himself with the new method.

46. The C-BE and the University of Texas people are willing to provide consultation on special problems.

47. The C-BE and the University of Texas people actually provide aid in in-service training of our faculty regarding this new method.

48. There are well-established mechanisms for feedback in the event that we have problems.

49. There are well-established mechanisms for feedforward to inform us of future modifications and improvements.

QUESTIONNAIRE (Continued)

50. What if the administration's attitude is poor toward the use of student proctors, which the new course requires?

51. What if the administration is unwilling to consider external computer resources required?

52. What if the administration is tied to traditional methods of teaching, and is not very open to innovative ideas such as this?

53. Comments:

APPENDIX C

Data From Questionnaire

Questionnaire	Data
NUMBER 1	3329111122122411223223222223422221133112322224211222322
NUMBER 2	2323111233131311132232213223333131331322321132222311
NUMBER 3	2323111123111311131323321333333331333333111112233231
NUMBER 4	3222221122214111222122221221212212222222211222222122
NUMBER 5	3224112123124312223223311232212312133121223212333233
NUMBER 6	2323122223131322232233322333133231332223322223333333
NUMBER 9	2323111133311211323233333333331312221233111122222231
NUMBER 10	1212223142313232133322322322313233223222212333222332
NUMBER 11	3313113133312332223223211211332721313333333321332333333
NUMBER 12	2313121133312312113133331233333333333113331112333331121
NUMBER 13	2323331123122211132332111123172133222223222222233332
NUMBER 14	2323111112111111113113311133222211123333232211111111221
NUMBER 16	3222111313122121121132221223333232233333321233333122
NUMBER 17	1212111233112222323233333132333213123212333212222211131
NUMBER 18	2212113123121111121233222213322131333333111212222131
NUMBER 19	1212221122212321222122322313312232333333211122222333
NUMBER 20	2223212233312113323223333332322213222412222112233323 1
NUMBER 23	2222221122131112222223322322332224222232221222222333
NUMBER 24	1313211132131112211233332133232113333223221133233131
NUMBER 25	2323111122211211223133333231312323133221231123222223 3
NUMBER 26	2323111122712231113123332222322213233112312121222121
NUMBER 27	2322111112111112121133321212222111111122221113222111
NUMBER 28	3232111111311312123233332333233322233322231112333231
NUMBER 29	2323112222312231131222221222322721313332322211122122231
NUMBER 30	2223112122211212213222232231223321112212222112122231
NUMBER 31	3222113333311231223113333332333333333333322111332121 31
NUMBER 32	1212111112312111111211222221333331313332232122121222221
NUMBER 33	3333111132111111131222212222322213222112331211222222331
NUMBER 34	3232111123131111113233332223333131333333333133333333332
NUMBER 35	1313223333311311133133233323333231333213211113331131
NUMBER 36	3232133222123113231233333333331313333333213233333132
NUMBER 37	3331321233322311121223112223322232332221111112222221
NUMBER 38	1212111123122111222233322322222231331123331133332333
NUMBER 39	1313111223112111231233211312322121313133331131233131
NUMBER 40	2323222231112112222222222222222121222222221122222232
NUMBER 41	1213111112121311131222212222222231331223111212121231
NUMBER 42	3221222222212222211211221223233233332333323311222122333

APPENDIX D

Output for Hierarchical Cluster Analysis

TIME IS NOW 4.657 SECONDS

QUESTIONNAIRE ANALYSIS

NE = 52
NV = 1
NTSV =
NTIA = 1
KOUT = 2

REQUIRED STORAGE = 2080 WORDS

ALLOTTED STORAGE = 6500 WORDS

FORMAT(20X,F4.2)

MINIMUM INCREASE IN WITHIN GROUP SUM OF SQUARES

WARD CRITERION.

QUESTIONNAIRE ANALYSIS

THIS RUN DEPICTS THE PORTION OF THE TREE GENERATED BETWEEN STAGE 1 AND STAGE 51 OF THE CLUSTERING.

THE CRITERION VALUES ARE SEGMENTED INTO THE FOLLOWING CLASSES.

CLASS	LOWER BOUND	UPPER BOUND
1	.	4.413449230E-01
2	4.413449230E-01	8.826898460E-01
3	8.826898460E-01	1.324034777E+00
4	1.324034777E+00	1.765379694E+00
5	1.765379694E+00	2.206724602E+00
6	2.206724602E+00	2.648069554E+00
7	2.648069554E+00	3.089414466E+00
8	3.089414466E+00	3.530759377E+00
9	3.530759377E+00	3.972104331E+00
10	3.972104331E+00	4.413449230E+00
11	4.413449230E+00	4.854794215E+00
12	4.854794215E+00	5.296139077E+00
13	5.296139077E+00	5.737484000E+00
14	5.737484000E+00	6.178828892E+00
15	6.178828892E+00	6.620173845E+00
16	6.620173845E+00	7.061518777E+00
17	7.061518777E+00	7.502863684E+00
18	7.502863684E+00	7.944208692E+00
19	7.944208692E+00	8.385553554E+00
20	8.385553554E+00	8.826898460E+00
21	8.826898460E+00	9.268243384E+00
22	9.268243384E+00	9.709588315E+00
23	9.709588315E+00	1.015093332E+01
24	1.015093332E+01	1.059227842E+01
25	1.059227842E+01	1.103362331E+01

QUESTIONNAIRE ANALYSIS

MERGE SEQUENCE

CLUSTERS 43 AND 45 MERGED AT STEP 1 AND RENAMED CLUSTER 43 LEAVING 51 CLUSTERS , CRITERION = 0. , PLOT LEVEL = 1
CLUSTERS 41 AND 42 MERGED AT STEP 2 AND RENAMED CLUSTER 41 LEAVING 50 CLUSTERS , CRITERION = 0. , PLOT LEVEL = 1
CLUSTERS 30 AND 31 MERGED AT STEP 3 AND RENAMED CLUSTER 30 LEAVING 49 CLUSTERS , CRITERION = 0. , PLOT LEVEL = 1
CLUSTERS 25 AND 26 MERGED AT STEP 4 AND RENAMED CLUSTER 25 LEAVING 48 CLUSTERS , CRITERION = 0. , PLOT LEVEL = 1
CLUSTERS 19 AND 20 MERGED AT STEP 5 AND RENAMED CLUSTER 19 LEAVING 47 CLUSTERS , CRITERION = 0. , PLOT LEVEL = 1
CLUSTERS 13 AND 14 MERGED AT STEP 6 AND RENAMED CLUSTER 13 LEAVING 46 CLUSTERS , CRITERION = 0. , PLOT LEVEL = 1
CLUSTERS 10 AND 11 MERGED AT STEP 7 AND RENAMED CLUSTER 10 LEAVING 45 CLUSTERS , CRITERION = 0. , PLOT LEVEL = 1
CLUSTERS 7 AND 8 MERGED AT STEP 8 AND RENAMED CLUSTER 7 LEAVING 44 CLUSTERS , CRITERION = 0. , PLOT LEVEL = 1
CLUSTERS 3 AND 4 MERGED AT STEP 9 AND RENAMED CLUSTER 3 LEAVING 43 CLUSTERS , CRITERION = 0. , PLOT LEVEL = 1
CLUSTERS 43 AND 44 MERGED AT STEP 10 AND RENAMED CLUSTER 43 LEAVING 42 CLUSTERS , CRITERION = 5.684342E-14, PLOT LEVEL = 1
CLUSTERS 5 AND 6 MERGED AT STEP 11 AND RENAMED CLUSTER 5 LEAVING 41 CLUSTERS , CRITERION = 5.000000E-05, PLOT LEVEL = 1
CLUSTERS 21 AND 22 MERGED AT STEP 12 AND RENAMED CLUSTER 21 LEAVING 40 CLUSTERS , CRITERION = 2.500000E-04, PLOT LEVEL = 1
CLUSTERS 46 AND 47 MERGED AT STEP 13 AND RENAMED CLUSTER 46 LEAVING 39 CLUSTERS , CRITERION = 4.500000E-04, PLOT LEVEL = 1
CLUSTERS 39 AND 40 MERGED AT STEP 14 AND RENAMED CLUSTER 39 LEAVING 38 CLUSTERS , CRITERION = 6.500000E-04, PLOT LEVEL = 1
CLUSTERS 17 AND 18 MERGED AT STEP 15 AND RENAMED CLUSTER 17 LEAVING 37 CLUSTERS , CRITERION = 8.500000E-04, PLOT LEVEL = 1
CLUSTERS 15 AND 16 MERGED AT STEP 16 AND RENAMED CLUSTER 15 LEAVING 36 CLUSTERS , CRITERION = 1.050000E-03, PLOT LEVEL = 1
CLUSTERS 1 AND 2 MERGED AT STEP 17 AND RENAMED CLUSTER 1 LEAVING 35 CLUSTERS , CRITERION = 1.250000E-03, PLOT LEVEL = 1
CLUSTERS 34 AND 35 MERGED AT STEP 18 AND RENAMED CLUSTER 34 LEAVING 34 CLUSTERS , CRITERION = 1.450000E-03, PLOT LEVEL = 1
CLUSTERS 28 AND 29 MERGED AT STEP 19 AND RENAMED CLUSTER 28 LEAVING 33 CLUSTERS , CRITERION = 1.650000E-03, PLOT LEVEL = 1
CLUSTERS 3 AND 5 MERGED AT STEP 20 AND RENAMED CLUSTER 3 LEAVING 32 CLUSTERS , CRITERION = 1.875000E-03, PLOT LEVEL = 1
CLUSTERS 9 AND 10 MERGED AT STEP 21 AND RENAMED CLUSTER 9 LEAVING 31 CLUSTERS , CRITERION = 2.141667E-03, PLOT LEVEL = 1
CLUSTERS 24 AND 25 MERGED AT STEP 22 AND RENAMED CLUSTER 24 LEAVING 30 CLUSTERS , CRITERION = 2.408333E-03, PLOT LEVEL = 1
CLUSTERS 12 AND 13 MERGED AT STEP 23 AND RENAMED CLUSTER 12 LEAVING 29 CLUSTERS , CRITERION = 2.675000E-03, PLOT LEVEL = 1
CLUSTERS 50 AND 51 MERGED AT STEP 24 AND RENAMED CLUSTER 50 LEAVING 28 CLUSTERS , CRITERION = 3.125000E-03, PLOT LEVEL = 1
CLUSTERS 48 AND 49 MERGED AT STEP 25 AND RENAMED CLUSTER 48 LEAVING 27 CLUSTERS , CRITERION = 3.575000E-03, PLOT LEVEL = 1
CLUSTERS 30 AND 32 MERGED AT STEP 26 AND RENAMED CLUSTER 30 LEAVING 26 CLUSTERS , CRITERION = 4.175000E-03, PLOT LEVEL = 1
CLUSTERS 37 AND 38 MERGED AT STEP 27 AND RENAMED CLUSTER 37 LEAVING 25 CLUSTERS , CRITERION = 4.975000E-03, PLOT LEVEL = 1
CLUSTERS 39 AND 41 MERGED AT STEP 28 AND RENAMED CLUSTER 39 LEAVING 24 CLUSTERS , CRITERION = 5.875000E-03, PLOT LEVEL = 1
CLUSTERS 17 AND 19 MERGED AT STEP 29 AND RENAMED CLUSTER 17 LEAVING 23 CLUSTERS , CRITERION = 6.775000E-03, PLOT LEVEL = 1

