A study of the effects of using a spreadsheet versus a preprogrammed statistical package on the learning of statistics

by

Stanley Kay Scheiding

A Thesis Submitted to the

Graduate Faculty in Partial Fulfillment of the

Requirements for the Degree of

MASTER OF SCIENCE

Department: Professional Studies in Education
Co-Majors: Education (Curriculum and Instructional Technology) and (Research and Evaluation)

Iowa State University
Ames, Iowa

1988

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

"Pure logical thinking cannot yield us any knowledge of the empirical world; all knowledge of reality starts from experience and ends with it."
– Albert Einstein, 1934

At present, the primary use of a computer in teaching statistics is to reduce the time necessary for calculation of mathematical formulas. Calculation of an analysis of variance (ANOVA) problem of a 3 X 4 design with 20 observations per cell may require 0.29 seconds to compute on a mainframe computer, or two hours by using pencil, paper and a hand calculator. The student's level of understanding of an ANOVA problem is quite different upon the completion of the two methodologies. The calculation of the problem with the mainframe provides the student with little clarity about the process of solving the problem, but the mainframe provides a quick and accurate answer. By comparison, the by-hand calculation may provide an in-depth understanding of the computational process, but it requires a great deal of time. In addition, the by-hand process may cause the student to tire of the process and commit mathematical errors in calculation, thus leading to an incorrect answer (Hsiao, 1985b).

For the beginning student, the process of learning educational statistics may require a higher level of interaction between the computer and the student's level of knowledge. Students who possess a limited background in statistics need to understand the problem solving process before they turn the process over to the computer. The computer does reduce the time spent in the calculation of a problem, but it also hides the inter-processes and relationships of the data manipulation (Hsiao, 1985b) and (Warren,1988).

In order to allow the student to learn statistics and to retain the information, Dillbeck (1983) suggests the student needs to have the ability to confirm the information presented in class with what he/she knows. The concept presented in Papert's Mindstorms, (1980) was that a computer based environment for learning may allow the student to test his/her understanding of complex ideas.

When using the computer language LOGO, students teach the turtle using the student's understanding of the interrelationships of plane geometry. This highly interactive process confirms whether the notion held by the student about the motion of the turtle is correct in producing the desired shape or design. Once the student understands the basics of turtle movement, more complex drawings can be attempted, using combinations of the simpler commands.

In statistics, students who work in an environment that allows them to progress logically to an understanding of unknown relationships of the smallest units of information of statistics (sum, average, variance, standard deviation), can generalize the information to other situations more frequently (Cooper and Sweller, 1987). A carefully developed instructional process might focus the student to investigate the relationships between the statistical concepts in order to increase his/her understanding. The computer has been used as a computational tool and can serve as a learning environment for statistics at the same time. The need is for a computer environment that allows the student to have control over the smallest units involved in the computational process and their own learning.

Historical Perspectives in Statistics

The history of statistics, as a field of mathematics, is depicted by the evolution of the mathematical formulas and thought processes leading up to our current understanding of the field (Hart, 1983). At the turn of the century the education of a student in statistics was taught through a series of increasingly complex calculations, requiring an increasingly higher level of mathematical background and abstract reasoning ability. The disadvantages of the process of completing calculations by using pencil and paper were the time required and calculation errors. Devices such as the "crank calculators" and slide rulers decreased the manual arithmetic, but did not decrease drudgery and time (Emond, 1982).

Complex statistical designs and computations were very time consuming and difficult to verify.

When computers became available, the problem facing the student was how to in write code that the computer could understand. The Fortran, APL and BASIC languages (Lyczak, 1980), were used by students in the early 1960s. Using the computer required the student to translate the abstract notions of statistics into a equally abstract programming language. Statistical textbooks like Lohnes and Cooley (1968), Introduction to Statistical Procedures: with Computer Exercises, included the FORTRAN computer language programs at the end of the chapters. Calculators became available in the early 1970s which gave students quick and accurate methods of computation, but still left the student in charge of the total process of analysis.

In the late 1970s, the microcomputer became available and placed the power of the mainframe at the disposal of students for a lower cost. The disadvantage for the beginning statistics student was the addition of another layer of abstractness because many students had no prior computer experience. While the student was able to compute the desired statistics in less time, the student did not gain the concrete understanding experienced in the by-hand method. With the advent of the microcomputer, the student had gained time but lost the ability to interact with mathematical concepts in a concrete manner.

It is this understanding of statistics through concrete interaction and manipulation of data that increases the student's knowledge. Students in education courses tend to concentrate on being able to apply the statistical tests rather than understand the theoretical basis of the test (Glass and Stanley, 1970). The learning of statistics is more than just using a particular statistical technique, it is coming to an understanding of assumptions of the technique. The acquisition of knowledge about statistics is in getting a "feel" for the data and data manipulations (Ward, 1984).

Students gain understanding of statistics by using instructional strategies that focus on the acquisition of statistical concepts. A review of four instructional strategies for increasing student learning of statistics was completed by Ward (1984). The disadvantage of the four systems reviewed was that while raising the level of statistical understanding, the systems required either costly supplemental tutors or greatly increased the demands on the instructor. Ward concluded his research by presenting a learning system of giving students multiple problems, tutoring support and multiple exams. The teaching system used in his research was to give students high frequency of exposure to problems and the opportunity to check their understanding with the tutor. When a student failed a section of an exam, the student was allowed to retake the exam after reviewing the material. The need for students to work through multiple statistical problems completely was presented by Glass and Stanley (1970) in the introduction to their text:

> Above all, the exercises and problems that follow each chapter must not be slighted. Working these exercises will put a fine edge on your knowledge of the subject. Skip the exercises and you may never know what you don't know about statistics. (p. 6)

In order to be beneficial part of an instructional strategy, the computer user might need a feedback system while allowing for high repetition of problems in order to students to increase his/her understanding.

The two suggestions made by Wegman and Gere (1972) for the use of the computer in statistics instruction are: (a) to facilitate the understanding of statistical concepts, and (b) to analyze real data in the manner of a professional researcher. Another set of researchers in the methods of teaching statistics, Gordon and Hunt (1986), suggest two different uses of the microcomputer: (a) one should be for graphical presentation of data and (b) the other is for simulations of statistical processes where students can alter the parameters and observe the effects. Both sets of suggestions involve the student actively manipulating the data and interacting according to the student's level of statistical knowledge.

Teaching Statistics with the Aid of a Computer

The development of the use of the computer in the teaching of statistics has evolved out of the need for instructors to use the computing power of the computer for facilitating the transfer of ideas. To assist students in learning statistics and in learning to use a computer, individuals developed computer-assisted instruction (CAI) in the late 1960s and early 1970s (Tubb,1977, cited in Stockburger, 1980). The early attempts to develop CAI were attempts to assess the feasibility of the emerging technology on teaching statistics. The researchers reviewed by Stockburger (1980) wished to determine what factors and areas of computer use aided the students in their understanding of statistics.

