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IMPLEMENTATION OF A CURRICULUM FOR A ONE-SEMESTER UNDERGRADUATE COURSE IN ELEMENTARY COMPUTER-ASSISTED STATISTICS

by

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TABLE OF CONTENTS

Chapter		Page
1.	THE PROBLEM	1
	INTRODUCTION	1
	STATEMENT OF THE PROBLEM	4
	SIGNIFICANCE OF THE STUDY	6
	DEFINITION OF TERMS USED	8
	LIMITATIONS OF THE STUDY	10
	ASSUMPTIONS OF THE STUDY	11
	ORGANIZATION OF THE STUDY	11
2.	REVIEW OF RELATED LITERATURE AND RESEARCH	13
	GENERAL HISTORY AND EVOLUTION OF THE COMPUTER	13
	EDUCATIONAL THEORIES AND PRACTICES SUPPORTING COMPUTER-ASSISTED INSTRUCTION	19
	LITERATURE AND RESEARCH ON COMPUTER-ASSISTED INSTRUCTION IN SUBJECT AREAS OTHER THAN MATHEMATICS	34
	LITERATURE AND RESEARCH ON COMPUTER-ASSISTED INSTRUCTION IN MATHEMATICS .	59
	LITERATURE AND RESEARCH ON INSTRUCTION IN STATISTICS	75
3.	SUBJECTS, MATERIALS, AND PROCEDURES . . .	91
	SUBJECTS	91
	MATERIALS	92
	PROCEDURES	94

Chapter		Page
4.	FINDINGS	99
	VALIDATION OF THE PROPOSED COMPUTER-ASSISTED STATISTICS CURRICULUM . . .	99
	ANALYSIS OF STUDENT PERFORMANCE ON CAI UNIT TESTS AND FINAL EXAMINATION	101
	COMPARISON OF MEAN SCORES OF STUDENTS ON THREE CAI UNIT TESTS	103
	PSYCHOMOTOR AND CONCEPTUAL LEARNING DIFFICULTIES ENCOUNTERED BY STUDENTS	104
	PERCEPTIONS OF STUDENTS AND INSTRUCTOR REGARDING COURSE PRESENTATION, CONTENT, AND SEQUENCE	106
5.	SUMMARY, CONCLUSIONS, IMPLICATIONS FOR TEACHING AND LEARNING, AND RECOMMENDATIONS FOR FURTHER RESEARCH	110
	SUMMARY	110
	Purpose of this study	110
	Subjects	111
	Materials	112
	Procedures	113
	Findings	115
	CONCLUSIONS	121
	IMPLICATIONS FOR TEACHING AND LEARNING	123
	RECOMMENDATIONS FOR FURTHER RESEARCH .	124
BIBLIOGRAPHY		126

Chapter Page

APPENDICES 137

Appendix A - LIST OF JURY OF EXPERTS FOR EVALUATION OF PROPOSED CURRICULUM 137

Appendix B - EXPLANATORY LETTER MAILED TO JURY OF EXPERTS 139

Appendix C - CURRICULUM EVALUATION QUESTIONNAIRE SUBMITTED TO JURY OF EXPERTS 141

Appendix D - SAMPLE RESPONSES TO CURRICULUM EVALUATION QUESTIONNAIRE FROM THREE EXPERTS 144

Appendix E - FOLLOW-UP LETTER TO TWO MEMBERS OF JURY OF EXPERTS 150

Appendix F - LETTERS OF PERMISSION FROM AUTHOR AND PUBLISHER TO USE STATISTICAL TEST ITEMS 152

Appendix G - MEASURES OF CENTRAL TENDENCY AND MEASURES OF VARIATION FOR STUDENT PERFORMANCE ON UNIT TESTS AND FINAL EXAMINATION 156

Appendix H - COMPARISON OF MEAN SCORES OF STUDENTS ON THREE CAI UNIT TESTS . 158

Appendix I - OBSERVATION RATING SCALE FOR STUDENTS' PSYCHOMOTOR AND CONCEPTUAL LEARNING DIFFICULTIES . 160

Appendix J - LIST OF JURY OF EXPERTS FOR VALIDATION OF OBSERVATION RATING SCALE FOR STUDENTS' PSYCHOMOTOR AND CONCEPTUAL LEARNING DIFFICULTIES 163

Appendix K - COMPUTED COEFFICIENTS OF CONCORDANCE AND OBSERVED CHI SQUARE VALUES FOR EACH PSYCHOMOTOR AND CONCEPTUAL SKILL ON OBSERVATION RATING SCALE 165

Chapter | Page

Appendix L - MEASURES OF CENTRAL TENDENCY AND MEASURES OF VARIATION FOR SECOND OBSERVATION OF STUDENTS BY INVESTIGATOR 167

Appendix M - QUESTIONS FOR INTERVIEWS WITH STUDENTS CONDUCTED BY THE INVESTIGATOR 169

Appendix N - PERCENT OF FREQUENCY DISTRIBUTION OF STUDENT RESPONSES TO INVESTIGATOR'S INTERVIEW QUESTIONS 173

Appendix O - FINAL AND VALIDATED ELEMENTARY COMPUTER-ASSISTED STATISTICS CURRICULUM 175

ABSTRACT 261

VITA 264

CHAPTER 1

THE PROBLEM

INTRODUCTION

During the past two decades we have become a computer-oriented society. In the 1950's, colleges and universities in the United States initially used the computer for research and administrative purposes, but the computer was soon to be assimilated into education as a tool of instruction.

As Molnar (1971) stated:

> Within the relatively short span of 15 years, computing in education has progressed to where nearly all universities and more than a third of the four-year colleges provide computing services for research and instruction. Approximately 70 percent of all college students are enrolled at institutions at which there is a computer of some kind for instruction.
>
> . . . Most of the use of the computer in instruction has been devoted to instruction about the computer as a subject of study or as a tool in problem solving. However, the use of the computer as an instructional medium is also expanding. In 1968, a survey listed 230 instructional programs. A 1970 survey provides an index to 910 instructional programs [p. 60].

Computers are now being used by educators in the instruction of mathematics, physics, chemistry, biology, medicine, economics, business, and environmental health (Begle, 1972).

Patrick Suppes was one of the first educators to experiment with computer-assisted instruction, commonly designated as CAI. In 1964 Suppes developed a program in computer-assisted arithmetic at Stanford University.

Broadly defined, CAI is any type of instruction in which there is an interaction between the student and the computer. Although educators do not agree on any one definition of CAI, there is almost universal agreement with Suppes' categorization of three modes of CAI— (1) the drill-practice mode, (2) the tutorial mode, and (3) the dialogue mode. In both the drill-practice and tutorial modes, the computer is used to guide, control, and monitor by repetition a specific task or a number of tasks to develop a predetermined level of proficiency in a skill (Salisbury, 1971). The difference between the first two modes of CAI is that the drill-practice mode is supplemental instructions, whereas in the tutorial mode original instruction is presented and more sophisticated responses are called for (Suppes, 1966).

The drill-practice and tutorial modes of CAI exemplify the automation by computer of the programmed text (Salisbury, 1971). For example, in the drill-practice mode, the computer prints out a question and waits for the student to type in an answer. If the student's answer is correct, he can proceed to the next problem. If he inputs the wrong answer, the computer prints out a message, such as NO TRY AGAIN, and presents the same problem again. After receiving a number of wrong responses to the same problem, the computer will print out a message, such as NO THE ANSWER IS: the computer then prints out the correct answer and proceeds to the next problem.

The third and least structured mode of CAI is the dialogue mode. In this mode the student can engage in true conversation with the computer (Salisbury, 1971). He can interact with the computer, input data, or ask for computer output at any point in the conversation.

Fishell (1970) observed that "CAI would appear to offer significant potential in providing individualized instruction. However we have barely begun the exploration and necessary development [pp. 22-23]."

Educational research must necessarily synthesize the two domains of learning theory and instructional strategies. Siedel (1971) has noted that computer-assisted instruction offers educators the opportunity to connect the theory of individualized instruction with classroom strategies. The University of Florida currently offers a CAI course called The Techniques of Programmed Instruction, in which students do interact with the computer. Dick and Gallagher (1972), the authors of this CAI course reported:

> The various components in the model are based upon concepts developed by various researchers; e.g., task analysis, Gagné; behavioral objectives, Mager;

formative evaluation, Cronbach; and media selection, Briggs [p.34].

Many educators are of the opinion that informally structured learning situations in classrooms can meet the needs of their students. Rosove (1972) aptly commented on a reference by Silberman in the latter's Crisis in the Classroom: The Remaking of American Education:

> In Silberman's discussion of the theoretical basis of the informal classroom, we find all the justification we need for the inclusion of components of educational technology in such a classroom. What are some of these educational theories? To begin with, learning grows out of what interests the learner, not what interests the teacher. What interests children is not just a function of their native endowments, but is also a function of their environment. Hence the teacher should provide things or "stuff" in the learner's environment to stimulate his interests.
>
> . . . Silberman quotes Piaget to the effect that teaching means creating situations where "structures" can be discovered by the child. He must be exposed to situations that "encourage him to experiment, to manipulate things and symbols, trying them out to see what results they produce." If this does not conjure up a picture of a child interacting with a computer via a teletype keyboard and some sort of terminal display, I do not know what would [p. 11].

STATEMENT OF THE PROBLEM

The purpose of the present study was to formulate, validate, and implement a one-semester undergraduate course in elementary computer-assisted statistics. This study further sought to determine, through the teaching of this curriculum by a college instructor other than the present investigator, the effectiveness of learning of students in a designated section of elementary statistics. Conceptual and psychomotor learning difficulties, as well as perceptions of both students and instructor regarding this CAI course, were also ascertained.

More specifically, this investigator attempted to answer the following questions:

1. Was there a consensus among CAI experts and statistical authorities as to the specific content and logical sequence of components comprising this CAI statistics curriculum?

2. Did the majority of students taking this CAI course succeed on each of the unit tests and on the final examination administered during this course?

3. How did the scores on tests taken later in this CAI course compare with the scores of tests taken earlier in this course?

4. What conceptual and psychomotor learning difficulties did students encounter in processing prepackaged computer programs and operating computer terminals?

5. What were the perceptions of students and of the instructor at the conclusion of this CAI course as determined by individual interviews concerning course presentation, content, and sequence?

SIGNIFICANCE OF THE STUDY

During the late 1950's computer mathematics courses were developed for graduate students, but gradually they came to be designed for undergraduate and for high school students as well (Fishell, 1970).

Many courses of study in universities, four-year colleges, and two-year colleges presently include a course in elementary or introductory statistics. For example, the City University of New York currently offers undergraduate courses in Economic Statistics, Business Statistics, Medical Statistics, Technical Statistics, as well as several levels of Mathematical Probability and Statistics.

In 1972 the Committee on the Undergraduate Program in Mathematics (CUPM) of the Mathematical Association of America (Rosenberg, et al., 1972) proposed a new major in mathematics and science that would combine courses in mathematics, computer science, and computational mathematics. The committee urged mathematics departments to experiment with innovative undergraduate mathematics programs which would emphasize the constructive and algorithmic aspects of mathematics, and which would acquaint students with the use of computers in mathematical applications.

Lippert (1971) emphasized that one particular aspect of a computer curriculum which needs to be developed is "providing a statistical analysis system of programs oriented to the user's point of view, so that it would be easy for the non-mathematician and non-computer scientist to use it for the analysis of data [p. 41]."

Skavaril (1974) of Ohio State University noted the lack of development of CAI instructional programs in elementary statistics:

> Over 20 CAI programs in statistics have been reported . . . ; however, the majority of these programs are short course segments on a variety of specific topics and written in various languages for various computers.
>
> To the best of my knowledge, there have been no reports of a combined use of time-sharing computers to establish a complete computer-based system for the instruction of introductory statistics, a base which combines the technology of CAI, computer generation of exercises and answers, and use of the computer by students for analyses [p. 33].

The Committee on the Undergraduate Program in Mathematics (1975) stressed the use of computers as an integral part of the undergraduate elementary statistics curriculum:

> A computer can serve three broad roles in the implementation of the goals of an introductory statistics course. It can: (1) clarify certain key ideas of the course, (2) perform routine numerical calculations, and (3) facilitate more active student participation in the development of statistical concepts [p. 509].

The Committee on the Undergraduate Program in Mathematics (1975) also noted the lack of evaluative research on the effectiveness of computers in such an elementary statistics curriculum:

> Despite their [computers'] wide use, however, only limited formal evaluation of the effectiveness of computers in the introductory statistics course has been carried out to date [p. 512].

DEFINITION OF TERMS USED

Terms used in this study are defined as follows:

Algorithm. An algorithm is a step-by-step procedure formulated and used to solve a particular general or mathematical problem.

Computer-assisted instruction (CAI). Narrowly defined, the term CAI refers to computerized programmed learning; defined broadly, CAI refers to the entire field of computerized instruction in which there is an interaction between the student and the computer (Zinn, 1970).

Computer-managed instruction (CMI). In CMI the primary function of the computer is to assist the classroom teacher in planning instructional sequences. Actual classroom instruction may or may not involve interaction between the student and the computer as is done in CAI (Zinn, 1970).

Conceptual learning difficulties. This term refers to human learning problems inherently related to the comprehension "of a process, structure, or quality stated in a form which indicates what has to be demonstrated or portrayed so a learner can perceive the process, structure or quality for himself (Woodruff, 1967, p. 102)." Gagné and Briggs (1974, p. 42) noted that an individual is said to have learned a defined concept when he can demonstrate the "meaning" of some particular class of objects, events, or relations.

Descriptive statistics. Descriptive statistics refers to that area of statistics which summarizes important features of numerical data.

Flowcharting. Flowcharting is the process used by a computer programmer to formulate and draw a diagram of the procedure a computer must follow to solve a problem.

Inferential statistics. Inferential statistics refers to that area of statistics in which predictions or decisions are made about a population, based on information contained in a random sampling of the population.

Prepackaged computer programs. Prepackaged computer programs are computer programs that are stored in the memory of a computer system. The user of a prepackaged computer program does not necessarily have to comprehend the logic or computer language used to write the program. The user of the program calls the program out of the memory of the computer, then feeds in specific data, and commands the computer to run the program with the given data.

Psychomotor learning difficulties. This term refers to those human learning problems inherently related to "manipulative skills, motor skills, and acts requiring neuromuscular coordination . . . [Harrow, 1972, pp. 31-32]."

LIMITATIONS OF THE STUDY

This investigation was limited by the following:

1. The curriculum initially formulated was limited by the present investigator's knowledge and experience in CAI and statistics.

2. The originally formulated curriculum, which was changed to include suggestions received from experts responding to the investigator's correspondence and queries, was modified in accordance with their specific opinions and perceptions.

3. The testing of the final curriculum was conducted in one designated section of computer-assisted statistics at one undergraduate college which was comprised of 19 students.

4. The study was limited to the teaching performance of one instructor at Queensborough Community College of the City University of New York.

ASSUMPTIONS OF THE STUDY

For the purposes of this study, the present investigator made the following assumptions:

1. The proposed curriculum as validated by experts in the field adequately constitutes a one-semester elementary computer-assisted statistics course.

2. The perceptions of students who completed this CAI course, as well as those of the instructor, represent to a reasonable degree an objective evaluation of the curriculum content, sequence, and presentation.

ORGANIZATION OF THE STUDY

This dissertation is divided into five chapters. The first chapter includes an introduction, significance of the study, statement of the problem, definition of terms used, limitations and assumptions of the study.

The following areas were thoroughly investigated in the review of the literature and research which comprise Chapter Two of the study: (1) general history and evolution of the computer, (2) educational theories and practices supporting computer-assisted instruction, (3) computer-assisted instructions in subject areas other than mathematics, (4) computer-assisted instruction in mathematics, and (5) computer-assisted instruction in statistics.

Chapter Three includes a detailed description of the investigator's outline of a curriculum for a one-semester undergraduate course in elementary computer-assisted statistics; the investigation procedures related to content and validation by specialists in the field; final formulation of the proposed curriculum; and procedures for testing the curriculum in an actual classroom situation.

Chapter Four contains the findings of the study concerning implementation of the curriculum, as well as student attitudes toward and perceptions of the CAI statistics course.

In Chapter Five the investigator offers a summary, conclusions, implications for teaching and learning, and recommendations for further research.

CHAPTER 2

REVIEW OF RELATED LITERATURE AND RESEARCH

The review of related literature and research has been divided into the following five categories: (1) general history and evolution of the computer, (2) educational theories and practices supporting computer-assisted instruction, (3) computer-assisted instruction in subject areas other than mathematics, (4) computer-assisted instruction in mathematics, and (5) computer-assisted instruction in statistics.

The present investigator obtained and used bibliographies of CAI materials from DATRIX, RISE, and ERIC educational services. In addition, he requested and received a large quantity of CAI materials from the University of Texas where college programs for computerizing instruction in several subject disciplines are now being implemented. The extensive CAI resources available at the IBM Research Center Library, Yorktown Heights, New York were also used with special permission.

GENERAL HISTORY AND EVOLUTION OF THE COMPUTER

Calculators, which basically consist of wheels that can perform additions by rotating forward and subtractions by rotating backward, are the forerunners of electronic computers. Calculators can perform multiplications by repetitive additions and divisions by repetitive subtractions.

Gerbert of Aurillac, who was Pope Sylvester II (999-1003), was among the first to try to mechanize arithmetic calculations. After visiting the Moors, who occupied southern Spain and Northern Africa, he brought back plans for a calculating machine which were never implemented (Rosenberg, 1969). Late in the fifteenth century Leonardo da Vinci compiled a set of notes and diagrams describing a calculator which included both a wheel and handle.

In 1645 the French mathematician, Blaise Pascal, constructed the first workable calculator when he was only 22 years old (Rosenberg, 1969). During his life-time Pascal labored to redesign and perfect his machine. He noted that addition, subtraction, multiplication, and division could each be done with a single movement in his machine. Pascal stated that his machine would compensate for ignorance, as well as for lack of practice (De Angelo and Jorgensen, 1970).

In 1825 Charles Babbage constructed a calculator which was driven by an engine and could do a series of operations without the operator's intervention. Gold-stein (1972) offered the following story which appeared in Babbage's autobiography written in 1822:

> The story is that Herschel and Babbage were once checking some astronomical calculations when Babbage in irritation is said to have remarked: "I wish to God these calculations had been executed by steam." To this Herschel replied: "It is quite possible [p. 11]."

Babbage's calculator served as the first motorized model for an electronic digital computer.

The beginning of the twentieth century was marked by the development of numerous types of adding machines and desk calculators some of which included paper roll outputs. In the 1930's an English mathematician and logician, Alan Turing, began to formulate plans for a simple abstract computer which could, in principle, carry out any defined calculation (Baer, 1972). In 1938 Turing was awarded a doctorate at Princeton University and offered a position as John von Neumann's assistant there. Turing declined the Princeton offer and returned to England to work on the development of his Automatic Computing Engine (ACE). John von Neumann, John W. Mauchly, and J. Presper Eckert worked on the development of the Sperry Rand Corporation's Electrical Numerical Integrator and Calculator (ENIAC) and Electronic Discrete Variable Automatic Computer (EDVAC) (Rosenberg, 1969).

From 1946 to 1951 Mauchly and Eckert developed Remington Rand's Binary Automatic Computer (BINAC) and Universal Automatic Computer (UNIVAC) (Rosenberg, 1969).

Kemeny (1972) recalled the following main points of a lecture given by von Neumann in 1946 at Los Alamos, New Mexico:

VON NEUMANN PROPOSALS

1. Fully Electronic Computers
2. Binary Number System
3. Internal Memory
4. Stored Program
5. Universal Computer

According to Kemeny, von Neumann stated:

> The computers of the day, which depended heavily on mechanical parts, were much too slow to be useful. Therefore he proposed an entirely electronic device. He went on to argue that, while the decimal system was perfectly practical for mechanical devices, a binary system would be much easier to implement electronically because of the efficiency of on-off devices. Next he pointed out that if we had faster machines it did not make sense for human beings to have to interfere after each step. Even if a given operation on fifty IBM cards were to be speeded up from a minute to a second, very little would be gained if the cards then had to be manually transferred to another box. Therefore he advocated the existence of an "internal memory" in which partial results could be retained so that the computer could automatically go through many rounds of operations.
>
> Next he pointed out that it is not necessary to build specialized computers for different tasks. The English mathematical logician, A.M. Turing, had shown that a machine which could carry out a few basic operations could, in principle, carry out any calculation. He therefore proposed that computers be such "universal Turing machines."
>
> His most important proposal, however, concerned the logical control of computers. All of us realized how ridiculous plugboards were as a means for achieving this end. If one was multiplying A by B and then the result by C, one could of course use the same computer. However, since on the second multiplication the information was contained in different columns, the entire plugboard had to be rewired before the cards were reinserted. Von

Neumann proposed that one should be able to store a set of instructions within the internal memory of the machine so that the computer could go from step to step by consulting its own memory without waiting for human interference. Such a set of instructions is now known as a "program," and the ability to program computers has been the single major break-through that differentiates a modern computer from an old-fashioned business machine.

Of course all the electronic components that von Neumann proposed some twenty-five years ago are now hopelessly out of date, but even the most complex modern machine is based on the principles that he outlined at that time. He was a prophet in predicting the impact of modern computers, but even he underestimated the rapid growth of electronic technology and therefore failed to anticipate the incredible increase in computing power and the impact that the computer would have within a generation [Kemeny, pp. 5-6].

The ACE, ENIAC, EDVAC, BINAC, and UNIVAC were the forerunners of the faster computers built in the 1940's. Some of the more widely acclaimed computers in the 1940's were the Mark I computer of International Business Machine Corporation; the IAS computer of Princeton University; and the Whirlwind I computer of Massachusetts Institute of Technology (Baer, 1972).

The computers manufactured during the 1940's were often as large as fifty feet long and eight feet high. These machines were programmed using the Binary (Machine) language in which all data, commands, and instructions were written using only two symbols (0 and 1).

From 1950 until the present time (1975) computer manufacturers have concentrated on the development of computers that are small in size, can store a large amount of data, can be programmed using languages other than Binary, and are applicable to specific fields of interest. International Business Machines, Remington Rand Corporation, Radio Corporation of America, and National Cash Register Company are the current leading computer companies. There are many smaller companies which specialize in the production of mini-computers, some of which are as small as two feet in length by three feet in height.

All of the major computer companies have supported the development of compiler languages, i.e., languages other than the Binary (Machine) language, formulated to resemble or adapt to the languages used in certain sciences or professions. The Formula Translation Language (FORTRAN), Beginner's All Purpose Symbolic Instruction Code (BASIC), Common Business Oriented Language (COBOL), Report Programmed Generator (RPG), and Programming Languages One and Two (PL1 and PL2) are some of the more widely used compiler languages which have been developed in the past two decades.

During the late 1950's and early 1960's computers were used by the federal government and private industry for a variety of tasks, while learning institutions used the computer only for administrative purposes. Since 1970 learning institutions have accepted and supported a variety of computer-assisted instruction programs.

Patrick Suppes was one of the first educators to experiment with CAI. In 1964 he developed a CAI arithmetic program which was used for remediation at Stanford University. Suppes' CAI arithmetic program and his pleas for the further research and development of CAI programs in other disciplines were not accepted until the late 1960's and early 1970's. Since Suppes' initial experimentation with CAI arithmetic, many CAI programs in a variety of subject areas have been developed and implemented. Stanford University, Ohio State University, Texas University, The University of Florida, Dartmouth College, and the University of Denver are some of the colleges that have developed and implemented CAI programs in the past eight years.

EDUCATIONAL THEORIES AND PRACTICES SUPPORTING COMPUTER-ASSISTED INSTRUCTION

Atkins and Holloway (1971) reported on the Student Program Management (SPM) of the Bridgeport, Michigan School District which attempts to educate all children to the maximum of their abilities. Bridgeport's SPM is a systems approach to individual learning. It consists of a computer-assisted program which tracks and monitors a student's educational program. Such a course sequence has been planned to meet the pupil's immediate and projected needs.

The education of children is far too important to rely on hunches, tradition, and guesswork. Atkins and Holloway (1971) offered the following supportive summary of the Bridgeport, Michigan district's SPM program:

> What is needed seems to be a system for keeping constant up-to-date information on students recognized as having learning problems. Student Program Management, as conceived at Bridgeport, is such a system. It is motivated by a responsibility to give every child the best possible education within his natural capabilities. SPM is essentially an educational computerized tracking system which keeps tab, intervenes, and corrects a course of action. It not only tracks a student's progress and performances, but it also attempts to make corrections based on previous data. In addition it allows constant monitoring of techniques, methods, and overall school programs [pp. 48-49].

In 1971 the Mentor Exempted Village School District in Cleveland, Ohio obtained a grant from the Ohio Department of Education to develop a project known as a Comprehensive Model Education Program. This project was designed to improve the education of elementary and secondary pupils by developing a comprehensive curriculum model to meet the individual needs of students from kindergarten to twelfth grade.

More than 5,000 performance objectives were developed by 125 staff members of the Mentor Exempted School District during the summer of 1973. Lorentz (1975) listed the following sampling of these performance objectives or aim statements:

> Each student will understand the basic economic concepts of production, distribution and consumption of goods and services (Social World).

> Each student should be able to make critical judgment of aesthetic experiences (Aesthetic World).
>
> Each student will learn the basic knowledge and skills as defined by each discipline (Basic Skills).
>
> Each student should recognize that problems often have many viable solutions (Creativity) [p. 27].

The Mentor Exempted School District's Honeywell 200 computer system was made available to the Comprehensive Model Education Program (CMEP). The computer support in the CMEP consisted of: (1) a complete file of aim statements, (2) a listing of aim statements by category description, and (3) a numerical listing of aim statements.

A computer program was written to record each student's performance on specific performance objectives. A coding sheet which included the desired behavior, performance level, operational condition, measurement instrument, and conclusions was developed in order to direct the computer to maintain files of student progress.

Lorentz (1975) noted that this computer program utilized the aim statement files and provided the following:

> 1. . . . A record of each performance objective along with the full text of the content and process aim from which it was derived.
>
> 2. . . . Aid in the writing of additional objectives into a logical instructional UNIT (sic).
>
> 3. . . . A medium for revising objectives. Any portion of the objective could be changed by merely

> inserting the appropriate section of the document and returning it to the computer center where that portion would be key-punched along with the associated performance objective number [p. 30].

Rogers (1971) described the implementation of Westinghouse Corporation's Program for Learning in Accordance with pupil needs (PLAN), at Robert Frost Elementary School in Salt Lake City, Utah. PLAN uses special instructional material and teaching devices to individualize classroom instruction.

PLAN also implements a prepackaged computer program to monitor each student's progress in a variety of subject areas. Each morning the computer prints out a list of instructions which gives each student a program for the day. The children then go off into small groups for study. This scheduling allows teachers and teacher aides to offer individual attention to student needs. At the end of the day the pupils take a series of multiple-choice tests, which are scored and evaluated by PLAN's prepackaged computer program.

Rogers (1971) listed the following personal comments of Lloyd Eldredge, principal of Robert Frost Elementary School:

> All my years in education I've been haunted by those little slow learners, slipping behind the class, trapped in a pattern of failure right at the beginning of their lives. PLAN does away with that. . . .
>
> Children seem to enjoy studying in PLAN. They especially take to the idea that each has his own study program, independently of any class. For a

> grass roots assessment PARADE put a question to 12-year-old Mark and 10-year-old Kristen, both of whom claimed to have vivid memories of conventional school. Would they like to go back? "Go back?" cried Kirsten. "Oh, no!" and Mark added firmly, "Never [p. 12]."

Seidel (1971) suggested that educational research should somehow connect the two domains of learning theory and instructional strategies. He also noted that too often motivations and incentives are viewed as after-thoughts or uncontrollable factors in educational research.

The problem of dealing with information can be studied by process-oriented theories as opposed to behavioristic theories. Seidel (1971) defined a process-oriented theory in the following way:

> What is a process-oriented theory? In such a theory, we consider the organism to be capable of processing information of varying types, of varying units and capable of providing a varied set of outputs. We don't do justice to the varieties of output if we call them "responses" [p. 41].

Computer-managed instruction (CMI) offers one method for implementing process-oriented theories in the classroom. Seidel (1971) listed the following innovative concepts and measures which are applicable in such a classroom environment:

> 1. Instead of a static, normative approach to psychometrics, we need a view of measurement that is based on a changing individual with his own reference points—that is, not only what his beginning capabilities are but, relative to his set of characteristics, what types and rates of change take place in performance over different stages of learning.

2. In the context of individualized instruction, we must represent the individual-learning combination as a vector, i.e., locate the combination uniquely and dynamically within a sample space.

3. Implementing these notions takes the form of a type of cybernetic system within which one models the parameters of learning for descriptive purposes and those of instruction for prescriptive purposes. This, in turn, implies manipulating certain characteristics for the decision-making capability within an instructional model and correlating the effects of other variables (intuited to have an effect upon criterion performance but awaiting substantiation for various weightings within the next cycle of the evolving instructional system). . . .

4. With respect to the role of the computer in studying and making effective individualized instructional strategies, some researchers, would advocate the use of CMI, or computer managed instruction, as the most feasible route to follow in today's educational environment. Others would advocate the use of the computer as a problem solving aid in this same so called conventional environment. I have previously made the point . . . that the futility of assessing the value of computer-aided instruction in this manner resides in the face that in many such applications the remaining elements of the instructional processes, the implicit strategies, are never available to detailed measurement and systematic variation. This is a limitation of the CMI usage, not a negation of either CMI or computer-aided problem solving, or drill-and-practice in using the computer, or computerized testing.

5. What is intended here is to state that whenever the computer is to be used in these subsets of instructional decision-making, it is essential that the remaining elements of the instructional decision process, the instructional strategy, also be explicitly available for study. Therefore, it is perfectly appropriate to use the computer in conjunction with such other objectifying types of instruction, like programmed instruction (whether it be through the use of films, tapes or tests). Using such techniques, the instructional decision-making, the objectives, the achievement units desired and so on are all made quite explicit, and the effects of strategy elements can be measured, as can systematic variation be made possible in the interests of effective and efficient progress in studying the roles of various characteristics in instruction that stem from the student

> or the input characteristics. These techniques, however, should be used in an integrated approach with other types of use of the computer, for example as a tutorial technique in which the total instructional decision-making is included in the control processes (student and system shared) and adaptive in the largest sense [pp. 44-45].

Rosove (1972) observed that there is no inconsistency or conflict between a humanistic approach to education and an approach in which educational technology is used, either with or without prior identification of behavioral objectives. He also stated that educators should endeavor to experiment with new learning environments which integrate humanism and educational technology. Rosove further suggested that the use of computers and CAI in the classroom is one of the ways to integrate these two approaches.

In many informal classrooms, students are provided with filmstrips, records, videotapes, and typewriters. Rosove (1972) suggested that the addition of computer terminals and CAI in such informal classrooms would stimulate student interest, provide practice in reading, and allow students to explore their own environment independently.

Rosove (1972) listed three types of existing CAI systems:

1. "Ad lib," in which the student is controlled minimally by the computer;

2. Games and simulation, in which the student is constrained by the rules of tne game, and

> 3. "Controlled learning," in which the learning process is closely controlled by the computer [p. 14].

He also noted that CAI programs are currently being developed in many subject areas for primary schools, elementary schools, high schools, colleges, and universities.

Rosove (1972) concluded his report by offering the following justification for the use of computers in education:

> If by "humaneness in education" we mean that educators and engineers or programmers do not impose their notions of learning objectives on helpless students, then I find no conflict between computer-based education and the informal classroom. As I have attempted to show, using CBE as an example, providing a linkage to a computer enriches the environment of the learner; it provides him with new modes of expression and a new way to explore the universe around him; and that, depending upon a wise selection of computer programs, modes of operation, and higher-order languages, CBE does not freeze the learner into a set of learning objectives prescribed by others. On the other hand, if drill and practice are needed to master a well-defined subject area, CBE provides that capability also. From this perspective, educators and learners are not the victims of technology. Technology can do for them what it has always done for man—widen the range of choices open to him [p. 18].

Zinn (1972) listed the following factors of interest to computer professionals: (1) the balance of control by the computer program and the student; (2) the extent of use of computer diagnosis of student difficulties and related corrective exercises; (3) the different types of information processing; (4) the types of interaction between the student and the computer; and (5) the role of the computer as seen by the student. He predicted that the following two trends in computer education will occur within a few short years: (1) there will be a shift of control in computer-based exercises from computer control to student control; and (2) students will find the computer more suitable as an aid to learning than as a drill master.

Zinn (1972) suggested that educators use the following guidelines for future development of computer programs and CAI:

> Hardware. More attention should be given to analog computing and hybrid systems. Analog devices have been used effectively in engineering and the implications for modeling and simulation in social sciences are significant. Hybrid systems provide alphanumeric input and processing which help interpret user specifications for design and control of the analog cirtuits. . . .
>
> Software. Extensibility of programming languages should be viewed from the user's orientation. Presently research and development facilities have been keyed to specialists in computer science. Programming languages and user packages should be adapted to the subject being taught, to the particular learning task, and to the needs of the students and teachers. Extensibility is one way of achieving programming convenience and transfer without giving up flexibility. Educationally oriented computing systems must remain flexible for a time if they are to provide convenience. . . .
>
> User support. Training and assistance for remote users of computing facilities should receive special attention. Projects which put most of their resources into system development may find they have elegant software and communications which are unused. Distribution of noncomputer supporting services is a difficult problem, certainly in regional networks, and also in local facilities which require a user to go some distance for documentation. . . .