CLUSTERS 24 AND 27 MERGED AT STEP 30 AND RENAMED CLUSTER 24 LEAVING 22 CLUSTERS , CRITERION = 7.783333E-03, PLOT LEVEL = 1

CLUSTERS 34 AND 36 MERGED AT STEP 31 AND RENAMED CLUSTER 34 LEAVING 21 CLUSTERS , CRITERION = 8.850000E-03, PLOT LEVEL = 1

CLUSTERS 3 AND 7 MERGED AT STEP 32 AND RENAMED CLUSTER 3 LEAVING 20 CLUSTERS , CRITERION = 1.025833E-02, PLOT LEVEL = 1

CLUSTERS 28 AND 30 MERGED AT STEP 33 AND RENAMED CLUSTER 28 LEAVING 19 CLUSTERS , CRITERION = 1.217833E-02, PLOT LEVEL = 1

CLUSTERS 46 AND 48 MERGED AT STEP 34 AND RENAMED CLUSTER 46 LEAVING 18 CLUSTERS , CRITERION = 1.420333E-02, PLOT LEVEL = 1

CLUSTERS 21 AND 23 MERGED AT STEP 35 AND RENAMED CLUSTER 21 LEAVING 17 CLUSTERS , CRITERION = 1.660333E-02, PLOT LEVEL = 1

CLUSTERS 33 AND 34 MERGED AT STEP 36 AND RENAMED CLUSTER 33 LEAVING 16 CLUSTERS , CRITERION = 1.961167E-02, PLOT LEVEL = 1

CLUSTERS 9 AND 12 MERGED AT STEP 37 AND RENAMED CLUSTER 9 LEAVING 15 CLUSTERS , CRITERION = 2.336167E-02, PLOT LEVEL = 1

CLUSTERS 37 AND 39 MERGED AT STEP 38 AND RENAMED CLUSTER 37 LEAVING 14 CLUSTERS , CRITERION = 3.086167E-02, PLOT LEVEL = 1

CLUSTERS 1 AND 3 MERGED AT STEP 39 AND RENAMED CLUSTER 1 LEAVING 13 CLUSTERS , CRITERION = 4.006583E-02, PLOT LEVEL = 1

CLUSTERS 15 AND 17 MERGED AT STEP 40 AND RENAMED CLUSTER 15 LEAVING 12 CLUSTERS , CRITERION = 4.969917E-02, PLOT LEVEL = 1

CLUSTERS 46 AND 50 MERGED AT STEP 41 AND RENAMED CLUSTER 46 LEAVING 11 CLUSTERS , CRITERION = 6.110750E-02, PLOT LEVEL = 1

CLUSTERS 15 AND 21 MERGED AT STEP 42 AND RENAMED CLUSTER 15 LEAVING 10 CLUSTERS , CRITERION = 8.246306E-02, PLOT LEVEL = 1

CLUSTERS 24 AND 28 MERGED AT STEP 43 AND RENAMED CLUSTER 24 LEAVING 9 CLUSTERS , CRITERION = 1.100903E-01, PLOT LEVEL = 1

CLUSTERS 43 AND 46 MERGED AT STEP 44 AND RENAMED CLUSTER 43 LEAVING 8 CLUSTERS , CRITERION = 1.511792E-01, PLOT LEVEL = 1

CLUSTERS 1 AND 9 MERGED AT STEP 45 AND RENAMED CLUSTER 1 LEAVING 7 CLUSTERS , CRITERION = 1.923512E-01, PLOT LEVEL = 1

CLUSTERS 33 AND 37 MERGED AT STEP 46 AND RENAMED CLUSTER 33 LEAVING 6 CLUSTERS , CRITERION = 2.557262E-01, PLOT LEVEL = 1

CLUSTERS 43 AND 52 MERGED AT STEP 47 AND RENAMED CLUSTER 43 LEAVING 5 CLUSTERS , CRITERION = 3.285440E-01, PLOT LEVEL = 1

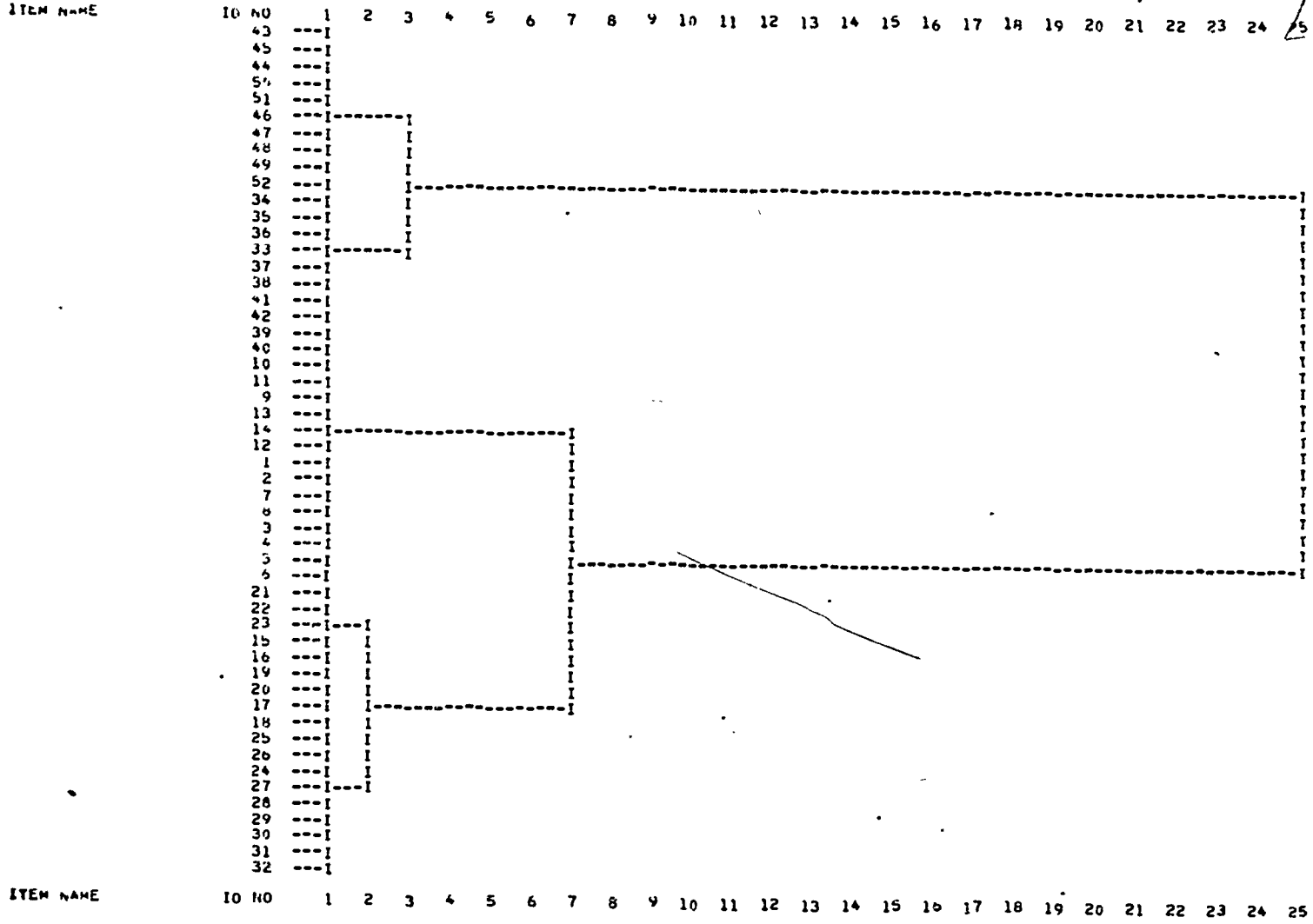
CLUSTERS 15 AND 24 MERGED AT STEP 48 AND RENAMED CLUSTER 15 LEAVING 4 CLUSTERS , CRITERION = 6.405940E-01, PLOT LEVEL = 2

CLUSTERS 33 AND 43 MERGED AT STEP 49 AND RENAMED CLUSTER 33 LEAVING 3 CLUSTERS , CRITERION = 1.249599E+00, PLOT LEVEL = 3

CLUSTERS 1 AND 15 MERGED AT STEP 50 AND RENAMED CLUSTER 1 LEAVING 2 CLUSTERS , CRITERION = 2.685867E+00, PLOT LEVEL = 7

CLUSTERS 1 AND 33 MERGED AT STEP 51 AND RENAMED CLUSTER 1 LEAVING 1 CLUSTERS , CRITERION = 1.103362E+01, PLOT LEVEL = 25

QUESTIONNAIRE ANALYSIS



APPENDIX E

Output for Non-Hierarchical Cluster Analysis*

```
 TRANSFORMED DATA - 2 CLUSTERS

NE =       52
NV =        5
NC =        2
NTIN =
NTOUT =     7
MINREL =
IPART =     1
METHOD =   -0

REQUIRED STORAGE =  116 WORDS

ALLOTTED STORAGE = 5000 WORDS

   FORGY METHOD OF CLUSTER ANALYSIS.  DATA SET STORED ON TAPE



 IPART = 1,  NUMBR ARRAY READ AS FOLLOWS


      5     29

   52 DATA UNITS MOVED ON ITERATION NUMBER  1
SUMMED DEVIATIONS ABOUT SEED POINTS =  9.40005011E+01

    5 DATA UNITS MOVED ON ITERATION NUMBER  2
SUMMED DEVIATIONS ABOUT SEED POINTS =  7.93132595E+01

    1 DATA UNITS MOVED ON ITERATION NUMBER  3
SUMMED DEVIATIONS ABOUT SEED POINTS =  7.78945193E+01

    1 DATA UNITS MOVED ON ITERATION NUMBER  4
SUMMED DEVIATIONS ABOUT SEED POINTS =  7.78590574E+01

    1 DATA UNITS MOVED ON ITERATION NUMBER  5
SUMMED DEVIATIONS ABOUT SEED POINTS =  7.78112874E+01

    1 DATA UNITS MOVED ON ITERATION NUMBER  6
SUMMED DEVIATIONS ABOUT SEED POINTS =  7.77914993E+01

    1 DATA UNITS MOVED ON ITERATION NUMBER  7
SUMMED DEVIATIONS ABOUT SEED POINTS =  7.78771238E+01

    1 DATA UNITS MOVED ON ITERATION NUMBER  8
SUMMED DEVIATIONS ABOUT SEED POINTS =  7.78825915E+01

    0 DATA UNITS MOVED ON ITERATION NUMBER  9
SUMMED DEVIATIONS ABOUT SEED POINTS =  7.79748028E+01
```