In examining the areas in which emerging computer technology was used to assist students in statistics education, researchers determined that five categories were apparent (Stockburger, 1980). The five categories of using a computer in statistical education were: (a) CAI (drill and practice routines and tutorial lessons), (b) as a means of teaching a computer language, (c) as a computational tool, (d) as a means to generate statistical tests and homework, and (e) as simulations (Stockburger, 1980).

The five categories of using a computer in statistical education were seen as having different levels of usefulness in teaching (Stockburger, 1980). The drill and practice programs were not received enthusiastically by students and produced little improvement in understanding of statistical problems. As a method of teaching programming, Wegman and Gere (1972) found the mathematically sophisticated and computationally experienced student was successful at learning, and the mathematically unsophisticated student and computationally inept student was unsuccessful. The use of the computer as a simulation environment has been the most successful in aiding the teaching of statistics. Elton and Waterford (1978), cited in Stockburger (1980), argue that computer simulations may teach concepts which are virtually impossible to teach in any other manner. Many of the fundamental concepts in statistics are of the form "I wonder what would happen if...?" (Stockburger,1980). The simulation is also the most difficult to program and it uses more computational power.

The early attempts at using CAI in statistics generally failed for two reasons. The CAI failed to be effective because it was (a) too expensive to program and run on the mainframe computer for individuals in statistical classes and (b) the computer lacked computational power to anticipate the instructional needs of the student (Stockburger, 1980). A CAI program that was interactive at evaluating the responses of the student and providing instruction to improve the areas in which the student was deficient was desired. As a result, the programs did not meet the educational goals set by the researchers due to the limited power of the computer and the programming language. The computer as a simulator of statistical phenomenon was still seen as the most powerful and the least available to the classroom teacher of statistics (Anderson, 1977). To provide educator's direction, other classifications and approaches to computer usage were proposed.

The classifications of computer usage proposed by Taylor (1980) were in terms of how the computer was used by the learner: (a) as a tool, (b) as a tutor, or (c) as a tutee. As a tool, the computer in the statistics classroom is used to calculate mathematical formulas. Consequently, with the advent of the microcomputer and integrated circuit technology, the microcomputer became an option for educators teaching statistics. The predominant use of the micro or mainframe in the statistics class is as a calculation tool. In the tutor mode, CAI programs present the concepts of statistics to the student with minimal interaction. The student is using the computer as a tutee when he/she teaches the computer the student's understanding of statistics. For example, when a student teaches the computer how to calculate the mean, the student demonstrates his/her knowledge of the statistical concept, mean. At this point, the computer is capable of replicating the procedure and freeing the student to explore a more difficult concept. This computer use then becomes advantageous to the student in his/her conceptual knowledge as well as knowledge of computational procedures.

Taylor (1980) lists three advantages to the tutee approach. First, "you can't teach what you do not know"; secondly, the student will learn how computers work from interacting with them, and finally, since no expensive predesigned tutor software is necessary, time and money are saved in not looking for quality software. Taylor (1980) explains the difference the tutee method can make in education.

> Learners gain new insights into their own thinking through learning to program, and teachers have their understanding of education enriched and broadened as they see how their students can benefit from treating the computer as a tutee. As a result, extended use of the computer as tutee can shift the focus of education in the classroom from end product to process, from acquiring facts to manipulating and understanding them. (p. 4)

Students who attend classes have diverse backgrounds. When the computer is used to teach the student, the approach may not interact with the student's background and abilities. The use of the computer as a tool, or tutee, may provide the flexibility to meet the student's preferences in approach and the high interactivity with the material may promote learning.

Graduate students taking a beginning statistics course have diverse backgrounds and abilities (Emond,1982). In training these beginning students in statistics, the instructor must be aware that students have different levels of ability to reason, use rules of logic, use mathematics, and to combine abstract rules to be applied to a new problem (Fong et al., 1986). Students make serious errors when reasoning about arbitrary symbols and relations (Evans, 1982). Students lack experience and development in using abstract thinking outside of a particular limited domain like algebra or geometry. Nisbett et al. (1983) states that people possess intuitive but abstract versions of statistical rules. Nisbett refers to their intuitive rules as "statistical heuristics." Many investigators have concluded from their research that people use only domain-specific rules and do not use abstract rules when solving concrete problems (Fong et al., 1986); thus, these people limit their ability to generalize their thinking. It should be possible to improve people's abstract statistical reasoning through formal training (Fong et al., 1986). The building of reasoning skills and problem solving skills comes from interacting with the material to be learned (Andre and Phye, 1986).

It is the use of an environment in which the student can interact with his/her own thinking about the concepts of statistics being learned and what they had previously known which provides the connecting link. The connecting of the facts and formulas of statistics is not completed outside of the mind of the individual student. Thus, the need for interaction again becomes relative.

The methods of learning statistics and teaching statistics vary in their demand for interaction between student and the material. The by-hand method requires a great deal of interaction, whereas the emphasis in using a main frame computer is limited to writing high level computer language statements like SPSSX to control the analysis of data. The computer as a tool is a reasonable application of technology once the concepts are understood by the user. Learning in the field of statistics has not occurred if the fundamentals have not been mastered (Glass and Stanley, 1970).

Psychology of Learning

In the study of the psychology of human cognition, several theories give support for students having a high level of interaction with the material to be learned. In Expert-Novice Differences and the Role of the Student Response in Acquiring Schemata in Science Learning (Andre,1987), the following belief on interaction with the material to be learned is proposed:

> The assumption that people learn what they do then translates to this formulation: mental/behavioral activity on the part of the learners lead to alterations in cognitive structure that influence their subsequent perception/comprehension and processing of situations and experiences. (p. 1)

Other researchers, Tennyson et al. (1987) proposed a learning and cognition model of schemata consisting of declarative, conceptual and procedural knowledge. Each form represents a different level of interaction between subject matter and memory system or function. In their simplest form Tennyson et al. (1987) proposed:

> Declarative knowledge implies an understanding and awareness of propositions and refers to "knowing that," for example, that underlining keywords in a text will help recall. Conceptual knowledge implies an understanding of when and why to select specific concepts, rules, strategies, etc. from the knowledge base. The selection process is governed by criteria (e.g., values and situational appropriateness). Procedural knowledge implies a "knowing how" to employ concepts, rules, strategies, etc. in the service of given situations. (p. 7)

The active process of learning necessitates participation by the student in examining his/her prior knowledge and linking of new knowledge to previously held notions by Roth (1985). In order to facilitate the learning of the student in statistics, as with the LOGO environment proposed by Papert (1980), the learner may need an "incubator of knowledge".