> <u>General education</u>. Programs to provide computer literacy for all should be encouraged and assisted by computer specialists. Experts in computer use should give some attention to the incorporation of information processing into all subject areas. Computing tools will be found to be useful in learning activities and the scholarly work of all students.
>
> Computer science courses should recognize the needs of students and the professional roles they may assume. For example, majors in computer science will later teach and design systems but may miss out on the opportunity to work with nonspecialist users during the training period. Potential users of computer should find convenient opportunity to enroll in service courses which are relevant to their needs and require the minimum effort necessary for the tasks they wish to do.
>
> Community and continuing education programs should receive greater participation of experts. The needs and interests of citizens cannot be put off until the next generation. Sound education about computing applications and the implications of information processing systems for the individual and society must be available to all ages. The careful application of computing aids to learning and problem-solving activities should be extended to all learners regardless of age, institution, or geographic location [pp. 650-651].

Pagni (1973) presented a research paper on "The Effect of Technology on School Organizational Task Structure" at the 1973 annual meeting of the American Educational Research Association. In 1970, 16,000 students and 150 teachers of Orange County, California participated in a study which consisted of the use of electronic computers and calculators as supplemental aids in the study of mathematics.

In order to measure any changes in the organizational task structure of the classroom, Pagni (1973) devised an observation system consisting of videotape recordings of both the control and experimental groups. The taping took place at the end of the school year in order to allow the experimental group ample opportunity to integrate computers into its classroom procedure.

Pagni (1973) offered the following summation and implications of his study:

> There is some evidence that a technological change at the classroom level may cause a change in the organizational task structure. This evidence is not strong and tends to say that there may be less overall teacher-dominated verbal behavior in terms of Teacher Talk and more overall pupil-centered verbal behavior in terms of Pupil Talk. This evidence would give reserved support for the model ascribing to technology a major role in the organization; affecting the task structure of the organization. In light of the limited administrative and consultative support given to the implementation of this innovation it is quite conceivable that the technology itself had an unfreezing effect on the classroom teacher-pupil interaction. The evidence cited above gives some credence to the theory that technological change can cause such a disruption on the classroom structure. Any hope of more specific changes in classroom management other than the broad measures of Teacher Talk and Pupil Talk can be discarded without administrative and consultative support of the innovation [pp. 34-37].

Jamison, Suppes, and Wells (1974) reported on the use of traditional classroom instruction (TI), instructional radio (IR), instructional television (ITV), programmed instruction (PI) and computer-assisted instruction (CAI) as alternative instructional procedures. They also noted that the lack of evaluative research on CAI programs is due to the fact that early CAI programs have been developmental and have encountered technical problems.

Jamison, Suppes, and Wells (1974) did note the following CAI studies which included statistical evaluations: (1) the 1966-1969 CAI arithmetic and reading programs at Stanford University; (2) the 1969-1970 Dial-a-Drill CAI program in the New York City Schools; (3) the 1968 CAI physics program at Florida State University; (4) the 1971 CAI health education program at Florida State University; and (5) the many CAI programs offered at the University of Texas.

Jamison, Suppes, and Wells (1974) listed the following areas of CAI for future evaluation:

> Our own feelings are that technology also has the potential, so widely heralded in the past, for improving the quality of education at every level. To realize this potential will require long-term commitment to research and development in this area. At least four considerations will probably be of importance for this in the future. Each will need more extensive study:
>
> First, we must examine if the savings in time exhibited in some of the studies using PI or CAI can be shown to be significant over longer periods and for a higher percentage of the total instructional program of students.
>
> Second, we do not yet have an appropriately detailed evaluation of the impact of the various technologies on the long-term motivation of students.
>
> Third, the long-term effects of individualization and the privacy of learning characteristic of some technologies also need more extensive evaluation. We do not know, for example, whether students who are given highly individualized programs in the

elementary school for most of their instruction will strongly prefer the continuation of such methods in secondary school and college or whether they will desire to return as they grow older to more traditional forms of instruction.

Fourth, it has been indicated at a number of points in this review that most evaluations, particularly those considered well controlled, compare TI to a form of IR, ITV, or CAI that closely resembles TI. It is at least plausible that many of the conclusions of this survey would be overturned were more imaginative uses of the media explored, which still permit comparative evaluation [pp. 58-59].

Milner and Wildberger (1974) offered three different factors for justifying the use of computers in instruction:

First, there are some uses of a computer in instruction for which there is no other competitive method for accomplishing the same result. Second, the computer has certain unique characteristics which can provide important instructional capabilities. Third, there are instances where the computer is simply the most economical way to perform instruction which may be done equally well by other methods [p. 7].

The authors justified their first factor by pointing out that in the modern world various fields such as air traffic, computer control processes, machine tools, and certain training systems necessitate the use of the computer (Milner and Wildberger, 1974).

Concerning the second factor, Milner and Wildberger noted that some of the unique benefits of CAI are the versatility of computer instruction, from tutorial CAI to dialogue (interactive CAI); the real-life simulation by the use of computers and computer terminals; and the computational and problem-solving aid of the computer.

In relation to the third factor of economy, the authors were of the opinion that computer-based instruction can become economical if a number of learning institutions share the cost of one large computer system by the use of time-sharing teletype terminals.

Milner and Wildberger (1974) stated:

> Clearly, the routine use of computers in mass instruction makes education less labor intensive, makes it easier to reach by a student body that is dispersed geographically, and facilitates treatment of students with special handicaps or widely different backgrounds [p. 10].

In his report on computer-managed instruction (CMI), Lippey (1975) offered the following taxonomy of computer uses in education:

TAXONOMY OF COMPUTER USES
IN EDUCATION

I. Research Tool
II. Student Programs
III. Operational Support
  A. Business
  B. Education Administration
  C. Instruction-Related Logistics
  D. Macro-Guidance
  E. Micro-Guidance

> I. <u>Research Tool</u>. This use of the computer involves data reduction statistical analysis and similar applications. It occurs most frequently among faculty and graduate students in universities. Public school administrators use the computer in this way when they process demographic data.
>
> II. <u>Student Programs</u>. This normally involves the execution of student-prepared computer programs. It includes all those situations where the computer is used as a subject of study for vocational education or computer literacy and concepts courses, or as

a subject of study for vocational education or computer literacy and concepts courses, or as a computational tool for so-called problem-solving. Sometimes the program executed is not prepared by the student himself, but is provided as a part of the course material.

III. Operational Support. This group contains all computer uses which support the operation of the educational institution, including day-to-day instruction. These have been further classified into the following five sub-categories.

IIIA. Business. This group includes all of those applications which are common to many businesses and other organizations, e.g., payroll, cost accounting, inventory control.

IIIB. Education Administration. These consist of administrative applications which are unique to the educational environment. They do not support instructional activities, though they often depend upon data from the classroom and produce reports concerned indirectly with instruction. Examples include attendance recording, grade reporting, and conventional class scheduling.

IIIC. Instruction-Related Logistics. This group involves using the computer to support instruction in clerical ways. These applications assist teachers, but do not contain built-in educational decisions; i.e., they do not involve either diagnosis or prescription. Examples are scoring of teacher-made tests, assistance in test construction, help in choosing classroom activities, and frequent (perhaps daily) rescheduling of classes. Sometimes these computer uses are regarded as CMI applications.

IIID. Macro-Guidance. This category contains those applications where the computer does make pedagogical decisions, but does not actually carry out instruction. Instruction occurs via conventional means, and the computer system rarely contains presentation material. Guidance is relatively long range, i.e., hours to years (instead of seconds). Turn around time may often be overnight. Most of the applications which are regarded as CMI are included in this group. Those which provide longer range academic or vocational counseling are also included; they too are sometimes considered to be CMI applications.

IIIE. Micro-Guidance. This includes all of the uses which can be roughly characterized as the computer's simulating an instructor or a rapidly changing environment. Guidance is short range and turn around time is measured in seconds. In this application, the student always interacts directly with the computer via a terminal. Applications in this group include giving the student practice (with immediate feedback of results), teaching new material by computer, or providing a real-time simulated experience. Such uses are usually called computer assisted or (more accurately) computer administered instruction (CAI) [pp. 9-10].

Nearly all CMI supports, or is eventually aimed at supporting, individualized instruction. Lippey (1975) suggested that developers of computer-managed instruction should study the reasons for past failures of other methods of individualized instruction. He also noted that too often researchers submerge themselves in activities of the present and disregard the past as irrelevant.

Lippey (1975) suggested that researchers use the following three criteria to identify practical CMI programs:

> Test 1: Was the application independently developed in several locations to meet local needs?
>
> . . . Test 2: Were most implementations initiated by classroom instructions?
>
> . . . Test 3: Are the operating expenses in most cases met through normal local funding practices? [pp. 12-13]

LITERATURE AND RESEARCH ON COMPUTER-ASSISTED INSTRUCTION IN SUBJECT AREAS OTHER THAN MATHEMATICS

In 1967 the Computing Activities Office of the

National Science Foundation sponsored a conference at the University of Maryland to ascertain and summarize current views of the role of the computer in various aspects of the undergraduate curriculum.

Lockard (1967) reported that the Physics Panel at the conference made the following recommendations: (1) elementary physics courses should include the algorithmic approach used by computer systems and apply this method to the solution of elementary problems; (2) intermediate physics courses should use the computer to simulate theoretical physics and aid in the development of student intuition; and (3) graduate or research physics courses should use the computer to summarize and analyze important features of numerical data.

The Physics Panel recommended that CAI physics programs be developed as soon as possible within the following four areas: (1) an algorithmic approach to problem solving; (2) simulation in order to bridge the theoretical and experimental aspects of physics; (3) analysis of data for more complex physics problems; and (4) mathematical modeling in physics.

Lockard (1967) reported that members of the Chemistry Panel were enthusiastic about the development of undergraduate CAI chemistry programs. However, they noted that the following actions must be taken before implementing any CAI chemistry programs:

> (a) introducing the computer to the student and teaching him to write programs, (b) introducing the computer and programming to those on the faculty who have not already had experience with the technique, (c) obtaining a set of suitable computer-oriented problems, a set of laboratory experiments in computer-instrument interaction, and a set of programs which are ready to run and can be used to study chemistry with little or no programming, and (d) obtaining the necessary hardware [p. 49].

The Chemistry Panel further suggested that the National Science Foundation support faculty members interested in developing a suitable set of computer-oriented chemistry problems and offer computer programming institutes for professors of chemistry. The members of the Chemistry Panel stated that although many computer systems are very expensive, the development of time-sharing systems offers great promise for inexpensive com-computer support in undergraduate chemistry courses.

In 1968 The Ohio State University College of Medicine granted released time to Dr. Helen Wikoff for the development of a tutorial self-evaluation CAI unit for dental students enrolled in the nutrition course.

Gaston (1971) reported that Dr. Wikoff's CAI unit was implemented with 150 dental students during the fall quarter of 1968. Only three IBM 1050 teletype terminals were made available to these 150 dental students.

Although each student received some CAI experience, many students were forced to "double up" at terminals, and many did not complete all of the CAI unit. No formal evaluation of the CAI unit was made, but many students were of the opinion that this unit was an aid in understanding the nutrition course and in serving as a review for the final examination.

Gaston further noted that in 1968 Klassen, Finch, and Vavalamis—three members of The Ohio State University College of Medicine—developed a CAI course on oral cancer recognition. The primary objective of the course was to simulate decision-making regarding oral diagnosis.

Sixty-five of 148 students elected to take this CAI course option. A majority of these students were enthusiastic regarding future CAI instruction. Most students expressed a desire for more CAI dentistry courses at the undergraduate, graduate, and continuing education levels.

Gaston (1971) reported on Klassen's use of CAI materials in dental education:

> If the course material were primarily designed for student use, rather than for continuing education of health practitioners, it would be a simple matter to program the information-gathering section (history, physical, and laboratory data) to store the requests from the learner. Then at the time of diagnosis selection, the computer program would indicate that insufficient information had been obtained, or that a different sequence of information gathering would have been more efficient. This is perhaps the best available method for training future practitioners in the art of history taking, short of a one-to-one teacher-student team for patient evaluation. Such a team would not give every student adequate exposure to complicated or unusual cases. The computer memory is an ever-handy repository for this type of material.

> Computer-assisted instruction is expensive. The equipment alone is still very costly, but development of the software (the programmed courses) is ultimately the greatest expense for such an instructional system. In the days of ever-increasing enrollments and the depersonalization of dental education, strangely enough, the computer becomes a tool for placing instruction on an individualized level. Certainly, CAI is not the sole instructional mode of the future. It is a valuable adjunct to lectures, seminars, clinical experiences, and laboratory work. It can assist the instructor in recognizing individual weaknesses in the student, and it can be a source of review, drill and practice, and patient management simulation heretofore unavailable to the dental student and his education [p. 16].

For his doctoral study Merrill (1970) investigated the effects of behaviorally stated objectives on the learning process. The task which was analyzed was one related to a hierarchical imaginary science presented by an IBM 1500/1800 computer-assisted instruction system to 130 introductory educational psychology and science education students at the University of Texas.

Before learning the assigned task, each of the 130 students was given six cognitive ability tests. The students were then randomly assigned to one of the following groups: example-only, objective-example, rule-example, and objective-rule-example. Each student had to meet a minimum criterion performance at each level of the assigned task before proceeding to the next level.

Merrill (1970) determined that rule groups needed less time and fewer examples to complete a task than non-rule groups. No significant differences were found between treatments on posttests and retention tests, but the rule groups scored significantly higher on a learning transfer test.

Reasoning had a high negative relationship to test-item response latency for students in the example-only group, but this relationship was much lower for each of the remaining groups. Merrill (1970) therefore concluded that the presentation of objectives or rules effected a reduction in the requirement for reasoning ability. He also found that objectives have both organizing and orienting effects which incline students to select process, and structure relevant information in agreement with the stated objectives.

Diamond, Theimer, and Charp (1971) reported the results of a preliminary evaluation of a CAI program called Project Grow, which was implemented in two Philadelphia junior high and two Philadelphia senior high schools. Project Grow used the tutorial mode of CAI to give instruction in biology and developmental reading to approximately 600 junior and senior high students. Remote computer terminals were used by students in these Project Grow schools.

The preliminary evaluation of the Project Grow program was conducted during the 1968-1969 and 1969-1970 school years. Evaluation of the program consisted of analyses of student attitudes, teacher attitudes, Gates-MacGinite Reading Test scores, and Nelson Biology Test

Form F scores.

Diamond, Theimer, and Charp (1971) offered the following summary and recommendations based upon their evaluation of Project Grow:

> The evaluation of the CAI program in the Philadelphia schools has demonstrated that the use of computers for instructional purposes is probably feasible and may be effective in teaching reading comprehension at the high school and junior high school levels. It has also shown that several areas need additional research. Such areas as the personality characteristics of students and their relationship to the acceptance or rejection of CAI are of great interest and need careful appraisal. If, for example, it can be demonstrated that students with particular traits can profit from the CAI and others who do not possess these traits do not, an effective scheduling paradigm might then be developed for the CAI classes.
>
> The results of the reading study are promising. Whereas both the reading and biology software were in the developmental stages, and will be revised during the summer, the tutorial approach has shown that it is an effective way of increasing reading comprehension skills. The results obtained in the schools where the CAI program was operating adequately demonstrate that this approach should be expanded [pp. 12-13].

Klassen (1971) noted that the development of computer-assisted instructional material has proceeded since the late 1960's and early 1970's. He also observed a neglect in the development of computer-assisted social science instructional materials.

In the summer of 1971 the National Science Foundation sponsored an institute for the development of computer-assisted materials. Ten of the 50 secondary school teachers who attended the institute were social studies teachers. Some of these ten teachers had considerable programming skills; others had no previous exposure to the computer. The teachers were asked to develop computer-assisted projects to be used in classroom instruction.

Klassen (1971) reported that the projects developed were in the following three broad categories:

> (1) simulation and gaming, in which the student is led into a simulation of some real-life problems and in which the computer controls the sequence and nature of simulated events; (2) inquiry approaches, in which the student attempts to explain a phenomenon by using the computer as a resource and research tool to seek and analyze information; and (3) tutorial and teacher-assistance systems ranging from didactic instruction in which branching programming techniques are used for teacher support in clerical and logistic ways [p. 8].

Klassen (1971) offered the following generalizations on the use of the computer in the social studies classroom:

> First, it seems quite evident that the interest in using the computer as an instructional tool in the social studies classroom is dramatically increasing. Social studies teachers are beginning to perceive the possibilities and advantages afforded them as teachers as a result of the introduction of the computer into the classroom. As this interest increases in intensity, the demand for usable curriculum materials will also increase. Ideas and application possibilities currently far outdistance the material available.
>
> In addition, the experience of the teachers attending the institute demonstrated the fact that it is possible to take a social studies teacher with no computer-related skills and within several weeks find him preparing computer-based curriculum materials. It is equally evident from the experience of these teachers that the development of full-scale computer-assisted instructional systems will require more time than the classroom teacher can devote to the process.

> In all cases, the projects developed were small-scale application units. The development of curriculum systems is likely to require the effort of a team of curriculum authors, programmers, and classroom teachers working together [p. 10].

Schiavone, Rowen, and Farrell (1971) noted that the use of CAI to supplement reading instruction has the following advantages over traditional methods: (1) Instruction can begin at each student's reading level; (2) Time allotment can vary for each student; (3) The computer comprises an ideal standardized mean for administering tests and developing norms; (4) The computer serves as a motivation factor for both children and adults; (5) The computer can efficiently handle a wide variety of instructional materials.

These authors stated that there are two excellent CAI reading programs at Columbia University and Brooklyn College in New York City. Participants in these programs use a variety of CAI equipment, including remote teletype terminals, earphones, slide projectors, and cathode ray tube screens. Such a program costs approximately seven dollars per student-hour.

Thompson (1972) developed a series of computer programs to simulate game theory problems in economics courses at Riverside City College of the University of California. Game theory provides a means of describing the strategic behavior of one or more players who must make choices in conflict situations (games) in which the winnings are a function of the choices made by all the players involved in the conflict.

Thompson (1972) summarized the following advantages of computer simulation of games in discovering reality:

> 1. They provide a laboratory midway between simplistic and fragmented models on one hand and the bewildering real world on the other.
>
> 2. They provide replication and experimenter-controlled manipulation.
>
> 3. They permit time compression.
>
> 4. They may reduce the number of variables that must be considered.
>
> 5. They permit study of processes that cannot be studied directly in nature.
>
> 6. They are serendipity-prone because the gamer is experimenting in a rich environment and will therefore usually discover something he did not expect [pp. 3-4].

For his evaluation of student attitudes toward the use of the computer and CAI materials, Thompson (1972, p. 41) listed the following results of responses to a student evaluation questionnaire:

> STUDENT EVALUATION
>
> A total of 183 students enrolled in day economics courses during the Spring 1972 semester experienced some form of computer assisted instruction (CAI). Of this number 98 used the APL computer terminal for one or more mandatory, optional, or remedial assignments. Obviously, one terminal available five or fewer hours per day cannot service a large student population. The following student questionnaire was prepared to assess the impact of CAI generally, and for those students who had experienced both "batch" and interactive terminal CAI, the relative impact of batch processing *versus* terminal processing.

% Responding*			Response Item
Yes	No Opinion	No	
73%	13%	13%	The use of the computer allowed me to understand economic concepts as well as or better than a textbook.
92	6	3	The use of the computer created more interest in the material covered than would have existed without it.
2	12	87	The prepared computer assignments were a bother and a waste of time.
7	30	62	Most students paid little attention to the computer exercises, games, and simulations.
83	10	6	I would like to see the college expand its computer services for instructional purposes.

* * * * *

Answer these questions only if you had experience with both the "batch" [group] games and the APL computer terminal.

39%	28%	33%	I prefer the batch processing to the terminal processing.
58	26	14	To me, the immediate feedback of the terminal system was preferable to waiting for the results from the batch method.
21	15	64	The terminals were too fast since I felt pressured to give a reply before I had time to think about it.
75	15	9	The computer terminal allowed me to explore realities or solve problems that would have been very difficult or impossible to accomplish by other means.

5%	29%	65%	It is unnecessary to have computer terminals in order to receive the full benefit of computerized learning experiences.

*(Note: Columns may not add to 100% due to rounding.)

One of the main topics discussed at the 1972 annual American Federation of Information Processing Systems (AFIPS) was test construction. Blaskovics and Kutsch (1972) listed the following specifications for their automatic Testing and Scoring System (TASSY):

1. It should be easy to use by both the student and the instructor;

2. It should allow for immediate feedback to the student;

3. It should allow the instructor, on demand, to review the progress of a student;

4. It should allow the student to individualize his request for proficiency;

5. It should have a high degree of security;

6. It should meet at least the minimum needs of the registrar for recording grades;

7. It should allow the student the option of taking an exam [sic] for diagnostic purporses or for grade purposes; and

8. It should maintain a record of each student's individual performance for instructor analysis of items [pp. 624-625].

These researchers developed TASSY during the fall 1972 semester. Students in a variety of courses contacted the computer by means of a remote teletype terminal. The computer asked for the student's course, section, and specific quiz he or she desired. Then the computer asked the students a series of randomly selected multiple-choice questions.

TASSY was developmental in nature, and no analysis or evaluation of the system was conducted. Blaskovics and Kutsch (1972) briefly described the purpose and limitation of the TASSY program:

> Our interest in developing TASSY was to explore the problems and potentials of using the computer in the educational process. TASSY served that purpose in many ways. Our first concern was the problem of software development and record design. We originally designed the question record to be 500 characters long. We found that this is too short. Our next version of TASSY will have the ability to hold a question and associated distractors totaling 1,000 characters on each record [p. 630].

In 1972 the University of Texas of the Permian Basin awarded a contract to Interface Industries to investigate the feasibility of converting its facilities to a totally computer-managed institution. Research analysts at Interface Industries studies existing computer-managed programs at The University of California at Los Angeles, Southern Illinois University, Florida Atlantic University, Lehigh University, Oakridge National Laboratories, University of Missouri, Northwestern University, Booth Library at Eastern Illinois University, Ohio State University, State University of New York at Binghampton, and Arizona State University.

In the first progress report of Interface Industries it was suggested the computer-managed program at the University of Texas be divided into the following main areas: (1) learning resources, (2) academic, (3) student services, and (4) miscellaneous. The proposed computer-managed system for the University of Texas centered around the use of an IBM System 360 computer with the model 30 release 20 IBM disc-operating system. Proposed learning resources consisted of a completely computerized library system and academic programs entailed the use of all three modes of CAI instruction in a variety of courses. Interface Industries (1972) listed the following application programs and output reports for computer-managed student services:

<u>Application Programs</u>

1. On line admissions program
2. On line registration program
3. On line computer-managed instruction program
4. Evaluation of courses
5. Program of extracurricular activity planning
6. Scheduling of courses, faculty, and room program
7. Programs for billing
8. Program for optimally scheduling students for graduation
9. For an accounting program which keeps track of the amount of time each terminal is in use and the user

<u>Output Reports</u>

1. Transcripts
2. Letters of admission
3. Transfer summary profile sheet
4. Hard copy of daily transactions
5. Labels for correspondence
6. Summary profile sheet for counselors, advisors, and departments
7. Daily status reports
8. Housing reports
9. Statistical reports—alphabetical list of students, faculty, past, present, and future [p. 30].

Suggestions listed by Interface Industries in the miscellaneous areas included the use of remote computer terminals for faculty research and student activities.

Elliot (1973) described two CAI projects which were funded by the National Science Foundation—the Mitre Project under the collaboration of the Mitre Corporation, the University of Texas, and Brigham Young University; and the PLATO IV Project developed at the University of Illinois in Urbana. The Mitre Project was developed exclusively for community college students, and the PLATO IV Project was developed for students in elementary schools, high schools, and community colleges.

Elliot (1973) listed the following characteristics of the Mitre Project and the major objectives of the PLATO IV Project:

> The Mitre Project. The Mitre Project is aimed exclusively at the community college audience. It proposes to serve as a catalyst for the mass dissemination of CAI. The hardware system has the following characteristics:
>
> 1. Probable terminal-hour costs of 25-50¢ in the near future for non-profit community college applications through the use of commercial television technology and low-cost/high-performance minicomputers.
> 2. A terminal that is able to deliver instructional movies, interactive computer-delivered graphics, voice, and text.
> 3. A distribution system which uses cable TV [sic] as a transmission medium, enabling an entire campus to be economically wired.
> 4. A size and cost ($200,000 purchase price) which can meet the needs of individual institutions.

Four full semester courses are to be developed—two in mathematics and two in English. These courses will emphasize learner control of the instructional strategy as a means to humanize education and to minimize the inadequacies of the hardware. . . .

The PLATO IV Project. The PLATO project has been divided into two major components. One will focus on reading and mathematics at the elementary school level. The other component will center on community colleges. At the community college level, sequences of "free-standing" modules which may be used individually or together depending on particular needs, are being planned and/or developed in the following areas: accounting, auto mechanics, biology, chemistry, English, the GED, mathematics, and nursing (other areas are contemplated). . . .

The major objectives of the PLATO Project are:

1. To develop, test and operate a large, geographically dispersed computer-based education network serving at least 500 student consoles at several educational institutions at the community college and elementary levels;
2. To implement an educational program involving cooperation with participating institutions. This program will include teacher-author training, curriculum planning, and curriculum development.
3. To carry out a two-year field test and demonstration project beginning in the fall of 1973.
4. To cooperate with the Educational Testing Service (the external evaluation team) in developing plans and strategies for evaluation and to assist in a systematic evaluation during the field test period [pp. 9-10].

In light of recent developments in time-sharing computers and federally-funded CAI projects, Elliot (1973) suggested that educators experiment with existing CAI programs and develop other applicable CAI programs. Elliot also recommended that community college instructors develop CAI occupational programs. In addition, he listed the areas of automotive mechanical diagnostics, clinical laboratory analysis of data, and appliance repairs as possible areas for future development of CAI programs.

The main topic of discussion at the annual American Federation of Processing Systems (AFIPS) computer conference in 1973 was computing in the junior or community college. At the conference, Highland (1973) stated that computer education in the junior or community college should be recognized by everyone engaged in computer education, business, industry, and government. He noted the excellent CAI programs developed by Ashworth of Central Texas College, Killeen, Texas; Bise of Orange Coast College, Costa Mesa, California; Davidson of Laguardia Community College of the City University of New York, Long Island City, New York; Maniotes of the Calumet Campus of Purdue University, Hammond, Indiana; and Thompson of New York State Agriculture and Technical College, Farmingdale, New York.

Highland (1973) used the term "academic computing in the junior community college" to include the following aspects of computer science:

> In some institutions, the term, "computer science," is used but many times the courses and the level at which they are taught bear no relationship to computer science taught at a four-year college, following the guidelines of Curriculum '68 which was developed under Dr. William F. Atchison.
>
> In other institutions, the term "data processing" is used; but here again there are extremely wide variations. Not all such programs are solely and purely business-oriented.

> The term "computer technology" is likewise encountered at the junior/community college. Some of these programs are designed to educate electronic technicians; others involve the training of computer operators. Still others more closely resemble computer science at the four-year college or data processing in a college of business administration.
>
> Finally, we are beginning to encounter the term, "information processing," since curriculum titles are being used at times to show that one is keeping up with the state of the art. Oftentimes, the courses and their content are far different from the program proposed by the ACM Curriculum Committee on Computer Education for Management . . . for undergraduate education under the leadership of Dr. J. Daniel Couger [p. 367].

Many junior or community colleges have experimented with CAI mathematics and science programs for students who wish to transfer to senior colleges. Highland (1973) suggested that those community college instructors who develop CAI should not disregard CAI programs for students involved in terminal programs. Some of the areas which need CAI experimentation are the two-year degree programs in business, economics, technology, and nursing.

In his doctoral study, Jones (1973) noted that many small scale CAI programs have been tested by the United States Army. The results of these tests indicated that this military unit should implement large scale CAI military training programs. Fifty-seven technical courses offered by the Army were identified as suitable for initial CAI applications.

Jones (1973) assessed the present CAI capability of ten Army Training and Doctrine Command Schools. His evaluation revealed that the Signal, Infantry, and Engineer Schools had significant CAI capability. He concluded that many intangible benefits of CAI may improve the efficiency and effectiveness of presenting, managing, controlling, and evaluating individualized instruction. He recommended a pooling of army-wide expertise to support large-scale CAI prototype testing and evaluation.

Couger (1974) reported that in 1966 only 11 percent of colleges accredited by the American Assembly of Collegiate Schools of Business (AACSB) required computer programming proficiency of students at the undergraduate level while, in 1974, 72 percent of such institutions required programming proficiency. In 1974 at the doctoral level half of the Ph.D. programs sponsored by the AACSB required proficiency in computer programming.

In his report on computer uses and computer curricula in schools of business, Couger (1974) stated that the majority of such schools required the following four phases of computer programming in the undergraduate curriculum:

> Coverage of computer fundamentals, system analysis/design and programming through a course required of all students early in their academic program.
>
> Coverage of the applications of computers through incorporation of this material into the functional area courses, e.g., computer applications in finance in the finance courses, computer applications in marketing in the marketing courses, etc.

> Coverage of computer capabilities for abetting decision-making in a dynamic business environment through computer-oriented business games.
>
> Coverage of integration and optimization of computer applications through a course on design and implementation of a sophisticated, computer-based management information system [p. 1].

Cougar (1974) also noted some encouraging developments in AACSB accredited colleges: a sharp increase in faculty computer proficiency; a decrease in formal lecture hours; an increase in computer-assisted instruction hours; development of applicable game theories and the use of computers to simulate these games; and a new emphasis on information systems curriculum.

At the computer conference of the American Federation of Information Processing Systems (AFIPS) Kerr (1974) noted the enormous business losses due to inadequate training of employees. He also observed that many institutions of learning have turned to computer-managed systems in order to utilize their faculty, staff, and equipment more efficiently. He described current advances in time-sharing equipment and the development of educational CAI training programs. He specifically mentioned the TUTOR program at the University of Illinois; the PLANIT program developed by System Development Corporation; and COURSEWRITER III developed by International Business Machines. Kerr suggested that equipment and programs such as those mentioned above can meet the training needs of business and industry.

Kerr (1974) recommended that time-sharing equipment and CAI training programs have the following characteristics:

> No computing knowledge required to produce training material;
>
> Editing and error correction aids are available to the coursewriter;
>
> Provision is made for the trainer to develop course material ranging from simple drill to complex simulation material;
>
> Complete records are maintained on all student activity and use of course material;
>
> Provision for a management mode that allows the trainer not only to manage his instructional environment but gives quantitative information on the readiness of a trainee to use the system;
>
> Provision for a management mode that allows the trainer to manage other types of instructional materials such as PI, Video Tapes, Films, Cassettes, etc. [p. 931].

Although he stressed the need for development of CAI applications in business and industry, Kerr (1974, p. 931) offered the following list of industries in which CAI is being used and general areas of application:

Banking
- Terminal training
- Data entry
- Management training
- Supervisory training
- Personnel policies
- Introduction to banking services

Life Insurance
- Data entry
- Terminal training
- Sales training
- Product information

Manufacturing
- Warehousing and inventory
- Terminal training
- Management training
- Computer techniques
- Creativity (Aero Space Company)

Food Processing
- Terminal training
- Data entry
- Warehousing and inventory

Retail
- Buyer training
- Management training
- Sales training
- Basic retail skills training.

Since 1969 the Faculty of Medicine at the University of Alberta has been experimenting with computer-based instruction. They currently use the IBM System 1500, in addition to 21 multimedia terminals and two standard teletype terminals in the instruction of a number of courses, including the basic cardiology course. Each multimedia terminal consists of an image projector, a cathode ray tube, a light pen, a keyboard, and an audio unit.

Obsaldeston (1974) stated that the principal objectives of the cardiology course are to develop reasoning processes in students based on computer simulation of various defects both inside and outside the heart. He has been implementing a CAI program which exposes students to situations in which they must work out the signs, symptoms, and results of investigations they might encounter in a clinical situation.

Each of the 208 students completing the computer-based cardiology course since 1971 was asked his or her attitude toward CAI in relation to conventional methods. The students rated each of the sections of the cardiology course from "Poor" to "Excellent" on a scale from 1 to 4. Each section was either a seminar or lecture, ward work, or CAI. The students enrolled in the 1971-1972 computer-based cardiology course reported the following attitude ratings: seminar/lecture mean = 3.17; ward work mean = 3.28; and CAI mean = 3.53. The 1972-1973 statistics were: seminar/lecture mean = 3.04; ward work mean = 3.52; and CAI mean = 3.56 (Obaldeston, 1974). The findings indicate a positive student attitude toward the computer-based cardiology course.

Flake (1975) developed a CAI teacher education program that simulates classroom situations about which the student must make decisions. The focus of Flake's CAI program was upon teaching strategies and questioning behaviors. The theoretical background for his program stemmed from: (1) teaching strategies for concepts and principles, (2) problem-solving strategies, (3) various questioning behaviors, (4) lesson planning (i.e., objective, motivation, subtask analysis, strategies, and evaluation), and (5) a simplified learning theory.

Flake (1975) implemented his CAI program in an inservice teacher education course at the University of

Illinois. Reactions to the CAI program were favorable as indicated in the following sample comments listed by Flake (1975, p. 55):

> "No amount of talking, reading or observation could have given me as much insight into planning, teaching, strategy, reacting to student responses, etc."
> "Truly interesting and educational. Really got me excited about working with the real victims."
> "It was neat to get the individual experience of being on my own and planning my own strategy. Got much more understanding of strategy and all."

Flake (1975) suggested that care should be taken in future simulation of classroom situations because they are abstracted from the real world. He noted that future teacher education CAI simulations need not be limited to teaching strategies and questioning behaviors.