TRANSFORMED DATA - 2 CLUSTERS

RAW MEMBERSHIP LIST

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
2 2

CLUSTER SIZES

28 24

TRANSFORMED DATA - 2 CLUSTERS

CLUSTER 1 CONTAINS 28 DATA UNITS

CENTROID COORDINATES

7.9454E-01 -2.5154E-01 -7.8550E-01 2.6436E-01 7.3811E-01

MEMBERSHIP LIST

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

CLUSTER 2 CONTAINS 24 DATA UNITS

CENTROID COORDINATES

-9.2708E-01 2.9358E-01 9.1650E-01 -3.0838E-01 -8.6121E-01

MEMBERSHIP LIST

29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52

APPENDIX F

Output for Discriminant Analysis

KEY = PROB NO. = 1 VARIABLES = 5 SAMPLE(1) = 28 SAMPLE(2) = 24 TAPE = 1 SELECTS = 0

PROBLEM NO. 1
NUMBER OF VARIABLES 5

VARIABLE MEANS BY GROUP AND DIFFERENCE IN MEANS

VARIABLE	MEAN 1	MEAN 2	DIFFERENCE	T STATISTIC
1	.79454	-.92708	1.72162	12.12113
2	-.65164	.29358	-.94523	-1.97616
3	-.78550	.91050	-1.70200	-11.10355
4	.60436	-.30438	.57273	2.12474
5	.73811	-.86121	1.59932	9.96910

SUM OF PRODUCTS OF DEV. FROM MEANS

INVERSE OF SUM OF PRODUCTS OF DEV. FROM MEANS

DISCRIMINANT FUNCTION COEFFICIENTS

1.18625 -.02395 -.21988 -.40000 -1.18977

DIFFERENCE OF MEANS TIMES DISCRIMINANT FUNCTION COEFFICIENTS

1 2.04227 2 .01306 3 .35892 4 -.22909 5 -1.90282

MAHALANOBIS USQUARE= 14.11679
PHI= 3.64865

F(5, 46)= 33.56756

POP. NO.	SAMPLE SIZE	MEAN Z	VARIANCE Z	STD. DEV. Z
1	28	.13027	.00561	.07488
2	24	-.15207	.00569	.07546

RANK	FIRST GROUP VALUES	SECOND GROUP VALUES	FIRST GROUP ITEM NO.	SECOND GROUP ITEM NO.
1	.23029		A1 2	
2	.23129		A1 3	
3	.22891		A1 5	
4	.21950		A1 9	
5	.21031		A1 6	
6	.20728		A111	
7	.20728		A112	
8	.19655		A1 1	
9	.19513		A1 4	
10	.17155		A1 7	
11	.17095		A115	
12	.15439		A1 8	
13	.14796		A113	
14	.14796		A114	
15	.14643		A110	
16	.11198		A117	
17	.10701		A116	
18	.10110		A119	
19	.09497		A122	
20	.08843		A121	
21	.08347		A123	
22	.07114		A127	
23	.05293		A118	
24	.04284		A120	
25	.04568		A126	
26	.01897		A125	
27	.01125		A128	
28	-.01798		A124	
29		-.02270		A2 2
30		-.02917		A2 1
31		-.03293		A2 4
32		-.07314		A2 6
33		-.07452		A2 3
34		-.08093		A2 7
35		-.08280		A2 8
36		-.08869		A2 5
37		-.11034		A211
38		-.13485		A2 9
39		-.16039		A217
40		-.17321		A213
41		-.17321		A214
42		-.19665		A219
43		-.19685		A221
44		-.20017		A220
45		-.20423		A218
46		-.21418		A215
47		-.21745		A216
48		-.21689		A210
49		-.22193		A222
50		-.22193		A223
51		-.22243		A212
52		-.28899		A224

APPENDIX G

Output for Testat

QUESTIONNAIRE ANALYSIS BY TESTAT

PARAMETERS
COL 1- 5 = 52
COL 6-10 = 37
COL 11-15 = 1004
COL 16-20 = -0
COL 21-25 = -0

DATA FORMAT = (A10,52I1)

ITEM N	1	2	3	4	5
	15.0000	17.0000	9.0000	11.0000	52.0000
MEANS	1	2	3	4	5
	27.0541	36.8919	20.5676	21.6216	16.1351
SIGMAS	1	2	3	4	5
	3.4715	4.9143	3.1153	3.8719	1.6160
ALPHAS	1	2	3	4	5
	.5159	.7808	.6630	.7522	.8262

ITEM	SCALE	MEAN	SIGMA	R(TOTAL)	R(SCALE)
1	1	2.08	.749	.2026	.3725
2	1	2.51	.500	-.1251	.2177
3	1	1.81	.651	.1171	.2557
4	1	2.49	.598	-.0784	-.0257
5	1	1.35	.580	.0362	.3935
6	1	1.38	.586	.3176	.4683
7	1	1.51	.758	.4349	.5135
8	1	1.49	.683	.3489	.4679
9	1	2.09	.651	.3405	.5218
10	1	2.57	.547	.4566	.3395
11	1	1.11	.452	.0420	.3750
12	1	1.78	.703	.2974	.2042
13	1	1.86	.741	.4935	.4650
14	1	1.65	.877	.2055	.4858
15	1	1.27	.444	.3591	.2535
16	2	1.57	.679	.1917	.4150
17	2	1.65	.625	.3659	.3927
18	2	2.59	.591	.3060	.3944
19	2	1.49	.551	.3351	.2589
20	2	2.08	.632	.3652	.4731
21	2	2.68	.468	.4058	.4312
22	2	2.62	.485	.3039	.5839
23	2	2.32	.737	.2223	.6363
24	2	1.86	.704	.3714	.6679
25	2	2.03	.636	.4717	.5456
26	2	2.49	.598	.2662	.6706
27	2	1.97	.716	.3915	.4369
28	2	2.08	.468	.5309	.3020
29	2	2.38	.711	.2976	.3598
30	2	2.41	.543	.4216	.5732
31	2	2.51	.500	.5370	.6168
32	2	1.57	.679	.2516	.3098
33	3	2.57	.718	.4969	.6292
34	3	1.43	.638	.2585	.2843
35	3	2.59	.635	.4251	.6082
36	3	2.08	.572	.4255	.6038
37	3	2.16	.789	.3233	.6114
38	3	2.03	.788	.2903	.6764
39	3	2.22	.576	.3047	.5794
40	3	2.62	.538	.1226	.3863
41	3	2.27	.684	.4455	.7833
42	4	1.73	.684	.1718	.5841
43	4	1.27	.444	.0496	.3424
44	4	1.41	.591	.2325	.2797
45	4	1.92	.749	.4806	.6418
46	4	2.30	.609	.5663	5290
47	4	2.11	.689	.6482	.6130
48	4	2.35	.580	.5061	.6854
49	4	2.22	.621	.5121	.6185
50	4	1.97	.788	.2137	.4484
51	4	2.70	.563	.4136	.3947
52	4	1.65	.813	.3376	.7051

CHOICE DISTRIBUTIONS (PERCENTAGES).

ITEM	KEY	KEY	ZERO	1	2	3	4	5	6	7	8	9
1	0	0	0	24	43	32	0	0	0	0	0	0
2	0	0	0	0	49	51	0	0	0	0	0	0
3	0	0	0	32	54	14	0	0	0	0	0	0
4	0	0	0	5	41	54	0	0	0	0	0	0
5	0	0	0	70	24	5	0	0	0	0	0	0
6	0	0	0	68	27	5	0	0	0	0	0	0
7	0	0	0	65	19	16	0	0	0	0	0	0
8	0	0	0	62	27	11	0	0	0	0	0	0
9	0	0	0	14	54	32	0	0	0	0	0	0
10	0	0	0	3	38	59	0	0	0	0	0	0
11	0	0	0	95	0	5	0	0	0	0	0	0
12	0	0	0	38	46	16	0	0	0	0	0	0
13	0	0	0	35	43	22	0	0	0	0	0	0
14	0	0	0	62	11	27	0	0	0	0	0	0
15	0	0	0	73	27	0	0	0	0	0	0	0
16	0	0	0	54	35	11	0	0	0	0	0	0
17	0	0	0	43	49	8	0	0	0	0	0	0
18	0	0	0	5	30	65	0	0	0	0	0	0
19	0	0	0	54	43	3	0	0	0	0	0	0
20	0	0	0	16	59	24	0	0	0	0	0	0
21	0	0	0	0	32	68	0	0	0	0	0	0
22	0	0	0	0	38	62	0	0	0	0	0	0
23	0	0	0	16	35	49	0	0	0	0	0	0
24	0	0	0	32	49	19	0	0	0	0	0	0
25	0	0	0	19	59	22	0	0	0	0	0	0
26	0	0	0	5	41	54	0	0	0	0	0	0
27	0	0	0	27	49	24	0	0	0	0	0	0
28	0	0	0	0	32	68	0	0	0	0	0	0
29	0	0	0	14	35	51	0	0	0	0	0	0
30	0	0	0	3	54	43	0	0	0	0	0	0
31	0	0	0	0	49	51	0	0	0	0	0	0
32	0	0	0	54	35	11	0	0	0	0	0	0
33	0	0	0	14	16	70	0	0	0	0	0	0
34	0	0	0	65	27	8	0	0	0	0	0	0
35	0	0	0	8	24	68	0	0	0	0	0	0
36	0	0	0	5	22	73	0	0	0	0	0	0
37	0	0	0	24	35	41	0	0	0	0	0	0
38	0	0	0	30	38	32	0	0	0	0	0	0
39	0	0	0	8	62	30	0	0	0	0	0	0
40	0	0	0	3	32	65	0	0	0	0	0	0
41	0	0	0	14	46	41	0	0	0	0	0	0
42	0	0	0	41	46	14	0	0	0	0	0	0
43	0	0	0	73	27	0	0	0	0	0	0	0
44	0	0	0	65	30	5	0	0	0	0	0	0
45	0	0	0	32	43	24	0	0	0	0	0	0
46	0	0	0	8	54	38	0	0	0	0	0	0
47	0	0	0	19	51	30	0	0	0	0	0	0
48	0	0	0	5	54	41	0	0	0	0	0	0
49	0	0	0	11	57	32	0	0	0	0	0	0
50	0	0	0	32	38	30	0	0	0	0	0	0
51	0	0	0	5	19	76	0	0	0	0	0	0
52	0	0	0	57	22	22	0	0	0	0	0	0

APPENDIX H

User's Manual for the

Management Information System

MIS: The Management Information System

To retrieve information using MIS one needs only to properly identify that item or those items of information, using "key" words, which one seeks. To properly identify the information, the user of MIS needs (1) a list of "key" words, (2) an understanding of the data base organization, and (3) a syntax into which the "key" words must be put.