When a student begins to learn statistics, he/she approaches it as a novice. A student needs to develop skills with the subject matter in order to move closer to becoming an expert (Mayer, 1980). By using the computer in the tutee mode, the student is using a technique of elaboration in teaching the computer what they know about the subject. As the student becomes involved in the material being presented, the difficulty level of the material increases, the load on working memory increases too (Cooper and Sweller, 1987). In referring to people solving the Tower of Hanoi puzzle, Cooper and Sweller, (1987) state:

> ...working memory load was an important differentiating factor and that this load could be reduced by automating the problem rules. Further, automated rules provided an effective vehicle for transfer--subsequent problems were solved more rapidly because cognitive resources could be devoted to appropriate planning rather than to details of legitimate moves. (p. 347-348)

The Spreadsheet as an Alternative

This researcher proposes the use of an electronic spreadsheet as a meaningful environment for the student of statistics to grow in his/her knowledge. The spreadsheet is a series of rows and columns in which text, data or formulas can be entered into the cells (Hewett,1986). The cells are located at the intersection of rows and columns. A blank spreadsheet looks like an accountant's ledger sheet (Brown,1986-87). Available to the user is a variety of mathematical functions to analyze the data and perform "what if" calculations. Since the user defines the relationships between the cells, the formulas used in the computation, and the data, many calculations can be performed.

The first electronic spreadsheet was developed around the concepts of the accountant's ledger sheet to run on a microcomputer (Levey,1984). The first spreadsheet was call VisiCalc, which was derived from Visible Calculation in 1979 by Brinklin and Frankston (Levey, 1984). Examples of a blank spreadsheet, one with values and labels, and one with the formulas is located in Appendix A.

The user defines a model of the relationships of the formulas and data. Factors affecting a model can be established as variables. The variables in the model can be changed by the user to determine their effect as reflected in the different results (Levey, 1984). In statistics, the by-hand method of solving a problem can be defined in terms of the spreadsheet functions. The appearance is similar to the way in which a student would construct the problem on paper. The wisdom of using a spreadsheet as a learning tool instead of computer programs or the by-hand methods is stated by Orzech and Shelton (1986):

> Using computer programs to solve problems can be detrimental to the students' understanding of the processes involved in a solution. That is, since a computer application may make even relatively complex problems easy to solve, the student can become adept at obtaining solutions without understanding the underlying concepts and limitations. Unfortunately, the alternative of having the student work the procedures through by-hand tends to be very tedious and subject to mathematical error. As a result, a manual solution, per se, may provide only a minimal improvement in the students' learning. (p. 429)

The use of a spreadsheet may be an important learning step, leading to understanding of the process of solving statistical problems, before turning the process over to a computer statistical package. The concept of using a spreadsheet is similar to attributes of using LOGO as a microworld as described by Papert (1980) in that it allows the user to structure the environment to represent the user's representation of his/her knowledge. Papert describes a microworld as:

> A subset of reality or a constructed reality whose structure matches that of a given cognitive mechanism so as to provide an environment where the latter can operate effectively. These concepts lead to the project of inventing microworlds so structured as to allow the human learner to exercise particular powerful ideas or intellectual skills. (p. 204)

The student can be learning by teaching the computer his/her level of understanding. This process of using the spreadsheet in tutee mode is similar to the elaboration technique referred to by Andre (1987), and Mayer (1980) and Papert (1980) microworlds. At first, the spreadsheet serves as a tutee to represent the student's knowledge and, after the spreadsheet template has been constructed, it can serve as a tool for calculation.

Statement of the Problem

The problem addressed in this study is to determine whether the use of computer spreadsheet activities in tutee mode can improve learning of graduate students enrolled in a basic educational statistics course.

Hypotheses

1. The students in the spreadsheet group will receive a higher average score than students in the traditional group on the total points on the four exams when statistically controlling for anxiety and differences on a pretest mathematical ability.

2. The students in the spreadsheet group will receive a higher average score than students in the traditional group on the total points of the multiple choice questions on the four exams when statistically controlling for anxiety and differences on a pretest of mathematical ability.

3. The students in the spreadsheet group will receive a higher average score than students in the traditional group on the total points of the mathematical questions on the four exams when statistically controlling for anxiety and differences on a pretest of mathematical ability.

4. The students in the spreadsheet group will receive a higher average score than students in the traditional group on the total points of the essay questions on the third and fourth exams when statistically controlling for anxiety and differences on a pretest of mathematical ability.

Statement of the Purpose

The purpose of this study is to conduct preliminary research that may indicate an intermediary method for teaching statistical procedures which will be more effective, yet will involve a moderate amount of time for graduate students enrolled in a basic educational statistics course.

The researchers propose the chart in Figure 1 as a visual to summarize the possible benefits of the use of a spreadsheet in the learning of statistics. The chart was created with the assistance of Dr. Richard D. Warren and Dr. Ann Thompson, Iowa State University professors. The calculation methods used in the teaching of statistics are listed on the left-hand side. The three areas of content knowledge are: Computer, Math, and Statistics. The category of "Content Knowledge" reflects the rating of how much background knowledge the student would be required to have as a prerequisite in order to perform well within the course using the listed calculation methods. The category of "Assumed Knowledge of User" is a rating of the level of knowledge the user needs before he/she will benefit from the associated teaching techniques with the calculation methods. The last column is the "Level of Retention or Learning " by the student under the various learning methods. The chart is being presented as a visual representation of the researchers' perception for the need of an intermediate method of learning statistics for the beginning student.

The inclusion of ratings of None to Very High are to symbolize the effort on the part of the learner in the columns of "Computer", "Math" and "Statistics". The column labeled "Assumed Knowledge of the User" is a rating of how much pre-learning of the components of the method must be learned by the student before being able to proceed independently. The last column, "Retention and Learning," is a rating of the long-term retention and level of learning obtained by the student.

Calculation Method	Content Knowledge			Assumed Knowledge of Users	Level of Retention/ Learning
	Computer	Math	Statistics		
1. By-hand Calculations	NONE	HIGH	HIGH	LOW	HIGH
2. Programming Fortran/BASIC	V-HIGH	MED	HIGH	LOW	HIGH
3. Spreadsheet	LOW/MED	MED	MED	LOW/MED	HIGH
4. SPSSx	MED	LOW	MED	HIGH	LOW
5. Statistical Package, pre-programmed	MED	LOW	MED	HIGH	LOW

Figure 1. Prerequisite knowledge

Limitations of the Study

The sample population utilized in this study consisted of Iowa State University graduate students taking a course in basic educational statistics. A limitation of the study was that conducting the research during the eight-week summer session rather than the sixteen-week session, may produce a different learning strategy. Another limitation was the number of subjects observed in the study was limited by the number who registered for the course—22 total subjects, 19 of whom completed the course. The analyses that will be performed on the data were based on a assumptions of larger sample sizes. The reader should be mindful of the sample size and that it is possible some of the underlying assumptions have been violated by analyses used.