Only a few programming languages are convenient for the handling of music data in the computer. Researchers at Stefan Bauer-Mengleberg Company have been trying to develop a prepackaged computer program that will recognize printed music and produce in the computer an alphanumeric code corresponding to music notation.

Prerau (1975) listed the following possible applications which a computer music recognition program could offer:

1. Read in an orchestral work and produce the separate parts for each instrument, or vice versa;

2. Obtain a piano reduction of a score;

3. Read in a newly engraved piece of music and proofread it for syntactic and other errors;

4. Transpose a music sample to any desired key;

5. Read various works in old editions and produce a new printing;

6. Replace the hand engraving process completely and print newly written music automatically (if the recognition program were extended to the recognition of handwritten music notation);

7. Read in a score and then play it out, using an appropriate audio-music-producing program (since the play-out program could be adapted as desired, the computer could be used as a combination musician and instrument);

8. Convert existing scores to Braille to aid blind musicians (a very complete system for denoting music notational symbols exists in Braille);

9. Read existing scores to transfer the data to storage or transmission media [p. 25].

Prerau reported that the Digital Optical-Recognizer Engraved-Music Information (DO-RE-MI) computer program is currently being tested at the Bauer-Mengleberg Company. This music recognition program is divided into three parts: the input section, the isolation section, and the recognition section. The input section takes a sample of music notation and digitizes it. The isolation section passes the isolated picture components to the recognition section which recognizes these components and produces a representation of the original music sample. Prerau noted that although DO-RE-MI is experimental in nature and its features need to be expanded, it represents an area of music research that can be of practical use.

LITERATURE AND RESEARCH ON COMPUTER-ASSISTED INSTRUCTION IN MATHEMATICS

The mathematics educator planning to use computers must make choices in order of importance. Zoet (1969) offered the following objectives for computer-oriented mathematics courses arranged in his order of preference:

> 1. To let students know about computers—impact on modern society and on mathematics.
>
> 2. To enable a student to understand the concepts involved in the design of a computer. This also consists of knowing about computers—but from a design point of view.
>
> 3. To develop a student's ability to use a particular computer in a manner that emphasizes its basic concepts and its potential for use.
>
> 4. To develop a student's ability to use a computer to solve some problems in mathematics in order that he can become aware of its potential and the strategies enlisted in using it to solve mathematical problems.
>
> 5. To develop the student's ability to use the computer to provide additional insight into some of the problems studied in classes such as advanced algebra.
>
> 6. To use the computer as an integral part of the teaching of advanced algebra (or other classes)—with all students required to use it in certain phases of the class.
>
> 7. To teach mathematics by programming the computer to interact with individual students in a fashion designed to achieve some particular behavioral objective [pp. 565-566].

A computer-augmented calculus course was developed and implemented by Bitter (1970) in the fall 1968 semester at Colorado College in Colorado Springs, Colorado. The four-credit elementary calculus course met weekly for three lecture-hours and one research hour. The instructor of the experimental CAI calculus course used the research hour for computer assignments and demonstrations. Twenty-six students initially enrolled in the experimental section; twenty-four of them completed the course. The topics of the calculus covered were limit, derivative, integral, and functions. It was necessary for students to understand a particular concept before running applicable computer programs.

Bitter (1970, p. 194) reported that no particular statistical test procedures were undertaken but recorded the following results of the final examination in Elementary Calculus:

CAI section (24 students)

Mean = 75
Median = 80

Non-CAI section (23 students)

Mean = 62
Median = 62

Bitter (1970) also listed the following selection of student comments on the CAI calculus course:

"Personally, I feel the time spent on computer programming was very worthwhile."

"It was stimulating and I think beneficial, both from the standpoint of future computer use and from that of disciplining the mind."

"It really helped in the section on functions and limits. It also showed effectively the way in which to find the area under a curve."

"I think the programs should be discussed in class to make them more worthwhile."

"The biggest disadvantage was the time spent on writing programs."

"Perhaps this course should be increased to 4-1/2 or 5 credits with more class time each week. This would make it better, I think, but even if that is not feasible, the course should still be continued."

"It was a good idea and I hope you do it again."

"I feel that the computer, on the whole, has been fun, challenging, and instructive."

"I am infinitely glad that the computer-oriented approach was offered. I wish we had a period to bring out and discuss the various programming ideas which different students used to solve a problem [p. 195]."

In 1969-1970 the United States Office of Educational Research sponsored the development of a computer-assisted program to guide undergraduate students in the learning of algorithms presented in an elementary numerical analysis course. Oldehoeft (1970) designed such a program to operate under the Purdue University Instructional and Computational Learning System language, referred to as PICLS.

According to Oldehoeft (1970) students in traditional numerical analysis courses are faced with the following problems: (1) The cumbersome arithmetic associated with such courses discourages students from working anything but the most simple problems; (2) The amount of material in traditional courses and arithmetic procedures makes it difficult to expose students to a variety of applicable problems; (3) Emphasis is usually placed on the mechanics and not the development of algorithms; (4) Very little verbal interaction takes place in the classroom; (5) The lectures are prepared for the average student, and little is done for weaker or stronger students; and (6) Most instructors cannot devote sufficient time to counseling students.

In developing his experimental program, Oldehoeft (1970) set the following objectives:

> 1. Design and implement a CAI program to teach computational mathematics and investigate the technical difficulties associated with constructing and using such a system;
>
> 2. Implement techniques that might be useful in an attack on problems 1-3 stated above; and
>
> 3. Experiment with the system in an attempt to determine student acceptance and compare this method with the conventional method of instruction [pp. 9-10].

Oldehoeft's program involved three stages: (1) A CAI tutorial presentation of the mathematical development of an algorithm is initially given to the student; (2) The student uses the computer as a tool to develop solutions to several required problems related to the algorithm; and (3) The student later uses the computer to develop the solutions to his own problems.

In keeping with the objectives of his investigation Oldehoeft (1970) sought answers to the following questions:

1. How do students react to the use of CAI for computational mathematics?

2. What expenditure in time and dollars is required by the teaching methods described. . . ?

3. How effective are these methods in teaching computational mathematics? [p. 63].

The findings of his study were limited because only three undergraduate students and one graduate assistant were selected from Purdue's numerical analysis course to use Oldehoeft's program. Three of the four students agreed that the tutorial mode of Oldehoeft's CAI program was beneficial, but suggested that the investigation mode should be dropped. The fourth student expressed a desire to retain all features of the CAI program. Although there is an obvious danger in drawing conclusions with small groups of students, Oldehoeft noted that the four CAI students, in comparison with other conventional students who completed equal mathematics semester-hours and achieved the same grade-point averages, performed as well on all course examinations.

The development and implementation of the experimental CAI program involved 100 man-hours at a cost of approximately 11 dollars per student for computer time.

No definite conclusions of the effectiveness of Oldehoeft's program can be drawn since his study was developmental in nature. It was suggested by Oldehoeft that other researchers use his program with larger samples.

Begle (1972) and the members of the Committee on Computer Education which was sponsored by the National Science Foundation made the following recommendations concerning computer education in secondary schools:

> A_1. We recommend the preparation of a junior high school course in "computer literacy" designed to provide students with enough information about the nature of a computer so that they can understand the roles which computers play in our society.
>
> A_2. We recommend that the process of preparing the text materials for the above course be such as to provide wide and rapid dissemination of information about the availability and feasibility of the course.
>
> B. We recommend that text materials for a number of other courses be prepared, including an introduction to computing, as a follow-up to the computer literacy course, some modules which integrate computing into high school mathematics courses, and other modules which utilize computers in simulating the behavior of physical or social phenomena and which enable the use of computers in the study of courses outside mathematics. (NOTE: While material exist for use in mathematics and science, the module-problem nature of the recommendation reflects a quite different approach . . .).
>
> C. We recommend the development of special programs for high school students showing unusual aptitude and promise in computer science.
>
> D. We recommend a major effort aimed at making vocational computer training more generally available and at the same time improving the quality of such training.
>
> E. We recommend that the National Science Foundation provide financial support for the development of a variety of programs for the training of teachers and of teachers of teachers of high school courses involving computers.
>
> F. We recommend the establishment of a clearinghouse for information about high school computer education [pp. 1-2].

Goguen (1972) rejected the view that computer science consists of tricks centered around the computer—a position which is held by some scientists and mathematicians. He indicated that computer science involves the theory of programming, the theory of process and processors, the theory of description of process and computational structures, and the theory of computer applications.

Goguen rejected the assertion that computer science is trivial. Computer science deals with the development of sophisticated and useful mathematical algorithms. In Goguen's opinion some of the algorithms developed in computer science courses can serve as a practical bridge between scientific and humanistic cultures. He noted that there are dangers in predicting the future of any new science.

Goguen (1972) stated that any science closely bound to mathematics, such as computer science, should be expected to be affected by current mathematical trends. He listed some recent trends in mathematics as algebracization, translation of algebra into category theory, and mathematical modeling. He suggested that computer science students should learn as much mathematics as possible, particularly algebra. In his view the mathematics studied by computer science students should be relevant and applicable to real life problems.

Marcus (1973) devised a system to provide computerized help with the essential mathematics required in chemistry, referred to as CHEMRIC. CHEMRIC consists of a diagnostic pretest used to determine specific mathematical abilities of students, and a computer program to analyze the pretest data and provide individual feedback related to problem explanations and homework exercises.

Four lecture sections of chemistry at Ohio State University implemented this remedial computer-assisted mathematics program. Students used the program to develop solutions of various mathematical problems which they had failed to solve correctly on the pretest. Although the findings of Marcus' (1973) doctoral study were related primarily to student performance on specific vaporization processes, it was noted that CHEMRIC aided students who were deficient in mathematics to perform calculations related to laboratory experiments.

Schoen (1973) stated that there is much resistance to the use of tutorial computer-assisted instruction. The main objections are that costs are high and CAI is not an improvement over existing modes of tutorial instruction.

Schoen devloped two CAI units to be used by 60 students enrolled in two sections of Precalculus Mathematics at Ohio State University. The first tutorial CAI unit (Unit A) included concepts prerequisite to the study of functions, such as sets, ordered pairs, and graphs. The second tutorial CAI unit (Unit B) included the definition of a function, functional notation, and graphs of functions. Both CAI units were based on a set of behavioral objectives developed by the researcher. The branched programmed CAI units were designed to help the students achieve the behavioral objectives.

Four types of feedback to incorrect responses were contained in the second CAI unit. Schoen (1973) offered the following explanations of each of the four types of feedback:

> I' - The student receives feedback following an incorrect response which states why his answer is incorrect and gives the correct response.
>
> II" - The student received feedback following an incorrect response which states that the given answer is incorrect and gives the correct answer with a reason why it is correct, but the feedback does not refer specifically to the student's response. . . .
>
> P' - The student's first name appears in some of the feedback to both correct and incorrect responses. The frequency of use of the first name was decided by what seemed reasonable to the researcher. The only pattern followed for use of the first name was that if the name was used in feedback to one response to a question it appeared in feedback to any response to that question. Hence, the student's error rate did not affect the frequency with which his first name appeared. To be exact, the name appeared in feedback to responses to 41 of 56 questions in Unit B.
>
> P" - The student's name never appeared in the feedback.
>
> The four types of feedback then were I'P', I'P", I"P', and I"P" which result from crossing the two levels of I with the two levels of P [pp. 5-6].

After the completion of units A and B the students took tests Q, R and S, and an attitude test (test T). The treatment in unit A was identical for all students, while the treatment in unit B was one of the four previously explained feedbacks for each student.

The null hypothesis of Schoen's study were: (1) There would be no significant differences between mean scores of the combined group I'P' and I'P" and the combined group I"P' and I"P"; and (2) There would be no significant differences between mean scores of the combined group I'P' and I"P' and the combined group I'P" and I"P" on each of the tests R, S and T. The hypotheses were tested using a two-way analysis of variance with R, S, and T test scores as the respective dependent variables.

In summarizing his research Schoen (1973) stated the following implications of his findings:

> (a) An important component of corrective feedback is an explanation of the concept in question if that explanation immediately precedes a new frame;
>
> (b) The attitude of students toward a CAI tutorial program is imporved by use of their names in the program; and
>
> (c) There is a direct relationship between student on-line time and attitude toward a CAI program [p. 11].

Within recent years Riedesel, Suydam, and Trueblood of Pennsylvania State University have devised a computer-assisted instruction program in modern mathematics teaching methods for elementary school teachers. An IBM 1500

Instructional Computer System with 16 mobile computer terminals was installed in Dryden, Virginia; in Gladeville, Virginia; and later in the States of California and Pennsylvania to administer this aforementioned computer-assisted course. This system was used during the evenings and late afternoons by elementary school teachers who commuted within a radius of approximately 20 miles.

Of the 444 students who used the mobile terminal stations, 387 completed the course. Fifty-five percent of the students were elementary school teachers; 19 percent were secondary school teachers; and the remainder were employed in private business. Two hundred forty of the students received credit from ten institutions of higher learning. The average course completion time was 19 hours. The shortest time for course completion was 12 hours, and the longest time was 56 hours.

A pretest and posttest of mathematics content were administered to students enrolled in this CAI course. The mean performance on the achievement test increased from 53 percent on the pretest to 73 percent on the posttest. Hall (1974) reported the results of evaluation of this CAI course:

> Perhaps the strongest demonstration of attitude toward the curriculum and the individualized instruction provided by computer-assisted instruction was the increased willingness and demand from the students to continue the daily schedule later and later into the evening hours as they became more involved with the course of study. . . .

> It has been demonstrated by this project that the concept of mobile computer assisted instruction is an effective means of providing inservice education in Appalachia. Mobile computer-assisted instruction has demonstrated the potential for providing high quality, individualized, inservice education to large numbers of students in sparsely populated areas [p. 61].

Although the use of the computer as an instructional tool has rapidly increased in colleges throughout the country, many college mathematics departments ignore the effects of CAI. Some mathematicians introduce the computer only as an application of the rules of symbolic logic.

Harrop (1975) offered the five factors that have inhibited the growth of CAI in college mathematics departments:

> (1) The tendency to dismiss mathematical logic as irrelevant has led to mathematics departments receiving far less stimulus in the recursivity (programming) area than might otherwise have been the case.
>
> (2) The extremely rapid developments in abstraction in pure mathematics over the last twenty years seem to have made interdisciplinary conversation even within pure mathematics itself increasingly difficult, and sometimes "unnecessary." Contact with computing has sometimes been seen as "unnecessary" and has often not occurred.
>
> (3) Real fears seem to exist among some mathematicians (a) that computing science brings with it lots of undesirable "easy options" into university courses and (b) that if mathematics gets too close to computing it would quickly be overpowered by it financially and in expansion possibilities.
>
> (4) There seems to have been a tendency by mathematics departments in some countries to reject anything which has a relation to physical reality, as if its inclusion would somehow affect the purity of the subject. Thus differential equations or even

abstract pure mathematics motivated from the theory of special functions can get classified as clearly "applied" mathematics. Computing science would probably find it difficult to get cooperation from such departments.

(5) Within applied mathematics sections of mathematics departments where physical problems are studied, there has sometimes been an undue emphasis on expressing the problems in a mathematically satisfactory form so that exact non-numerical calculations and investigations could be carried out, while reference to related experimental results was being considered as irrelevant or improper [p. 66].

Business, data processing, electrical technology, and mechanical technology departments on the college level have shown an increase in enrollment, while the number of mathematics majors is on the decline. Perhaps one of the reasons for this increase in enrollment is the use of automata theory in fields or occupations related to the departments mentioned above. According to Harrop (1975), college mathematics departments must experiment with CAI in a spirit of interdepartmental cooperation.

Harrop made a plea for experimentation in CAI instruction:

Whether we like the idea of the use of computers in education or not, we should not ignore the possibility of their being used. They will probably be used! Among mathematicians there seems at present to be much apathy toward CAI and where there is not apathy there is a tendency to polarized views of enthusiastic approval and antagonistic disapproval.

. . . If too few of us who are mathematics teachers or professors get involved in formulating a reasoned assessment of the potential for computer usage and in ourselves obtaining some firsthand

> experience in the development of some CAI programs, we may find ourselves in a few years time faced with a mass of second or third rate material and not be in a position meaningfully to assess it, or to see if it can be improved and, if so, how [p. 69].

Orchard (1975) supported Wegner's contention that if computer science education is developed as a form of general liberal arts education for a technical society, then educators need not be concerned with questions of supply and demand for computer scientists. Wegner is responsible for the Bachelor of Science and Master of Science programs in computer science, both of which were initiated in 1971 at Fairleigh Dickinson University in New Jersey.

The basic philosophy underlying Fairleigh Dickinson's computer science programs is a well-balanced course of study in computer architecture, software, applications, and theories. The B.S. program requires a solid background in the natural sciences, liberal arts, and humanities. A minor field of study and free electives have been provided for computer science majors.

Orchard (1975, pp. 293-294) formulated the following table of courses which comprise the B.S. computer science curriculum offered at Fairleigh Dickinson University:

B.S. COMPUTER SCIENCE CURRICULUM

Required Computer Science Courses	Credits
CS 250 Computer Laboratory	1
CS 206 Computer Laboratory	1
CS 241 Fundamentals of Digital Computer Systems	3
CS 245 Computer Systems	3
CS 246 Computer Systems	3
CS 252 Foundations of Computer Science	3
CS 255 Applied Mathematics for Computer Science	3
CS 256 Applied Mathematics for Computer Science	3
CS 291 Current Topics in Computer Science	3
CS 292 Current Topics in Computer Science	3
CS 308 Digital and Analog Computer Programming.	3
CS 371 Mathematical Modeling and Computer Simulation (Continuous)	3
CS 372 Mathematical Modeling and Computer Simulation (Discrete)	3
	35

Required Mathematics Courses	Credits
MA 201 Analytic Geometry and Calculus	4
MA 202 Analytic Geometry and Calculus	4
MA 203 Analytic Geometry and Calculus	3
MA 210 Differential Equations	3
MA 231 Advanced Calculus	3
MA 250 Numerical Analysis	3
	20

N.B. Selected topics in probability, statistics, matrix theory, combinatorics and operations research are covered in CS 255 and CS 256. Selected algebraic topics are incorporated in CS 252.

Required Liberal Arts Courses	Credits
EN 101 English Composition	3
EN 102 English Composition	3
SO 101 Sociology	3
SO 102 Sociology	3
	12

Required Science Courses	Credits
BI 101 General Biology	3
BI 102 General Biology	3
CH 111 Physical Principles of Chemistry	3

Required Science Courses (cont'd.)	Credits
CH 112 Physical Principles of Chemistry	3
PH 203 General Physics	4
PH 204 General Physics	4
	20

Electives	Credits
Liberal Arts Electives	14
Free Electives	27
	41

It is interesting to note the percentage distribution of courses in the B.S. curriculum: Mathematics 15.6%, Computer Science 27.4%, Science 15.6%, Liberal Arts and Humanities 20.4%, and Free Electives 21%. This distribution is in accordance with the philosophy of Fairleigh Dickinson University in providing a well-balanced undergraduate computer science curriculum.

Orchard (1975, p. 297) devised the following table of courses to describe graduate computer science curriculum at Fairleigh Dickinson University:

M.S. COMPUTER SCIENCE CURRICULUM

Program Prerequisites: Advanced Calculus and CS 705 (Introduction to Computer Programming) or their equivalent.

Required Core Courses

CS 703 Fundamentals of Computer Architecture
CS 706 Introduction to Computer Programming
CS 725 Systems Programming
CS 730 Mathematical Foundations of Computer Science
CS 540 General Systems Theory

Choose six elective courses for a concentration.

Systems Software

CS 726 Systems Programming
CS 733 Applied Mathematics for Computer Science
CS 734 Applied Mathematics for Computer Science
CS 742 Mathematical Modeling and Computer Simulation (Discrete)
CS 810 Special Topics in Computer Science (repeatable)
CS 841 Special Projects in Computer Science
CS 842 Advanced Special Projects

Theoretics

CS 735 Mathematical Logic
CS 761 Theory of Automata
CS 762 Theory of Automata
CS 765 Theory of Recursive Functions
CS 810 Special Topics in Computer Science

Computer Applications

CS 510 Numerical Techniques
CS 733 Applied Mathematics for Computer Science
CS 734 Applied Mathematics for Computer Science
CS 741 Mathematical Modeling and Computer Simulation (Continuous)
CS 742 Mathematical Modeling and Computer Simulation (Discrete)
CS 841 Special Projects in Computer Science
CS 842 Advanced Special Projects
CS 541 Seminar in General Systems Theory
Electives (3-6 credits in fields of computer application)

LITERATURE AND RESEARCH ON INSTRUCTION IN STATISTICS

Hartman and Schoonard (1967) were among the first researchers to advocate the implementation of a computer-assisted statistics course on the undergraduate level. They developed a CAI problem laboratory for introductory statistics consisting of a workbook, a prepackaged program which provides procedural or step-by-step tutoring for homework problems, and additional classroom problems stored in the memory of a computer. Their workbook and prepackaged subroutines or programs consist of 13 units in descriptive and inferential statistics. Units in the workbook contain solutions to problems typical of homework problems to be solved by students.

For implementation of their program Hartman and Schoonard made the following suggestions:

> One feasible course paradigm using the CAI problem laboratory is as follows: A student is introduced to a particular concept by reading an assignment in a textbook and attending lectures. He reviews the worked examples and attempts to solve the homework problems in the workbook. When he has completed the problems to the best of his ability, he goes to the computer for a tutored recitation [p. 2].

They further suggested that a number of details, such as articulation with printed materials, alterable content, efficient tutoring, student preparation, and review materials must be considered when designing CAI statistical programs.

In 1967 the Office of Computing of the National Science Foundation initiated a conference to ascertain and summarize current views of the role of the computer in various aspects of the undergraduate curriculum.

Lockard (1967) reported that members of the Statistics Panel at this conference made the following recommendations for immediate action: (1) development of case studies for exploring data analysis; (2) collation of sets of data for sample statistical problems; (3) exploration of the feasibility of a current nationally available time-sharing system in undergraduate statistics courses; and (4) the support of statistical software packages and systems.

The Statistics Panel also urged the establishment of an ongoing program before carrying out the foregoing recommendations. Lockard (1967) stated that such an ongoing program should move simultaneously in the following ways:

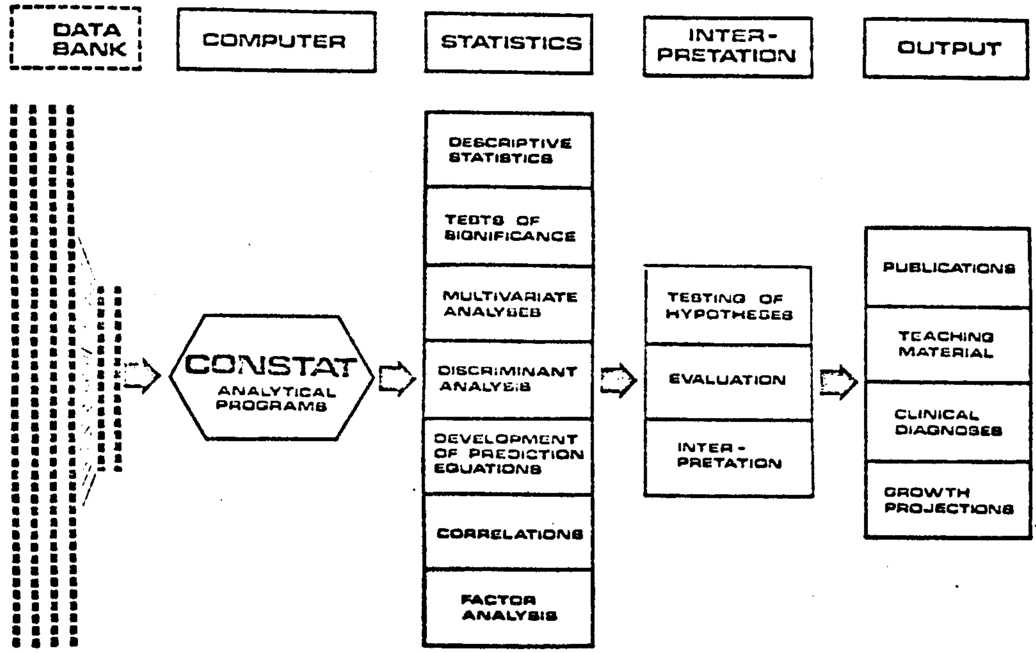
> 1. Much has to be done, as was noted above, to make available bodies of diverse well-documented and relevant data.
>
> 2. The methods and techniques to be applied to these and other bodies of data need to be supplemented and re-examined.
>
> 3. New textual materials will have to be prepared.
>
> 4. Software components making widely different demands upon the computer sophistication of users and upon the character, complexity and power of hardware need to be prepared.
>
> 5. All these activities need to be coordinated gently enough to avoid unnecessary road blocks along the way, but firmly enough to avoid unnecessary incompatibilities in the products (There will be many necessary incompatibilities!) [p. 32].

Members of the Statistics Panel further urged the National Science Foundation to support two planning stages for the fiscal year 1968. The first recommended planning stage was concerned with identifying professionals who would be willing to participate in the development of CAI statistics materials. This stage also involved the collation of background material for the development of these materials and a survey of current programs in computer-assisted statistics. The second recommended planning stage involved the organization of a two-week summer institute to be attended by 20 to 40 selected educators and specialists who would benefit from the development of CAI statistics materials. The members of the institute would decide on the format, formal sponsorship, and details of implementation of a CAI statistical program.

For his doctoral study Crothamel (1969) formulated a statistical unit in which statistical concepts were simulated on a computer. He used a problem-solving approach in which students are asked to simulate the type of statistical work done by research teams. Crouthamel included problems which applied statistics to topics in mathematics, science, education, and philosophy. Crouthamel's investigation was developmental in nature, and no evaluation of his statistical unit was undertaken.

Kowalski (1972) discussed the implementation of a statistics course for graduate students in the School of Dentistry at the University of Michigan. This course—Design and Analysis in Research—had three main objectives. The first objective was to provide graduate students with sufficient knowledge of statistics for analyzing the statistical content of the articles appearing in journals of dentistry. The second objective was to employ the use of calculators and/or computers for descriptive statistical procedures on numerical data and use this information to draw statistical inferences. The final objective was to facilitate the interaction of students with consulting statisticians on complex problems.

The Research Laboratory at the University of Michigan utilizes a computer program called CONSTAT which is a console-oriented, user-prompting computing system. CONSTAT provides a number of subroutines or small computer programs that perform descriptive statistical techniques on numerical data and analyzes these data. The students learn how to communicate with the computer via a remote computer terminal using English instead of a programming language.



Kowalski (1972, p. 72) devised the above flowchart to illustrate how students at the University of Michigan use CONSTAT.

Tack (1972) developed a program in statistics which centered on the use of the PDP-12 mini- or small digital computer. For his doctoral study Tack investigated the following subproblems: (1) the feasibility of using the PDP-12 with a 4K core memory for instructional purposes; (2) the development of selected statistical topics; (3) the development of necessary software to implement these statistical topics; and (4) the selection of a method for creating statistical units.

The two statistical concepts studied were linear regression and correlation. Instruction was given to students at Iowa State University with the use of the cathode ray tube and the teletype interchangeably. The software developed for implementing the curriculum consisted of the following routines: (1) display point, (2) add point, (3) delete point, (4) line display, and (5) a print text program. These software packages were used by the investigator to give computer-assisted instruction. In Tack's developed program students were allowed to explore the statistical units in any order they choose. Tack found the PDP-12 with 4K to be limited in basic statistical calculations. Since his study was developmental in nature no experimentation or evaluation of Tack's program was undertaken to compare the effectiveness of this system to another system or to another teaching approach.

Neter and Chervany (1973) reported on their investigation of changes in attitudes of students who completed a graduate statistics course in which computers were utilized at the University of Minnesota. Graduate students in the School of Business Administration at the University of Minnesota are required to take a basic two-quarter statistics course consisting of introductory probability, statistics, and decision making. This basic course may be followed by an optional intermediate course consisting of advanced inferential statistics and nonparametric statistics. Each of these three-credit courses meets twice a week for one hour and fifteen minutes. Neter and Chervany integrated the use of a CDC3200 computer and the OMNITAB programming language into both the basic and intermediate statistics courses. They administered a nine-page questionnaire concerning student attitudes at the beginning of each course. After completing the courses the students were given a followup questionnaire. The main objective of the questionnaires was to measure changes in student attitudes concerning the value of using computers in the teaching of statistics, as well as in business applications. Neter and Chervany (p. 136) reported their findings in the following table:

Student Attitudes on Value of Computer in Statistics Course

A. Basic Statistics Course (n = 34)

Value of Computer for:	Pre-course Mean	Post-Course Mean	Percent Changing in Deviant Direction
1. Real-world problems	5.53	5.97	24
2. Homework computations	5.09	6.15*	18
3. Correct conclusions in homework	4.03	4.68*	15
4. Understanding ideas	3.68	3.85	33
5. Increased course coverage	4.09	2.79*	15
6. Reduced class time	3.27	2.56*	18

B. Intermediate Statistics Sequence (n = 23)

Value of Computer for:	Pre-Course Mean	Post-Course Mean	Percent Changing in Deviant Direction
1. Real-world problems	5.78	5.96	30
2. Homework computations	5.57	6.17*	9
3. Correct conclusions in homework	4.48	4.61	30
4. Understanding ideas	3.74	4.13	22
5. Increased course coverage	3.17	3.61	13
6. Reduced class time	2.70	3.22	26

*change significant at .05 level

Neter and Chervany determined that there were no significant attitude changes, and reported the following findings of their study:

1. The increased evaluation by students of the computer's ability to aid with homework was encouraging, if somewhat predictable.

2. The decreased assessments by students in the basic course of the computer's value for increasing course coverage and reducing formal class time, in contrast to the increased assessments by the intermediate sequence students, are understandable. In a basic course which emphasizes statistical concepts, the computer may assist in obtaining an understanding of concepts without, however, saving time. In an intermediate sequence which focuses relatively

> more on statistical techniques, on the other hand, the computer may indeed permit increased course coverage.
>
> 3. The lack of substantial increase in student assessments of the computer's ability to help with an understanding of statistical concepts was most surprising. Much of our use of the computer, particularly in the basic course, was intended to assist in the learning of concepts and not merely as a large computational device. In the absence of a controlled experiment which could have provided definitive information as to whether possible explanations may be considered:
>
> a. A change in attitudes occurred, but our crude measurement instrument failed to detect it.
>
> b. Students obtained a better understanding of statistical concepts but did not perceive the computer's role.
>
> c. Students did not obtain a better understanding of statistical concepts.
>
> Our personal observations in class could lead us to reject (c). Students asked more sophisticated questions regarding concepts in class than previously, and their ability to utilize the statistical concepts appeared stronger than in earlier years. Personal impressions, however, are not a substitute for a controlled experiment [p. 138].

For a number of years Hope College in Holland, Michigan offered a standard two-semester course in mathematical probability and statistics. Each semester consisted of three lecture-and-discussion periods a week and offered three undergraduate credits. Tanis (1973) modified this course by adding a two-hour computer laboratory for one credit to each semester of the course.

In this computer laboratory, which is still operating in 1975, students utilize an IBM 1130 computer and a number of prepackaged computer programs to make empirical applications to many of the theoretical concepts which are proved in class. The first hour of the laboratory is spent in discussion of the computer printouts for the previous week's assignment; the second hour is devoted to introducing and running the new assignment.

Tanis developed his laboratory materials from June, 1971 through August, 1973 and presented these materials for the first semester at the 1972 Conference on Computers in the Undergraduate Curricula. These materials contained empirical solutions to problems in descriptive statistics, counting, and probability. Tanis also later presented the computer laboratory materials for the second semester at the 1973 conference. These materials contained empirical solutions to problems in inferential statistics.

During the 1973 Computer Conference, Tanis offered the following brief report on student reaction, faculty evaluation, and summation of the initial two-hour computer laboratory organized for the fall 1972 mathematical probability and statistics course at Hope College:

STUDENT REACTION

> This laboratory has been taken by two classes of junior and senior mathematics and science majors. The general reaction of most of the students to the

laboratory has been favorable. Of the 25 students in this year's class who responded to the question "Did the laboratory help you understand more clearly the theoretical concepts?", 18 said yes, 4 said no, and 3 said somewhat.

One student thought the laboratory was very helpful in highlighting the material in class. Another said it took a lot of time but was interesting and helpful. Still another student felt that many of the theoretical principles of statistics were reinforced by the lab work. A few students suggested that the use of more data which had been collected in science laboratories would have been interesting. For one student the laboratory was not beneficial because she generally believed the theoretical concepts without the empirical printout. . . .

FACULTY EVALUATION

August 14-18, 1972, we held a conference at Hope College for 51 college teachers of statistics from the midwest and east. During this conference we described our use of the computer in our statistics curriculum. From this conference we received both written and verbal comments, some of which I would like to summarize.

It is not always possible to add a laboratory because of insufficient staff time or in adequate facilities. In such cases it is perhaps possible for students to write only a few computer programs while the instructor illustrates most of the ideas with printouts or transparencies. However mathematics majors might be less intrigued with just seeing others' results without actually being able to perform the exercises on their own. Also students seem to gain intuition when they use the computer.

A valuable by-product of the statistics laboratory is the opportunity for students to do some research as undergraduates. Their mathematical maturity and background may not be sufficient to prove certain results theoretically but they are able to obtain answers empirically. . . .

SUMMARY

A computer laboratory in statistics provides new and interesting challenges to both student and

> teacher. A lot of extra time is required. However if the exercises are meaningful and not just busywork, the time is well spent [p. 10].