The "key" words are words or abbreviations which identify items of information. For example, the item "federal salary" could be identified by the key words SALFED, FEDSAL, or both words. A key word may be as long as 10 alphabetical characters or as short as 1 character. The best size for key words is between 3 and 7 characters since 10 character key words waste space and 1 character key words lead to (1) misinterpretation of output or (2) erroneous retrievals. Neumonic key words are often used which makes the key words easier to remember and the interpretation of the output easier.

The data base organization is similar to an outline. There are two types of relationships between the various items of data. There are explicit relationships and implicit relationships. Consider the information contained in the following outline.

I. Department - Number 1 - Electronics

A. Manager is Jones.

1. First name is Tom.
2. Salary is $1300.
3. Age is 35.

B. Employee is Doe.

1. First name is John.
2. Salary is $800.
3. Age is 30.

C. Employee is Smith.

1. First name is Joe.
2. Salary is $500.
3. Age is 27.

II. Department - Number 2 - Shoes

A. Manager is Johnson.

1. First name is Howard.
2. Salary is $700.
3. Age is 37.

B. Employee is Wilson.

1. First name is Jane.
2. Salary is $500.
3. Age is 22.

C. Employee is Smith.

1. First name is George.
2. Salary is $300.
3. Age is 45.

John Doe and Joe Smith are directly or explicitly related to the Electronics Department. John Doe's salary is directly related to John Doe, but only indirectly or implicitly related to the Electronics Department. To put this information into a data base accessable to MIS, one needs only to decide on key words and enter the information correctly. It could be done in the following manner where key words are given in capitals and the information is in parenthesis.

DEPT (01) TITLE (Electronics) $MGR (Jones) FIRST (Tom) SAL (1300) AGE (35) $EMPLY (Doe) FIRST (John) SAL (800) AGE (30) $EMPLY (Smith) FIRST (Joe) SAL (500) AGE (27) $# DEPT (02) TITLE (Shoes) $MGR (Johnson) FIRST (Howard) SAL (700) AGE (37) $EMPLY (Wilson) FIRST (Jane) SAL (500) AGE (22) $EMPLY (Smith) FIRST (George) SAL (300) AGE (45) $#

The "#" separates information pertaining to the Electronics Department from the information pertaining to the Shoe Department. The "$" separates the subgroups within departments. Thus the "$" allows one to have the key word SAL within different subgroups and yet there is no ambiguity.

Thus, the user of MIS needs to be given a chart such as the following one to retrieve information. The key words are given in capitals.

I. Department Number - DEPT

A. Department Title - TITLE

B. Manager - MGR

1. First name - FIRST

2. Salary - SAL

3. Age - AGE

C. Employee - EMPL

1. First name - FIRST

2. Salary - SAL

3. Age - AGE

The user of MIS must also be given the rules of syntax by which his requests will be evaluated. A request to MIS is made up of two parts. They are (1) an object clause and (2) a modifier clause. The object clause indicates in a specified manner which items of information are sought. The modifier clause helps MIS locate the correct information by adding constraints to the request.

The object clause contains "objects" in special configurations. The "objects" can be key words, integer numbers or real numbers. The simplest object clause is made up of only one object. The next simplest form is several objects separated by AND'S, where the total number of objects is less than or equal to ten. The third form is several objects separated by the arithmetic operators, +, -, *, and /. In clauses using the arithmetic operators, all processing is done left to right with no precedence relationships between the

operators. In the case where an object has no numerical value, it is assigned a value of zero. If this should cause division by zero, the error is non-fatal and the entire request is given a value of zero. More complicated forms of object clauses involve putting one of five simple commands before the object clause. Those five commands are:

1) ALL
2) TOTAL
3) AVERAGE
4) TOTAL ALL
5) AVERAGE ALL

When the ALL command precedes a normal object clause, MIS finds and locates all occurrences of each object subject to the constraints given in the modifier clause. The ALL command is not used with object clauses which contain arithmetic operators.

The TOTAL command does exactly what one would expect. That is, it totals all the values of the objects in the object clause. Once again, an object which has a non-numeric value is given a numeric value of zero.

The AVERAGE command acts exactly as the TOTAL command except that it divides the total by the number of objects.

The TOTAL ALL command is the combination of the ALL command and the TOTAL command. It totals all occurrences of the objects, subject to the constraints of the modifier clause.

The AVERAGE ALL command is the combination of the ALL command and the AVERAGE command. It keeps track of how many occurrences of the

objects it finds which satisfy the constraints of the modifier clause. Then it totals all the objects and divides by the appropriate number.

The modifier clauses are very important, for they enable MIS to make judgments while searching for information. The items denoted in our outline by Roman numerals are the main keys. That is, they are directly or indirectly related to any information contained in a group under any other Roman numeral. These main keys are the most important modifiers and will be referenced either explicitly or implicitly in every MIS request. In our case, the main keys are the department numbers. They could be employee numbers, contract numbers, or anything similar.

The modifier clauses are made up of two parts. These parts are FOR clauses and WHERE clauses.

The FOR clause tells MIS which main key we are referencing. This saves a great deal of time in searching the data base. The simplest FOR clause is the word FOR followed by one main key. The next simplest is where the FOR is followed by up to ten main keys separated by AND's. If you have a request which references all the main keys, you can say FOR ALL. This is the default value if the FOR clause is left out.

The WHERE clause adds constraints in the form of ordered triples to the request. The first part of the ordered triple is a key word. The next part is a conditional. The last part is a value either numeric or non-numeric. The three conditionals available are =, > , and < . The ordered triples of the WHERE clause are evaluated before any other information is processed.

There can be up to three ordered triple separated by either AND's or OR's. If an AND separates the triples, all the triples must evaluate true before the conditions are met. If the triples are separated by OR's, the conditions are met when the first triple is evaluated true. Look again at the data base where certain groups are treated as complete entities when considering a WHERE clause. For example, the modifier clause.

FOR ELECTRONICS WHERE MCR = JONES AND AGE = 27

would be evaluated false and no information would be retrieved.

There are several other aspects of MIS which need to be explained here. If the data base contains years they are treated as integer numbers. However, in the case of specific dates, a special convention is used to make processing easier. The date October 23, 1969, would be entered both in the data base and the request as the integer number 691023, when the first two digits represent the year, the second two digits represents the month and the last two digits represent the day of the month.

If it is advantageous to use more than one key word to refer to items of information, they will be put into the data base as follows:

SALFED/FEDSAL.

If a request becomes long and takes more than one line, there is a symbol which indicates this to MIS. Simply type a "?" at the end of a line, and MIS knows to continue processing the request on the next line.

The final convention can be valuable if it is used with discretion by someone who knows the data base intimately. It is a form of abbreviation for key

words. If the key word is AGE, one can type A, AG, AGE, GE, or E, and the same information will be located, assuming that these combinations do not occur in any other key words.

Following this, there is a set of example outputs using the data base we hypothesized previously. Also there is a listing of the MIS program.