Definition of Terms

Traditional Instruction:	The way in which students have been presented instruction in statistics at Iowa State University. When a new concept is introduced, students work several statistical problems by-hand, and then move to using the micro or mainframe computer for calculation.
SPSSX:	Statistical Package for the Social Sciences. A mainframe statistical package for which students must write a seven-section program to compute statistics via a remote

terminal. A problem is translated by the computer into program and data statements, an answer is computed, and the requested statistics are available to view or print. Version 2.1, SPSSX Inc., Chicago, Illinois.

Elzey Statistical Package:	A menu-driven statistical package on an Apple 2e or IBM PC microcomputer. The data may be loaded into a separate data file and stored on disk or entered directly from the keyboard for calculation. Output from the analysis of the data can be viewed on the screen or printed. Developed by Freeman F. Elzey.
Spreadsheet Instruction:	Students work with data and formulas of statistical analyses on an electronic calculation work sheet similar to an accountant's ledger sheet. The student places the organization, understanding and structure of the statistical problem on the spreadsheet.
Elaboration	A technique of expressing the relationship between two concepts in the text/problem or between a concept in the text/problem and some concepts in the person's memory, either verbally or in written form.

CHAPTER 2: REVIEW OF THE LITERATURE

Students engaged in the learning of statistics with the instructional use of a computer may benefit from an approach that makes few assumptions about their level of abilities to solve statistical problems and allows for optimal student control. In this study, the effect on student learning of statistics with a microcomputer spreadsheet used in the tutee mode is examined.

The use of the computer treatment in this study incorporates previous research in the following areas: (1) learning theory as applied to statistical problems, (2) taxonomies of CAI, (3) spreadsheets, and (4) factors which influence the teaching and the learning of statistics. Review of literature pertinent to each of these concepts is presented in the order above. Each is discussed as it relates to the treatment program used in this study.

Learning Theory as Applied to Statistical Problem Solving

In order to facilitate the learning of statistical concepts through an instructional process using a microcomputer spreadsheet, the cognitive aspects of learning will be considered. When a student begins the study of statistics, the use of an instructional process that: (a) promotes awareness of the relationships of the components in the problem, (b) builds associations between the material being learned and previously learned material (schema induction), and (c) facilitates the automation of problem solving operations (automation), may promote the greatest amount of learning (Cooper and Sweller, 1987). These three factors used individually are not significant in increasing student learning. When the three factors are combined in the instructional process, they promote a significant increasing student learning (Cooper and Sweller, 1987).

The process of providing an environment for acquisition and retention of information is important in the educational process. Learning can be defined as an active process of moving from a state of not knowing, to a state of knowing (Strike, 1975). Students are often unaware of the similarities in problems presented in class (Reed, Ernst, and Barnerji, 1974, as cited in Cooper and Sweller, 1987). This seems to be the case especially in mathematical problem solving (Cooper and Sweller, 1987). Research findings (Merrill and Tennyson, 1978 cited in Tennyson and Cocchiarella, 1986) demonstrate that the structural form of the information clearly affects the form of the knowledge coded into memory. The work of Merrill and Tennyson showed that learners directly encode the instructional information as presented, and structure it in his/her memory as conceptual and procedural knowledge. If the relationship of the problems is provided in the form of worked examples, this seems to be a superior learning method for students being able to work similar and slightly different problems.

The other method of problem learning in Cooper and Sweller (1987) was to have students solve equivalent problems without any format provided to assist them. The process of having students work multiple problems of a specific nature without an overall structure being provided is relatively ineffective at fostering skills to solve slightly different problems. When students encounter problems that are not identical to the ones they were taught, they fail to realize the underlying similarities of the problems (Cooper and Sweller, 1987). A model for student learning in which the student has a memory classification for types of problems is said to have declarative knowledge (Tennyson and Cocchiarella, 1986). At this stage of learning the student has only classified problems into broad categories. When a student comes to an understanding of "when and why" to select various processes in solving a problem, he/she has reached a declarative level of knowledge. At this stage, the student is actively interacting with his/her schema of the concept being considered (Cooper and Sweller, 1987). If the student fails to make connections between the current problem and previous problems stored in memory, the student will not be able to generalize the solution of problems (Cooper and Sweller, 1987).

However, when the student receives instruction, he/she will not experience meaningful learning if new knowledge is simply added into memory. According to schema theory, meaningful learning cannot occur unless old knowledge is appropriately linked to new knowledge (Roth, 1985; Andre,1987; Andre and

Phye, 1986; Mayer, 1981). New technical information enters the human cognitive system from the outside and must go through the following steps for meaningful learning to occur (Cooper and Sweller, 1987):

a) Reception: First, the learner must pay attention to the incoming information so that it reaches short-term memory.

b) Availability: Second, the learner must possess appropriate prerequisite concepts in long term memory to use in assimilating the new information.

c) Activation: Finally, the learner must actively use this prerequisite knowledge during learning so that the new material may be connected with it.

The process of the learner being an active participant in his/her learning of new information and applying it to other problems assumes the process has been automated within the schema of the learner (Cooper and Sweller, 1987). The procedural knowledge of "knowing how" to employ concepts, rules, and strategies assumes the learner possesses declarative and conceptual knowledge (Tennyson, Thurlow, and Breuer, 1987).

The ability of the student to generalize from one type of problem to another assumes the problem solving operations has been automated to some degree (Cooper and Sweller, 1987). Initially, a schema may categorize only a limited number of very similar problems. With the development of expertise, two processes may occur. First, category boundaries may expand with an increase in the number and variety of problems encompassed by a schema. Second, and simultaneously, problem solving operators may become automated. As a consequence, an expert problem solver faced with an unfamiliar problem is more likely than a novice to be able to incorporate it into an existing schema because his/her existing schema encompasses a greater variety of problems. In addition, because problem solving operators are automated, the problem solver has greater capacity available to deal with those aspects of the new problem that were unfamiliar (Cooper and Sweller, 1987, p. 348)

Student learning in statistics involves problem solving and a great variety of problems. The components of statistical problems appear to be unrelated on the surface, but are related by their fundamental root in logic mathematics and algebra (Glass and Stanley, 1970). In teaching mathematical problems, when the relationships and similarities of problems were explained to the student, this did not insure that the students would be able to perform the calculations on similar problems Reed, Dempster, and Ettinger (1985) cited in Cooper and Sweller (1987).