For his doctoral dissertation Ozarowski (1973) designed a CAI statistics curriculum using the Coursewriter Interactive Language to teach statistics by use of a remote teletype terminal and the Assembler Programming Language (APL) to enter and manipulate statistical data. After designing the CAI statistics curriculum, he used the principle of matched pairs to randomly select the experimental and control groups. Each group consisted of 23 adult employees, ages 22-53, of the Quality Control department of IBM Corporation, East Fishkill, New York.

Ozarowski implemented his CAI statistics curriculum with the experimental group. Only minimal classroom instruction concerning the inputting of data was presented to the experimental group, who received instruction from a teaching program written in the Coursewriter Language and ran sample problems using prepackaged statistical programs. The emphasis of the Coursewriter teaching program was on the understating, interpretation, and application of statistical concepts.

The adult control group received instruction in the same statistical concepts, which were presented by another instructor who used the traditional lecture method and also emphasized understanding, interpretation, and application of statistical concepts.

Both the control and experimental groups covered the following topics: types of distributions, measures of central tendency, measures of dispersion, normal distributions, hypothesis testing, correlation, and probability. A pretest and posttest were administered to each group. The items on these tests were obtained from the United Armed Forces Institute.

Ozarowski listed the following as limitations of his study: the test questions were confidential and could not be reprinted; and the findings were restricted by the size of each sample (23) and the ages of the students (22-53).

Ozarowski (1973) sought to answer the following questions:

> 1. Can the basic fundamentals of statistics be learned through the use of an integrated computer system using the APL and Coursewriter languages?
>
> 2. If learning results, is there a significant difference in learning between subjects instructed via the traditional classroom method and those receiving instruction through the computer assisted instruction method?
>
> 3. If learning takes place, is there a significant difference in the amount of time taken to learn statistics via an integrated computer system method of instruction as opposed to a traditional classroom method of instruction?
>
> 4. Is the ability to compute statistical formulas a requirement for learning and applying the basic concepts of statistics [pp. 6-7]?

The findings revealed that comparison of the group mean and the population mean on the posttest showed a significant difference beyond the .01 level of significance. Therefore Ozarowski's answer to question one was that learning did take place in the experimental group.

The initial test comparing the mean changes on pretests and posttests of the experimental and control groups indicated no significance at the .05 level. However, using the formula for analysis of covariance, Ozarowski determined that the F-ratio was significant at the .05 level. Therefore the researcher's answer to question two was that the learning which took place in the experimental group was significantly greater than that which took place in the control group.

Students in the control group took 18 hours to complete the statistics course, while members of the experimental group worked at their own rates, with many students taking less than 18 hours and some students taking more than 18 hours to complete the course. The experimental mean time was determined to be less than the control mean time. A t-test comparing the mean times of the two groups showed a significant difference at the .01 level of significance. The investigator therefore concluded that the experimental group mean time was significantly less than the control group mean time at the .01 level of significance.

Ozarowski (1973) thus ascertained that learning did take place in the experimental group; learning in the experimental group was greater than that in the control group; and the experimental mean course completion time was less than that of the control group. The practice of computation by use of statistical formulas was not required for the experimental group. Therefore, in responding to question four, the researcher concluded that the ability to compute by use of statistical formulas was not a requirement for learning and applying statistical concepts.

At Ohio State University Skavaril (1974) noted the lack of development of CAI instructional programs in elementary statistics. He developed a computer-based approach to Genetics 650: Analysis and Interpretation of Biological Data. Genetics is a one-quarter introductory course in biological statistics which was originally presented with one required two-hour laboratory period and four required one-hour lecture periods per week for ten weeks. Skavaril used a computer-based approach to Genetics 650 which included the following software: 29 modules of computer-assisted instruction; nine programs which generate statistical problems; 21 analysis programs; and various programs supplied by the University. Skavaril stated that his computer-based instruction of Genetics 650 offers advantages as compared to the traditional approach to this course, which he also instructed. Students can proceed through the course at their own pace, which is dependent on their individual abilities and course loads.

Skavaril (1974, p. 37) also determined the following comparison of average class hours for 70 students enrolled in the computer-based approach and for 50 students enrolled in the standard lecture approach used:

	Computer-Based Mean	Standard Lecture Mean
Lecture hours	3.2	32.8
Laboratory hours	3.0	20.0
CAI hours	21.7	0.0
Computer-analysis programs	8.0	0.0
Examination hours	3.4	3.4
Total course hours	39.3	56.2

These statistical findings indicate that the students enrolled in the computer-based section spent less time to complete Genetics 650 than students enrolled in the standard lecture section.

Skavaril (1974, p. 38) also reported the following statistical data concerning the final examination in Genetics 650:

	Computer-Based	Standard Lecture
Mean	0.60	0.57
Variance	270.68	363.32
Standard Error of the Mean	1.97	2.69

These statistical findings indicate that the computer-based approach yielded results at least as good as the standard lecture approach.

CHAPTER 3

SUBJECTS, MATERIALS, AND PROCEDURES

This chapter includes: (1) a description of the subjects or undergraduate students who were taught the contents of the curriculum as implemented by the instructor; (2) a description of the contents of the packet of materials sent to experts in the field, which constitutes the present investigator's proposed curriculum for a one-semester undergraduate course in elementary computer-assisted statistics; (3) a report on the correspondence to and from these specialists concerning the content and validation of the investigator's proposed curriculum; (4) an outline of the final, validated curriculum; and (5) the instructional procedures for testing the curriculum in an actual classroom situation with one designated section of undergraduate students taught by an instructor other than the present investigator.

SUBJECTS

The final, revised curriculum was tested with one designated section of computer-assisted statistics at Queensborough Community College of the City University of New York. This designated section contained 19 matriculated Liberal Arts students who were non-mathematics majors. The prerequisite for this course is completion of Math 20: Intermediate Algebra, or a satisfactory score on the Omnibus Placement Test administered by the Department of Mathematics at Queensborough Community College. Although the CAI statistics course satisfies Queensborough's general Liberal Arts requirements in mathematics for all students, a large majority who enroll in this course are pursuing a two-year program in Environmental Health or one in Medical Laboratory Technology.

MATERIALS

In order to answer Question One the investigator devised a packet of CAI statistics materials, consisting of a specifically stated sequence of proposed statistical topics and 13 prepackaged statistical programs, each of which included a general description and purpose, flow-chart, and coding in the Basic programming language. The purpose of this packet was to describe the proposed one-semester elementary computer-assisted statistics course in which algorithms and prepackaged computer programs are used as practical tools to solve statistical problems. In January, 1975 the investigator sent an explanatory letter (Appendix B, p. 139), together with the packet of CAI statistics materials to 12 experts (Appendix A, p. 137) in the field of computer-assisted instruction and statistics. A Curriculum Evaluation Questionnaire (Appendix C, p. 141) was submitted to ascertain these experts' perceptions of the content, sequence, and practicability of the proposed CAI curriculum.

By March 15, 1975 the investigator had received responses from ten of the 12 experts to whom the CAI materials were mailed (sample responses, Appendix D, p. 144). In May, 1975 he sent a follow-up letter (Appendix E, p. 150) to the two experts who had not responded. By July 1, 1975 no responses had been received from these two experts, and no further letters were sent to them.

In general, six of the experts agreed that the proposed CAI statistics curriculum was viable as presented, and recommended that this curriculum be implemented without changes. The other four experts suggested that the present investigator should carefully select and offer a sufficient number of problems for each of the 13 prepackaged programs in the proposed CAI statistics curriculum. Two of these aforementioned four experts suggested minor changes for clarity and brevity in the prepackaged programs called STAT2, STAT3, STAT4, and STAT5.

The investigator and his mentor carefully scrutinized these respondents' recommended curriculum changes and, in accordance with these suggestions, made the following changes: (1) One exercise for each of the prepackaged statistical programs was added to the packet of CAI materials; (2) The DATA statements in STAT2, STAT3, STAT4, and STAT5 were assigned the same statement number in each of the programs; (3) STAT3 was amended to avoid the computer overflow in large counting problems; and (4) STAT4 was changed so that the computer would add the partial sums for multiple binomial probability problems.

The investigator then formulated his final elementary computer-assisted statistics curriculum (Appendix O, p. 175) as validated by the jury of experts.

PROCEDURES

During the fall 1975 semester one instructor, other than the present investigator, implemented the final validated CAI curriculum with one class of 19 Liberal Arts students at Queensborough Community College. The instructor used an algorithmic approach in which flow-charting and prepackaged computer programs were utilized as practical tools in the solution of elementary statistical problems. He administered three unit tests and a final examination to the students enrolled in this CAI course.

The questions on the unit tests and final examination were selected from Johnson's Test Item Card File for Elementary Statistics 1974. The statistical test items in this publication had been validated by its author (Appendix F, p. 152), a professor of mathematics at Monroe Community College in Rochester, New York. The present investigator received written letters of permission from both the author and the publisher (Appendix F, p. 152) to use certain statistical test items for the unit tests and final examination.

In order to answer Question Two concerning student performance on unit tests and the final examination, the investigator computed measures of central tendency—the mean, median, and mode. Measures of variation—range, variance, and standard deviation—were also calculated for each of the unit tests and for the final examination (Appendix G, p. 156).

In reference to Question Three concerning test score comparisons, the present investigator compared early test scores with later test scores to determine whether there was a higher academic achievement as the topic content of the material presented became more comprehensive. He tested the hypotheses that the class mean of Unit Test Two was greater than that of Unit One; that the class mean of Unit Test Three was greater than that of Unit One; and that the class mean of Unit Test Three was greater than that of Unit Test Two. The prepackaged program STAT9 (Appendix O, p. 175) was used to test each of these three motivated hypotheses at the .95 level of significance.

In order to answer Question Four concerning conceptual and psychomotor learning difficulties encountered by students when processing prepackaged computer programs and operating computer terminals, the investigator employed the following procedure. He formulated an Observation Rating Scale for Psychomotor and Conceptual Learning Difficulties (Appendix I, p. 160) for use by two professionally qualified and experienced computer laboratory technicians selected by the investigator to serve as observers, and for use by the present investigator himself. This Observation Rating Scale, consisting of six specified psychomotor and six specified conceptual learning skills necessary for operating a computer terminal was submitted for validation to three experts (Appendix J, p. 163) of The City University of New York (CUNY) in the field of testing and computer science. The present investigator and the two selected observers subsequently employed this validated instrument for the initial observation of the selected group of students. The three observers later worked to remove any difficulties or ambiguities inherent in the Observation Rating Scale, and interacted concerning their findings. Using Kendall's Coefficient of

Concordance (Siegel, 1956, pp. 229-239; Ferguson, 1971, pp. 313-320) the investigator then computed the coefficients of interrater reliability. Upon obtaining a statistically acceptable interrater reliability, he then observed the sample population a second time and recorded further observations related to students' psychomotor and conceptual skills.

After this final observation of students the investigator computed the mean, variance, standard deviation, and standard error of the mean for each of the 12 items on the Observation Rating Scale (Appendix I, p. 160).

In order to answer Question Five concerning the perceptions of students regarding course presentation, content, and sequence, the investigator interviewed each of the nine students who completed the course outside the classroom situation. He asked each student 20 questions devised by himself and the two selected observers (Appendix M, p. 169).

A frequency distribution showing the percent of Yes, No, and Undecided responses to each of the first 19 questions was formulated (Appendix N, p. 173), and additional student comments were received and reported in reply to the last question on the Student Questionnaire.

Finally, the instructor of the course was interviewed by the investigator regarding his perceptions of the quality and quantity of the curriculum content, level of unit or topic difficulties, specifics of the course sequence presented, and students' responses and their academic performance. The instructor's perceptions and opinions were reported and compared with those of the students.

CHAPTER 4

FINDINGS

The purpose of this chapter is to report and analyze the obtained data in the following related areas: (1) the validation of the proposed computer-assisted statistics curriculum; (2) student performance on each of the unit tests and the final examination administered during the CAI course; (3) specific psychomotor and conceptual learning difficulties encountered by students when processing prepackaged computer programs and operating computer terminals; and (4) perceptions of students and the instructor concerning course presentation, content, and sequence.

VALIDATION OF THE PROPOSED COMPUTER-ASSISTED STATISTICS CURRICULUM

In January 1975 the investigator sent an explanatory letter (Appendix B, p. 139), a packet of CAI statistics materials, and a Curriculum Evaluation Questionnaire (Appendix C, p. 141) to 12 experts (Appendix A, p. 137) in the field of computer-assisted instruction and statistics. By March 15, 1975, the investigator had received responses from ten of these 12 experts. A follow-up letter failed to produce further responses from the remaining two experts.

In general, six of the ten responding experts agreed that the proposed computer-assisted statistics curriculum was viable as presented, and suggested that this curriculum be implemented without changes. The other four of the ten responding experts recommended that the present investigator should carefully select and offer a sufficient number of problems for each of the 13 prepackaged programs in the CAI statistics curriculum. Two of these aforementioned four experts suggested minor changes for clarity and brevity in the prepackaged programs called STAT2, STAT3, STAT4, and STAT5.

The investigator and his mentor carefully scrutinized these respondents' suggested curriculum changes and, in accordance with these suggestions, made the following changes: (1) One exercise for each of the prepackaged statistical programs was added to the packet of CAI materials; (2) The DATA statements in STAT2, STAT3, STAT4, and STAT5 were assigned the same statement number in each of the programs; (3) STAT3 was amended to avoid computer overflow in large counting problems; and (4) STAT4 was changed so that the computer would add the partial sums for multiple binomial probability problems. The investigator then formulated his final elementary computer-assisted statistics curriculum (Appendix O, p. 175) as validated by the jury of ten experts.

ANALYSIS OF STUDENT PERFORMANCE ON CAI UNIT TESTS AND FINAL EXAMINATION

During the fall, 1975 semester one instructor, other than the present investigator, implemented the final validated computer-assisted statistics curriculum with one class of 19 Liberal Arts students at Queensborough Community College. He administered three unit tests and a final examination. The questions on the unit tests and final examination were selected from Johnson's Test Item Card File for Elementary Statistics (1974). The statistical test items in this publication had been validated by its author (Appendix F, p. 152), a professor of mathematics at Monroe Community College, Schenectady, New York.

Unit Test One consisted of items from Basic programming and descriptive statistics. Unit Test Two was based on material related to sophisticated counting and probability. Unit Test Three contained selected problems from inferential statistics. The final examination covered topics for each of the previously administered unit tests.

The investigator subsequently computed the mean, median, mode, variance, and standard deviation for each of the unit tests and for the final examination (Appendix G, p. 156). Three of the 19 students enrolled in the computer-assisted statistics course withdrew from the course before Unit Test One was administered (n = 16 for Unit Test One). Three students were absent for Unit Test Two, and three additional students withdrew from the course before this second test was administered (n = 10 for Unit Test Two). One student was absent for Unit Test Three, and three more students withdrew from the course before taking the third test (n = 9 for Unit Test Three). These nine remaining students completed the final examination (n = 9 for final examination).

Sixteen students obtained a mean score of 59.69 on Unit Test One. On Unit Test Two the ten remaining students obtained a mean score of 70.50. Nine students obtained a mean score of 84.00 on Unit Test Three. Nine students obtained a mean score of 72.33 on the final semester examination. The final evaluative grades obtained by the nine students who completed this CAI statistics course were as follows: two students obtained a grade of A- (90-95); one student obtained a grade of B (84-86); two students obtained a grade of B- (80-83); two students obtained a grade of C (74-76); and two students obtained a grade of F (0-59). These test results and final evaluative grades indicate that a high majority of the nine students completing this CAI statistics course succeeded on the unit tests and the final examination.

COMPARISON OF MEAN SCORES
OF STUDENTS ON THREE
CAI UNIT TESTS

In reference to Question Three concerning comparisons of the three unit test scores, the investigator employed the student's t-test to determine whether significant differences existed between (1) the class mean (70.50) of Unit Test Two scores and the class mean (59.69) of Unit Test One scores; (2) the class mean (84.00) of Unit Test Three scores and the class mean (59.69) of Unit Test One scores; and (3) the class mean (84.00) of Unit Test Three scores and the class mean (70.50) of Unit Test Two scores.

The investigator determined the following findings: (1) The mean of Unit Test Two scores was significantly greater than the mean of Unit Test One scores, as indicated by a calculated t = 1.51555 which was significant at the .10 level (Appendix H, p. 158). (2) The mean of Unit Test Three scores was significantly greater than the mean of Unit Test One scores, as indicated by a calculated t = 3.32225 which was significant at the .005 level. (3) The mean of Unit Test Three scores was significantly greater than the mean of Unit Test Two scores, as indicated by a calculated t = 1.70163 which was significant at the .10 level. Thus the mean scores of Unit Tests taken later in the course were significantly greater than the mean scores of unit tests taken previously.

PSYCHOMOTOR AND CONCEPTUAL LEARNING DIFFICULTIES ENCOUNTERED BY STUDENTS

In order to answer Question Four concerning psychomotor and conceptual learning difficulties encountered by students when processing prepackaged computer programs and operating terminals, the investigator formulated an Observation Rating Scale for Psychomotor and Conceptual Learning Difficulties (Appendix I, p. 160). This Observation Rating Scale, consisting of six specified psychomotor and six specified conceptual learning skills necessary for operating a computer terminal, was validated by three experts of The City University of New York who work in the field of testing and computer science (Appendix J, p. 163).

During the second week of the fall, 1975 semester the investigator and two qualified observers selected by him subsequently employed this validated instrument for the initial observation of the class of 19 students. Each of the three observers observed each of the 19 students initially enrolled in the computer-assisted statistics course. The investigator then employed the statistical technique of Kendall's Coefficient of Concordance (Siegel, 1956, pp. 229-239; Ferguson, 1971, pp. 313-320) to determine interrater reliability for each of the items on this Observation Rating Scale.

Each of the 12 skills observed yielded a high coefficient of concordance (Appendix K, p. 165). The observed Chi-square value for each of these 12 skills (Appendix K, p. 165) was then determined to be significant at the .01 level. After obtaining significant coefficients of concordance (W) and related Chi-square (χ^2) values for each of the 12 psychomotor and conceptual skills, the investigator was able to establish interrater reliability between observers for each skill.

The investigator and the two selected observers then met to discuss their individual observations. In general, they agreed on the following perceptions: (1) There were no difficulties observed on Psychomotor Skills One (use of ON-OFF and LINE-LOCAL terminal switches) and Two (contacting the computer *via* a telephone call). (2) Some minor student difficulties were observed for Psychomotor Skills Three (use of acoustic coupler), Four (use of terminal keyboard), Five (punching program on tape), and Six (operation of papertape reader). (3) No student difficulties were observed on Conceptual Skill Three (commanding the computer to run a prepackaged program). (4) Minor student difficulties were found for Conceptual Skills One (loading the prepackaged program), Two (entering data), Four (interpreting computer output), and Six (loading a second prepackaged program). (5) Considerable student difficulties were observed on Conceptual Skill Five (editing data).

Two weeks after the first observation of students, the investigator observed the 19 students a second time. The resultant high mean values and low standard error values (Appendix L, p. 167) for each of the 12 skills on the Observation Rating Scale indicated that most students experienced no psychomotor or conceptual learning difficulties at the time of this second observation.

The investigator concluded that although most of the students in this CAI course initially had some psychomotor and conceptual difficulties operating a computer terminal, they appeared to overcome these difficulties reasonably after two or three practice sessions.

PERCEPTIONS OF STUDENTS AND INSTRUCTOR REGARDING COURSE PRESENTATION, CONTENT, AND SEQUENCE

During the last week of the fall, 1975 semester the present investigator interviewed for approximately 30 minutes each of the nine students who completed this computer-assisted statistics course. He obtained their perceptions of the course presentation, content, and sequence by asking each student 20 questions (Appendix J, p. 163) devised by the two selected observers and himself.

The investigator then formulated a percent of frequency distribution of Yes, No, and Undecided responses to each of the first 19 questions (Appendix N, p. 173). Seven of the nine students (77.8%) completing this CAI course indicated the following: (1) The running of prepackaged programs enhanced their appreciation and knowledge of computers (Question 6). (2) This CAI statistics course apparently gave students a general appreciation and understanding of elementary statistics (Question 11). (3) Flowcharting was useful in the solution of statistical problems (Question 12). (4) The topics covered in this CAI course were presented in a logical and sequential order (Question 18). (5) The instructor's teaching of the subject matter was covered clearly and logically (Question 16).

Six of the nine students (66.7%) stated that: (1) in general they liked this CAI statistics course (Question 2). (2) They gained self-confidence in using the computer as a tool to solve statistical problems (Question 10). (3) They would rather take a statistics course using a computer than take the same course without using a computer (Question 17). (4) The contents of questions covered on the unit tests were adequately covered by the instructor in class (Question 19). Five of the nine students (55.6%) were of the opinion that: (1) They were under some pressure in this CAI statistics course (Question 1). (2) The students' academic backgrounds in mathematics were generally inadequate for this course (Question 3). (3) The statistical techniques presented were not of practical use (Question 4). (4) The statistical problems presented seemed to be worthwhile and practically related to everyday life (Question 5). (5) This CAI course attempted to cover too much material in too short a time (Question 13). (6) There should have been more computer laboratory technicians available for individual instruction (Question 14). (7) Students did not develop a more positive attitude towards mathematics (Question 15).

Four of the nine students (44.4%) stated: (1) They were able to think clearly when working statistical problems in class (Question 7). (2) They became confused when attempting to operate computer terminals in class (Question 8).

The following four verbatim responses to the last question (Question 20) were made by the students to the investigator as general comments on this CAI statistics course as a learning experience:

"More work with computer."

"I think that this course was very difficult and that the tests should have been easier. However, the professor is an excellent teacher and helped us very much in understanding the work as much as possible."

"Our professor is a good statistics instructor; however his tests are extremely hard and cover too much material on each test. He does take time out to help his fellow students. But his tests are too much to cope with."

"It would be better if there are more examples."

The investigator later discussed various aspects of this computer-assisted statistics course with the instructor, who offered the following comments: (1) Flow-charting and prepackaged computer programs serve as practical tools in the solution of statistical problems. (2) The topics in this investigator's CAI statistics curriculum were, in general, developed in a logical and sequential order. (3) The academic deficiencies of the particular students enrolled in this instructor's CAI statistics course appeared to be greater than the academic deficiencies of students enrolled in statistics courses previously taught by this instructor at Queensborough Community College.

The investigator therefore concluded that the students and the instructor appeared to be in general agreement that the computer-assisted statistics curriculum was presented in a logical and sequential order. They also seemed to be in general agreement as to the use of flowcharting and prepackaged computer programs as practical tools in the solution of statistical problems. However, it appeared that the students and the instructor disagreed as to the level of difficulty for each of the unit tests.

CHAPTER 5

SUMMARY, CONCLUSIONS, IMPLICATIONS FOR TEACHING AND LEARNING, AND RECOMMENDATIONS FOR FURTHER RESEARCH

SUMMARY

Purpose of this study. The purpose of this study was to formulate, validate, and implement a one-semester undergraduate course in elementary computer-assisted statistics. This investigation further sought to determine, through the teaching of this curriculum by a college instructor other than the present investigator, effectiveness of learning of students in a designated section of elementary CAI statistics. Students' conceptual and psychomotor learning difficulties, as well as perceptions of both students and instructor regarding this CAI course, were also ascertained.

More specifically, this study proposed to answer the following questions:

1. Was there a consensus among CAI experts and statistics authorities as to the specific content and logical sequence of components comprising this CAI statistics curriculum?

2. Did the majority of students taking this CAI course succeed on each of the unit tests and on the final examination administered during this course?

3. How did the scores on tests taken later in this

CAI course compare with the scores of tests taken earlier in this course?

4. What conceptual and psychomotor learning difficulties did students encounter in processing prepackaged computer programs and operating computer terminals?

5. What were the perceptions of students and of the instructor at the conclusion of this CAI course as determined by individual interviews concerning course presentation, content, and sequence?

Subjects. The final, validated statistics curriculum was tested with one designated section of computer-assisted statistics at Queensborough Community College of The City University of New York. This section contained 19 matriculated Liberal Arts students who were non-mathematics majors. The prerequisite for this course is completion of Math 20: Intermediate Algebra or a satisfactory score on the Omnibus Placement Test administered by the Department of Mathematics at Queensborough Community College. Although the CAI statistics course satisfies Queensborough's general Liberal Arts requirements in mathematics for all students, a large majority who enroll in this course are pursuing a two-year program in Environmental Health or one in Medical Laboratory Technology.

Materials. The investigator devised a packet of CAI statistics materials, consisting of a specifically stated sequence of proposed statistical topics and 13 prepackaged statistical programs, each of which included general description and purpose, flowchart, and coding in the Basic programming language. The purpose of this packet was to describe the proposed one-semester elementary computer-assisted statistics course in which computer programs are used as practical tools to solve statistical problems.

In January, 1975 the investigator sent an explanatory letter, the packet of CAI statistical materials, and a Curriculum Evaluation Questionnaire to 12 experts in the field of computer-assisted instruction and statistics. By March 15, 1975 the investigator had received responses from ten of the 12 experts to whom the CAI materials were mailed.

The investigator and his mentor carefully scrutinized these respondents' recommended curriculum changes and in accordance with their suggestions made the following revisions: (1) One exercise for each of the prepackaged statistical programs was added to the packet of CAI materials. (2) The DATA statements in STAT2, STAT3, STAT4, and STAT5 were assigned the same statement number in each of the programs. (3) STAT3 was amended to avoid computer overflow in large counting problems.

(4) STAT4 was changed so that the computer would add the partial sums for multiple binomial probability problems. The investigator then completed formulation of his final elementary computer-assisted statistics curriculum (Appendix O, p. 175).

Procedures. During the fall 1975 semester one instructor, other than the present investigator, implemented the final validated CAI curriculum with one class of 19 Liberal Arts students at Queensborough Community College of the City University of New York. This instructor administered three unit tests and a final examination to the students enrolled in this CAI course.

The questions on the unit tests and final examinations were selected from Johnson's Test Item Card File for Elementary Statistics (1974). The statistical test items in this publication had been validated by its author, a professor of mathematics at Monroe Community College in Rochester, New York.

In order to answer Question Two concerning student performance on unit tests and the final examination, the investigator computed measures of central tendency—the mean, median, and mode. Measures of variation—range, variance, and standard deviation—were also calculated for each of the unit tests and for the final examination.

In order to answer Question Three concerning test score comparisons, the present investigator compared early unit-test scores with later unit test scores to determine whether there was a higher academic achievement as the topic content of the material presented became more comprehensive. He tested the hypotheses that the class mean of Unit Test Two was greater than that of Unit Test One; that the class mean of Unit Test Three was greater than that of Unit Test One; and that the class mean of Unit Test Three was greater than that of Unit Test Two.

In order to answer Question Four concerning conceptual and psychomotor learning difficulties encountered by students and operating computer terminals, the investigator formulated an Observation Rating Scale for Psychomotor and Conceptual Learning Difficulties. This Observation Rating Scale consisted of six specific psychomotor, and six specific conceptual learning skills necessary for operating a computer terminal. It was submitted for validation to three experts in the field of testing and computer science. The present investigator and two selected observers subsequently employed this validated instrument for the initial observation of the selected group of students. Upon obtaining statistically acceptable interrater reliability for each of 12 items on the Observation Rating Scale, the investigator observed the sample population a second time and recorded further observations related to students' psychomotor and conceptual skills.

After this final observation the investigator computed the mean, variance, standard deviation, and standard error of the mean for each of the 12 items on the Observation Rating Scale.

In order to answer Question Five concerning the perceptions of students regarding course presentation, content, and sequence, the investigator interviewed each of the students who completed the course. He asked each student 20 questions devised by himself and the two selected observers.

A frequency distribution of Yes, No, and Undecided responses to each of the first 19 questions was formulated, and additional student comments were received and reported in reply to the last question on the Student Questionnaire.

Finally, the instructor of the course was interviewed by the investigator. The instructor's perceptions and opinions were reported and compared with those of the students.

Findings. The results of the analysis of the data collected from this study are summarized as follows:

1. In general, six of the ten responding experts agreed that the proposed computer-assisted statistics curriculum was viable as presented and suggested that this curriculum be implemented without changes. The other four experts recommended that the investigator should carefully select and offer a sufficient number of

problems for each of the 13 prepackaged programs in the CAI statistics curriculum. Two of these aforementioned four experts suggested minor changes for clarity and brevity in the prepackaged programs called STAT2, STAT3, STAT4, and STAT5.

2. Sixteen students obtained the following scores on Unit Test One: mean = 59.69, median = 55.50, mode = 60, range = 55, variance = 298.09, and standard deviation = 17.27. Ten students obtained the following results on Unit Test Two: mean = 70.50, median = 75.50, modal scores = 82 and 83, range = 51, variance = 274.45, and standard deviation = 16.59. Nine students obtained the following results on Unit Test Three: mean = 84, median = 91.00, mode = 91, range = 55, variance = 258.22, and standard deviation = 16.07. The final examination results for the nine students completing the CAI statistics course were as follows: mean = 72.33, median = 74.00, no modal score existed, range = 46, variance = 275.11, and standard deviation = 16.59.

Unit Test One consisted of topics from Basic programming and descriptive statistics. Unit Test Two included topics from sophisticated counting and probability. Unit Test Three was based on selected topics from inferential statistics. The final examination covered topics from each of the previously administered unit tests.

3. The investigator employed the student's _t_-test to determine the following significant differences between unit test score means:

a. The class mean (70.5) of Unit Test Two was found to be significantly higher at the .10 level than the class mean (56.69) of Unit Test One.

b. The class mean (84) of Unit Test Three was found to be significantly higher at the .005 level than the class mean (59.69) of Unit Test One.

c. The class mean (84) of Unit Test Three was found to be significantly higher at the .10 level than the class mean (70.5) of Unit Test Two.

4. Using the investigator's _Observation Rating Scale for Psychomotor and Conceptual Learning Difficulties_ consisting of six psychomotor and six conceptual learning skills, the investigator and two observers determined interrater reliability after an initial observation of students. In general they perceived the following:

a. There were no difficulties observed on Psychomotor Skill One (use of ON-OFF and LINE-LOCAL terminal switches) and Two (contacting the computer _via_ a telephone call).

b. Minor student difficulties were observed for Psychomotor Skills Three (use of acoustic coupler), Four (use of terminal keyboard), Five (punching programs on tape), and Six (operation of paper tape reader).

c. No student difficulties were observed on Conceptual Skill Three (commanding the computer to run a prepackaged program).

d. Minor student difficulties were found for Conceptual Skills One (loading the prepackaged program), Two (entering data), Four (interpreting computer output), and Six (loading a second prepackaged program).

e. Considerable student difficulties were observed on Conceptual Skill Five (editing data).

A subsequent second observation of students by the investigator provided data for resultant high mean values and low standard error values (Appendix L, p. 167) for each of the 12 skills on the Observation Rating Scale.

5. During the last week of the fall 1975 semester the present investigator interviewed each of the nine students who completed the computer-assisted statistics course. He obtained their perceptions of the course presentation, content, and sequence. The investigator recorded the following results:

a. Seven of the nine students (77.8%) completing this CAI course indicated the following: (1) The running of prepackaged programs enhanced their appreciation and knowledge of computers (Question 6). (2) This CAI statistics course apparently gave students a general appreciation and understanding of elementary statistics (Question 11). (3) Flowcharting was useful in the solution of statistical problems (Question 12). (4) The topics covered in this CAI course were presented in a logical and sequential order (Question 18). (5) The instructor's teaching of the subject matter was covered clearly and logically (Question 16).

b. Six of the nine students (66.7%) stated that: (1) In general they liked this CAI statistics course (Question 2). (2) They gained self-confidence in using the computer as a tool to solve statistical problems (Question 10). (3) They would rather take a statistics course using a computer than take the same course without using a computer (Question 17). (4) The contents of questions covered on the unit tests were adequately covered by the instructor in class (Question 19).

c. Five of the nine students (55.6%) were of the opinion that: (1) They were under some pressure in this CAI statistics course (Question 1). (2) The students' academic backgrounds in mathematics were generally inadequate for this course (Question 3). (3) The statistical techniques presented were not of practical use (Question 4). (4) The statistical problems presented seemed to be worthwhile and practically related to everyday life (Question 5). (5) This CAI course attempted to cover too much material in too short a time (Question 13).

(6) There should have been more computer laboratory technicians available for individual instruction (Question 14). (7) They did not develop a more positive attitude towards mathematics (Question 15).

d. Four of the nine students (44.4%) stated: (1) They were able to think clearly when working statistical problems in class (Question 7). (2) They became confused when attempting to operate computer terminals in class (Question 8).

The following four verbatim responses to the last question (Question 20) were made by the students to the investigator as general comments on various aspects of this CAI statistics course as a learning experience:

"More work with computer."

"I think that this course was very difficult and that the tests should have been easier. However, the professor is an excellent teacher and helped us very much in understanding the work as much as possible."

"Our professor is a good statistics instructor; however his tests are extremely hard and cover too much material on each test. He does take time out to help his fellow students. But his tests are too much to cope with."

"It would be better if there are more examples."

6. The investigator later discussed various aspects of this computer-assisted statistics course with

the instructor, who offered the following comments: (1) Flowcharting and prepackaged computer programs serve as practical tools in the solution of statistical problems. (2) The topics in this investigator's CAI statistics curriculum were, in general, developed in a logical and sequential order. (3) The academic deficiencies of the particular students enrolled in this instructor's CAI statistics course appeared to be greater than the academic deficiencies of students enrolled in statistics courses previously taught by this instructor at Queensborough Community College.

CONCLUSIONS

On the basis of the findings of this study the following conclusions seem to be warranted:

1. The responding experts in the field of computer-assisted instruction and statistics generally agreed that the proposed computer-assisted statistics curriculum was viable as presented by the investigator and should be implemented without changes.