EXAMPLE OUTPUT OF MIS

```
YOU ARE NOW  COMMUNICATING IN REAL TIME
WITH THE MANAGEMENT, INFORMATION SYSTEM


 WHEN YOU SEE THE ASTERISK, TYPE IN YOUR
 QUESTION. IF YOU WISH TO TERMINATE THE
 COMMUNICATION, TYPE STOP


*MGR OF 1
  DEPARTMENT #            1
 MGR          = JONES
*MGR AND SAL AND AGE OF 1
  DEPARTMENT #            1
 MGR          = JONES
 SAL          =        1300
 AGE          =          35
*SAL/AGE+7000 OF 1
  DEPARTMENT #            1
 NUM          =    7037.14
*SAL / AGE +7000 OF 1 WHERE MGR=JONES
  DEPARTMENT #            1
 NUM          =    7037.14
*SAL/AGE+7000 OF 2 WHERE EMP=SMITH
  DEPARTMENT #            2
 NUM          =    7006.67
*ALL EMPL OF 2
  DEPARTMENT #            2
 EMPL         = WILSON
 EMPL         = SMITH
*TOTAL SAL OF 2
  DEPARTMENT #            2
 SAL          =         700
                  ----------
 TOTAL        =      700.00
*TOTAL ALL SAL OF 2
  DEPARTMENT #            2
 SAL          =         700
 SAL          =         500
 SAL          =         300
                  ----------
 TOTAL        =     1500.00
*AVERAGE ALL SAL OF 2
  DEPARTMENT #            2
 SAL          =         700
 SAL          =         500
 SAL          =         300
                  ----------
 AVERAGE      =      500.00
```

```
*AGE  WHERE EMPL=SMITH AND FIRST=GEORGE
  DEPARTMENT #          1
 CONDITIONS NOT SATISFIED    T    F    T
  DEPARTMENT #          2
 AGE          =         45
*TOTAL ALL SAL
  DEPARTMENT #          1
 SAL          =       1300
 SAL          =        800
 SAL          =        500
  DEPARTMENT #          2
 SAL          =        700
 SAL          =        500
 SAL          =        300
   GRAND TOTAL =    4100.00
*TOTAL ALL SAL OF 1 AND 2
  DEPARTMENT #          1
 SAL          =       1300
 SAL          =        800
 SAL          =        500
                  ----------
 TOTAL        =     2600.00
  DEPARTMENT #          2
 SAL          =        700
 SAL          =        500
 SAL          =        300
                  ----------
 TOTAL        =     1500.00
*MGR WHERE DEP=1
  DEPARTMENT #          1
 MGR          = JONES
  DEPARTMENT #          2
 CONDITIONS NOT SATISFIED    F    T    T
*DEPT WHERE TITLE=SHOES
 DEPT         =          2
*77.77 OF 2
  DEPARTMENT #          2
 NUM          =     77.77
*STOP
 STOP
```

```
      PROGRAM TRANS(TAPE1,TAPE2,TTY=77,OUTPUT=TTY)
      COMMON/INPUIL/INLIN(8),IBFN,IPT,XVAL,IEND,JBFN,JBF(2)
      COMMON/ARRAYS/OB1(10),OB2(10),NAME(50),QUAL(10),COND(10),VAL(10)
      COMMON/AA/OB5(10),OB6(10),OP(10),OP1(10)
      COMMON/FLAG/IFLG9,IFLG10,ISUM,NUM,IOP
      DATA IEQ,IGT,ILT/1H=,1H>,1H</
      COMMON/SEC/OB3(10),OB4(10),NTAB(100),IFLAG,IFLG6,IFLG7,N1
      DATA A,W,O,F/3-AND,5HWHERE,2HOF,3HFOR/
      DATA IOR,I4/2HOR,1H#/
      DATA PLUS,MIN,DIV,MUL/1H+,1H-,1H/,1H*/
      DATA AA,GO/1HA,1H2/
      INTEGER OB1,OB2,QUAL,COND,OB3,OB4,AA,IW,GO
      INTEGER A,W,O,F,OP,PLUS,MIN,DIV,MUL,OP1,ORF
      IOUT=3L(1)T
      CALL ERROR(1,IOUT)
      CALL READF
53.   I=J=K=L=N=0
      ISUM=NUM=IFLG9=IFLG10=0
      IOP=1 H
      JBF=0
      IFLAG=0
      IFLG6=IFLG7=0
      DO 999 I=1,N1
999   NAME(I)=0
      DO 1 I=1,15
      VAL(I)=OB3(I)=OB4(I)=OB5(I)=OB6(I)=0
      OB1(I)=OB2(I)=QUAL(I)=COND(I)=OP(I)=OP1(I)=10H
1     CONTINUE
2     CALL RDLINE
888   CALL ISCAN(INLIN,IBFN,IPT,XVAL,IEND,JBFN,JBF)
      IF(JBF .NE. GO)GOTO 889
      CALL RDLINE $ GOTO 888
889   IF (IEND) 1,333,2
3     IVAL=XVAL
      CALL ERROR(2,IVAL) $ GOTO 500
4     CALL ERROR(3,A)  $ GOTO 500
5     CALL ERROR(4,JBF) $ GOTO 500
6     CALL ERROR(5,W) $ GOTO 500
7     CALL ERROR(6,JBF) $ GOTO 500
8     CALL ERROR(7,JBF) $ GOTO 500
9     CALL ERROR(8,JBF) $ GOTO 500
10    IVAL = XVAL
      CALL ERROR(9,IVAL) $ GOTO 500
11    CALL ERROR(10,W) $ GOTO 500
12    CALL ERROR(11,A) $ GOTO 500
13    CALL ERROR(12,A) $ GOTO 500
14    CALL ERROR(13,A) $ GOTO 500
15    CALL ERROR(14,A) $ GOTO 500
16    CALL ERROR(15,JBF) $ GOTO 500
17    CALL ERROR(16,W) $ GOTO 500
30    CALL ERROR(29,A) $ GOTO 500
31    CALL ERROR(2 ,A) $ GOTO 500
18    IF (JBF .EQ. 4HSTOP) STOP
      IF(JBF .EQ. 3HALL)GOTO 6[illegible]
      IF(JBF.EQ.[illegible] .OR. JBF.EQ.3HAVG)GOTO 800
      IF(JBF.EQ.3H[illegible] .OR. JBF.EQ.5HADD .OR.JBF.EQ.5HTOTAL)GOTO 700
      IF(JBF.EQ.5HLET)GOTO 900
      IF(JBF .EQ. 5HPRINT)GOTO 25
1001  CALL ISCAN(INLIN,IBFN,IPT,XVAL,IEND,JBFN,JBF)
      IF(JBF .NE. GO)GOTO 887
      CALL RDLINE $ GOTO 1001
887   IF (IEND) 20,333,3
333   J=1
      OB1(1)=3HNUM
      OB3(1)=3
      OB5(1)=XVAL
334   CALL ISCAN(INLIN,IBFN,IPT,XVAL,IEND,JBFN,JBF)
      IF(JBF .NE. GO)GOTO 335
      CALL RDLINE $  GOTO 334
335   IF(IEND)338,3,4
338   IF(JBFN .EQ. 1)GOTO 339
      GOTO 21
340   IF(JBF-AA)341,28,341
341   IF(JBF-I4)3,100,3
339   IF(JBF-DIV)336,336,340
336   IF(JBF-PLUS)340,337,337
337   OP(1)=JBF
      GOTO 28
20    J=J+1
      OB1(J)=JBF
      OB3(J)=JBFN
   32 CALL ISCAN(INLIN,IBFN,IPT,XVAL,IEND,JBFN,JBF)
      IF(JBF .NE. GO)GOTO 33
      CALL RDLINE $ GOTO 32
   33 IF (IEND) 21,3,10,4
21    IF(JBFN-3) 22,23,24
22    IF(JBF-O)26,25,26
26    IF(JBF-AA)71,28,71
71    IF(JBF-PLUS)72,81,72
72    IF(JBF-MIN)73,81,73
73    IF(JBF-DIV)74,81,74
74    IF(JBF-MUL)29,81,29
81    OP(J)=JBF
      GOTO 28
   62 J=J+1
      OB1(J)=3HNUM
      OB3(J)=3
      OB5(J)=XVAL
      GOTO 32
25    CALL ISCAN(INLIN,IBFN,IPT,XVAL,IEND,JBFN,JBF)
      IF(JBF .NE. GO)GOTO 34
      CALL RDLINE $ GOTO 25
   34 IF (IEND) 1006,50,6
24    IF(JBF-W)29,100,29
29    IF(JBF-I4)7,100,7
23    IF(JBF-F)27,25,27
27    IF(JBF-A)8,28,8
28    CALL ISCAN(INLIN,IBFN,IPT,XVAL,IEND,JBFN,JBF)
      IF(JBF .NE. GO) GOTO 35
      CALL RDLINE $ GOTO 28
   35 IF(IEND)20,82,9
55    K=K+1
      IVAL=XVAL
      NAME(K)=IVAL
52    CALL ISCAN(INLIN,IBFN,IPT,XVAL,IEND,JBFN,JBF)
      IF(JBF .NE. GO) GOTO 36
      CALL RDLINE $ GOTO 52
   36 IF (IEND) 53,10,51
51    IF(L .EQ. 0)GOTO 1003
      IF((J .GT. 1) .AND. (IFLG7 .EQ. 1))GOTO 31
1003  CALL MATCH(J,K,L)
      IF(L .GT. 66) GOTO 1013
      GOTO 500
```