The student may increase his/her ability to solve a mathematical problem by actively reflecting on previous problems completed which have similar attributes. The student who can build associations in memory from completing similar problems can link similar components of the problems to aid in the solving process. This assumes that the student has completed problems by examining the components of the problem and has not considered the problem as a isolated unit. In order for the student to form these associations in memory, the problems must be seen as "consisting of overlapping elements of related problems" (Cooper and Sweller, 1987). This process builds a schema in memory and expands the base of known relationships to facilitate additional generalizability of problem solving (Cooper and Sweller, 1987).

Taxonomies of Educational Software

The classification of computer software can serve as reflection of its use by educators and describe the emphasis of the locus of user control in the interaction with/by the computer. The use of a computer to increase student learning effectively might take advantage of the learning theory presented above. The three taxonomies, presented in this section, illustrate differences in the locus of user control and the level of the integration of the information presented with previous experiences of the user.

The current use of computers in the classroom can be seen as an extension of the predominant forms of educational delivery currently used in educational settings. The major areas of software classification for educational purposes are drill and practice, tutorial, and simulation (Thomas and Boysen, 1984). Drill and practice software is typically used for presenting a single concept repeatedly. The tutorial form of CAI can present information sequentially to the viewer and reinforce his/her correct understanding. The simulation usage of CAI is placing the student in charge of an artificial computer environment to manipulate factors of physical or theoretical systems. The usage of software in the above categories is a reflection of the uses of CAI in the educational classroom. These categories do not provide guidance on how a particular application should be used in the educational setting, and they do not focus the teacher's attention on a student's weaknesses (Thomas and Boysen, 1984).

A taxonomy proposed by Thomas and Boysen (1984) for classification of educational software focuses on three issues. The three issues of the taxonomy are (a) the the needs of the learner, (b) providing guidance for development of computer-based lessons and their instructional use, and (c) facilitating the design of research and communication the result of the studies. The taxonomy also proposes five categories for the classification of software used in education.

The five categories proposed are experiencing, informing, reinforcing, integrating, and utilizing. According to Thomas and Boysen, "the classifying variable is the state of the student with respect to the knowledge, skill or attitude being acquired". It should also be recognized that informing and reinforcing applications are usually computer-directed; whereas, experiencing, integrating and utilizing are learner-directed.

Another taxonomy that approaches the classification of CAI from the point of the user being in charge of the interaction is proposed by Taylor (1980). He proposes three classifications of all educational software when (a) the computer functions as a tutor, (b) the computer functions as a tool, and (c) the computer functions as a tutee or student.

The computer functioning as a tutor of some subject must be programmed by experts in programming and in that subject (Taylor, 1980). The computer presents some subject material, the student responds, the computer evaluates the response, and, from the results of the evaluation, determines what to present next. When the software is well designed, it can tailor its presentation to accommodate individual differences (Taylor, 1980). The computer as a tool in the classroom, need only have some useful capability programmed into it such as word processing or statistical analyses. The computer as a tool assists the user in performing many tedious and repetitive tasks, preserving intellectual energy and time (Taylor, 1980). To use the computer as a tool or tutor can improve and enrich learning and does not require that the user know a great deal about computers. Taylor also states that the computer as a tool or tutor does not provide the user with as much of the educational benefit associated with the computer in the tutee mode.

When the computer is functioning in the tutee mode, the user is teaching the computer his/her understanding of a subject. In order to teach the computer, the user must learn to communicate with the computer in a language it understands. The student is performing an elaboration technique which increases student understanding and retention (Mayer,1980). Taylor (1980) presents several benefits to the user of the tutee mode. First, the user needs to understand what he/she is trying to "teach" the computer and the user will learn the material being taught to the computer. Second, by working within the structure and logic of the computer as the learner, the student will see how the computer functions and his/her own thinking processes (Bar-On,1986; Goetzfried and Hannafin, 1985). The product of the student's teaching the computer can become a tool or tutor for themselves and others. Although the outcomes of the programming may have many benefits, the process of how the learner completes the process may be more important than the product (Brown, 1985; Papert, 1980; Luehrmann, 1980, cited in Taylor, 1980). In summarizing the benefits of the tutee mode, Taylor states:

> Learners gain new insights into their own thinking through learning to program, and teachers have their understanding of education enriched and broadened as they see how their students can benefit form treating the computer as tutee. As a result, extended use of the computer as tutee can shift the focus of education in the classroom from end product to process, from acquiring facts to manipulating and understanding them. (p. 4)

In the tutee mode of using the computer, the student has control over the computer, the product, and the process of his/her own learning.

Effects of Locus of Control on Learning

When educators are planning for the use of CAI in the classroom, or developing a lesson involving CAI, the type of classification of the software may effect the amount of learning. The classifications vary by their amount of control a student has over the CAI program (Tennyson and Buttrey, 1980 cited in Goetzfried and Hannafin, 1985) and the state of the student with respect to the knowledge, skill or attitude being acquired (Thomas and Boysen, 1984).

The level of control a student has over a CAI program may have implications for the learning process. The issue of the learner being in control of his/her learning environment and the amount of learning has been addressed by many researchers (Andre and Phye, 1986; Andre, 1987; Brown, 1982; Tennyson and Cocchiarella, 1986).

The amount of control students have over the viewing of CAI lessons and the level and amount of assistance available to the students may affect their learning rate and time on task (Goetzfried and Hannafin, 1985). In examining the advantages of a particular CAI instructional strategy, the instructor needs to be aware that the amount of information a student covers with a CAI method may not be the best indicator of learning. If a student spends less time on the task of learning a concept, the short-term effect of learning may be equivalent across methods and may not produce significant differences. The interaction of the learner with the material while in control over his/her learning may produce greater retention and understanding (Goetzfried and Hannafin,1985). Computer environments that promote user control over the process and the level of interaction with the material presented may or may not produce better long term gains (Tennyson and Buttrey, 1981; Ross and Rakow, 1980; Ross, Rakow, and Bush, 1980; Tennyson, 1980 cited in Goetzfried and Hannafin (1985).

Spreadsheet as a Learner Controlled Tool

The use of a spreadsheet in the learning of statistics is to provide an electronic learning environment to increase student interaction with the material. Originally designed to simulate and replace the larger paper worksheet used in accounting and financial planning, the spreadsheet simulator is a more generally useful tool which can be used to study and explore functional relationships among a number of parameters (Hewett, 1986). The spreadsheet can also serve as a simulation environment for students to manipulate the factors that affect a problem (Wells and Berger, 1985/86).

The electronic spreadsheet is oriented around a matrix of rows and columns, into which the user enters text, data, formulas or instructions which tell the program to look up a value in another location and then use it in a calculation or in some other way. The typical spreadsheet simulator also offers some limited programming language capabilities, including the ability to manipulate strings and do interactive calculations. Although the spreadsheet program requires that the simulation designer be able to specify the relationships explored, it does not require the end user be a programmer (Wells and Berger, 1985/86). Programing languages have built in functions, and so do spreadsheets. A spreadsheet is a computer program whose instructions are contained in all of its individual cells (Luehrmann, 1986). The advantage of using a spreadsheet is in involving students in designing investigations without the need to know a programming knowledge (Catterall and Lewis,1985).