2. Results of scores on the unit tests and final examination indicated that a large majority of the students who completed the computer-assisted statistics course succeeded on each of the unit tests and the final examination.

3. Learning in this class of CAI students appeared,

to become more effective, in general, as the course progressed. Class score means of unit tests taken later in this CAI course were significantly higher than the score means of unit tests taken earlier in this course.

4. Both the initial and follow-up observations of students operating computer terminals indicated that although most of the students in this CAI course initially had some psychomotor and conceptual learning difficulties operating a computer terminal, they appeared to overcome reasonably these difficulties after two or three practice sessions.

5. A large majority of the students agreed that flowcharting and prepackaged computer programs were useful as practical tools in the solution of statistical problems.

6. A large majority of the students were of the opinion that the topics covered in this CAI course were practical and presented in a logical and sequential order.

7. A small minority of the students perceived that their academic background in mathematics was inadequate for the variety of topics covered in this CAI course.

8. A small majority of the students preferred to take a CAI statistics course rather than a traditional statistics course.

9. While a large majority of the students were of the opinion that the instructor was an excellent

teacher who covered each topic thoroughly, they believed that his unit tests were too difficult.

10. The instructor and the students who completed this CAI course appeared to be in general agreement that the course was presented in a logical and sequential order.

11. There was general consensus between students and instructor on the use of flowcharting and prepackaged computer programs as practical tools in the solution of statistical problems.

12. The students and the instructor generally disagreed on the level of difficulty for each of the unit tests.

IMPLICATIONS FOR TEACHING AND LEARNING

The following recommendations stem directly from the findings of this study and are relative to possible course of action:

1. For an instructor's presentation of a CAI statistics course, provision of additional relevant problem sets for each of the CAI prepackaged programs should be made to afford students an opportunity for additional practice with each prepackaged program.

2. A committee of college instructors in different educational institutions should jointly develop and validate a comprehensive series of unit tests for

this elementary CAI statistics curriculum.

3. Closer guidance and greater assistance to students by a sufficient number of adequately trained laboratory technicians in the computer laboratory situation would greatly enhance effectiveness of learning in an elementary CAI statistics course.

4. Consideration should be given by college computer personnel to establishing courses specifically prerequisite for students who pursue a computer-assisted statistics course.

5. More elucidation in teaching should be placed at the outset of CAI statistics courses on the essential process of flowcharting.

RECOMMENDATIONS FOR FURTHER RESEARCH

The findings of this study suggest the desirability of research in the following areas:

1. An attempt should be made to implement this CAI statistics curriculum with a larger sample drawn from a population other than Queensborough Community College.

2. An experimental study should be conducted which would compare the academic performance of students completing this computer-assisted statistics curriculum (experimental group) and students completing the same statistics curriculum without the use of computers

(control group).

3. An investigation should be made which would compare the academic performance of students completing the CAI statistics curriculum who have met the prerequisite of intermediate algebra and that of students completing this CAI course who have met the prerequisite of advanced albegra should be made.

4. Determination should be made as to whether the contents of an elementary CAI statistics course should be covered in one semester or two semesters. Such an investigation might compare the effectiveness of learning in a one-semester and two-semester elementary CAI statistics course.

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APPENDIX A

LIST OF JURY OF EXPERTS FOR EVALUATION OF PROPOSED CURRICULUM

JURY OF EXPERTS

George Daneluk, Ph.D.	Jersey City State College, Jersey City, New Jersey
William S. Dorn, Ph.D.	University of Denver, Denver, Colorado
John G. Kemeny, Ph.D.	Dartmouth College, Hanover, New Hampshire
Henry T. Lippert, Ph.D.	Brooke Army Medical Center, San Antonio, Texas
William I. Miranker, Ph.D.	IBM Research Center, Yorktown Heights, New York
Louis Nashelsky, Ph.D.	Queensborough Community College, Bayside, New York
John Reckzeh, Ph.D.	Jersey City State College, Jersey City, New Jersey
Herman Rosenberg, Ph.D.	Jersey City State College, Jersey City, New Jersey
Thomas T. Satty, Ph.D.	University of Pennsylvania, Philadelphia, Pennsylvania
Robert J. Seidel, Ph.D.	Program Director Instructional Technology Group, Alexandria, Virginia
Russell V. Skavaril, Ph.D.	The Ohio State University, Columbus, Ohio
Patrick Suppes, Ph.D.	Stanford University, Stanford, California

APPENDIX B

EXPLANATORY LETTER MAILED TO
JURY OF EXPERTS

Telephone (212) 631-6364

QUEENSBOROUGH COMMUNITY COLLEGE
OF THE CITY UNIVERSITY OF NEW YORK

Bayside, New York 11364

February 12, 1975

Dr. John G. Kemeny, President
Dartmouth College
Hanover, New Hampshire 03755

Dear Dr. Kemeny:

For the past seven years I have been using the BASIC programming language, which you helped develop at Dartmouth, in the instruction of mathematics. I have also used your Introduction to Finite Mathematics and Basic Programming textbooks.

I am currently working on my doctoral dissertation in mathematics education in the Division of Curriculum and Teaching at Fordham University, Lincoln Center, New York City.

As an instructor of mathematics at Queensborough Community College of the City University of New York for the past five years, I have been involved in the formulation and teaching of computer-assisted mathematics courses.

For my doctoral dissertation I have been working on the formulation of a proposed curriculum for a one-semester undergraduate course in elementary computer-assisted statistics.

I am herein submitting to you the following components of my proposed curriculum—a subject matter sequence of topics covered in this one-semester course; 13 pre-packaged statistical programs, each of which includes a general description, purpose, flowchart, and coding in the BASIC programming language.

The proposed curriculum is intended to present students with the use of flowcharting and pre-packaged computer programs as tools to solve problems in a one-semester undergraduate course in elementary statistics.

I would appreciate your perusal of these materials and response to the enclosed brief questionnaire regarding the proposed curriculum. While I have not included the 39 sets of problems I have devised for use with the curriculum, I would be glad to send them to you if you are interested. I have enclosed a stamped, self-addressed envelope.

Thank you for any help or any criticism you may offer.

Sincerely yours,
Frank Scalzo
Frank Scalzo
Assistant Professor of Mathematics

FS/m

The Queensborough Community College of The City University of New York is administered by the Board of Higher Education under the program of the State University of New York

APPENDIX C

CURRICULUM EVALUATION QUESTIONNAIRE SUBMITTED TO JURY OF EXPERTS

CURRICULUM EVALUATION QUESTIONNAIRE

1. Do you think the content of materials in this proposed curriculum adequately constitutes a one-semester undergrauate course in elementary statistics?

   COMMENTS: ______________________________

2. Do you think the sequence of topics in the proposed curriculum is logically developed and clearly presented?

   COMMENTS: ______________________________

3. Do you think the 13 flowcharts and pre-packaged statistical programs serve as practical tools in the solution of statistical problems?

   COMMENTS: ______________________________

4. Do you have any specific recommendations for additions or deletions for the contents or topics included in this proposed curriculum?

   COMMENTS: ______________________________

CURRICULUM EVALUATION QUESTIONNAIRE
Page 2

5. Do you agree with the sequence of topics developed in this curriculum?

COMMENTS: ______________________________

____

____

____

6. In your opinion is this computer-assisted curriculum for elementary statistics a practical or viable offering of the material?

COMMENTS: ______________________________

____

____

____

APPENDIX D

SAMPLE RESPONSES TO CURRICULUM EVALUATION QUESTIONNAIRE FROM THREE EXPERTS

CURRICULUM QUESTIONNAIRE

1. Do you think the content of materials in this proposed curriculum adequately constitutes a one-semester undergraduate course in elementary statistics?

   COMMENTS: Definitely yes.

2. Do you think the sequence of topics in the proposed curriculum is logically developed and clearly presented?

   COMMENTS: Yes.

3. Do you think the 13 flowcharts and prepackaged statistical programs serve as practical tools in the solution of statistical problems?

   COMMENTS: Yes.

4. Do you have any specific recommendations for additions or deletions for the contents or topics included in this proposed curriculum?

   COMMENTS: My major concern is that the students do not merely run programs without understanding what is happening. I believe the students should be made to compute most of these things by hand on small well chosen sets of numbers so that computation is minimal.

5. Do you agree with the sequence of topics developed in this curriculum?

   COMMENTS: There is no one sequence for this material but the sequence seems logical to me.

6. In your opinion is this computer-assisted curriculum for elementary statistics a practical or viable offering of the material?

   COMMENTS: Yes.

CURRICULUM QUESTIONNAIRE

1. Do you think the content of materials in this proposed curriculum adequately constitutes a one-semester undergraduate course in elementary statistics?

   COMMENTS: It would be difficult to cover all the topics in one semester, but the selection of topics is comprehensive and allows for selective presentation.

2. Do you think the sequence of topics in the proposed curriculum is logically developed and clearly presented?

   COMMENTS: Yes.

3. Do you think the 13 flowcharts and prepackaged statistical programs serve as practical tools in the solution of statistical problems?

   COMMENTS: I think the flowchart block descriptions should be more in terms of the language of the problem instead of the programming language. They would help a student understand the logic of the program but not the motivation for the logic. Some documentation in the program itself would also be helpful.

4. Do you have any specific recommendations for additions or deletions for the contents or topics included in this proposed curriculum?

   COMMENTS: The selection is good. The topics include follow closely those I try to cover in our course Descriptive Statistics when I teach it.

5. Do you agree with the sequence of topics developed in this curriculum?

   COMMENTS: Yes. I also follow pretty much the same sequence when I teach it.

6. In your opinion is this computer-assisted curriculum for elementary statistics a practical or viable offering of the material?

   COMMENTS: Yes. I have incorporated the use of the computer very closely in the elementary course I have taught and found that doing so induces a high level of motivation in what has traditionally been considered a dry subject. There are very few computer oriented statistics texts available on an elementary level so I would be interested in seeing a copy of the proposed materials when completed. Since most of the students do not have previous experience with the computer, I try to present everything in the lecture. All the material on computing is presented in lecture so again it would be helpful to have a treatment of the topics on computing incorporated with the material on statistics in the text for reference.

CURRICULUM QUESTIONNAIRE

1. Do you think the content of materials in this proposed curriculum adequately constitutes a one-semester undergraduate course in elementary statistics?

   COMMENTS: Yes. It covers most of the usual topics in such a course. However, I wonder whether the 'average' student can fully comprehend the wealth of material in such a course as this is in one semester. (NOTE: This comment applies to other non-computer oriented statistics courses as well.) It would be better, in my opinion, to require some elementary probability as a prerequisite for such a course and then to delete Units 3 and 4 from the present syllabus.

2. Do you think the sequence of topics in the proposed curriculum is logically developed and clearly presented?

   COMMENTS: Yes.

3. Do you think the 13 flowcharts and prepackaged statistical programs serve as practical tools in the solution of statistical problems?

   COMMENTS: It seems to me that most students who take such a course will not write many computer programs themselves nor will they use these particular computer programs when they have completed their education and moved on to work in their chosen field. Rather it is likely that, if they use statistics at all, they will use the packaged programs available from the computing center at the place of their employment. Therefore, it would seem to be more useful to take the college's packaged statistics programs (every computing center has such a collection) as an example and to assist the students in learning how to use them. Having done so the students will have some idea of how to approach the problem of using a new package of programs when they reach a new location, and this is a valuable and far from trivial skill.

4. Do you have any specific recommendations for additions or deletions for the contents or topics included in this proposed curriculum?

   COMMENTS: The packaged programs in this syllabus are directed primarily at computational methods which existed and were in use prior to the appearance of computers either in statistics or in education. I would prefer to concentrate on methods which were unavailable until the computer appeared on the scene. For example I would prefer a heavy emphasis on Monte Carlo-type simulation, and on methods for computing the normal probability integral and the Chi-square distribution. These latter distributions have traditionally been contained in a table in the appendix of the statistics book, and the indications are that this will be the case in this course as well. However, the computer eliminates the need for such tables and should be exploited in that way.

5. Do you agree with the sequence of topics developed in this curriculum?

   COMMENTS: Yes. However, the computer programs clearly are prepackaged and well-documented. Therefore, I wonder at the need to teach BASIC programming in Unit 1 or at any place for that matter. Why not simply let the students run the programs without ever seeing the listing; i.e., use the "black-box" approach? In addition I would like to see other distributions, e.g., Poisson, introduced with some discussion of how to select from one distribution given a different one. This is important when using random number generators on a computer. See also the comments of probability under 1 above.

6. In your opinion is this computer-assisted curriculum for elementary statistics a practical or viable offering of the material?

   <u>COMMENTS</u>: See comments under 4 above.

APPENDIX E

FOLLOW-UP LETTER TO TWO MEMBERS OF
JURY OF EXPERTS

April 14, 1975

Professor ___________
____
____
____
____

Dear Professor ____________:

You may recall that in January of this year I sent you a packet of materials and a curriculum questionnaire regarding my dissertation proposal "Implementation of a One-Semester Undergraduate Course in Elementary Computer-Assisted Statistics." I have not yet received your reply.

I realize this imposition on your valuable time, but I am in need of responses concerning this curriculum from qualified epxerts in the field such as yourself.

Sincerely yours,

Frank Scalzo

Frank Scalzo
Assistant Professor
Department of Mathematics

FS/mss

APPENDIX F

LETTERS OF PERMISSION FROM AUTHOR AND PUBLISHER TO USE STATISTICAL TEST ITEMS

MONROE COMMUNITY COLLEGE

memorandum

DATE 4/7/75

TO Frank Scalzo FROM Robert Johnson

RE Discrimination Index

Below are three separate explanations or views of the discrimination index.

1. The discrimination index is the point biserial correlation coefficient of the single item with the remaining items that comprise the test. (The Pearson product-moment correlation coefficient becomes a point-biserial when one of the variables is scored 1 or 0.) By correlating the single item with the remaining items a correction for spurious overlap of the single item with criterion is made. Opposed to this advantage is the disadvantage that each item is correlated with a different criterion.

2. The discrimination index indicates how well the single item is testing whatever the entire test is testing. Although it is debatable, some consider this index as the validity coefficient of the item.

3. The discrimination index indicates how well the single item separates the "men from the boys," i.e. the high scorers from the low scorers. The higher the discrimination index the greater is the difference in total test scores between those who answered it correctly and those who answered it incorrectly.

Note: The "entire test" that each item was correlated with is the set of test items for the chapters to which the individual item is a member.

Reference: Guilford, J.P. Psychometric Methods, New York: McGraw-Hill Book Company, 1954.

MONROE COMMUNITY COLLEGE
1000 EAST HENRIETTA ROAD · ROCHESTER, N.Y. 14623
CODE 716 442-9950

9 April 1975

Professor Frank Scalzo
Department of Mathematics
Queensborough Community College
Bayside, N.Y.

Dear Professor Scalzo:

I apologize for the delay. I have forwarded your letter to Alexander Kugushev, Publisher with Duxbury Press. He must issue you the copyright permissions that you requested. If you have not heard from him, perhaps you can contact him directly to obtain the permission necessary.

Address: 6 Bound Brook Court
North Scituate, Mass 02060 Phone: 617 545-2674

I have enclosed a statement describing the discrimination index reported on the test cards.

Sincerely yours,

Robert R. [illegible]

Assoc. Professor of Mathematics

WADSWORTH PUBLISHING COMPANY, INC.

BELMONT, CALIFORNIA 94002

21 April 1975

Professor Frank Scalzo
Department of Mathematics
Queensboro Community College
Bayside NY 11364

Dear Professor Scalzo:

Your letter of 18 February to Johnson was forwarded to us concerning permission to use material from our publication, TEST ITEM CARD FILE FOR ELEMENTARY STATISTICS by Johnson.

You have our permission to use material as needed in connection with your dissertation; however, if our material is to be reprinted for general distribution, you must reapply for permission at that time.

You may give credit in whatever form your school requires.

Sincerely yours,

Diana A. Griffin

Diana A. Griffin
Permissions Department

dag

APPENDIX G

MEASURES OF CENTRAL TENDENCY AND MEASURES OF VARIATION FOR STUDENT PERFORMANCE ON UNIT TESTS AND FINAL EXAMINATION

MEASURES OF CENTRAL TENDENCY AND MEASURES OF VARIATION FOR STUDENT PERFORMANCE ON UNIT TESTS AND FINAL EXAMINATION

UNIT TEST	NO. OF STUDENTS	MEAN	MEDIAN	MODE	RANGE	VARIANCE	STANDARD DEVIATION
1	16	59.69	55.50	60	55.00	298.09	17.27
2	10	70.50	75.50	82 and 83	51.00	274.45	16.59
3	9	84.00	91.00	91	55.00	258.22	16.07
Final Examination	9	72.33	74.00	None	46.00	275.11	16.59

APPENDIX H

COMPARISON OF MEAN SCORES OF STUDENTS ON
THREE CAI UNIT TESTS

COMPARISON OF MEAN SCORES OF STUDENTS ON THREE
CAI UNIT TESTS

MEAN SCORE OF TEST ONE	MEAN SCORE OF TEST TWO	MEAN SCORE OF TEST THREE	t-SCORE	LEVEL OF SIGNIFICANCE
59.69	70.50		1.51555	*
59.69		84.00	3.32225	**
	70.50	84.00	1.70163	*

* Significant at the .10 level.
** Significant at the .005 level.

APPENDIX I

OBSERVATION RATING SCALE FOR STUDENTS' PSYCHOMOTOR AND CONCEPTUAL LEARNING DIFFICULTIES

OBSERVATION RATING SCALE FOR STUDENTS' PSYCHOMOTOR AND CONCEPTUAL LEARNING DIFFICULTIES

DIRECTIONS:

As an observer of an individual student operating a computer terminal, you are asked to record your evaluation of his/her psychomotor or conceptual skills for each of the 12 skills listed below.

Please rate each skill on a numerical basis using the following scale of displayed ability:

5 - Excellent
4 - Good
3 - Satisfactory
2 - Fair
1 - Poor

PSYCHOMOTOR SKILLS:

	5	4	3	2	1
1. The student's ability to use the ON-OFF and LINE-LOCAL switches of a computer terminal.	( )	( )	( )	( )	( )
2. The student's ability to contact the central computer *via* a telephone call.	( )	( )	( )	( )	( )
3. The student's ability to activate the acoustic coupler once the central computer center has been contacted.	( )	( )	( )	( )	( )
4. The student's ability to operate physically the computer terminal keyboard to type information directly into the computer.	( )	( )	( )	( )	( )
5. The student's ability to pre-punch a computer program on paper tape.	( )	( )	( )	( )	( )

	5	4	3	2	1
6. The student's ability to operate the paper tape reader on a computer terminal.	( )	( )	( )	( )	( )

CONCEPTUAL SKILLS

1. The student's ability to command the computer to place the desired pre-packaged program in the space allotted for his use.	( )	( )	( )	( )	( )
2. The student's ability to enter data in the proper place in a prepackaged computer program.	( )	( )	( )	( )	( )
3. The student's ability to command the computer to run a prepackaged program with specific data.	( )	( )	( )	( )	( )
4. The student's ability to read and interpret the computer output.	( )	( )	( )	( )	( )
5. The student's ability to edit the data if necessary.	( )	( )	( )	( )	( )
6. The student's ability to command the computer to place a second prepackaged program in the user's space when the student has finished processing the first program.	( )	( )	( )	( )	( )

APPENDIX J

LIST OF JURY OF EXPERTS FOR VALIDATION OF OBSERVATION RATING SCALE FOR STUDENTS' PSYCHOMOTOR AND CONCEPTUAL LEARNING DIFFICULTIES

LIST OF JURY OF EXPERTS FOR VALIDATION OF OBSERVATION RATING SCALE FOR STUDENTS' PSYCHOMOTOR AND CONCEPTUAL LEARNING DIFFICULTIES

Louis Nashelsky, Ph.D.	Queensborough Community College, City University of New York Bayside, New York
Peter Stark, P.E.	Queensborough Community College, City University of New York Bayside, New York
Mary White, Ph.D.	Queensborough Community College, City University of New York Bayside, New York

APPENDIX K

COMPUTED COEFFICIENTS OF CONCORDANCE AND OBSERVED CHI SQUARE VALUES FOR EACH PSYCHOMOTOR AND CONCEPTUAL SKILL ON OBSERVATION RATING SCALE

COMPUTED COEFFICIENTS OF CONCORDANCE AND OBSERVED CHI SQUARE VALUES FOR EACH PSYCHOMOTOR AND CONCEPTUAL SKILL ON OBSERVATION RATING SCALE

Psychomotor Skill	Coefficient of Concordance	Observed Chi-square
1	0.76132	43.3952*
2	0.79464	45.2945*
3	0.852625	48.5996*
4	0.927054	52.8421*
5	0.812865	46.3333*
6	0.693095	39.5064*

Conceptual Skill	Coefficient of Concordance	Observed Chi-square
1	0.743933	42.4042*
2	0.75965	43.3*
3	0.727678	41.4777*
4	0.703577	40.1039*
5	0.756015	43.0929*
6	0.66177	37.7209*

*Significant at the .01 level.

APPENDIX L

MEASURES OF CENTRAL TENDENCY AND MEASURES OF VARIATION FOR SECOND OBSERVATION OF STUDENTS BY INVESTIGATOR

MEASURES OF CENTRAL TENDENCY AND MEASURES OF VARIATION FOR SECOND OBSERVATION OF STUDENTS BY INVESTIGATOR

PSYCHOMOTOR SKILL	MEAN	VARIANCE	STANDARD DEVIATION	STANDARD ERROR OF MEAN
1	4.73684	.193909	.440351	.101023
2	4.47368	.249309	.499309	.114549
3	4.47368	.249309	.499309	.114549
4	4.21053	.376731	.613784	.140812
5	3.73684	.404435	.635952	.145897
6	3.63158	.337952	.581336	.133368

CONCEPTUAL SKILL	MEAN	VARIANCE	STANDARD DEVIATION	STANDARD ERROR OF MEAN
1	3.94737	.470915	.686233	.157433
2	4.19526	.30471	.552005	.126639
3	4.31579	.426594	.653142	.149841
4	3.78947	.481995	.694258	.159274
5	3.78947	.271468	.521026	.119532
6	3.78947	.376731	.613784	.140812

APPENDIX M

QUESTIONS FOR INTERVIEWS WITH STUDENTS CONDUCTED BY THE INVESTIGATOR

QUESTIONS FOR STUDENTS' PERSONAL INTERVIEWS

Student's Name ______________________

Date Interviewed ______________________

		YES	NO	UNDECIDED
1.	Were you under any pressure in this computer-assisted statistics course?	( )	( )	( )
2.	Did you like this computer-assisted statistics course in general?	( )	( )	( )
3.	Do you consider your academic background in mathematics to be inadequate for the level of presentation in this statistics course?	( )	( )	( )
4.	In your opinion were the statistical techniques covered in this class of practical use?	( )	( )	( )
5.	Did the statistical problems assigned seem to be worthwhile and practically related to everyday life?	( )	( )	( )
6.	Did the running of prepackaged computer programs enhance your appreciation and knowledge of operating computers	( )	( )	( )
7.	Were you able to think clearly when working the statistical problems in this class?	( )	( )	( )

	YES	NO	UNDECIDED
8. Did you become confused when attempting to operate terminals in this class?	( )	( )	( )
9. Would you like to pursue other computer-assisted mathematics courses in the future?	( )	( )	( )
10. Do you think you gained self confidence in using the computer as a tool when solving elementary statistical problems?	( )	( )	( )
11. Did this CAI statistics course give you a general appreciation and understanding of elementary statistics?	( )	( )	( )
12. Did your learning the process of flowcharting in this course prove useful to you in the solution of statistical problems?	( )	( )	( )
13. Did you think this statistics course attempted to cover too much material in too short a time?	( )	( )	( )
14. Do you think there should have been more computer laboratory assistants available for individual instruction in operating computer terminals?	( )	( )	( )
15. As a result of taking this computer-assisted statistics course have you developed a more positive attitude towards mathematics in general?	( )	( )	( )

	YES	NO	UNDECIDED
16. In your opinion was the instructor's presentation and teaching of the subject matter covered clearly and logically developed?	( )	( )	( )
17. Would you rather take a statistics course using a computer than take the same course without using a computer?	( )	( )	( )
18. In your opinion were the topics which were covered in this CAI course presented in a logical and sequential order?	( )	( )	( )
19. In your opinion were the contents of questions asked on the unit tests adequately covered by the instructor in class?	( )	( )	( )
20. Do you have any additional comments or opinions about any aspect of this CAI statistics course?	( )	( )	( )

APPENDIX N

PERCENT OF FREQUENCY DISTRIBUTION OF STUDENT RESPONSES TO INVESTIGATOR'S INTERVIEW QUESTIONS

PERCENT OF FREQUENCY DISTRIBUTION* OF STUDENT RESPONSES TO INVESTIGATOR'S INTERVIEW QUESTIONS

QUESTION	YES	NO	UNDECIDED
1	5 (55.6%)	3 (33.3%)	1 (11.1%)
2	6 (66.7%)	3 (33.3%)	
3	4 (44.4%)	5 (55.6%)	
4	4 (44.4%)	5 (55.6%)	
5	5 (55.6%)	3 (33.3%)	1 (11.1%)
6	7 (77.8%)	2 (22.2%)	
7	4 (44.4%)	4 (44.4%)	1 (11.1%)
8	3 (33.3%)	4 (44.4%)	2 (22.2%)
9	3 (33.3%)	6 (66.7%)	
10	6 (66.7%)	3 (33.3%)	
11	7 (77.8%)	2 (22.2%)	
12	7 (77.8%)	2 (22.2%)	
13	5 (55.6%)	4 (44.4%)	
14	5 (55.6%)	4 (44.4%)	
15	4 (44.4%)	5 (55.6%)	
16	7 (77.8%)	1 (11.1%)	1 (11.1%)
17	6 (66.7%)	2 (22.2%)	1 (11.1%)
18	7 (77.8%)		2 (22.2%)
19	6 (66.6%)	2 (22.2%)	1 (11.1%)
20	4 (44.4%)	5 (55.6%)	

*Approximate calculated percentages.

APPENDIX O

FINAL AND VALIDATED ELEMENTARY COMPUTER-ASSISTED STATISTICS CURRICULUM

AN OUTLINE OF A PROPOSED ONE-SEMESTER UNDERGRADUATE COURSE IN ELEMENTARY COMPUTER-ASSISTED STATISTICS

UNIT 1

UNDERSTANDING THE USE OF COMPUTERS

1.1 Introduction

1.2 Steps in Computer Problem-Solving (Flowcharting, Coding, Inputing, Running, De-Bugging)

1.3 Flowcharting

1.4 Sample Flowcharts

Problem Set 1

1.5 Coding in the Basic Language

Problem Set 2

Problem Set 3

Problem Set 4

1.6 Operating a Computer Terminal

Problem Set 5

1.7 Subscripted Variables

1.8 Prepackaged Programs

Problem Set 6

UNIT 2

DESCRIPTIVE STATISTICS AND RELATED PREPACKAGED COMPUTER PROGRAMS

2.1 Introduction

3.4 Multiple Operations with Sets

Problem Set 12

3.5 Sophisticated Counting

Problem Set 13

3.6 Order *Versus* No Order

3.7 Factorial Notation

3.8 Permutations

Problem Set 14

3.9 Combinations

3.10 The Binomial Theorem

Problem Set 15

3.11 A Prepackaged Counting Program

Problem Set 16

UNIT 4

ELEMENTARY PROBABILITY CONCEPTS WITH A PREPACKAGED PROGRAM FOR THE BINOMIAL EXPERIMENT

4.1 The Sample Space, Sample Point, and Event

4.2 Acceptable Assignment of Probabilities

4.3 Probability of an Event

Problem Set 17

4.4 Three Probability Theorems

Problem Set 18

4.5 Conditional Probability

4.6 Bayes' Theorem

4.7 Proof for Bayes' Theorem for Three Events E_1, E_2, E_3

2.2 Descriptive Statistics - Ungrouped Data

2.3 Three Measures of Central Tendency - Ungrouped Data

2.4 Measures of Deviation - Ungrouped Data

Problem Set 7

2.5 A Prepackaged Program for Ungrouped Data

Problem Set 8

2.6 Descriptive Statistics - Grouped Data

2.7 Graphing Frequency Distributions

2.8 The Frequency Histogram

2.9 The Frequency Polygon

2.10 The Cumulative Frequency Graph

2.11 Percent Graphs

2.12 The Percent of Frequency Polygon Graph

Problem Set 9

2.13 Measures of Central Tendency for Grouped Data

2.14 Measures of Deviation for Grouped Data

Problem Set 10

2.15 A Prepackaged Program for Grouped Data

Problem Set 11

UNIT 3

SETS, PERMUTATIONS, AND THE BINOMIAL THEOREM, WITH A PREPACKAGED COMPUTER PROGRAM

3.1 Introduction to Sets

3.2 Subsets

3.3 Operations with Sets

Problem Set 19

4.8 The Binomial Experiment

Problem Set 20

4.9 A Prepackaged Program of the Binomial Experiment

Problem Set 21

UNIT 5

RANDOM VARIABLES, NORMAL DISTRIBUTIONS, AND RELATED PREPACKAGED PROGRAMS

5.1 Discrete Random Variables

Problem Set 22

5.2 The Mean of a Discrete Random Variable

5.3 The Mean of a Binomial Random Variable

5.4 The Variance and Standard Deviation of a Discrete Random Variable

5.5 The Variance and Standard Deviation of a Binomial Random Variable

Problem Set 23

5.6 Continuous Random Variables

5.7 Normal Distributions

5.8 The Standardized Normal Distribution

5.9 Using Tables for Computing Areas (Probabilities) Under the Standard Normal (Z) Curve

Problem Set 24

5.10 Using the Normal Curve to Approximate Binomial Probabilities

Problem Set 25

5.11 A Prepackaged Program for Computing the Z-Score/Scores When Using the Normal Curve to Approximate Binomial Probabilities.

Problem Set 26

5.12 Normalizing Raw Test Scores Via a Prepackaged Computer Program

Problem Set 27

UNIT 6

HYPOTHESIS TESTING AND RELATED PREPACKAGED COMPUTER PROGRAMS

6.1 Inferential Statistics

6.2 The Central Limit Theorem and Confidence Intervals

Problem Set 28

6.3 A Prepackaged Program for Computing Confidence Intervals for the Mean of a Population

Problem Set 29

6.4 Testing for Significant Differences Between a Sample's Mean and a Mean of a Population

6.5 Testing for Significant Differences Between a Small Sample's Mean and the Mean of a Population

6.6 One-Tailed Test <u>Versus</u> Two-Tailed Test

6.7 Steps to Follow When Testing Hypothesis Concerning the Difference Between a Sample's Mean and a Mean of a Population

6.8 A Prepackaged Program for Computing Observed Z-Score or Observed T-Score for Differences Between a Sample's Mean and a Mean of a Population

Problem Set 30

6.9 More on Confidence Intervals

Problem Set 31

6.10 Testing for Significant Differences Between Two Sample Means

6.11 A Prepackaged Program for Computing the Observed Z-Score or t-Score for Differences Between Two Sample Means

Problem Set 32

UNIT 7

ADDITIONAL STATISTICAL TECHNIQUES AND RELATED PREPACKAGED PROGRAMS

7.1 The Chi-Square Distribution

Problem Set 33

7.2 A Prepackaged Program for Computing the Observed Chi-Square Value

Problem Set 34

7.3 Introduction to Linear Regression

7.4 Regression by the Method of Least Squares

Problem Set 35

7.5 A Prepackaged Program for Finding the Estimated Linear Regression Equation

Problem Set 36

7.6 The Coefficient of Correlation

7.7 A Prepackaged Program for Computing the Coefficient of Correlation

Problem Set 37

7.8 Analysis of Variance: One-Way Classification

Problem Set 38

7.9 A Prepackaged Program for Computing the Observed F (Variance) Ratio

Problem Set 39

PREPACKAGED COMPUTER PROGRAMS

STAT1	A Prepackaged Program for Ungrouped Data
STAT2	A Prepackaged Program for Grouped Data
STAT3	A Prepackaged Counting Program
STAT4	A Prepackaged Program for the Binomial Experiment
STAT5	A Prepackaged Program for Computing the Z-Score/Scores When Using the Normal Curve to Approximate Binomial Probabilities
STAT6	Normalizing Raw Test Scores Via a Prepackaged Computer Program
STAT7	A Prepackaged Program for Computing Confidence Intervals for the Mean of a Population
STAT8	A Prepackaged Program for Computing Observed Z-Score or Observed t-Score for Differences Between a Sample's Mean and a Population's Mean
STAT9	A Prepackaged Program for Computing the Observed Z-Score or t-Score for Differences Between Two Sample Means
STAT10	A Prepackaged Program for Computing the Observed Chi-Square Value
STAT11	A Prepackaged Program for Finding the Estimated Linear Regression Equation
STAT12	A Prepackaged Program for Computing the Coefficient of Correlation
STAT13	A Prepackaged Program for Computing the Observed F (Variance) Ratio

STAT1

A PREPACKAGED PROGRAM FOR UNGROUPED DATA

INSTRUCTIONS FOR STAT1

NAME: STAT1

DESCRIPTION: This program computes the arithmetic mean, variance, and standard deviation of N numbers.

INSTRUCTIONS: Enter the data beginning in line 150 as follows:

150 DATA N, X_1, X_2, X_3, ..., X_n

where: N represents the number of raw scores

X_1, X_2, ..., X_n are the raw scores.

NOTE: Line 200 is the END statement.