104

```
1013  WRITE(IOUT,701)
      DO 7703 M=1,L
7703  WRITE (IOUT,7702)OP2(M),OP1(M),OP(M),COND(M),QUAL(M),VAL(M)
7701  FORMAT(6X,'OP2',7X,'OP1',7X,'OP',7X,'COND',6X,'QUAL',6X,'VAL')
7702  FORMAT(1X,A10,F10.2,3A10,F10.2)
      GOTO 800
55    IF(JOP-M)55,60,55
60    IF(JOP-AA)56,60,56
56    IF(JOP-1H)58,100,56
58    IF(JOP-1H)11,100,11
60    CALL ISCAN(INLIN,IBFN,IPT,XVAL,IEND,JBFN,JBF)
      IF(JBF .NE. 60) GOTO 37
      CALL RDLINE $ GOTO 60
   37 IF (IEND) 12,50,12
100   IF(IFLGO .EQ. 0)GOTO 1002
      IFLG=1
1002  CALL ISCAN(INLIN,IBFN,IPT,XVAL,IEND,JBFN,JBF)
      IF(JBF .NE. 60) GOTO 36
      CALL RDLINE $ GOTO 1002
   36 IF (IEND) 101,63,13
63    L=L+1
      OP(L)=AVAL
      OP2(L)=JBFNOP
      OP1(L)=J
66    CALL ISCAN(INLIN,IBFN,IPT,XVAL,IEND,JBFN,JBF)
      IF(JBF .NE. 60)GOTO 65
      CALL RDLINE $ GOTO 66
65    IF(JBF-MPLUS)66,69,66
66    IF(JBF-MINUS)67,69,67
67    IF(JBF-DIV)68,69,68
68    IF(JBF-MULT)891,69,891
69    OP1(L)=JBF
      GOTO 1002
891   IF(JBF-LAT)892,200,892
892   IF(JBF-LLT)893,200,893
893   IF(JBF-LEQ)13,109,13
101   L=L+1
      OP2(L) = JBF
      OP1(L)=JBFN
   39 CALL ISCAN(INLIN,IBFN,IPT,XVAL,IEND,JBFN,JBF)
      IF(JBF .NE. 60)GOTO 40
      CALL RDLINE $ GOTO 39
   40 IF (IEND) 102,14,14
102   IF (JBF-L) 14,103,14
103   IF(JBF-IEQ)90,109,90
90    IF(JBF-MPLUS)91,94,91
91    IF(JBF-MINUS)92,94,92
92    IF(JBF-DIV)93,94,93
93    IF(JBF-MULT)891,94,891
94    OP1(L)=JBF
      GOTO 1002
105   COND(L) = JBF
104   CALL ISCAN(INLIN,IBFN,IPT,XVAL,IEND,JBFN,JBF)
      IF(JBF .NE. 60)GOTO101
      CALL RDLINE $ GOTO 104
   41 IF (IEND) 105,201,15
105   QUAL(L) = JBF
      ONF=ONF+1
106   CALL ISCAN(INLIN,IBFN,IPT,XVAL,IEND,JBFN,JBF)
      IF(JBF .NE. 60)GOTO 42
      CALL RDLINE $ GOTO106
   42 IF (IEND) 107,16,51
107   IF(JBF-M)108,300,106
108   IF(JBF-AA)200,300,400
200   COND(L)=JBF
   43 CALL ISCAN(INLIN,IBFN,IPT,XVAL,IEND,JBFN,JBF)
      IF(JBF .NE. 60)GOTO 44
      CALL RDLINE $ GOTO 43
   44 IF (IEND) 17,201,17
201   VAL(L)=AVAL
      ONF=ONF+1
      GOTO 100
300   IF(IFLAG-1)100,301,30
400   IF(JBF-ICR)16,401,16
401   IF(ONF-1)402,402,405
402   IFLAG=1
      GOTO 100
405   IF( IFLAG .GT. 0)GOTO 100
      GOTO 30
800   IFLGO=1 $ GOTO 1001
700   IFLG=1 $ IOP=JBF(1) $ GOTO 888
800   IFLG9=IFLG1G=1 $ IOP=JBF(1) $ GOTO 886
900   PRINT 1000 $ GOTO 2
1000  FORMAT(1X,'THIS TYPE OF COMMAND IS NOT AVAILABLE YE(')
1004  IF(IFLGO .EQ. 0)GOTO 4
      GOTO 1003
1006  IF(JBF .NE. SMALL)GOTO 6
      N2=2*N1-1
      K=1
      DO 1007 I1=1,N2,2
      NAME(K)=NAT2B(I1)
1007  K=K+1
      K=K-1
      GOTO 52
      END
      SUBROUTINE MATH(ACC,VAL,IOP)
      IOUT=3LITY
      IF(IOP .EQ. 1H+ ) GOTO 1
      IF(IOP .EQ. 1H* ) GOTO 2
      IF(IOP .EQ. 1H/ ) GOTO 3
      IF(IOP .EQ. 1H-)GOTO 4
1     ACC=ACC+VAL  $  RETURN
4     ACC=ACC-VAL  $  RETURN
2     IF(VAL .EQ. 0) GOTO 5
      ACC=ACC*VAL  $  RETURN
5     ACC=0  $  RETURN
3     IF(VAL .EQ. 0)GOTO 6
      ACC=ACC/VAL  $  RETURN
6     WRITE(IOUT,7)
7     FORMAT(1X,'* MATH ERROR, DIVISION BY ZERO, NONFATAL *',/)
      RETURN
      END
      SUBROUTINE RDLINE
      COMMON /INPUTL/ INLIN(8),IBFN,IPT,XVAL,IEND,JBFN,JBF(2)
      DATA ITTY/3LITY/
      DATA ISTAR/4125000000000000000B/
      WRITE (1TTY) ISTAR
      READ 1TTY
      READ (ITTY,10) INLIN
   10 FORMAT (8A10)
      IPT=1
      IBFN=60
      RETURN
      END
```

```
      SUBROUTINE BRANCH(J,I)
      GOTO(1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21) J
1     PRINT 101 $ PRINT 102 $ PRINT 103 $ PRINT 104
      PRINT 105 $ RETURN
2     PRINT 106,I $ RETURN
3     PRINT 107 $ RETURN
4     PRINT 108,I $ RETURN
5     PRINT 109 $ RETURN
6     PRINT 110 $ RETURN
7     PRINT 111,I $ RETURN
8     PRINT 112 $ RETURN
9     PRINT 113,I $ RETURN
10    PRINT 114 $ RETURN
11    PRINT 115 $ RETURN
12    PRINT 116 $ RETURN
13    PRINT 117 $ RETURN
14    PRINT 118 $ RETURN
15    PRINT 119,I $ RETURN
16    PRINT 120 $ RETURN
17    PRINT 121,I $ RETURN
18    PRINT 122 $ RETURN
19    PRINT 123 $ RETURN
20    PRINT 124 $ RETURN
21    PRINT 125 $ RETURN
101   FORMAT(1X,///,* YOU ARE NOW  COMMUNICATING IN REAL TIME *)
102   FORMAT(1X,*WITH THE MANAGEMENT INFORMATION SYSTEM *,///)
103   FORMAT(1X,* WHEN YOU SEE THE ASTERISK, TYPE IN YOUR *)
104   FORMAT(1X,* QUESTION. IF YOU WISH TO TERMINATE THE *)
105   FORMAT(1X,* CONVERSATION, TYPE STOP *,///)
106   FORMAT(1X,/,I10,* IS AN ILLEGAL TYPE OF OBJECT *,/)
107   FORMAT(1X,/,* NEED MORE INFORMATION, PLEASE RETYPE QUESTION*,/)
108   FORMAT(1X,/,A10,* IS AN ILLEGAL WORD IN THIS POSITION*,/)
109   FORMAT(1X,/,* SOME MUST BE FOLLOWED BY CONTRACT NUMBER*,/)
110   FORMAT(1X,/,A10,* ONLY NAMES IS LEGAL IN THIS POSITION*,/)
111   FORMAT(1X,/,A10,* : MUST BE =AND=,=OR=,OR =BUT=*,/)
112   FORMAT(1X,/,*=AND= MUST BE FOLLOWED BY ALPHANUMERIC*,/)
113   FORMAT(1X,/,A10,* : NUMBER IS ILLEGAL IN THIS POSITION*,/)
114   FORMAT(1X,/,* NAMES MUST BE FOLLOWED BY =AND= OR =WHERE=*,/)
115   FORMAT(1X,/,* =AND= SEPARATES ONLY SIMILAR QUANTITIES*,/)
116   FORMAT(1X,/,*FIRST PART OF CONDITIONAL MUST BE ALPHANUMERIC*,/
117   FORMAT(1X,/,* ILLEGAL CONDITION IN CONDITIONAL*,/)
118   FORMAT(1X,/,*LAST PART OF CONDITIONAL IS MISSING*,/)
119   FORMAT(1X,/,A10,* : IS ILLEGAL HERE*,/)
120   FORMAT(1X,/,* < AND > MUST BE FOLLOWED BY A NUMBER*,/)
121   FORMAT(1X,/,I10,*  IS NOT A LEGAL ACCOUNT NUMBER*,/)
122   FORMAT(1X,/,*FOUND OBJECT BUT NO VALUE*,/)
123   FORMAT(1X,/,* IMPROPERLY CONNECTED CONDITIONALS*,/)
124   FORMAT(1X,/,*TOO MANY OBJECTS FOR =ALL= =WHERE= QUERY*,/)
125   FORMAT(1X,/,*ERROR IN COMPUTATION,MOST LIKELY NONNUMERIC*,/,
     1*VALUE FOR OBJECT IN EXPRESSION, FATAL*,/)
      E..
      SUBROUTINE ISCAN(INLIN,N,I,X,IEND,JHFN,JBF)
      ( TESTER PLAN
      DIMENSION INLIN(8),JBF(2)
      DATA IFO,IFN,IPNT,BLANK/1H0,1H9,1H.,1H /
      DATA IC4/1H4/
      IFLAG=0
      X=0.0
      AF=1
      JBFN=0
      DO 1 I=1
      IF(I-N)1,1,39
    1 CALL PULL(I,INLIN,K)
      IF(K-IF0)4,70,9898
 9898 IF(IF9-K)4,70,70
    4 IF(K-IPNT)5,60,5
    5 IF(IFLAG-2)10,40,40
   10 IF(K-BLANK)15,100,15
   15 IF(IFLAG-1)20,40,40
   20 IF(K-IC4)34,34,139
   34 JBF(2)=1H
   36 JBFN=JBFN+1
      CALL PUSH(JBFN,JBF,K)
   35 I=I+1
      IF (I .GT. N) GO TO 38
      CALL PULL(I,INLIN,K)
      IF(K .GT. IC4) GOTO 36
      IF(JBFN .EQ.20) GOTO 35
      GO TO 36
   38 IEND=-1
      RETURN
39    IEND=1
      RETURN
139   JBFN=1
      CALL PUSH(JBFN,JBF,K)
      IEND=-1
      I=I+1
      RETURN
   40 IEND=
      RETURN
   60 IF(IFLAG-3)65,40,65
   65 IFLAG=3
      GO TO 100
   70 AK=K-IF0
      IF(IFLAG-3)80,90,80
   80 X=X*10+AK
      IFLAG=2
      GO TO 100
   90 X=X+AF*AK
      AF=AF*.1
  100 I=I+1
      IF(I-N)1,1,110
  110 IF(IFLAG)*0,39,*
      EN.
      SUBROUTINE MATCH(J,K,L)
      COMMON ICODE(1),IR(700)
      COMMON /INPUTL/ INLIN(8),IHFN,IPT,XVAL,IEND,JBFN,JBF(2)
      COMMON/FLAG/IFLG9,IFLG10,ISUM,NUM,IOP
      COMMON/ARRAYS/CB1(10),OB2(10),NAME(50),QUAL(10),COND(10),VAL(1
      COMMON/AA/OB5(10),OB6(10),OP(10),OP1(10)
      COMMON/ITEXT/ITEXT(16),IFLGA,NNNN
      COMMON/SEC/OB3(10),OB4(10),NTAB(100),IFLAG,IFLG6,IFLG7,N;
      COMMON/IS/IS(10),LLL,IFLG2,IFLG4
      DATA IEN,IGT,ILT/1H=,1H>,1H</
      LOGICAL C(3)
      INTEGER EE,NTAB,ITAT(10),OB3,OB4,OB1,OB2,QUAL,COND
      INTEGER OP,OP1,FLAG1
      IFLG2=IFLG4=0
      KK=JJ=LL=0
      AVG=AVGNUM=SUM=AVG1=AVGM1=SUM1=0.0
      N2=2*N-1
      A1=N
      LLL=1
      ACC=0.0
```

```
      IFLG=0
      DO 7500 I=1,16
7500  IF(A(I).EQ.IVAR
      A(I)=0.
      IF(K(I).EQ.0)K=I
    2 IF(IFLG1 .EQ. 1)GOTO 6600
      IF(IFLG7 .EQ. 1)GOTO 6500