The spreadsheet template can be constructed by the student. Having the student construct the templates might provide them with a better understanding of the process (Orzech and Shelton, 1986). This approach to using a spreadsheet requires the student to think through a procedure while manipulating data. In entering the formulas and data, the student is in charge of all of the decisions on combining formulas (Orzech and Shelton, 1986). However, the student is relieved from the necessity of making arithmetic computations as a result of the capabilities of the electronic spreadsheet (Orzech and Shelton, 1986). The basic idea is not to provide procedures which work out a solution automatically, but rather to present procedures which show underlying computational process (Brown, 1982; Orzech and Shelton, 1986).

The spreadsheet can be used both as a tool for calculation and for learning statistics. The spreadsheet format can serve as a blank environment in which the student teaches it his/her current knowledge; this concept is called elaboration (Mayer, 1980; Andre, 1987). When a student constructs a spreadsheet, he/she teaches the spreadsheet his/her view of the problem. The values entered into the spreadsheet model are easily changed and the effect of the change immediately seen (Orzech and Shelton, 1986). In order to take advantage of the flexibility of the spreadsheet, various disciplines have turned to using the spreadsheet to act as a simulation environment. Examples of spreadsheets as simulations appear in the fields of psychology (Hewett, 1986), economics and statistics (Hsiao, 1985c), engineering (Becker, 1986), and marine ecology (Silvert, 1984), to name a few.

Computer spreadsheet simulations may prove to be a valuable tool through which educators can help learners develop higher level cognitive process and problem solving skills (Wells and Berger, 1985/86). The effects on student learning in a simulation are enhanced when the student programs the spreadsheet themselves (Marks, 1982, and Spain, 1983, cited in Wells and Berger, 1985/86). Spain, in referring to the value of computer simulation stated that " ...when students program the simulation, thereby actively gaining and demonstrating a firm grasp of the concepts being learned." Tennyson, Thurlow and Breuer (1987) in referring to problem-oriented simulations state that "the purpose for using simulations is to teach a task as a complete whole instead of in parts". Statistics as a field should not be considered as unconnected segments but as a collection of associated concepts (Glass and Stanley, 1970).

The spreadsheet as a simulation does not require high level programming skills (Wells and Berger, 1985/86). The student may benefit from a high level of interaction of with his/her current level of statistical knowledge by using a spreadsheet as a tool for understanding. The use of the computer in the teaching of statistics did not always aid in the understanding of statistics.

When computers were introduced to statistical instruction, the intent was to increase the understanding of statistics and to reduce the amount of time needed for computation. The student had to learn how to use a computer, write a program to compute the calculation, in addition to learning statistics. The benefit of the introduction of the computer was to people who already understood the statistical concepts. The beginning student needed to learn how to use the computer and computer language in addition the statistical concepts.

The History of the Computer in the Teaching of Statistics

The early attempts of educators in statistics to introduce the use of the computer as an instructional system was filled with obstacles (Stockburger, 1980).

In addition, the instruction of statistics is also influenced by various learner characteristics and abilities.

Early articles point out the expensive cost of mainframe computer usage balanced against the benefits (Guthrie 1970; Milton and Nelder, 1969; Gere, 1971, cited in Stockburger, 1980). The introduction of the computer systems also added the necessity of students learning the computer system and software (Stockburger,1980). The intent of the use of the computer in the teaching of statistics was twofold: (a) to reduce the time spent on calculations and (b) to increase the amount of learning of statistics. Due to the limitations of the computer hardware capabilities, the decrease in computational time did not increase student understanding of statistics. As a result, in order to increase student learning, the amount of time spent in instruction and homework took more time (Stockburger,1980). A review of the major approaches used in teaching statistics addresses the time and learning issue.

The five approaches in which the use of computer as an instructional tool was investigated to increase learning and reduce the time required to learn statistics were: (a) CAI (drill and practice routines and tutorial lessons), (b) as a means of teaching a computer language, (c) as a computational tool, (d) as a means to generate statistical tests and homework, and (e) as simulations (Stockburger, 1980). The five approaches were not equal in their effectiveness of reducing time and increasing learning. There were problems encountered by the educators as they attempted to integrate the use of computer technology into the teaching of statistics. The mainframe was burdened by the high demands of users and the microcomputers lacked the computational power of the mainframe.

The use of the computer, as a controller of a question and answer format of interaction to stimulate student learning (Stockburger, 1980) met with limited success. The intent of the drill and practice was to provide opportunities for enhancement of skills already learned while tutorials can provide primary instruction of new material (Wells and Berger, 1985/86). By the late 1970s, the psychologists and statisticians who were attempting to develop the CAI lesson had become disenchanted with method of instruction (Elton, 1978, cited in Stockburger, 1980). The CAI failed for two reasons: (a) the learning of the student was at the same level as looking at a solved problem in a book (Wegman and Gere, 1972), only more expensive, and (b) the computer was not able to anticipate the deficiencies of the learner and mindlessly repeated previously covered material. The computer program was not capable of branching to a different section after evaluating the responses of the user. One illustration of a drill and practice program that was thought to be successful at stimulating student thinking on statistics, required the student to guess the value of the graphic display before proceeding to the correct answer (Anderson, 1977, cited in Stockburger, 1980).

The learning of the computer programming languages was introduced as a means of increasing the students knowledge of the computers and the statistical process to be calculated (Wegman and Gere, 1972). According to Wegman and Gere, writing and testing computer programs produced positive results for the mathematically sophisticated and computationally experienced student. Students who were not mathematically sophisticated or computationally experienced found the experience to be burdensome and required an immense amount of time (Wegman and Gere, 1972; Stockburger, 1980).

The use of a computer as tool for computing answers to statistical problems is a predominant use of the computer in statistics (Stockburger, 1980). Using either a preprogrammed, self-contained, "canned" statistical package such as Statistical Package for the Social Sciences (SPSSX), students enter data and a limited number of commands and allow the computer to compute the results. This process limits the interaction of the user with the computational process to pressing return and looking at printouts, and does not help the user develop a "feel" for the data (Wegman and Gere, 1972).

In using a computer software system to generate student homework and tests, allowed the instructor to emphasize the concepts that the instructor felt were important. The system described in Stockburger (1980) allows the instructor to generate individual problems for each class member that are similar in concept. The advantage of this system is that students would not be able to copy from one another and would be required to work a unique problem. A system, developed by Miller (1987), creates unique problems and the correct answers for the instructor to compare the student answer against. This extension of computer technology is centered on the instructor and not directly on student learning.