EXAMPLE:

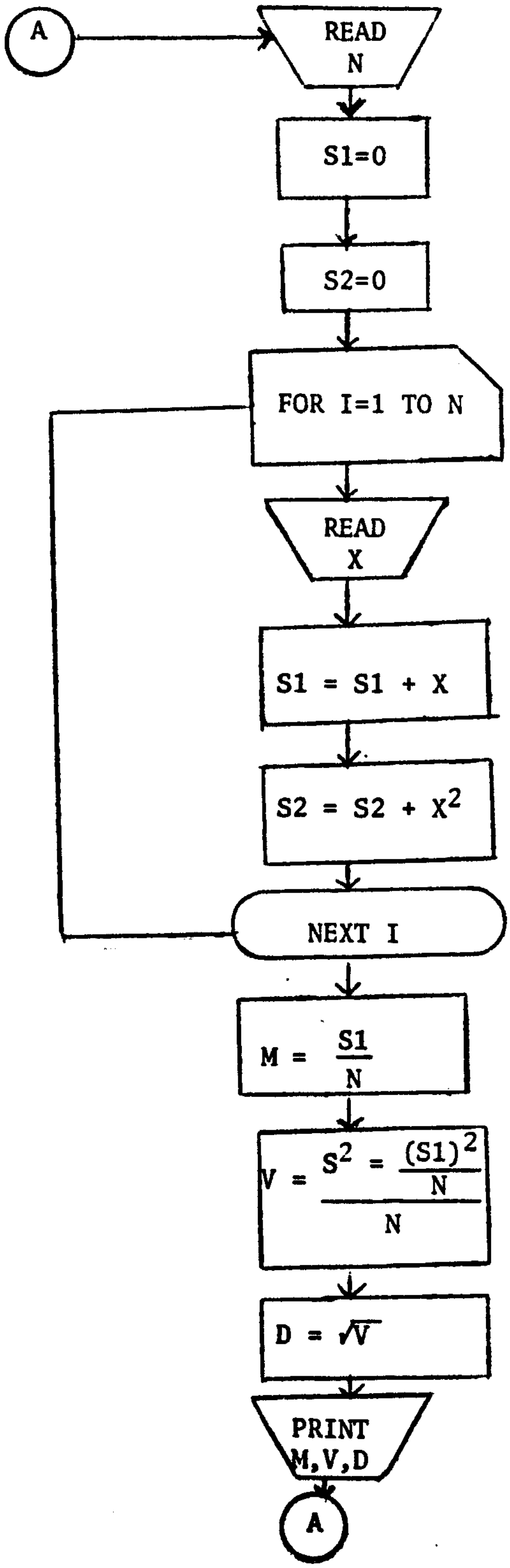
User's Input

```
GET-STAT1
150 DATA 5, 70, 90, 100, 40, 50
151 DATA 5, 70, 68, 72, 67, 73
RUN
```

Computer Output

```
STAT1
MEAN = 70    VARIANCE = 520    ST. DEV. = 22.8035
MEAN = 70    VARIANCE = 5.2    ST. DEV. = 2.28035
OUT OF DATA IN LINE 5
```

FLOWCHART FOR STAT1



CODING OF STAT1

```
5 READ N
10 LET S1=0
15 LET S2=0
20 FOR I=1 TO N
25     READ X
30     LET S1=S1+X
35     LET S2=S2+X↑2
40 NEXT I
45 LET M=S1/N
50 LET V=(S2-(S1) 2/N)/N
55 LET D=SQR(V)
60 PRINT "MEAN="M; "VARIANCE="V; "ST. DEV.="D
65 GO TO 5
150 DATA
200 END
```

PROBLEM SET FOR STAT1

1. The following final examination scores for two different sections of statistics were reported as follows:

SECTION 1	SECTION 2
75	75
70	55
82	95
81	80
68	81
70	82
70	70
75	91
81	67
82	52

Use STAT1 to compute $\overline{X}$ (mean, s^2 (variance) and s (standard deviation) for each section.

2. Use STAT1 to compute $\overline{X}$, s^2, s for the five daily stock prices ($31.85, $31, $31, $31,15, $31,50).

3. Use STAT1 to compute $\overline{X}$, s^2, s for the following sampling of 20 senior grade point averages at Orange University: 3.2, 2.5, 3.1, 2.1, 3.3, 3.7, 1.9, 2.2, 2.2, 2.6, 2.1, 2.9, 2.8, 3.6, 3.0, 2.0, 3.5, 2.2, 2.6, 3.1.

4. Use STAT1 to compute $\overline{X}$, s^2 and s for the following amounts which represent a truck driver's weekly gross earnings for the past 9 weeks: $257, $315, $291, $301, $315, $288, $313, $352, $299.

STAT2

A PREPACKAGED PROGRAM FOR GROUPED DATA

INSTRUCTIONS FOR STAT2

NAME: STAT2

DESCRIPTION: This program computes the mean, median, variance and standard deviation for a set of grouped data.

INSTRUCTIONS: Enter the data beginning in line 150 as follows:

150 DATA N, F(1), X(1), F(2), (X2), ..., F(N), X(N)

where: N represents the number of class intervals, N≤16

F(1), F(2), ..., F(N) represent the number of frequencies in each class.

X(1), X(2), ..., X(N) represent the midpoints in each class.

NOTE: Line 200 is the END statement.

SAMPLE PROBLEM:

CLASS INT.	CLASS BOUND.	f	x MIDPOINT
1.4-1.6	1.35 - 1.65	4	1.5
1.7-1.9	1.65 - 1.95	20	1.8
2.0-2.2	1.95 - 2.25	35	2.1
2.3-2.5	2.25 - 2.55	40	2.4
2.6-2.8	2.55 - 2.85	11	2.7
2.9-3.1	2.85 - 3.15	20	3.0
3.2-3.4	3.15 - 3.45	20	3.3

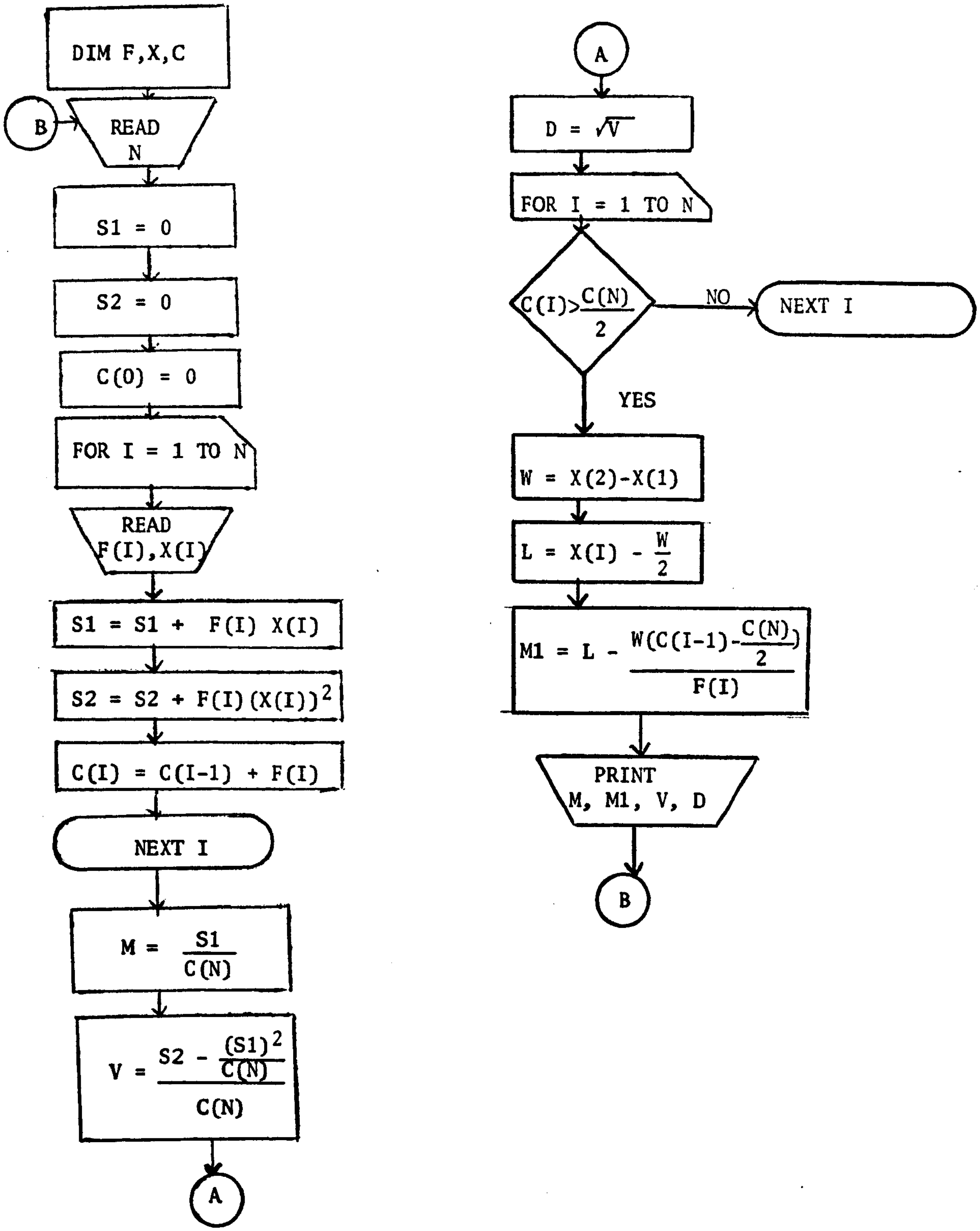
User's Input

```
GET-STAT2
150 DATA 7,4,1.5,20,1.8,35,2.1,40,2.4,11,2.7,20,3,20,3.3
RUN
```

Computer Output

```
STAT2
MEAN      MEDIAN     VARIANCE     ST. DEV.
2.448      2.37       .2509        .5009
OUT OF DATA IN LINE 10
```

FLOWCHART FOR STAT2



CODING OF STAT2

```
5 DIM F(16), X(16), C(16)
10 READ N
15 LET S1=0
20 LET S2=0
25 LET C(0) = 0
30 FOR I = 1 TO N
35     READ F(I), X(I)
40     LET S1 = S1 + F(I)*X(I)
45     LET S2 = S2 + F(I)*X(I) ↑ 2
50     LET C(I) = C(I-1) + F(I)
55 NEXT I
60 LET M = S1/C(N)
65 LET V = (S2 - (S1) ↑ 2/C(N))/C(N)
70 LET D = SQR(V)
75 FOR I = 1 TO N
80     IF C(I)>C(N)/2 THEN 90
85 NEXT I
90 LET W = X(2) - X(1)
95 LET L = X(I) - W/2
100 LET M1 = L-W*(C(I-1) - C(N)/2)/F(I)
105 PRINT "MEAN", "MEDIAN", "VARIANCE", "ST. DEV."
110 PRINT M, M1, V, D
115 PRINT
120 GO TO 10
150 DATA
200 END
```

PROBLEM SET FOR STAT2

1. Use STAT2 to compute the mean, median, variance, and standard deviation of the following frequency distributions:

(a)

CLASS	CLASS INTERVAL	CLASS BOUNDARIES	MIDPOINT	f
1	15-17	14.5-17.5	16	2
2	18-20	17.5-20.5	19	5
3	21-23	20.5-23.5	22	3
4	24-26	23.5-26.5	25	12
5	27-29	26.5-29.5	28	4
6	30-32	29.5-32.5	31	4

(b)

CLASS	CLASS INTERVAL	CLASS BOUNDARIES	MIDPOINT	f
1	1.4-1.6	1.35-1.65	1.5	4
2	1.7-1.9	1.65-1.95	1.8	20
3	2.0-2.2	1.95-2.25	2.1	35
4	2.3-2.5	2.25-2.55	2.4	40
5	2.6-2.8	2.55-2.85	2.7	11
6	2.9-3.1	2.85-3.15	3.0	20
7	3.2-3.4	3.15-3.45	3.3	20

(c)

CLASS	CLASS INTERVAL	f
1	0-2	10
2	3-5	10
3	6-8	5
4	9-11	3
5	12-14	1
6	15-17	1

(d)

CLASS	CLASS INTERVAL	CLASS BOUNDARIES	MIDPOINT	f	cf
1	65-69	64.5-69.5	67	2	2
2	70-74	69.5-74.5	72	2	4
3	75-79	74.5-79.5	77	9	13
4	80-84	79.5-84.5	82	19	32
5	85-89	84.5-89.5	87	14	46
6	90-94	89.5-94.5	92	3	49
7	95-99	94.5-99.5	97	1	50

(e)

CLASS	CLASS INTERVAL	f	CUMULATIVE f
1	50-59	3	3
2	60-69	6	9
3	70-79	15	24
4	80-89	22	46
5	90-99	24	70
6	100-109	15	85
7	110-119	10	95
8	120-129	4	99
9	130-139	1	100

(f)

CLASS	CLASS INTERVAL	f	CUMULATIVE f
1	65-69	3	3
2	70-74	6	9
3	75-79	10	19
4	80-84	23	42
5	85-89	14	56
6	90-94	1	57
7	95-99	3	60

STAT3

A PREPACKAGED COUNTING PROGRAM

INSTRUCTIONS FOR STAT3

NAME: STAT3

DESCRIPTION: This program computes the number of permutations of r objects selected from n distinct objects or the number of combinations of r objects selected from n distinct objects.

INSTRUCTIONS: Enter the data beginning in line 150 as follows:

150 DATA N, R, D

where: N represents the total number of distinct objects.

R represents the number of objects to be selected from the N distinct objects

$$D = \begin{cases} 0 \text{ if we want } {}_nP_r \\ 1 \text{ if we want } {}_nC_r \end{cases}$$

NOTE: Line 200 is the END statement.

SAMPLE PROBLEM: Find ${}_8P_3$ and ${}_8C_3$.

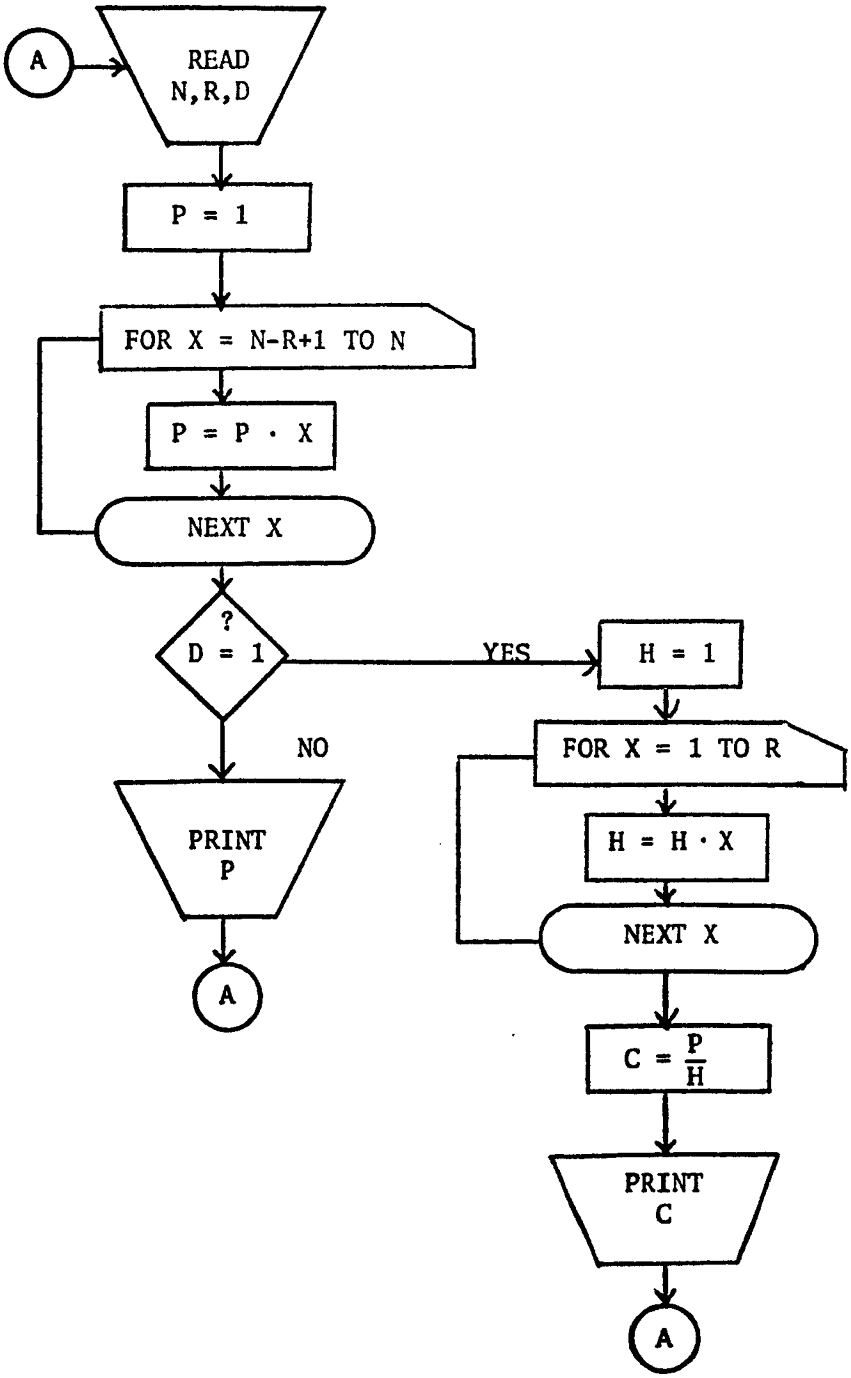
User's Input

```
GET-STAT3
150 DATA 8, 3, 0
151 DATA 8, 3, 1
RUN
```

Computer Output

```
STAT3
P(8, 3) = 336
C(8, 3) = 56
OUT OF DATA IN LINE 5
```

FLOWCHART FOR STAT3



CODING OF STAT3

```
5 READ N,R,D
10 LET P = 1
15 FOR X = N - R + 1 TO N
20     LET P = P * X
25 NEXT X
30 IF D = 1 THEN 45
35 PRINT "P("N;",";R;") = "P
40 GO TO 5
45 LET H = 1
50 FOR X = 1 TO R
55     LET H = H * X
60 NEXT X
65 LET C = P/H
70 PRINT "C("N;",";R;") = "C
75 GO TO 5
150 DATA
200 END
```

PROBLEM SET FOR STAT3

1. Use STAT3 to compute the following:

(a) ${}_{11}P_3$

(b) ${}_{9}C_5$

(c) ${}_{12}P_4$

(d) ${}_{10}C_7$

(e) ${}_{11}C_7$

(f) ${}_{8}P_5$

2. Use STAT3 to show that ${}_{10}C_5 = {}_{9}C_4 + {}_{9}C_5$.

STAT4

A PREPACKAGED BINOMIAL EXPERIMENT PROGRAM

INSTRUCTIONS FOR STAT4

NAME: STAT4

DESCRIPTION: This program computes the probability of r successes in n independent trials of a binomial experiment.

INSTRUCTIONS: Enter the data in line 150 as follows:

150 DATA N, R, P, D

where: N is the number of independent trials of the binomial experiment.

R is the number of desired successes.

P is the probability of success on any one trial of the binomial experiment.

D = { 0 if we want to print the desired total binomial probability, or
1 if we want to compute and print a partial sum for a binomial probability.

NOTE: Line 200 is the END statement.

SAMPLE PROBLEMS:

(1) Find the probability of obtaining exactly five successes in seven trials of a binomial experiment where the probability of success on any one trial is .83.

User's Input

```
GET-STAT4
150 DATA 7, 5, .83, 0
RUN
```

Computer Output

```
#TRIALS     #SUCCESSES     PR. OF SUCC.     BINOMIAL PROB.
 7           5              .83              .23906
#TRIALS     #SUCCESSES     PR. OF SUCC.     BINOMIAL PROB.
OUT OF DATA IN LINE 35
```

(2) Find the probability of obtaining at least five successes in seven trials of a binomial experiment where the probability of success on any one trial is .83.

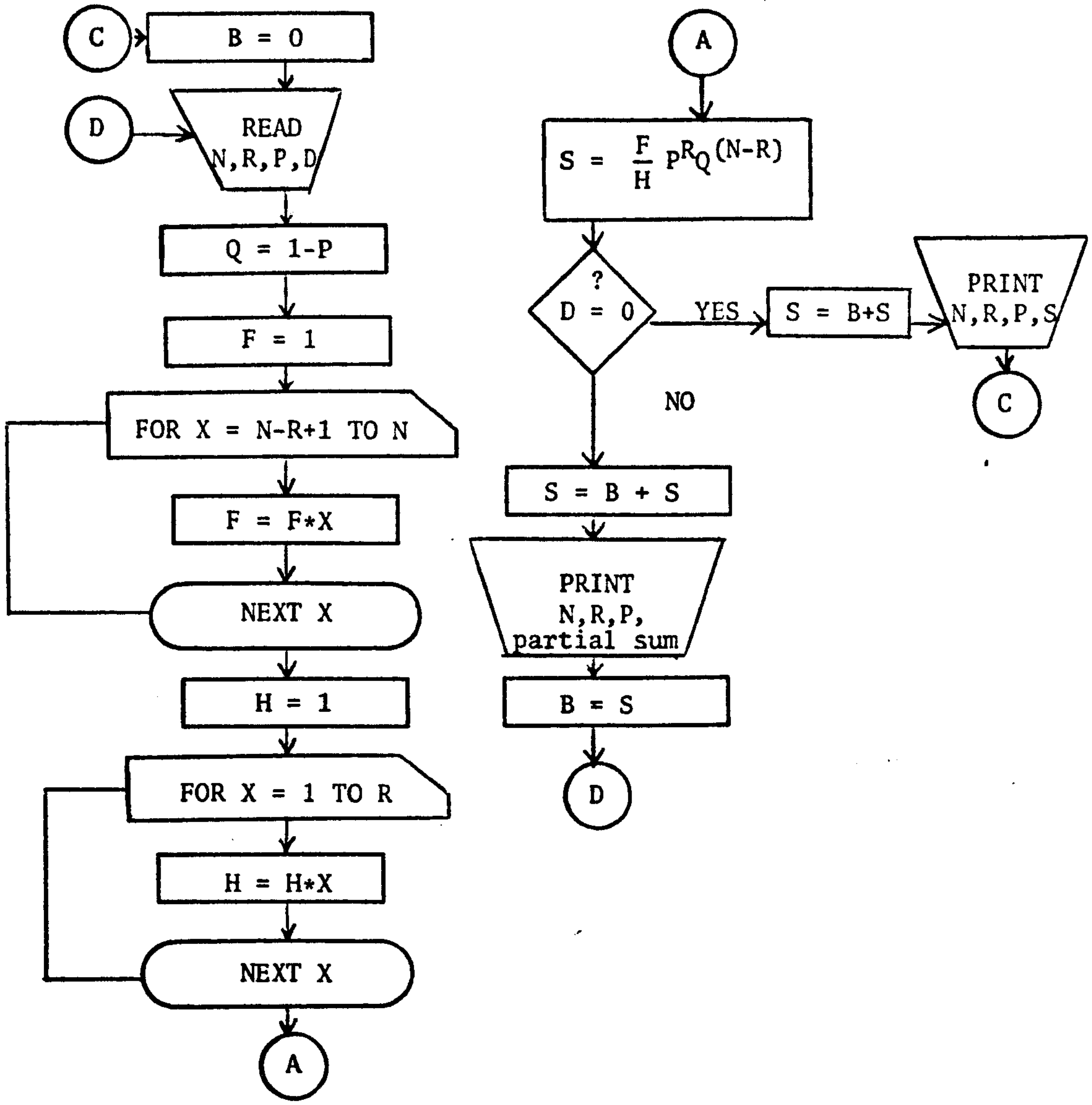
User's Input

```
GET-STAT4
150 DATA 7, 5, .83, 1
151 DATA 7, 6, .83, 1
152 DATA 7, 7, .83, 0
RUN
```

Computer Output

```
#TRIALS    #SUCCESSES    PR. OF SUCC.    BINOMIAL PROB.
 7          5             .83        PARTIAL SUM= .23906
 7          6             .83        PARTIAL SUM= .628119
 7          7             .83          .899479
#TRIALS    #SUCCESSES    PR. OF SUCC.    BINOMIAL PROB.
OUT OF DATA IN LINE 35
```

FLOWCHART FOR STAT4



CODING OF STAT4

```
 5 LET B = 0
10 PRINT
15 PRINT
20 PRINT
25 PRINT "#TRIALS", "#SUCCESSES","PR. OF SUCC.","BINOMIAL PROB."
30 PRINT
35 READ N,R,P,D
40 LET Q = 1-P
45 LET F = 1
50 FOR X = N - R + 1 TO N
55     LET F = F * X
60 NEXT X
65 LET H = 1
70 FOR X = 1 TO R
75     LET H = H * X
80 NEXT X
85 LET S = F/H * P ↑ R * Q ↑ (N - R)
90 IF D = 0 THEN 115
95 LET S = B + S
100 PRINT N,R,P, "PARTIAL SUM="S
105 LET B = S
110 GO TO 35
115 LET S = B + S
120 PRINT N,R,P,S
```

```
125 GO TO 5
150 DATA
200 END
```

PROBLEM SET FOR STAT4

Use STAT4 as a tool to solve the following problems:

1. The probability that a flu vaccine will be effective on any one person is .8. If 4 people are selected at random and injected with the vaccine, what is the probability that none of the 4 people will contract the flu?

2. A certain professional basketball player shoots his foul shots with a .9 accuracy. What is the probability that he will miss 5 of the next 10 foul shots he attempts?

3. The probability that any one battery produced by the Live Wire Company will be rejected is .01. If three batteries are selected at random, then tested and labeled A (accepted) or R (rejected), what is the probability that at least 2 of the 3 randomly selected batteries tested will be accepted?

4. A woman professional golfer qualifies for .7 of the tournaments in which she desires to participate. What is the probability that she will not qualify for 2 of 5 randomly selected tournaments she wishes to enter?

5. The Snapshot Company advertises that its flashbulbs work with .999 accuracy. If the company's claim is true, what is the probability that all of 3 randomly selected flashbulbs will be defective?

STAT5

A PREPACKAGED PROGRAM FOR APPROXIMATELY BINOMIAL PROBABILITIES VIA THE STANDARD NORMAL CURVE

INSTRUCTIONS FOR STATS

NAME: STATS

DESCRIPTION: This program computes the Z-score/scores and tells which area to compute when using the normal curve to approximate binomial probabilities.

INSTRUCTIONS: Enter the data beginning in line 150 as follows:

150 DATA N, P, R_1, R_2, X

where: N represents the number of independent tirals in the binomial experiment.

P represents the probability of success on any one trial.

R_1 and R_2 are the desired number of successes if we have a lower limit and upper limit, otherwise $R_1 = R_2$.

X =
- 0 if we want exactly $R_1 = R_2$ successes;
- 1 if we want less than $R_1 = R_2$ successes;
- 2 if we want more than $R_1 = R_2$ successes;
- 3 if we want at most $R_1 = R_2$ successes;
- 4 if we want at least $R_1 = R_2$ successes;
- 5 if we want between R_1 and R_2 successes;
- 6 if we want between R_1 and R_2 inclusive successes.

NOTE: Line 200 is the END statement.

SAMPLE PROBLEM:

If we randomly select and test 10 fenders from a lot of fenders where the probability of selecting a good fender on any one try is .7, we use the normal curve approximation to find the probability of obtaining:

(1) exactly 5 good fenders (P(X=5)):

User's Input
```
GET-STATS
150 DATA 10, .7, 5, 5, 0
RUN
```

Computer Output
```
FIND AREA BETWEEN Z= -1.72516 AND Z= -1.0351
```

User's Calculations: $p(-1.73<Z<-1.04) = .4582 - .3508 = .1074$

(2) less than 5 good fenders $(P(X<5))$:

User's Input	GET-STAT5 150 DATA 10, .7, 5, 5, 1 RUN
Computer Output	FIND THE AREA TO THE LEFT OF Z= -1.38013
User's Calculations	$p(Z<-1.38) = .5000 - .4162 = .0838$

(3) more than 5 good fenders $(P(X>5))$:

User's Input	GET-STAT5 150 DATA 10, .7, 5, 5, 2 RUN
Computer Output	FIND THE AREA TO THE RIGHT OF Z= -1.38013
User's Calculations	$p(Z>-1.38) = .5000 + .4162 = .9162$

(4) at most 5 good fenders $(p(X\geq 5))$:

User's Input	GET-STAT5 150 DATA 10, .7, 5, 5, 3 RUN
Computer Output	FIND THE AREA TO THE LEFT OF Z= -1.0351
User's Calculations	$p(Z<-1.04) = .5000 - .3508 = .1492$

(5) at least 5 good fenders $(P(X\geq 5))$:

User's Input	GET-STAT5 150 DATA 10, .7, 5, 5, 4 RUN
Computer Output	FIND THE AREA TO THE RIGHT OF Z= -1.72516

User's Calculations	p(Z>-1.73) = .5000 + .4582 = .9582

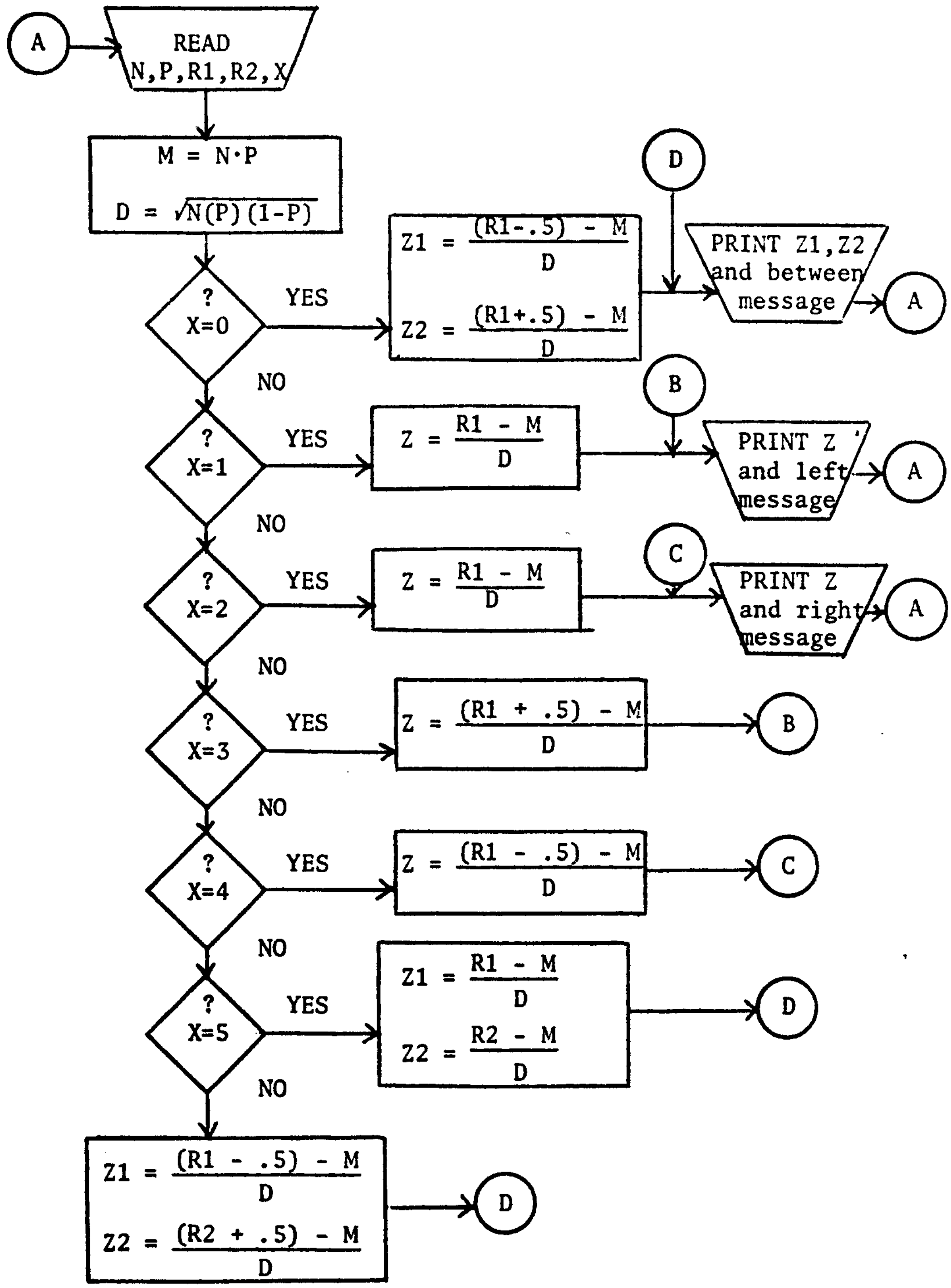
(6) between 4 and 9 good fenders (P(4<X<9)):

User's Input	GET-STATS 150 DATA 10, .7, 4, 9, 5 RUN
Computer Output	FIND AREA BETWEEN Z= -2.0702 AND Z= 1.38013
User's Calculations	p(-2.07<Z<1.38) = .4808 + .4162 = .8970

(7) between 4 and 9 inclusive good fenders ($P(4 \le X \le 9)$):

User's Input	GET-STATS 150 DATA 10, .7, 4, 9, 6 RUN
Computer Output	FIND AREA BETWEEN Z= -2.41523 AND Z= 1.72516
User's Calculations	p(-2.52<Z<1.73) = .4922 + .4582 = .9504

FLOWCHART FOR STAT5



CODING OF STATS

```
 5 READ N, P, R1, R2, X
10 LET M = N * P
15 LET D = SQR*(N*P*(1-P))
20 IF X = 0 THEN 70
25 IF X = 1 THEN 85
30 IF X = 2 THEN 100
35 IF X = 3 THEN 115
40 IF X = 4 THEN 125
45 IF X = 5 THEN 135
50 LET Z1 = ((R1 - .5) - M)/D
55 LET Z2 = ((R2 + .5) - M)/D
60 PRINT "FIND AREA BETWEEN Z=" Z1; "AND Z=" Z2
65 GO TO 5
70 LET Z1 = ((R1 - .5) - M)/D
75 LET Z2 = ((R1 + .5) - M)/D
80 GO TO 60
85 LET Z = (R1 - M)/D
90 PRINT "FIND THE AREA TO THE LEFT OF Z=" Z
95 GO TO 5
100 LET Z = (R1 - M)/D
105 PRINT "FIND THE AREA TO THE RIGHT OF Z=" Z
110 GO TO 5
115 LET Z = ((R1 + .5) - M)/D
120 GO TO 90
```

```
125 LET Z = ((R1 - .5) - M)/D

130 GO TO 105

135 LET Z1 = (R1 - M)/D

140 LET Z2 = (R2 - M)/D

145 GO TO 60

150 DATA

200 END
```

PROBLEM SET FOR STATS

Use STAT5 and the standard normal curve to approximate the desired binomial probabilities in each of the following exercises:

1. The probability that a flu vaccine will be effective on any one person is .8. If 200 people are selected at random, and injected with the vaccine, what is the probability that less than 20 people will contract the flu?