*     KK=KK+1
      IF(N-KK)2000,3,3
3     DO 10 I=1,N2,2
10    IF(NAME(KK) .EQ. NTAB(I)) GO TO 11
      CALL ERROR(17,NAME(KK))
      GOTO 2
11    IF(IFLG)12,12,601
12    WRITE(IOUT,2010) NAME(KK)
601   III=NTAB(I+1)
      IF(L)100,100,4000
100   IF(J) 999,990,13
13    JJ=JJ-1
      IF(J-JJ)14,15,15
14    JJ=0
      GOTO 2
999   WRITE(IOUT,998)EE
998   FORMAT(1X,* ERROR NO.=*,I3)
2000  IF(ICTR-1)2001,2002,2001
2001  RETURN
2002  WRITE(IOUT,2003)
      GOTO 2001
2010   FORMAT(1X,* ACCOUNT = *,I10)
2003  FORMAT(1X,* NO ONE SATISFIES THE CONDITIONS*)
500   K=1
      DO 501 I=1,N2,2
      NAME(K)=NTAB(I)
501   N=K+1
      IFLG=1
      K=K-1
      DO 505 MMM=1,J
      IF(OB1(MMM) .EQ. 8HACCOUNTS .OR. OB1(MMM) .EQ.7HACCOUNT)GOTO510
505   CONTINUE
      IFLG=0
      GO TO 2
510   OB1(MMM)=7HACCOUNT
      OB3(MMM)=7
      GOTO 2
999   EE=3
      GOTO 999
61    WRITE(IOUT,61) OB1(JJ)
61    FORMAT(1X,* UNABLE TO LOCATE INFORMATION ABOUT *,A10)
      GOTO 13
76    WRITE(IOUT,81) OB1(JJ),JJBF
81    FORMAT(1X,F10.*  = *,A10)
      IF(IFLG6 .EQ. 1) GOTO 3000
      GOTO 3
79    IF(FLAG1 .EQ. 1)GOTO 7900
      WRITE(IOUT,82) OB1(JJ),IIVAL
7901  SUM=SUM+AVAL
82    FORMAT(1X,A10,* = *,I10)
      IF(IFLG6 .EQ. 1) GOTO 3000
      GOTO 3
7900  WRITE(IOUT,7982)OB1(JJ),XVAL
      GOTO 7901
7982  FORMAT(1X,A10,* = *,F10.2)
15    ISUBS=(SHIFT(ICODE(III),-4)
      IFLG2=0
      IF(OB1(JJ) .EQ. 3HNOW)GOTO 7003
      CALL FINDER(ISTOP,OB1(JJ),OB3(JJ),ISUBS,JJBF,IIVAL,XVAL,FLAG1)
      IF(ISTOP)7000,7000,7300
7000  IF(JJ-NE. 1) GOTO 7100
7007  IF(OP(JJ) .NE. 1H  )GOTO 7001
      IF(IFLG8 .EQ. 1) GOTO 91
      IF(ISTOP)78,79,78
7001  IF(ISTOP .EQ. 0)GOTO 7002
      CALL ERROR(21,ACC)  $ RETURN
7002  ACC=XVAL
      GOTO 13
7003  IF(JJ .NE. 1) GOTO 7200
      ACC=OB5(JJ)
      IF(OP(JJ) .EQ. 1H  )GOTO 7210
      GOTO 13
7200  JJ1=JJ-1
      CALL MATH(ACC,OB5(JJ),OP(JJ1))
      IF(OP(JJ) .NE. 1H  )GOTO 13
7210  WRITE(IOUT,7201) OB1(JJ),ACC
7201  FORMAT(1X,A10,*=*,F10.2)
      ACC=0.0
      GOTO 13
7100  JJ=JJ-1
      IF(OP(JJ) .EQ. 1H  )GOTO 7007
      IF(ISTOP .EQ. 0) GOTO 7101
      CALL ERROR(21,ACC) $ RETURN
7101  OB5(JJ)=XVAL
      GOTO 7200
7300  JJ2=JJ-1
      IF(OP(JJ) .EQ. 1H  .AND. OP(JJ2) .EQ. 1H  )GOTO 60
      WRITE(IOUT,7301) OB1(JJ)
7301  FORMAT(1X,*FAILED TO LOCATE *,A10,*,ZERO ASSUMED*)
      GOTO 13
91    CALL OUT(OB1(JJ))
      IF(IFLG6 .EQ. 1)GOTO 3000
      GOTO 13
200   IFLG4=0
      C(1)=C(2)=C(3)=.TRUE.
      LLL=1
201   IFLG2=0
      ISUBS1=LSHIFT(ICODE(III),-4)
      ISUBS=ISUBS1
      CALL FINDER(ISTOP,OB2(LLL),OB4(LLL),ISUBS,JJBF,IIVAL,XVAL,FLAG);
199   IF(ISTOP)202,202,203
203   IF(IFLAG)204,204,205
204   C(LLL)=.FALSE.
      ICTR=ICTR+1
      IF(IFLG)253,253,2
253   WRITE(IOUT,252) C(1),C(2),C(3)
252   FORMAT(1X,*CONDITIONS NOT SATISFIED*,3L5)
      GOTO 2
205   C(LLL)=.FALSE.
      IS(LLL)=5
      LLL=LLL+1
      IF(LLL-L)200,200,300
206   DO 207 MMM=1,LLL
      IF( IS(MMM) .EQ.0 )GOTO 207
      IFLG2=1
```

```
      GOTO 214
200   CONTINUE
      GOTO 201
202   CALL NIGHT(CONC(LLL),QUAL(LLL),VAL(LLL),ISTOP,JJBF,XVAL,IC)
      IF(IC)213,213,211
211   CALL FINDER(ISTOP,OB2(LLL),OB4(LLL),ISUBS,JJBF,IIVAL,XVAL,FLAG1)
      GOTO 199
213   IFLG2=1
      LLL=LLL+1
      IF(LLL-L)214,212,300
214   DO 22 NNN=1,LLL
      IF( IS(NNN) .EQ. 0)GOTO 220
      IFLG4=1
      CALL FINDER(ISTOP,OB2(LLL),OB4(LLL),IS(NNN),JJBF,IIVAL,XVAL,FLAG1)
      IF(ISTOP)213,213,220
215   CALL NIGHT(CONC(LLL),QUAL(LLL),VAL(LLL),ISTOP,JJBF,XVAL,IC)
      IF(IC)214,214,220
216   IS(LLL)=0
      GOTO 210
220   CONTINUE
      IFLG2=IFLG4=1
      GOTO 21
300   IF(IFLAG)301,301,302
301   IF( C(1) .AND. C(2) .AND. C(3) )GOTO 400
      GOTO 200
302   DO 303 I=1,L
      IF( C(I) )GOTO 400
303   CONTINUE
      GOTO 200
400   IFLG2=0
      DO 405 JJ=1,J
      DO 1 LLL=1,L
      IF( IS(LLL) .EQ. 0) GOTO 401
      IFLG2=IFLG4=1
      ISUBS=IS(LLL)
      IF(OB1(JJ) .EQ. 3HNUM )GOTO 7403
      CALL FINDER(ISTOP,OB1(JJ),OB3(JJ),ISUBS,JJBF,IIVAL,XVAL,FLAG1)
      IF(ISTOP)7400,7402,401
7400  IF(JJ .NE. 1) GOTO 7510
7402  IF(OP(JJ) .NE. 1H  ) GOTO 7401
      IF(IFLG4 .EQ. 1) GOTO 451
      IF(ISTOP.NE.4)5,402
7401  IF(ISTOP .EQ. 0)GOTO 7402
      CALL ERROR(21,ACC) $ RETURN
7402  ACC=XVAL
      GOTO 405
7403  IF(JJ .NE. 1)GOTO 7610
      ACC=XVAL
      IF(OP(JJ) .EQ. 1H  )GOTO 7610
      GOTO 405
7406  JJ=JJ+1
      CALL MDIM(ACC,OB5(JJ),OP(JJ))
      IF(OP(JJ) .NE. 1H  )GOTO 405
7610  WRITE(IOUT,7611) OB1(JJ),ACC
      ACC=0
      GOTO 405
7510  JJ=JJ-1
      IF(OP(JJ) .EQ. 1H  )GOTO 7407
      IF(ISTOP .EQ. 0) GOTO 7501
      CALL ERROR(21,ACC) $ RETURN
7501  OB5(JJ)=XVAL
      GOTO 7600
7700  JJ2=JJ-1
      IF(OP(JJ)  .EQ. 1H  .AND. OP(JJ2) .EQ. 1H  )GOTO 406
      WRITE(IOUT,7701) OB1(JJ)
      GOTO 405
451   CALL OUT(OB1(JJ))
      GOTO 405
406   WRITE(IOUT,81) OB1(JJ),JJBF
      GOTO 405
403   IF(FLAG1 .EQ. 1)GOTO 7903
      WRITE(IOUT,82) OB1(JJ),IIVAL
7904  NUM=NUM*1
      SUM=SUM+XVAL
      GOTO 405
7903  WRITE(IOUT,7982)OB1(JJ),XVAL
      GOTO 7904
401   CONTINUE
      IFLG2=IFLG4=0
      ISUBS=ISUBS1
      IF(OB1(JJ) .EQ. 3HNUM)GOTO 7403
      CALL FINDER(ISTOP,OB1(JJ),OB3(JJ),ISUBS,JJBF,IIVAL,XVAL,FLAG1)
      IF(ISTOP)7400,7400,7700
406   WRITE(IOUT,81) OB1(JJ)
405   CONTINUE
      GOTO 1
3000  CALL FINDER(ISTOP,OB1(JJ),OB3(JJ),ISUBS,JJBF,IIVAL,XVAL,FLAG1)
      IF(ISTOP)3001,3001,12
3001  IF(IFLG8 .EQ. 1) GOTO 91
      IF(ISTOP)78,79,78
4000  IF(IFLG7 .EQ. 0)GOTO 200
      ISUBS2=ISUBS1 T(ICODE'II)+4)
      ISUBS=ISUBS2
6000  LLL=1
      CALL FINDER(ISTOP,OB1(1),OB3(1),ISUBS,JJBF,IIVAL,XVAL,FLAG1)
      ISUBS3=ISUBS
      ISTOP1=ISTOP
      IF(ISTOP)4001,4002,8002
4001  JJBF=JJBF $ GOTO 4003
4002  IIVAL = IIVAL  $  XVAL1=XVAL
4003  IF( IS(LLL) .EQ. 0) GOTO 4004
      IFLG2=IFLG4=1
      ISUBS=IS(LLL)
      ISUBS4=ISUBS
      GOTO 4005
4004  IFLG2=1
      ISUBS=ISUBS2
4005  C(1)=C(2)=C(3)=.TRUE.
4009  CALL FINDER(ISTOP,OB2(LLL),OB4(LLL),ISUBS,JJBF,IIVAL,XVAL,FLAG1)
      IF(ISTOP)4006,4006,4007
4006  CALL NIGHT(CONC(LLL),QUAL(LLL),VAL(LLL),ISTOP,JJBF,XVAL,IC)
      IF(IC)4008,4008,4007
4007  C(LLL)=.FALSE.
4008  LLL=LLL+1
      IF(LLL-L)4010,4010,4011
4010  ISUBS=ISUBS4
      GOTO 4009
4011  IF(IFLAG .EQ. 1)GOTO 4012
      IF(C(1) .AND. C(2) .AND. C(3))GOTO 5000
6001  ISUBS=ISUBS3
      IFLG2=IFLG4=0
      GOTO 6000
4012  DO 4013 I=1,L
      IF(C(I))GOTO 5000
```

```
      SUBROUTINE OUT(ICH)
      COMMON/ITEXT/ITEXT(16),IFLGR,NNNNN
      IOUT=3LITY
      WRITE(IOUT,1)ICH,(ITEXT(I),I=1,NNNNN)
1     FORMAT(1X,5H*****,A10,5H*****,/,1X,6*10,/,1X,5A10,/,1X,*A10)
      IX=6H=0
      DO 2 I=1,NNNNN
2     ITEXT(I)=10H
      NNNNN=0
      RETURN
      END
      SUBROUTINE RIGHT(COND,QUAL,VAL,ISTOP,JJBF,XVAL,IC)
      DATA IEQ,IGT,ILT/1H=,1H>,1H</
      LOGICAL C
      INTEGER QUAL,COND
      C=.TRUE.
      IC=0
      IOUT=3LITY
      IF(ISTOP)220,220,290
22    IF( COND-IEQ )222,230,221
221   IF( COND-IGT )222,250,222
222   IF( COND-ILT )223,240,223
223   WRITE(IOUT,224) COND
224   FORMAT(1X,* ILLEGAL CONDITION DUE TO *,A10)
290   L=.FALSE.
      GOTO 210
230   IF(ISTOP)23),235,290
231   IF( QUAL .NE. JJBF) C=.FALSE.
      GOTO 210
235   IF( VAL .NE. XVAL) C=.FALSE.
      GOTO 210
240   IF(ISTOP)290,241,290
241   IF( VAL .LE.AVAL ) C=.FALSE.
      GOTO 210
250   IF(ISTOP)290,251,290
254   IF( V L .GE. XVAL ) C=.FALSE.
210   IF( C ) RETURN
      IC=1
      RETURN
      END
      SUBROUTINE FINDEM(ISTOP,IOB1,IOB3,ISUBS,JJBF,IIVAL,XXVAL,FLAG1)
      COMMON ICODE(1),IB(700)
      COMMON/A/MODE,IPTR,ITEMP