The computer has been most successfully utilized in the teaching of statistics when used to simulate statistical concepts (Stockburger, 1980). Elton and Waterford (1978), as cited in Stockburger (1980), propose that the computer simulations may teach concepts which are virtually impossible to teach in any other manner. One approach used was to encourage students to estimate or guess the calculated result based on the parameters entered prior to viewing the computer calculated result (Goodman, 1986). In these interactive simulation environments, if the student was incorrect, he/she was allowed to modify the data. The goal was to change the calculated value by manipulating the input data to attempt to come close to the proposed value (Goodman, 1986). The programs were written in the language in Beginners All-Purpose Symbolic Instruction Code (BASIC) and were not integrated into a larger curriculum of similar programs for different statistical concepts (Goodman, 1986). A second example of a simulation, written by Stockburger (1980), allowed students to manipulate various aspects on an ANOVA simulation. The students could change the number of treatments, number of subjects, relative size of the error term, distribution of the error term, and size of the treatment effects (Stockburger, 1980). Stockburger states that students could see from the printouts the effects of various predetermined levels of the variables. The program, having been adapted for the microcomputer, was slow and allowed students to complete about one simulation an hour. The lack of computing power of the microcomputer prevented students from receiving the printouts for several hours. The disadvantage of using the same program on the mainframe as on the microcomputer was students could not get access to terminals due to high demand for usage.

The computer technology available limited the attempts of educators in implementing their ideas of how to use the computer to increase learning. The initial enthusiasm waned as the attempts to initiate the use of the computer to stimulate learning were not producing the results desired and further attempts have been slow in developing (Elton, 1978, as cited in Stockburger, 1980).

The issue of using computer technology and software in creative ways was not the only obstacle to student learning of statistics. Students bring to class their own unique qualities of past experiences, learning style preferences and various levels of characteristics that have been determined to affect the learning of statistics.

Students who are not familiar with the concepts of statistics often have difficulty in visualizing a statistical concept in their minds. The ability of students to mentally visualize spatial concepts was found to be a significant predictor of success in an applied statistics course (Elmore and Vasu,1980). The inclusion of graphics in a statistical course is seen as beneficial to student learning (Emond, 1982, and Stockburger, 1980). Graphic displays were slow on micro based teaching systems and complicated to program, thus a key weakness of the systems.

Factors Which Influence the Learning of Statistics

In teaching statistics, the factors that may influence student success in the course can be categorized in terms of the abilities of the student to process the information related in the course. The field of statistics is a combination of mathematics, inductive and deductive reasoning (Hays, 1963).

Statistics is represented in the abstract symbols of mathematics and logic (Fong et al., 1986). Problems presented to students are solved by decomposing their features and relationships into elements that are coded in such a way that the student can interpret these abstract rules (Fong et al., 1986). Students make serious logical error when reasoning about arbitrary symbols and relationships (Evans,1982). If students solve a problem correctly it is because they are sufficiently familiar with the content domain to have induced a rule that allows them to solve problems in that domain (Fong et al., 1986).

The student may be limited in his/her understanding of the abstract concepts presented by his/her level of preparation and experience in prior courses. Although learning is an individual process, certain characteristics of students emerge as predictors of success in a statistics course.

In studying the factors which affected success of graduate students in an introductory educational statistics course, Brown (1933) found basic mathematical knowledge heavily influenced the students' ability to succeed. A 28-item test was administered to 990 educational graduate students at a variety of graduate schools. The findings showed that the students were unable to solve the simple math problems; several multiplication problems like "7-4 X 12 =" were missed by over 77 percent of those taking the test. A more complex problem like writing the equation of a straight line was completed incorrectly by about 88 percent of the students. The study was replicated by O'Dell (1977) and very similar results were found almost 40 years later. The inability of the students to correctly calculate simple mathematical problems has a great influence on the teaching of statistics. If the students are unable to perform simple mathematics that are not nested in more complex formulas, the assumption that the student using a formula will arrive at a correct answer is invalid. When students do not understand the formula for a straight line, the instructor of statistics must be cautious in teaching correlation using it as conceptual base for understanding. The inability to use mathematics to solve a statistical problem also influences student learning by interfering with the establishment of the link of process used to solve the problem with the correct answer.

Factors which influence a student's success in a statistics course are not limited to mathematical ability. Approaches to analyzing what characteristics a successful student in statistics will possess have been examined in three basic areas (Elmore and Vasu,1980). In their review of the research factors affecting student performance in a statistics course, Elmore and Vasu found the following areas to be significant: (a) the student's previous experiences in mathematics and statistics; (b) the student's ability to perform specified mental operations on spatial visualization tests like on the Fennema and Sherman Mathematics Attitude scales; (c) self-perceptions on masculinity-femininity on interest patterns as specified on the Minnesota Multiphasic Personality Inventory (MMPI). The researchers concluded that overall student performance in an applied statistics course was affected by the factors outlined above.

In research conducted by Miller (1987), he found similar areas that predicted success in an applied statistics course using a mainframe statistical package. The variables which were identified through analysis of multiple regression at the .05 alpha level, were: (a) gender, (b) undergraduate major (social science versus physical science), (c) graduate major, (d) whether or not the student planned to find employment in education or outside of education, (e) level of degree sought, Ph.D.,or M.S., (f) amount and depth of prior mathematical and statistical course work, and (g) prior computer experience and proficiency level. The influence of the above characteristics varied in their statistical weighting in the regression equation. When an instructor of statistics uses the above categories, he/she will notice that at the beginning of the semester all of the reported variables are fixed.

Elmore and Vasu's (1980) research does not address whether or not the specified student characteristics change as a student grows in his/her understanding of statistics. The issue of whether or not the characteristics presented can be remediated to increase the student's ability to understand statistics is also not clear. In the review of the research there was an absence of research on teaching techniques or approaches that increased student learning of statistics.

The factors that seem to influence student performance in courses on statistics are related to mathematical and quantitative areas. These include spatial reasoning, number and recency of prior math and statistics courses, and interests in quantitative areas in using computers and undergraduate course work in a physical science versus a social science area (Elmore and Vasu, 1980; Miller, 1987). The intent of this research is not to determine how the differences in individual abilities came about, it is in determining if a proposed learning techniques will increase learning in statistics. The individual differences in mathematical ability must be acknowledged if students are not grouped according to ability when teaching a course in statistics.

Summary

The emphasis in the teaching of educational statistics is for students to develop an understanding of the scientific process in order that he/she might be able to conduct and understand educational research. Nested within the explanation of the emphasis for the learning of statistics is the expectation that the student make a significant contribution to the body of knowledge. In order for a student to conduct research and understand the literature, the student should have a firm understanding of the field of statistics. The use of the computer in teaching of statistics and the need for students to be highly interactive with the material has been reviewed.