2. A certain professional basketball player shoots his foul shots with a 0.9 accuracy. What is the probability that he will make at least 35 out of 40 randomly selected foul shots he attempts?

3. The probability that any one battery produced by the Live Wire Company is rejected is .01. If 100 batteries are selected at random, then tested and labeled A (accepted) or R (rejected), what is the probability that at least 2 batteries are rejected but at most 4 batteries are rejected (i.e., $p(2<X<4) = p(X=2) + p(X=3) + p(X=4)$)?

4. A certain woman professional golfer qualifies for 5 out of 10 of the tournaments in which she desires to participate. What is the probability that she will qualify for exactly 35 of 50 randomly selected tournaments she wishes to enter?

5. The Snap Shot Company advertises that its flashbulbs work with 0.999 accuracy. If its claim is true, what is the probability that at most 4 out of 1000 randomly selected flashbulbs are defective?

6. A marksman claims he hits the bullseye on 6 out of every 10 shots he fires. If his claim is true, what is the probability that he will not hit the bullseye on 6 of his next 15 shots?

STAT6

A PREPACKAGED PROGRAM TO NORMALIZE
RAW TEST SCORES

INSTRUCTIONS FOR STAT6

NAME: STAT6

DESCRIPTION: This program normalizes a set of n raw scores where $n \leq 45$.

INSTRUCTIONS: Enter the data beginning in line 150 as follows:

150 DATA N, X_1, X_2, ..., X_n, U, D

where: N is the number of raw scores.

X_1, X_2, ..., X_n are the actual raw scores.

U is the mean or approximately mean of the population.

D is the standard deviation or approximated standard deviation of the population.

NOTE: Line 200 is the END statement.

SAMPLE PROBLEM:

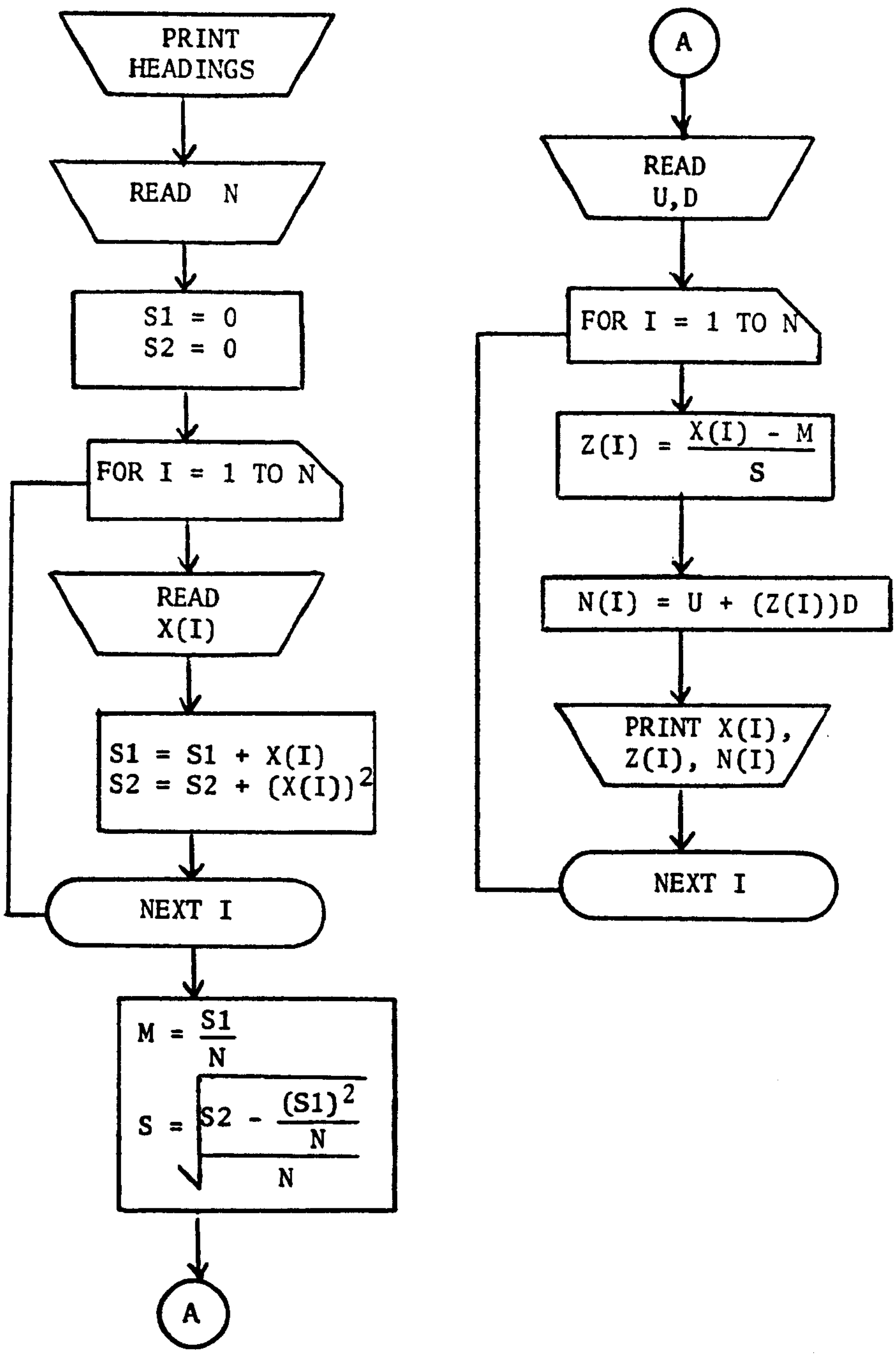
User's Input

```
GET-STAT6
150 DATA 5, 50, 40, 75, 82, 60, 75, 15
RUN
```

Computer Output

```
X           Z              N
50          -.736111       63.9583
40          -1.38182       54.2727
75           .878168       88.1725
82          1.33017        94.9525
60          -9.03992E-2    73.644
OUT OF DATA IN LINE 10
```

FLOWCHART FOR STAT6



CODING OF STAT6

```
  2 DIM X(30), Z(30), N(30)
  5 PRINT "X", "Z", "N"
 10 READ N
 15 LET S1 = 0
 20 LET S2 = 0
 25 FOR I = 1 TO N
 30     READ X(I)
 35     LET S1 - S1 + X(I)
 40     LET S2 = S2 + (X(I))↑2
 45 NEXT I
 50 LET M = S1/N
 55 LET S = SQR((S2-S1↑2/N)/N)
 60 READ U, D
 65 FOR I = 1 TO N
 70     LET Z(I) = (X(I)-M)/S
 75     LET N(I) = U + Z(I)*D
 80     PRINT X(I), Z(I), N(I)
 85 NEXT I
 90 PRINT
 95 GO TO 5
150 DATA
200 END
```

PROBLEM SET FOR STAT6

Use STAT6 to normalize the raw score test results for each of the following two sections of statistics, given the population's mean = 70 and the population's standard deviation = 10.

SECTION ONE X_i	SECTION TWO X_i
64	90
76	67
62	85
60	67
65	65
65	75
74	82
70	78
55	84
61	70
78	98
87	74
51	48
30	90
64	61
80	78
84	95
73	70
46	66
58	100
37	70
48	
91	
70	
70	
33	
65	

STAT7

A PREPACKAGED PROGRAM FOR COMPUTING CONFIDENCE INTERVALS

INSTRUCTIONS FOR STAT7

NAME: STAT7

DESCRIPTION: This program computes confidence intervals for the mean of a population.

INSTRUCTIONS: Enter the data beginning in line 150 as follows:

150 DATA M, D, N

where: M is the population mean = μ or the mean of a sample = $\bar{X}$ of size n.

D is the population standard deviation = σ if and only if M = μ; otherwise

$$D = \frac{\sigma}{n} \quad \text{or } D = \frac{s}{n},$$

where s = the standard deviation of a sample and n is the size of the sample.

$$N = \begin{cases} 1 \text{ if we want the 95\% confidence interval,} \\ 2 \text{ if we want the 99\% confidence interval,} \\ 3 \text{ if we want the 99.9\% confidence interval.} \end{cases}$$

NOTE: Line 200 is the END statement.

SAMPLE PROBLEM:

User's Input

```
GET-STAT7
150 DATA 2.02, .028, 1
151 DATA 2.02, .028, 2
152 DATA 2.02, .028, 3
RUN
```

Computer Output

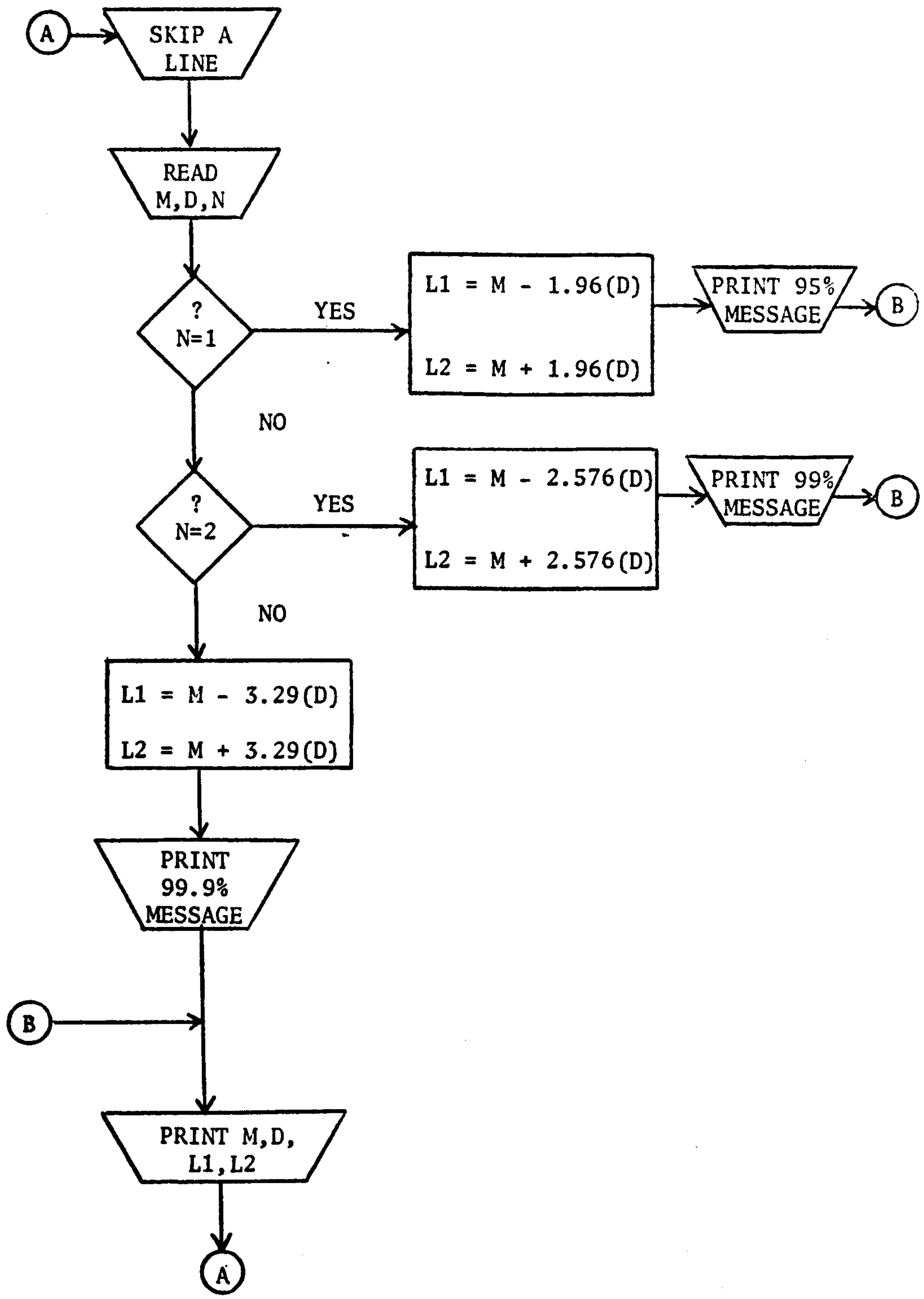
```
STAT7
THE 95 PERCENT CONFIDENCE INTERVAL
WITH M = 2.02 and SD = .028 IS:
1.96512 TO 2.07488 INCLUSIVE.

THE 99 PERCENT CONFIDENCE INTERVAL
WITH M = 2.02 and SD = .028 IS:
1.947872 TO 2.092128 INCLUSIVE.

THE 99.9 PERCENT CONFIDENCE INTERVAL
WITH M = 2.02 and SD = .028 IS:
1.92788 TO 2.11212 INCLUSIVE.

OUT OF DATA IN LINE 10
```

FLOWCHART FOR STAT7



CODING OF STAT7

```
 5 PRINT
10 READ M,D,N
15 IF N = 1 THEN 55
20 IF N = 2 THEN 75
25 LET L1 = M - 3.29 * D
30 LET L2 = M + 3.29 * D
35 PRINT "THE 99.9 PERCENT CONFIDENCE INTERVAL"
40 PRINT "WITH M="M; "AND SD="D; "IS:"
45 PRINT L1; "TO" L2; "INCLUSIVE."
50 GO TO 5
55 LET L1 = M - 1.96 * D
60 LET L2 = M + 1.96 * D
65 PRINT "THE 95 PERCENT CONFIDENCE INTERVAL"
70 GO TO 40
75 LET L1 = M - 2.576 * D
80 LET L2 = M + 2.576 * D
85 PRINT "THE 99 PERCENT CONFIDENCE INTERVAL"
90 GO TO 40
150 DATA
200 END
```

PROBLEM SET FOR STAT7

Use STAT7 as a tool to solve the following problems:

1. The Smooth Riding Tire Company states that the lifespan of its radial tires are normally distributed with a mean lifespan of 40,000 miles and a standard deviation of 4,500 miles. What is the 95% level of confidence for the mean of a random sampling of Smooth Riding radial tires?

2. A random sampling of 300 freshmen at Jersey College had a mean grade-point average of 2.23 with a standard deviation of .48. Find the 95% level of confidence for the mean freshman grade-point average at this college.

3. A random sampling of 100 patients at Hope Hospital showed that they had a mean amount of glucose (sugar) in their blood of 105.6 mg/100ml with a standard deviation of 3.8 mg/100ml. Find the 99% level of confidence for the mean amount of glucose in the blood of patients at Hope Hospital.

4. A medical report states that the population mean age of a woman who has a normal child birth delivery is 23.8 years with a standard deviation of 6.1 years. Find the 99% level of confidence for the mean of a random sampling of 100 ages of women who had normal childbirths.

5. A supervisor for the Monroe Department of Sanitation reports that a random sampling of 100 daily loads of garbage for a three-man crew shows a mean load of 2,600 pounds with a standard deviation of 620 pounds. Find the 95% level of confidence for the mean number of pounds of garbage carried daily by a crew of three men.

6. Given a random sample of 100 drawn from a given population, with an obtained mean = 70, and a standard deviation = 10, find the following confidence intervals for the population:

   (a) 95% confidence interval

   (b) 99% confidence interval

STAT8

A PREPACKAGED PROGRAM FOR COMPUTING AN OBSERVED Z-SCORE OR t-SCORE FOR THE DIFFERENCE BETWEEN A SAMPLE'S MEAN AND THE POPULATION'S MEAN

INSTRUCTIONS FOR STAT8

NAME: STAT8

DESCRIPTION: This program computes observed Z-score or observed t-score for differences between a sample's mean and a population's mean.

INSTRUCTIONS: Enter the data beginning in line 150 as follows:

150 DATA M1, M2, D, N

where: M1 is the sample's mean.

M2 is the population's mean.

D is the population's standard deviation (σ) or the sample's standard deviation(s).

N is the size of the sample.

NOTE: Line 200 is the END statement.

SAMPLE PROBLEM:

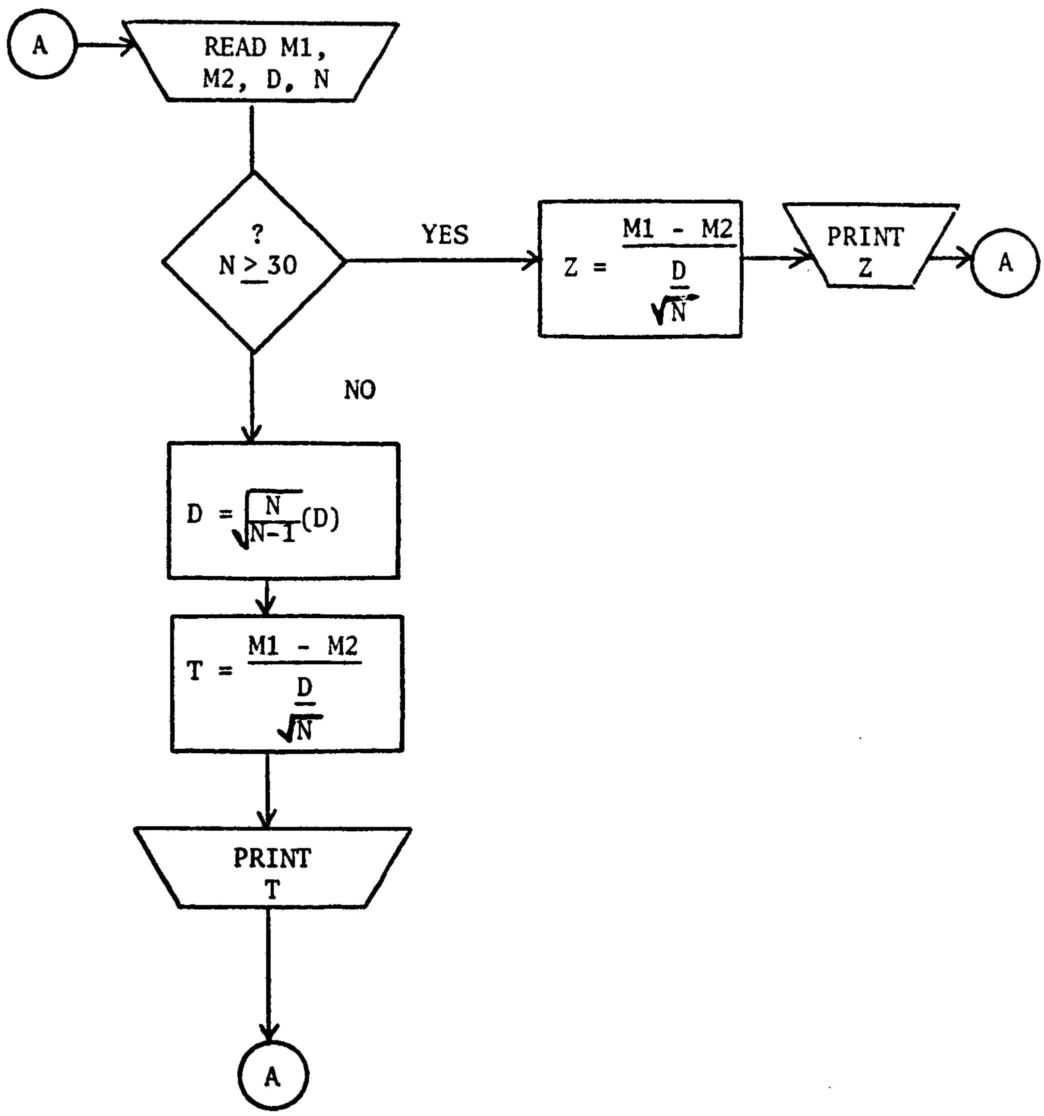
User's Input

```
GET-STAT8
150 DATA 110.4, 108.5, 8.0, 150
151 DATA 5.9, 7.0, 3.3, 29
RUN
```

Computer Output

```
STAT8
OBSERVED Z = 2.9087688
OBSERVED T = -1.76383
OUT OF DATA IN LINE 5
```

FLOWCHART FOR STAT8



CODING OF STAT8

```
  5 READ M1, M2, D, N
 10 IF N >= 30 THEN 35
 15 LET D = SQR(N/(N-1))*D
 20 LET T = (M1 - M2)/(D/SQR(N))
 25 PRINT "OBSERVED T="T
 30 GO TO 5
 35 LET Z = (M1 - M2)/(D/SQR(N))
 40 PRINT "OBSERVED Z="Z
 45 GO TO 5
150 DATA
200 END
```

PROBLEM SET FOR STAT8

Use the algorithm for hypothesis testing and/or STAT8 as tools to solve the following problems:

1. The college entrance exam used by State University has a $\mu = 400$ and $\sigma = 100$. A random sampling of 125 students from the northern part of the state determines a $\bar{X} = 420$ on the State University entrance examination. You suppose the sampling of 125 students indicates that, on the average, students from the northern part of the state perform better on the entrance examination than the general population.

   (a) Test your hypothesis at the .05 level of significance.

   (b) Test your hypotehsis at the .01 level of significance.

2. A national health survey reports the mean age of a woman who has a normal childbirth delivery is 23.8 years. A random sampling of 25 patients at Sweet Charity Hospital shows the mean age and standard deviation for normal deliveries to be $\bar{X} = 22.4$ years and $s = 7$ years. You assume that the information obtained in the sample above indicates that, on the average, the age of women who have normal deliveries at Sweet Charity Hospital is less than the national average. Test your hypothesis at the .05 level of significance.

3. A certain city reports that a 3-man crew in its department of sanitation collects a daily mean of 2,600 pounds of garbage. A supervisor randomly selects 28 3-man crews and finds their daily collection of garbage to weight, on the average, 2,500 pounds with a standard deviation of 625 pounds. Assume that this random sampling of 28 3-man crews indicates that this sample does not support the department of sanitation's report. Test your hypothesis at the .05 level of significance.

4. The Business Training Institute reports that its graduates earn a mean salary of \$12,000 with a standard deviation of \$3,000. A random sampling of 169 Business Training Institute graduates shows their salaries to have a $\bar{X} = \$12,300$. You hypothesize that, on the average, the mean of the sample of 169 salaries is higher than the mean salary of the general population of Business Training Institute graduates. Test your hypothesis at the .10 level of confidence.

   HINT: In a one-tail test of H_m: $\bar{X} > \mu$, the critical-Z for the .10 level of confidence would be $Z = 1.282$.

STAT9

A PREPACKAGED PROGRAM FOR COMPUTING THE OBSERVED Z-SCORE
OR t-SCORE FOR THE DIFFERENCE BETWEEN
TWO SAMPLE MEANS

INSTRUCTIONS FOR STAT9

NAME: STAT9

DESCRIPTION: This program computes observed Z-score or observed t-score for differences between two sample means.

INSTRUCTIONS: Enter the data beginning in line 150 as follows:

150 DATA M1, M2, V1, V2, N1, N2

where:

M1 is the first sample's mean.

M2 is the second sample's mean.

V1 is the first sample's variance.

V2 is the second sample's variance.

N1 is the size of the first sample.

N2 is the size of the second sample.

NOTE: Line 200 is the END statement.

SAMPLE PROBLEM:

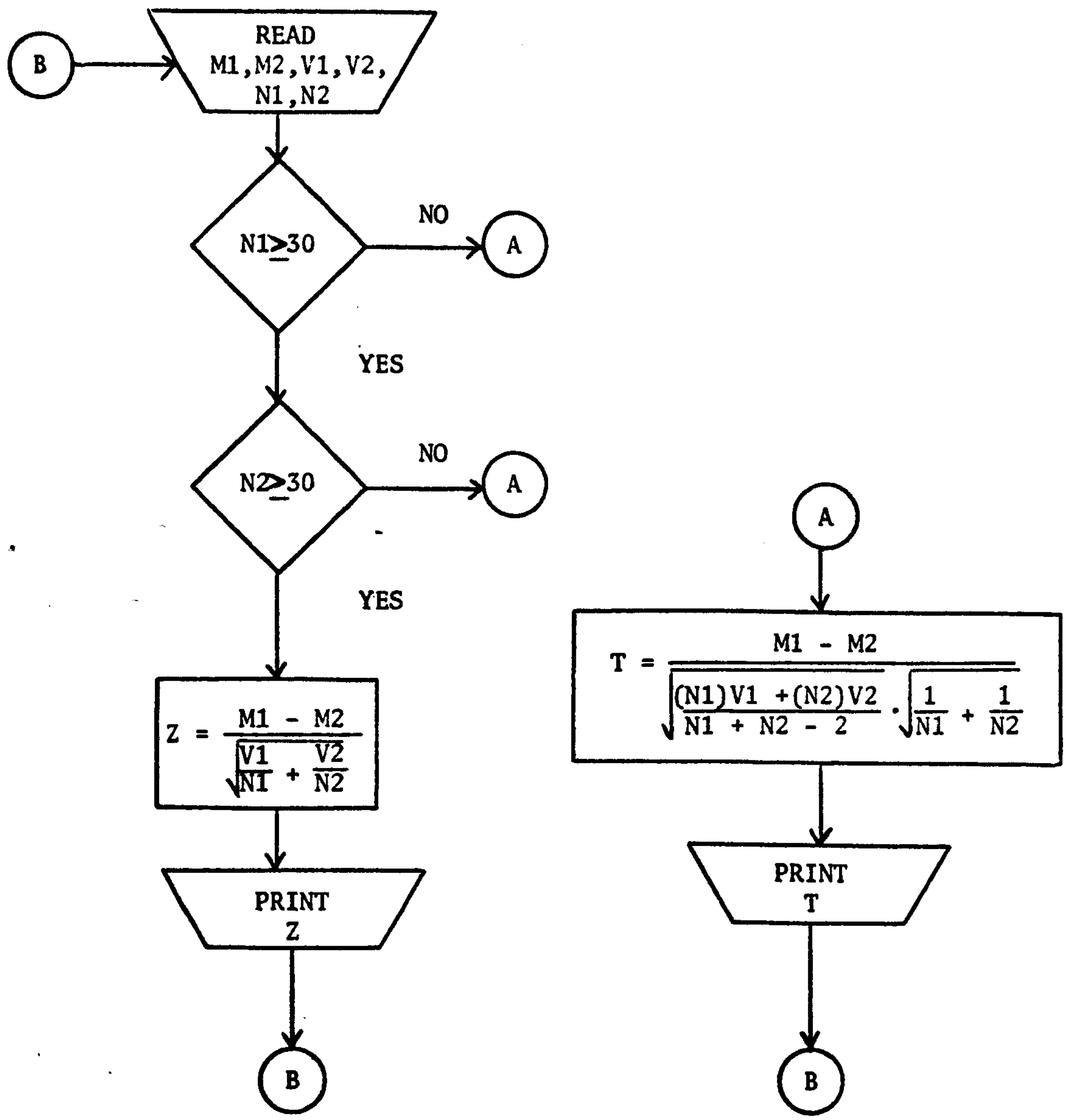
User's Input

```
GET-STAT9
150 DATA 108.7, 110.4, 62.5681, 77.44, 174, 150
151 DATA 74.4, 71.8, 262.64, 160.56, 5, 5
RUN
```

Computer Output

```
STAT9
OBSERVED Z= -1.81649
OBSERVED T= 0.252774
OUT OF DATA IN LINE 5
```

FLOWCHART FOR STAT9



CODING OF STAT9

```
 5 READ M1, M2, V1, V2, N1, N2
10 IF N1 > = 30 THEN 30
14 LET D = SQR((N1)*V1+(N2)*V2)/(N1+N2-2))*SQR(1/N1+1/N2)
15 LET T = (M1-M2)/D
20 PRINT "OBSERVED T="T
25 GO TO 4
30 IF N2 >= 30 THEN 40
35 GO TO 14
40 LET Z= (M1 - M2)/SQR(V1/N1 + V2/N2)
45 PRINT "OBSERVED Z="Z
50 GO TO 5
150 DATA
200 END
```

PROBLEM SET FOR STAT9

Use the algorithm for hypothesis testing and/or STAT9 as tools to solve the following problems.

1. The City of Hoboken, New Jersey has two junior high schools, Demarest Junior High and Brandt Junior High. A random sampling of 6 ninth-grade student IQ scores are selected from each of the two junior high schools. The results are as follows:

DEMAREST IQ SCORES	BRANDT IQ SCORES
100	100
107	105
110	111
95	90
90	92
120	115

You assume that the sampling above indicates that, on the average, Demarest Junior High School's ninth-grade students have higher IQ scores than Brandt Junior High School's ninth-grade students. Test your hypothesis at the .05 level of significance.

2. Two machines A and B produce 15¢ candy bars for the Cavity Candy Company. A random smpling of 100 candy bars produced by machine A shows the mean weight of 3.2 ounces with a variance of 0.0289 ounces. A random sampling of 90 candy bars produced by machine B determines a mean weight of 3.15 ounces with a variance of 0.0225 ounces. You suppose that the samples above indicate that, on the average, machine B produces candy bars of less weight than those produced by machine A. Test your hypothesis at the .05 level of significance.

3. Test the hypothesis in Problem 2 above at the .01 level of significance.

4. Given the following information for two random samples:

SAMPLE 1: $\overline{Y}_1 = 50;\ s_1^2 = 100;\ n_1 = 35$

SAMPLE 2: $\overline{Y}_2 = 46.174;\ s_2^2 = 95;\ n_2 = 40$

(a) Test the motivated hypothesis H_m: $\overline{Y}_1 \neq \overline{Y}_2$ at the .05 level of significance.

(b) Test the motivated hypothesis H_m: $\overline{Y}_1 \neq \overline{Y}_2$ at the .01 level of significance.

5. Machines A, B and C manufacture the same type of pipe for the Wet Plumbing Company. The following table indicates a random sampling of pipes and their diameters made by machines A, B, and C.

MACHINE	NUMBER IN SAMPLE	DIAMETER IN INCHES	VARIANCE OF DIAMETER IN INCHES
A	35	2.03	0.001
B	40	2.032	0.015
C	35	2.038	0.030

Test the following motivated hypotheses at the .05 level of significance.

(a) H_m: $\overline{A} < \overline{B}$

(b) H_m: $\overline{C} > \overline{B}$

(c) H_m: $\overline{A} \neq \overline{B}$

(d) H_m: $\overline{A} = \overline{C}$

6. Given the following information for two random samples:

SAMPLE 1: $\overline{Y}_1 = 75$; $s_1{}^2 = 100$; $n_1 = 10$

SAMPLE 2: $\overline{Y}_2 = 80$; $s_2{}^2 = 68$; $n_2 = 8$

Test the motivated hypothesis H_m: $\overline{Y}_1 < \overline{Y}_2$ at the .01 level of significance.

STAT10

A PREPACKAGED PROGRAM FOR COMPUTING AN OBSERVED CHI-SQUARE VALUE

INSTRUCTIONS FOR STAT10

NAME: STAT10

DESCRIPTION: This program computes the observed χ^2 - (chi-square) value for a given set of observed frequencies.

INSTRUCTIONS: Enter the data beginning in line 150 as follows:

150 DATA N, P, M1, F1, M2, F2, ..., MN, FN

where:

N is the number of distinct samples.

M1, M2, ..., MN are the number of observations in each distinct sample.

F1, F2, ..., FN are the number of observed frequencies in each distinct sample.

P = value of probability of successes on one trial if known, or 0 if probability of success on one trial is unknown.

NOTE: Line 200 is the END statement.