      COMMON/INPUTL/INLIN(8),IOFA,IPT,XVAL,IEND,JOFN,JBF(2)
      COMMON/IS/IS(10),LLL,IFLG2,IFLG4
      COMMON/ITEXT/ITEXT(16),IFLGB,NNNNN
      DATA ILP,IEQF,IEQR,ILB,IRB/1H(,1H=,1H>,1H[,1H]/
      DIMENSION ITXT(10)
      INTEGER FLAG1
      FLAG1=
      IL=ISUBS
      XXVAL=0.0
      ISS=
      DO 1 I=1,10
1     ITXT(I)=10H
      DO 20 I=1,10
      CALL PULL(1,IOB1,ICH)
      IF(ICH .NE. IB ) GOTO 21
20    ISTOP=1
      RETURN
```

```
      GOTO 6800
      END
      SUBROUTINE OUT(ICH)
      COMMON/ITEXT/ITEXT(16),IFLGR,NNNNN
      IOUT=3LITY
      WRITE(IOUT,1)ICH,(ITEXT(I),I=1,NNNNN)
1     FORMAT(1X,5H*****,A10,5H*****,/,1X,6*10,/,1X,5A10,/,1X,*A10)
      IX=6H=0
      DO 2 I=1,NNNNN
2     ITEXT(I)=10H
      NNNNN=0
      RETURN
      END
      SUBROUTINE RIGHT(COND,QUAL,VAL,ISTOP,JJBF,XVAL,IC)
      DATA IEQ,IGT,ILT/1H=,1H>,1H</
      LOGICAL C
      INTEGER QUAL,COND
      C=.TRUE.
      IC=0
      IOUT=3LITY
      IF(ISTOP)220,220,290
22    IF( COND-IEQ )222,230,221
221   IF( COND-IGT )222,250,222
222   IF( COND-ILT )223,240,223
223   WRITE(IOUT,224) COND
224   FORMAT(1X,* ILLEGAL CONDITION DUE TO *,A10)
290   L=.FALSE.
      GOTO 210
230   IF(ISTOP)23),235,290
231   IF( QUAL .NE. JJBF) C=.FALSE.
      GOTO 210
235   IF( VAL .NE. XVAL) C=.FALSE.
      GOTO 210
240   IF(ISTOP)290,241,290
241   IF( VAL .LE.AVAL ) C=.FALSE.
      GOTO 210
250   IF(ISTOP)290,251,290
254   IF( V L .GE. XVAL ) C=.FALSE.
210   IF( C ) RETURN
      IC=1
      RETURN
      END
      SUBROUTINE FINDEM(ISTOP,IOB1,IOB3,ISUBS,JJBF,IIVAL,XXVAL,FLAG1)
      COMMON ICODE(1),IB(700)
      COMMON/A/MODE,IPTR,ITEMP
      COMMON/INPUTL/INLIN(8),IOFA,IPT,XVAL,IEND,JOFN,JBF(2)
      COMMON/IS/IS(10),LLL,IFLG2,IFLG4
      COMMON/ITEXT/ITEXT(16),IFLGB,NNNNN
      DATA ILP,IEQF,IEQR,ILB,IRB/1H(,1H=,1H>,1H[,1H]/
      DIMENSION ITXT(10)
      INTEGER FLAG1
      FLAG1=
      IL=ISUBS
      XXVAL=0.0
      ISS=
      DO 1 I=1,10
1     ITXT(I)=10H
      DO 20 I=1,10
      CALL PULL(1,IOB1,ICH)
      IF(ICH .NE. IB ) GOTO 21
20    ISTOP=1
      RETURN
```

```
21    ITAT1=ICH
      IF( IOBJ-1)27,27,22
22    NXT=2
      III=I+1
      DO 25 I=III,10
      CALL PULL(I,IOBI,ICH)
      IF(ICH .NE. IR )GOTO 28
      GOTO 27
28    ITAT(NXT)=ICH
25    NXT=NXT+1
      ENTRY FINDER1
27    NXT=IOBJ
      +1
      IF(IFLG1)26,26,91
26    DO 36 I=1,10
      CALL PULL(I,IB(ISUBS),ICH)
      IF(ICH .NE. IECH)GOTO 32
      IF(IFLG2)33,33,34
34    ISTOP=1
      RETURN
33    ISS=ISUBS
32    IF(ICH-IEOF)31,61,31
31    IF(ICH .NE. ITAT(1))GOTO 30
      ISUBS)=ISUBS
46    IF(NXT-1)75,75,45
45    DO 46 I=2,NXT
      JJJ=I+1-1
      CALL PULL(JJJ,IB(ISUBS),ICH)
      IF(ICH .NE. ITAT(I))GOTO 43
      IF(IFLG2)47,47,34
47    ISUBS=ISUBS
43    IF(ICH .EQ. ITAT(II)) GOTO 46
      IF(ICH-IEOF)44,61,44
44    GOTO 30
46    CONTINUE
      GOTO 75
30    CONTINUE
      I=I
      ISUBS=ISUBS+1
      GOTO 26
75    IS(ILL)=ISS
      GO TO (21),21
      CALL PULL(JJJ+1,IB(ISUBS),ICH)
      IF(ICH-IEOF)76,100,76
76    IF(ICH-ILP) 78,77,78
78    CONTINUE
      ISUBS=ISUBS+1
      ISTOP=1
      RETURN
77    IBPNT=JJJ+1+(I-1)*(ISUBS-IL))
      CALL PACKBIN(ISUBS),IBPNT,JJJ+I+1,XVAL,IEND,JBFR,JBF)
      XVAL=XVAL
      IF(IEND)79,79,80
80    ISTOP=1
      JJJP=JJJP(1)
      ISUBS=ISUBS+1
      RETURN
79    ISIGN=0
      IIVAL=XVAL
      FMAXVAL=FLOAT(IIVAL)
      IF(F .GT. 0)FLAG1=1
      ISUBS=ISUBS+1

      RETURN
91    DO 91 I=1,10
      CALL PULL(I,IB(ISUBS),ICH)
      IF(ICH-IEOR)90,92,90
92    N=I+1
      GOTO 26
90    CONTINUE
      GOTO 6
100   JJJJ=JJJ+I+1
      IFLG=1
      DO 102 II=1,16
      DO 102 M=1,10
      CALL PULL(JJJJ,IB(ISUBS),ICH)
      IF(ICH-IRB)101,104,101
101   CALL PUSH(M,ITEXT(II),ICH)
102   JJJJ=JJJJ+1
104   NNNN=II
      ISUBS=ISUBS+NNNN+1
      NNNNN=NNNN
      ISTOP=-1
      JBFF=MAXXX
      RETURN
      END
      SUBROUTINE READF
      DIMENSION IBF(8)
      COMMON/SEC/OB3(10),OB+(10),NTAB(100),IFLAG,IFLG0,IFLG7,N1
      DIMENSION IBF4(8),ITAT(6)
      COMMON ICODE(1),IB(700)
      IOUT=3LITY
      CALL RFL(IFL,0)
      ISP=IFL-LOCF(ICODE(1))
      ILIM=ISP/7
      IBPMAX=ISP-ILIM-8
      CALL IOBIN(6HRE  IND,1)
      ME=IND 6
      READ(2,5)N1
5     FORMAT(I5)
      J=1
      DO 1 I=1,N1
      II=J+1
      READ(2,3)NTAB(J),NTAB(II)
      J=J+2
3     FORMAT(I10,I5)
      IF(EOF,2)2,1
1     CONTINUE
2     NMLIN=0
      IBP=ILIM
   13 IEOF=IOBIN(SHOREAD,1,IBF,6)
      IF (IEOF .LT. 0) GO TO 30
      IF (IEOF .EQ. 8) GO TO 13
   14 NMLIN=NMLIN+1
      IBPS=IBP
      IMAX=1
      DO 16 I=1,6
      IB(IBP)=IBF(I)
      IBP=IBP+1
   16 IF (IBF(I) .NE. IR ) IMAX=I
      ICODE(NMLIN)=LSHIFT(IBPS-1)+IMAX
      IBP=IBPS+IMAX
      IF (IBP .LT. IBPMAX .AND. NMLIN .LT. ILIM) GO TO 13
      IF (IFL .GE. 77700B) GO TO 20
      JFL=IFL+1024
```

```
      IF (JFL .GE. 77700B) JFL=77700B
      CALL RFL(IFL,JFL)
      INUM=INUM-ILIM
      ISP=IFL-LOCF(ICODE(1))-NWLIN-INUM
      IMOVE=(ISP/7-ILIM
      IF (IMOVE .LE. 0) GO TO 25
      DO 20 J=1,INUM
      J1=INUM-J
      J2=J1+IMOVE
   20 IW(J2)=IW(J1)
      J1=LOCF(IMOVE+4)
      DO 22 J=1,NWLIN
   22 ICODE(J)=ICODE(J)+J1
      ILIM=ILIM+IMOVE
      ISP=ISP+IMOVE
   25 ISPMAX=IFL-LOCF(ICODE(1))-ILIM-8
      GO TO 13
   26 PRINT 28
   28 FORMAT (* INSUFFICIENT SPACE - PLEASE SEE RANDY(471-3061)*)
      STOP
   30 RETURN
      END
```

```
          IDENT     RFL
          ENTRY     RFL
RFL       DATA      0
          SA0       RFLP
          SA1       B1
          LX1       18
          S=2       B2
          BX6       X5*X1
          BA6       X6*X2
WAIT1     S=5       1
          NZ        X5,WAIT1
          SA6       1
WAIT2     S=5       1
          NZ        X5,WAIT2
          EQ        RFL
RFLP      DATA      =LHFLP
          END
          IDENT     PULPSH
          ENTRY     PULL
          ENTRY     PUSH
PULL      DATA      0
          SA4       B1
          PX3       X1
          NX3       X3
          SA4       C9
          FX0       X4*X3
          S=5       C10
          FX4       X0/X5
          UX0       B4,X4
          LX0       B4,X0
          SB4       X0
          PX4       X0
          NX4       X4
          FX6       X4*X5
          FX7       X3*X5
          FX6       X7-X6
          SA5       C6
          FX5       X5*X6
          S=4       B4-1
          SA2       B2+B4
```

```
          UX5       B5,X5
          LX5       B5,X5
          SB5       X5
          LX2       B5,X2
          SA3       C77
          BX6       X3*X2
          S 6       B3
          EQ        PULL
PUSH      DATA      0
          SA4       B1
          PX3       X1
          NX3       X3
          SB4       C9
          FX0       X4*X3
          S=5       C10
          FX4       X0/X5
          UX0       B4,X4
          LX0       B4,X0
          SB4       X0
          PX4       X0
          NX4       X4
          FX6       X4*X5
          FX7       X3*X5
          FX6       X7-X6
          SA5       C6
          FX5       X5*X6
          S=4       B4-1
          SA2       B2+B4
          UX5       B5,X5
          LX5       B5,X5
          SB5       X5
          LX2       B5,X2
          S 3       B3
          SA4       C777M
          BX6       X4*X2
          BA6       X6+X3
          SB6       -B5
          SB6       B6+B0
          LX6       B6,X6
          S 6       A2
          EQ        PUSH
C9        DATA      9.0
C10       DATA      10.0
C6        DATA      6.0
C77       DATA      77M
C777M     DATA      777777777777777700B
          END
```

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