SAMPLE PROBLEMS:

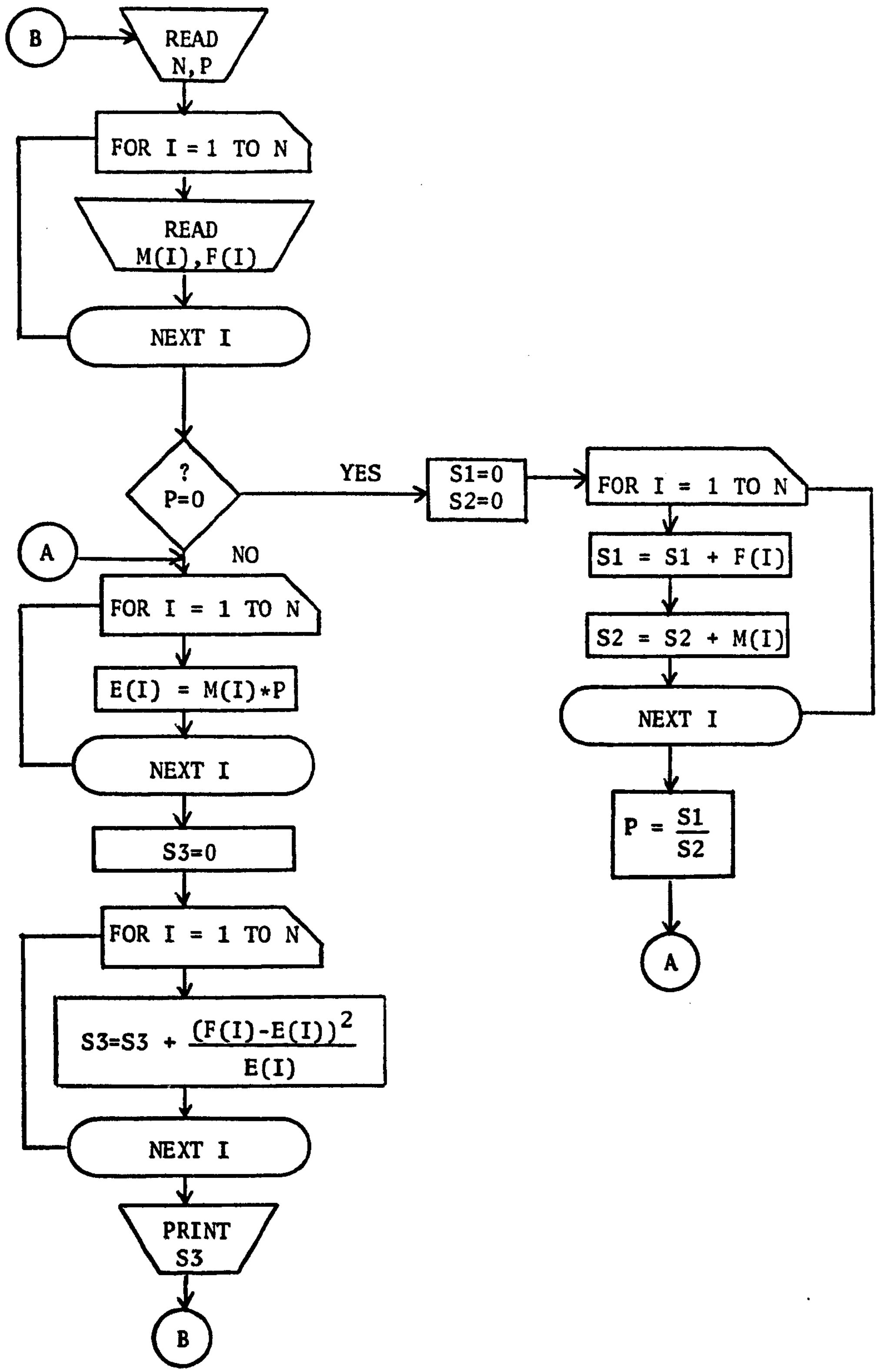
User's Input

```
GET-STAT10
150 DATA 3,0,500,210,460,200,520,300
151 DATA 5,.001,5000,2,5000,3,5000,8,5000,5,5000,8
RUN
```

Computer Output

```
STAT10
OBSERVED CHI-SQUARE VALUE = 15.8951
OBSERVED CHI-SQUARE VALUE = 6.2
OUT OF DATA IN LINE 5
```

FLOWCHART FOR STAT10



CODING OF STAT10

```
  2 DIM M(30), F(30), E(30)
  5 READ N,P
 10 FOR I = 1 TO N
 15    READ M(I), F(I)
 20 NEXT I
 25 IF P = 0 THEN 75
 30    FOR I = 1 TO N
 35    LET E(I) = M(I)*P
 40 NEXT I
 45 LET S3 = 0
 50 FOR I = 1 TO N
 55    LET S3 = S3 + (F(I) - E(I))↑2/E(I)
 60 NEXT I
 65 PRINT "OBSERVED CHI-SQUARE VALUE="S3
 70 GO TO 5
 75 LET S1 = 0
 80 LET S2 = 0
 85 FOR I = 1 TO N
 90    LET S1 = S1 + F(I)
 95    LET S2 = S2 + M(I)
100 NEXT I
105 LET P = S1/S2
110 GO TO 30
150 DATA
200 END
```

PROBLEM SET FOR STAT10

Use STAT10 to compute the chi-square statistic needed for each of the following problems:

1. A survey of residents in New York City found that 150 of 200 Queens County residents, 300 of 600 Manhattan residents, and 200 of 300 Bronx residents attended church services every week. Test the motivated hypothesis that the residents of Queens, Manhattan, and Bronx counties do not have the same church attendance habits at the .01 level of significance.

2. The State Health Department reports that 6 out of every 10 high school students smoke cigarettes. A random sampling of five State high schools shows the following results:

	SCHOOL				
	1	2	3	4	5
NUMBER IN SAMPLE	100	100	50	200	300
NUMBER IN SAMPLE WHO SMOKE	50	70	25	130	185

Test the motivated hypothesis that the sampling of students in five high schools does not support the State Health Department's claim at the .05 level of significance.

3. The Fresh Smelling Soap Company reports that one out of every three housewives uses its fabric softener. A random sampling of housewives shows the following results:

	SUPERMARKET			
	1	2	3	4
NUMBER OF HOUSEWIVES IN SAMPLE	50	30	100	50
NUMBER IN SAMPLE WHO USE FRESH SMELLING SOFTENER	20	8	20	10

Test the motivated hypothesis that the random sampling of housewives does not support the Fresh Smelling Soap Company's claim at the .05 level of significance.

4. Given the following information:

	MATH COURSE			
	MA10	MA20	MA21	MA22
NUMBER OF STUDENTS IN SAMPLE	100	100	100	100
NUMBER OF STUDENTS IN SAMPLE WHO PASSED COURSE LAST YEAR	35	45	70	80
NUMBER OF STUDENTS EXPECTED TO PASS COURSE	50	50	60	70

(a) Test the motivated hypothesis that the students in the sample are not representative of the population at the .05 level of significance.

(b) Test the hypothesis in (a) above at the .01 level of significance.

5. A study showed that 35 of 100 owners of new Cadillacs were single; 50 of 100 owners of new Buicks were single; and 65 of 100 owners of new Volkswagens were single. Test the motivated hypothesis that there is a difference between the proportions of single owners of Cadillacs, Buicks, and Volkswagens at the .01 level of significance.

6. A recent survey disclosed the following results:

	OIL COMPANY			
	A	B	C	D
NUMBER OF SUPERVISORS IN SAMPLE	100	100	100	100
NUMBER OF SUPERVISORS IN SAMPLE WITH A COLLEGE DEGREE	70	60	85	90

Test the motivated hypothesis that there is a difference between the proportions of supervisors with college degrees at the .05 level of significance.

STAT11

A PREPACKAGED PROGRAM FOR FINDING
LINEAR REGRESSION EQUATIONS

INSTRUCTIONS FOR STAT11

NAME: STAT11

DESCRIPTION: This program computes the slope and y-intercept for an estimated linear regression equation.

INSTRUCTIONS: Enter the data beginning in line 150 as follows:

150 DATA N, X1, Y1, X2, Y2, ..., XN, YN

where: N is the number of given ordered pairs.

X1, X2, ..., XN are the values of the independent variable.

Y1, Y2, ..., YN are the values of the dependent variable (variable to be predicted).

NOTE: Line 200 is the END statement.

SAMPLE PROBLEM:

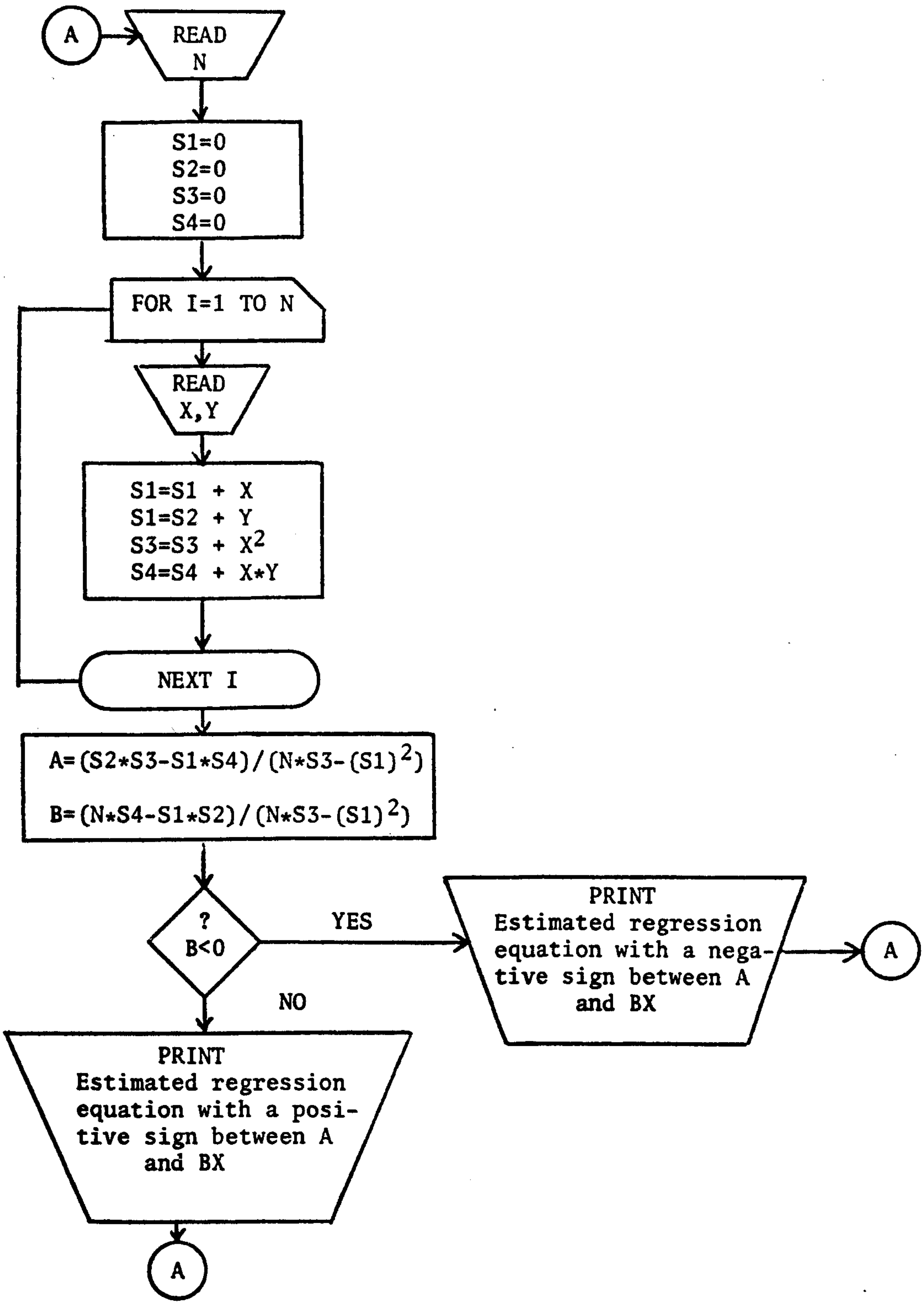
User's Input

```
GET-STAT11
150 DATA 5,70,2.1,75,2.6,80,2.9,85,3.3,90,3.8
151 DATA 6,59,175,65,176,73,168,72,170,68,172,60,170
152 DATA 4,1,12000,2,14000,3,13000,4,17000
153 DATA 4,1,14.2,2,13,3,10,4,9.6
RUN
```

Computer Output

```
Y = -3.6199 + 8.1992E - 2 X
Y = 191.8284 - 0.3021925 X
Y = 10500 + 1400 X
Y = 15.9 - 1.68 X
OUT OF DATA IN LINE 5
```

FLOWCHART FOR STAT11



CODING OF STAT11

```
  5 READ N
 10 LET S1 = 0
 15 LET S2 = 0
 20 LET S3 = 0
 25 LET S4 = 0
 30 FOR I = 1 TO N
 35    READ X,Y
 40    LET S1 = S1 + X
 45    LET S2 = S2 + Y
 50    LET S3 = S3 + X↑2
 55    LET S4 = S4 + X*Y
 60 NEXT I
 65 LET A = (S2*S3-S1*S4)/(N*S3-(S1)↑2)
 70 LET B = (N*S4-S1*S2)/(N*S3-(S1)↑2)
 75 IF B<0 THEN 90
 80 PRINT "Y="A; "+"B; "X"
 85 GO TO 95
 90 PRINT "Y="A; B; "X"
 95 PRINT
100 GO TO 5
150 DATA
200 END
```

PROBLEM SET FOR STAT11

Use STAT11 to estimate the linear regression equation for each of the following problems:

1. Seven people are enrolled in an experimental speed reading program. The following table shows the increase in the number of words per minute they could read and the number of weeks they were enrolled in the program:

x NUMBER OF WEEKS	y INCREASE IN WORDS PER MINUTE
1	10
2	25
3	22
4	35
5	60
6	55
7	80

   (a) Find the estimated linear regression equation to predict the increase in words per minute read given the number of weeks of participation in the program.

   (b) Use the estimated linear regression equation obtained in (a) to preduct the increase in the number of words per minute read for a person enrolled in the experimental program for 3.5 weeks and 8 weeks.

2. From the freshman students enrolled at Jersey City State College who attended Hoboken High School, eight were randomly selected. The following table indicates their freshman grade point average at Jersey City State and their class rank upon graduation from Hoboken High School

x CLASS RANK	y FRESHMAN G.P.A.
20	3.5
100	2.5
10	3.4
50	3.2
65	3.0
210	1.8
70	2.8
150	2.6

   (a) Find the estimated linear regression equation to predict a student's freshman G.P.A. at Jersey City State College given his/her class rank at Hoboken High School.

(b) Use the estimated linear regression equation in (a) to predict the freshman G.P.A. at Jersey City State of students whose class ranks at Hoboken High School were 200, 300, 5.

3. The following table illustrates the average number of cigarettes smoked daily by a person and his/her corresponding age at death as determined by a recent survey.

x AVERAGE NUMBER OF CIGARETTES DAILY	y AGE AT DEATH
10	65
20	58
30	50
40	51
50	45
5	70
8	65

(a) Find the estimated linear regression equation to predict a person's age at death given the average number of cigarettes he/she smokes daily.

(b) Use the estimated linear regression equation in (a) to predict the age at death of persons smoking an average of 15, 25, and 0 cigarettes daily.

4. The Strongman Tool and Die Company lists the following information which shows the age of a machine and the corresponding number of 4-inch bolts it produces in 8 hours:

x AGE IN YEARS	y NUMBER OF 4 INCH BOLTS IN 8 HOURS
1/2	2500
1	2400
2	2000
3	1800
4	1500

(a) Find the estimated linear regression equation to predict the number of 4-inch bolts produced by a machine in 8 hours given the age in years of the machine.

(b) Use the estimated linear regression equation in (a) to predict the number of 4-inch bolts produced by a machine in 8 hours for machines that are 1.5 years old, 2.5 years old, 2 months old.

5. The following table illustrates the amount of money a producer invested in a Broadway play and the corresponding net return on his investment:

x INVESTMENT	y NET RETURN
50,000	100,000
200,000	100,000
70,000	30,000
500,000	-100,000
250,000	1,000,000

(a) Find the estimated linear equation to predict the net return on a Broadway producer's investment, given the amount of the investment.

(b) Use your estimated linear equation determined in (a) to predict the net returns on a producer's investments of $800,000; $1,000,000; $450,000.

6. The following table lists the ages and second-hand prices charges for the Hurricane sedan:

AGE (years)	PRICE (dollars)
1	$2,500
3	2,175
8	1,375
9	1,125
5	1,525
5	1,600
1	2,375

(a) Determine the estimated linear equation to predict the second-hand price charged for the Hurricane car, given the car's age in years.

(b) Use this linear equation you determined in (a) to predict the second-hand prices charged for Hurricane cars which are 10 yeras old; 2 years old; 7 years old.

STAT12

A PREPACKAGED PROGRAM FOR COMPUTING THE
COEFFICIENT OF CORRELATION

INSTRUCTIONS FOR STAT12

NAME: STAT12

DESCRIPTION: This program computes the coefficient of correlation for a set of ordered pairs (x,y), where x is the independent variable and y is the dependent (predicted) variable.

INSTRUCTIONS: Enter the data beginning in line 150 as follows:

```
150 DATA N, X1, Y1, X2, Y2, ..., XN, YN
```

where:

N is the number of given ordered pairs.

X1, X2, ..., XN are the values of the independent variable.

Y1, Y2, ..., YN are the values of the dependent (predicted) variable.

NOTE: Line 200 is the END statement.

SAMPLE PROBLEM:

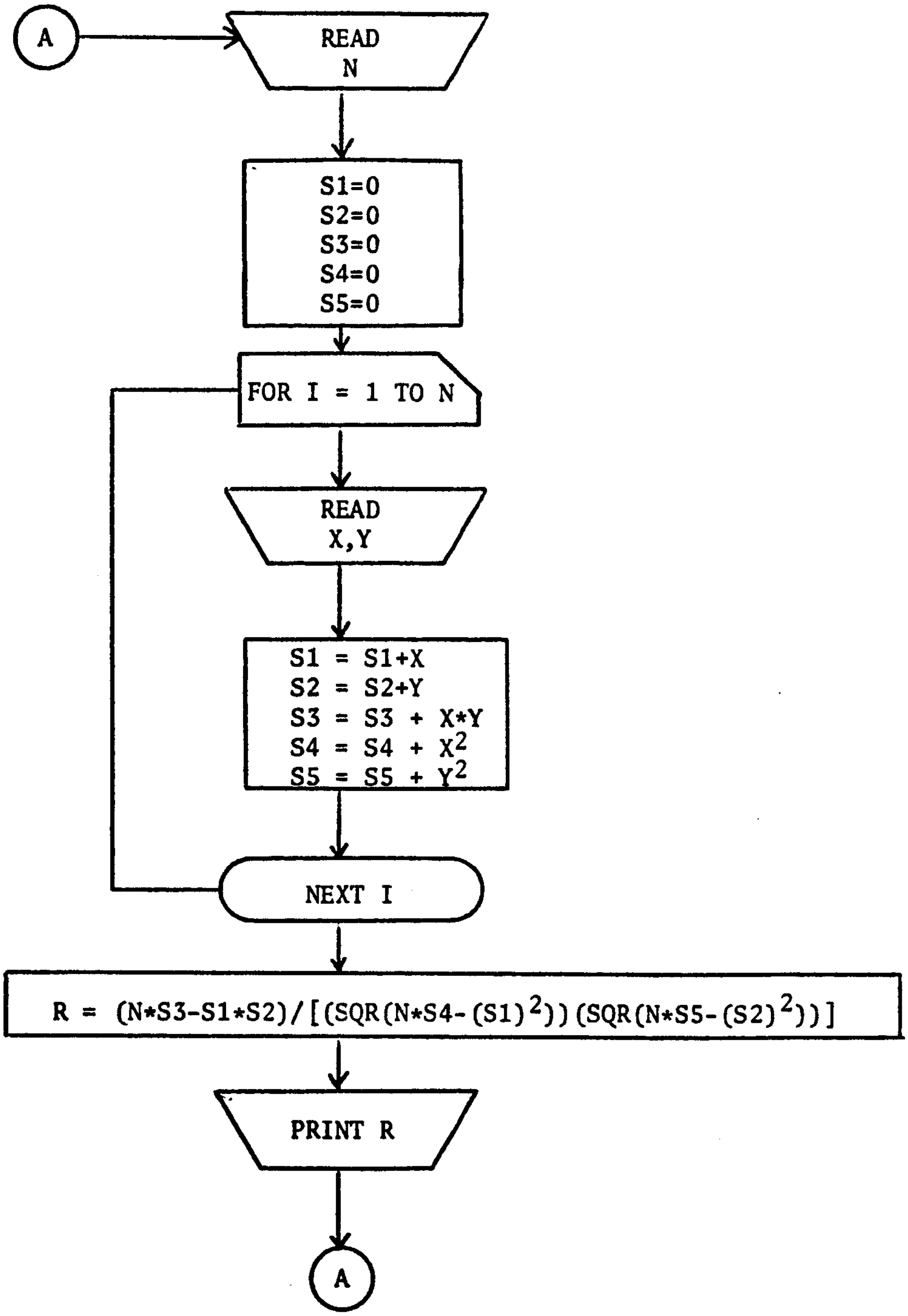
User's Input

```
GET-STAT12
150 DATA 5,70,2.1,75,2.6,80,2.9,85,3.3,90,3.8
151 DATA 4,1,14.2,2,13,3,10,4,9.6
RUN
```

Computer Output

```
COEFF. OF CORRELATION R = 0.996735
COEFF. OF CORRELATION R = -0.96228
OUT OF DATA IN LINE 5
```

FLOWCHART FOR STAT12



CODING OF STAT12

```
 5 READ N
10 LET S1 = 0
15 LET S2 = 0
20 LET S3 = 0
25 LET S4 = 0
30 LET S5 = 0
35 FOR I = 1 TO N
40 READ X,Y
45     LET S1 = S1 + X
50     LET S2 = S2 + Y
55     LET S3 = S3 + X * Y
60     LET S4 = S4 + X ↑ 2
65     LET S5 = S5 + Y ↑ 2
70 NEXT I
75 LET R = (N*S3-S1*S2)/(SQR(N*S4-S1↑2)*SQR(N*S5-S2↑2))
80 PRINT "COEFF. OF CORRELATION R="R
85 GO TO 5
150 DATA
200 END
```

PROBLEM SET FOR STAT12

1. For each of the exercises in the Problem Set for STAT11:

   (a) Use STAT12 to compute the coefficient of correlation for the given sets of data.

   (b) Use Table 7 to determine what type of correlation you have (i.e., positive, negative, or zero) and whether or not the coefficient of correlation is significant at the .05 level.

   (c) Determine whether or not the coefficient of correlation is significant at the .01 level.

STAT13

A PREPACKAGED PROGRAM FOR COMPUTING THE OBSERVED F-RATIO

INSTRUCTIONS FOR STAT13

NAME: STAT13

DESCRIPTION: This program computes the calculated F ratio in an analysis of variance procedure.

INSTRUCTIONS: Enter the data beginning in line 180 as follows:

```
180 DATA K, T1, T2, ..., TK, X1, X2, ..., XN
```

where: K is the number of different independent variables.

T1 is the number of scores from the first independent variable.

T2 is the number of scores from the second independent variable, etc ... until TK is the number of scores from the last independent variable.

X1, X2, ..., XN is the listing of all the scores.

First list the scores from the first independent variable; then list the scores from the second independent variable; finally list the scores from the last independent variable.

NOTE: Line 200 is the END statement.

SAMPLE PROBLEM:

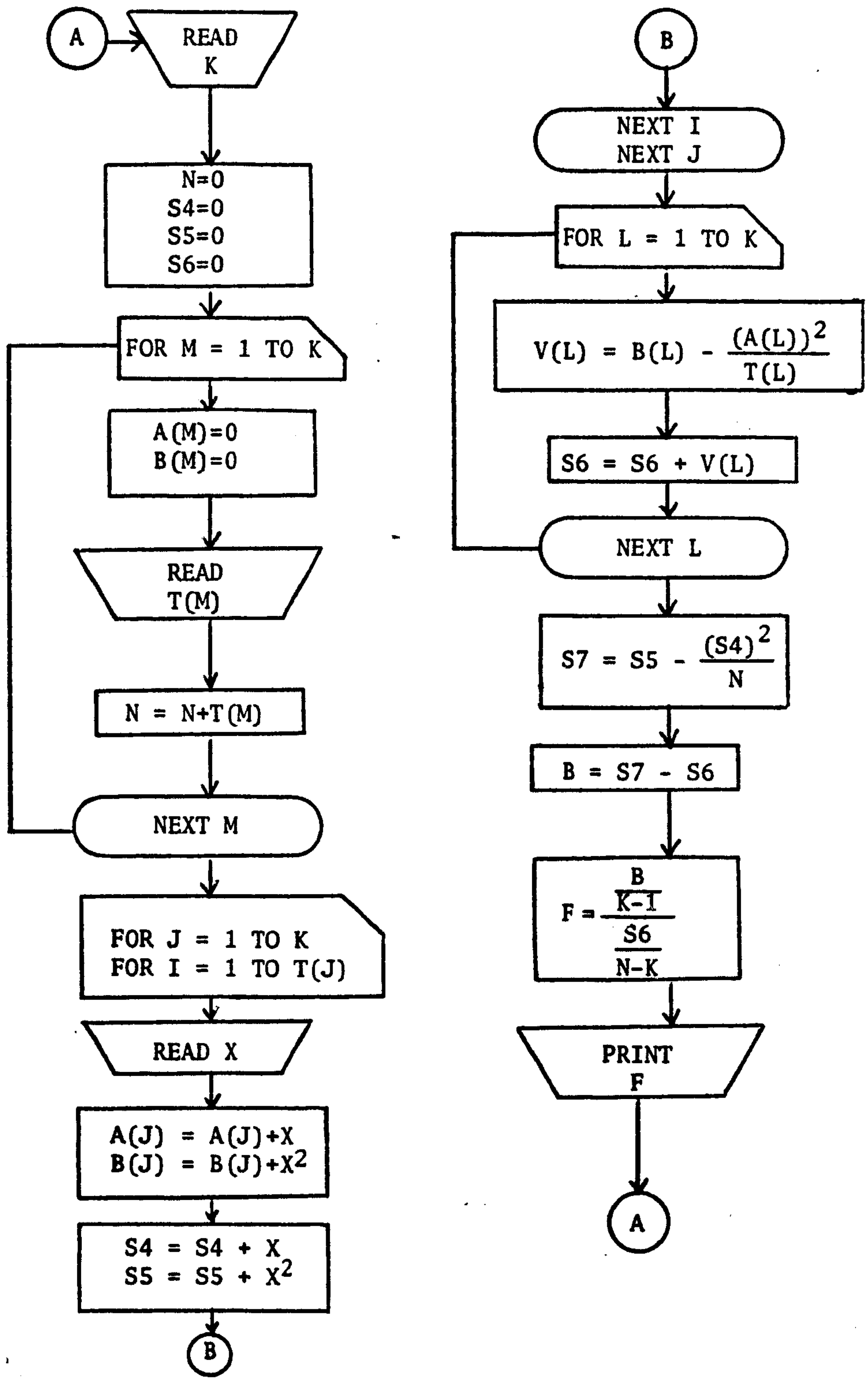
User's Input

```
GET-STAT13
180 DATA 4,7,7,7,7,10,15,8,20,7,9,11
181 DATA 22,13,9,11,20,20,15
182 DATA 5,22,19,18,10,10,10
183 DATA 14,12,11,10,8,9,8
RUN
```

Computer Output

```
STAT13
OBSERVED F = 1.77495
DF FOR NUMERATOR = 3
DF FOR DENOMINATOR = 24
OUT OF DATA IN LINE 5
```

FLOWCHART FOR STAT13



CODING OF STAT13

```
  2 DIM A(10), B(10), T(10), V(10)
  5 READ K
 10 LET N = 0
 15 LET S4 = 0
 20 LET S5 = 0
 25 LET S6 = 0
 30 FOR M = 1 TO K
 35 LET A(M) = 0
 40 LET B(M) = 0
 45 READ T(M)
 50 LET N = N + T(M)
 55 NEXT M
 60 FOR J = 1 TO K
 70 FOR I = 1 TO T(J)
 75     READ X
 80     LET C = C + 1
 85     LET A(J) = A(J) + X
 90     LET B(J) = B(J) + X ↑ 2
 95     LET S4 = S4 + X
100     LET S5 = S5 + X ↑ 2
110 NEXT I
120 NEXT J
125 FOR L = 1 TO K
130 LET V(L) = B(L) - A(L) ↑ 2/T(L)
135 LET S6 = S6 + V(L)
```

```
140 NEXT L
145 LET S7 = S5 - S4 ↑ 2/N
150 LET B = S7 - S6
155 LET F = (B/(K-1))/(S6/(N-K))
160 PRINT "OBSERVED F="F
165 PRINT "DF. FOR NUMERATOR ="K-1
170 PRINT "DF. FOR DENOMINATOR="N-K
175 GO TO 5
180 DATA
200 END
```

PROBLEM SET FOR STAT13

Use STAT13 to find the observed F-ratio for each of the following problems:

1. Three different machines (A, B, C) produce radio tubes for the Now Sound Radio Corporation. For each of five consecutive days 100 radio tubes are selected from each of the three machines and tested for defects. The following table indicates the number of defective radio tubes for each machine for five consecutive days.

DAY	MACHINE A	MACHINE B	MACHINE C
1	2	2	6
2	7	1	3
3	8	5	2
4	3	3	1
5	5	3	10

(a) Test the motivated hypothesis that there exist significant differences among the means of the numbers of defective radio tubes in the three samples at the .05 level of significance.

(b) Now test the motivated hypothesis at the .01 level of significance.

2. Four different bus companies service the route from Quietown U.S.A. to Swingtown, U.S.A. Three trips from Quietown to Swingtown are randomly selected for each of the four bus companies, and the length of time in minutes for each trip is recorded as follows:

TRIP	BUS CO. 1	BUS CO. 2	BUS CO. 3	BUS CO. 4
1	50	50	58	50
2	52	57	50	50
3	54	45	49	50

Test the motivated hypothesis that there are significant differences in the mean times for the four bus companies at the .01 level of significance.

3. Six students are randomly selected from each of three different speed reading schools. Their increase in number of words per minute is recorded below after 3 weeks in each school:

STUDENT	SCHOOL 1	SCHOOL 2	SCHOOL 3
1	22	30	25
2	20	30	25
3	30	21	30
4	35	35	30
5	20	22	32
6	25	30	32

Test the motivated hypothesis that there are significant differences among the mean increases of words per minute for students enrolled in the three different schools at the .05 level of significance.

4. Given the following final examination information for four different sections of statistics at a local university:

SECTION 1	SECTION 2	SECTION 3	SECTION 4
80	70	80	80
60	76	50	75
55	90	75	60
90	60	70	90
85	52	62	75

Test the motivated hypothesis that there exist significant differences among the mean final exam scores of the four different sections of statistics:

(a) at the .05 level of significance;

(b) at the .01 level of significance.

5. The table below lists the weekly salaries of four salesmen for the Atlas Aluminum Siding Company for the last three weeks. Calculate F and:

(a) test at the .05 level of significance the motivated hypothesis that significant differences exist among the average weekly salaries of these four salesmen for this given period of three weeks;

(b) also test the motivated hypothesis at the .01 level of significance.

AXELROD	INGE	MILLER	WILLIAMS
$ 226	$ 251	$ 208	$ 247
218	237	191	218
252	237	222	209

6. Twenty-four homogeneous fifth-grade pupils were divided into three equal subgroups for the purpose of comparing the effectiveness of three distinct methods of teaching reading. Each groups was taught one of these methods, and at the end of the school year, the pupils were given the same reading test. The test scores were reported as follows:

METHOD 1	METHOD 2	METHOD 3
75	90	77
91	75	84
80	80	83
82	83	90
79	78	85
81	76	84
83	84	87
80	88	81

Test at the .05 level of significance the motivated hypothesis that significant differences exist among the mean test scores of pupil subgroups taught reading by the three different methods.

IMPLEMENTATION OF A CURRICULUM FOR A ONE-SEMESTER UNDERGRADUATE COURSE IN ELEMENTARY COMPUTER-ASSISTED STATISTICS

Frank Scalzo, Ph.D.
Fordham University, 1976

Mentor: Rowland S. Hughes, Ph.D.

The purpose of this study was to formulate, validate, and implement a one-semester undergraduate course in elementary computer-assisted statistics. This investigation further sought to determine, through the teaching of this curriculum by a college instructor other than the present investigator, effectiveness of learning of students in a designated section of elementary CAI statistics. Students' conceptual and psychomotor learning difficulties, as well as perceptions of both students and instructor regarding this CAI course, were also ascertained.

The present investigator devised a packet of CAI statistics materials, consisting of a specifically stated sequence of proposed statistical topics and 13 prepackaged statistical programs, each of which included a general description and purpose, flowchart, and coding in the Basic programming language. This CAI statistics curriculum was validated by ten experts in the field of computer-assisted instruction and statistics.

During the fall 1975 semester one instructor, other than the investigator, implemented the final

validated CAI curriculum with one class of 19 Liberal Arts students at Queensborough Community College of The City University of New York. The instructor administered three unit tests and a final examination to the students enrolled in this CAI course. The questions on the unit tests and the final examination were selected from Johnson's Test Item Card File for Elementary Statistics (1974).

An Observation Rating Scale for Psychomotor and Conceptual Learning Difficulties was formulated by the investigator and subsequently validated by three experts in the field of testing and computer science. This validated instrument was used to determine conceptual and psychomotor learning difficulties encountered by students when operating computer terminals.

The investigator interviewed the instructor and each of the students who completed the course outside the class situation. He asked each student 20 questions concerning their perceptions of the course presentation, content, and sequence.

Among the major conclusions were:

1. The responding experts in the field of computer-assisted instruction and statistics agreed that the proposed computer-assisted statistics curriculum was viable as presented by the investigator and should be implemented without changes.

2. Results of the scores on the unit tests and the final examination indicated that a large majority of the students who completed the computer-assisted statistics course succeeded on each of the unit tests and the final examination.

3. Learning in this class of CAI students, appeared to become more effective, in general, as the course progressed.

4. Although most of the students in this CAI course initially had some psychomotor and conceptual learning difficulties while operating a computer terminal, they appeared to overcome reasonably these difficulties after two or three practice sessions.

5. A large majority of the students were of the opinion that flowcharting and prepackaged computer programs were useful as practical tools in the solution of statistical problems.

6. A small majority of the students preferred to take a CAI statistics course rather than a traditional statistics course.

7. The instructor and the students who completed this CAI course appeared to be in general agreement that the course was presented in a logical and sequential order.

VITA

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