Different taxonomies used by educators to classify the use of computer software within educational settings help determine the role of the computer's use in the the teaching of statistics. The ability of the computer to facilitate learning is limited by the amount of stimulation it causes with the student's own knowledge of the domain of statistics. The student learns when he/she is active in building associations in his/her memory (Andre, 1987).

The benefit of being interactive with the material and the student with his/her own thinking about the material in a computer environment was reviewed. The schemata of statistics within the student's mind can be activated through usage of an interactive process. The use of simulations and specifically, the use of computer spreadsheets, as a computer simulation was reviewed to provide the format to build and link schemata within the student's mind. As a result of this researcher's review of the literature, the researcher proposes to use an active learning environment facilitated by the elaboration technique to build the associations in the memory of the student in order to make to the knowledge retained by the student more automated in solving problems.

The research of this chapter, summarized above, provides the foundation upon which this study was based. The treatment used in this study was computer-based learning environment which was used as a substitute for the traditional laboratory microcomputer experience in an educational statistics course.

CHAPTER III. METHODOLOGY

This chapter contains a description of the treatment CAI programs used in the study, the study sample, data analysis measures, and the steps taken in carrying out the research project. The CAI programs and their uses in the study are explained in detail. This section is followed by presentation of the characteristics of the population. The population and actual sample of this study are described and tables of their demographic characteristics presented. Finally, a detailed account of the steps taken to collect and analyze data are given.

Description of the Population and Sample

The population for this study is graduate students taking an introductory graduate level Educational Statistics course at Iowa State University. The group of 22 students who registered for Research and Evaluation 552, Basic Educational Statistics, during the summer session of 1987 at Iowa State University was the sample for this study. Out of the sample of students, three withdrew during the first three weeks of the summer term. Two subjects withdrew from the course left due to a feeling of inadequate time to complete the work load of the class. One subject withdrew in order to assist a relative who was ill. The total number of subjects completing the study was nineteen. It should be noted that two subjects were taking this course for a second time, with one subject being placed in each treatment level.

Students who enrolled in Research and Evaluation 552, Beginning Educational Statistics, represent a wide variety of graduate disciplines. Students enrolled in the course were master's or doctoral candidates in the professional studies, agriculture, education, and other social science disciplines. The course is taught with an emphasis on the use of basic statistics for conducting educational research. The students generally are seeking a degree in the areas listed and are currently educators at the elementary, secondary, post-secondary or administrative levels in public education. They range in ages from 22 to over 50 years. Their undergraduate degrees are typically from the social science and education, and not in the physical science areas.

Description of the Treatment

During the first class meeting a mathematical test, a statistical anxiety test, and demographic data was collected from all students. Syllabuses were distributed and the students were informed that they were being asked to participate in a study. They were asked to return to class the next day for their assignment to a particular laboratory treatment group. At that same time, course lectures began.

After the first class meeting the demographic data collected were examined by the researcher. Within the total group, differences in the quantity and depth of prior computer usage existed among the students. So as not to risk the loading of students with high prior computer usage into the experimental or control group, a stratified random assignment was completed. Three strata of prior computer usage were evident: (a) high prior usage and proficiency (knowledge and use of two or more microcomputers and one software package per machine), (b) basic proficiency with at least one micro or mainframe computer (knowledge and use of one microcomputers and one software package), or (c) no prior experience. Stratified random sample assignment was made among the individuals in the three categories into the two treatment groups.

The students received instruction in the classroom as a single group, mainframe instruction as a single group, and CAI treatment as two separate groups. The students received the same lecture from the class instructor, Dr. Anton Netusil and were given identical problem assignments. In order to provide experiences required for Research and Evaluation 553, Advanced Educational Statistics, the sequel to 552, all students received mainframe computer instruction on SPSSX using the WYLBUR operating system. Due to time restrictions, the researcher did not teach both lab experiences. Homework was assigned daily by the instructor and was not used as part of this study. It was used only to check for understanding of the students on a weekly basis. Dr. Netusil conducted the lab experience for the traditional group and the researcher instructed the experimental group. In the weekly labs, the assignments and data used for computational experience was coordinated prior to instruction.

The course was divided into four time periods of approximately two weeks. Examinations were administered four times during the semester and are presented in Appendix B. All four exams consisted of multiple choice questions on concept areas and mathematical calculation problems. On the last two exams, essay questions were also added to further assess the depth of the knowledge held by the students. The instructor chose the content for the tests and multiple choice questions. The researcher assisted in constructing the essay questions.

The test-taking periods were limited to three hours and were of the open book, open note style. The students were free to choose among the following techniques when doing their test: (a) calculation by-hand,(b) calculation by using either microcomputer method, or (c) calculation using the mainframe computer.

Laboratory Experiences

In this section, a listing of events which occurred in the lab sections of the treatment groups is presented. Students attended one lab experience per week for one hour. Since tests were scheduled every two weeks, students received two scheduled lab experiences prior to each exam. Students were encouraged to work with their particular program outside of lab in order to gain further understanding and solve statistical problems. It was not possible to limit the time usage or assure usage outside of lab for either software package. Each lab had at least two of the same problems assigned weekly, using the program presented in his/her lab.

Traditional Lab Experience

The traditional CAI group used an Apple 2e microcomputer with a statistical program entitled Introductory Statistics: A Microcomputer Approach by Freeman F. Elzey. Dr. Netusil had obtained permission from the publisher to use the program for instructional purposes.

The program is menu-driven and is a self-contained statistical program with limited graphics options. The student can create a data disk and store data on the disk or enter data directly within a program. Upon booting the program, a menu with the options available to the user appears. The Appendix C contains a copy of the menu screen. The student enters a letter "A" through "Q" to select the desired program. With the exception of entering data, all other choices within the program required the student to enter a single letter to choose among the menu of options presented. The steps on how to use the program were taught to the traditional treatment group students in the first lab and reviewed in the second lab. The students could receive assistance on how to use the program at any time. A copy of the instruction manual was made available to the students outside of lab.

The program generates the desired statistics and prints to the screen or printer as selected by the user. No formulas or statistical processes are discussed by the product, only the results of the selected analysis are presented on the data entered. The printout of the first lab exercise is shown in Appendix C to help the reader understand what the student receives on his/her printout.

In the first lab experience of the traditional group, the instructor presented students with the process of booting the program and how to select options from the menus. The students were given the disk containing the program so they could use it in the lab experience or in the IRC lab to solve homework problems. The program selection of C, Sample Statistics, was demonstrated and used to solve several example problems. At the second lab experience, student questions were addressed and more problems from the chapters of the Hinkle et al. (1979) text were calculated. Each additional lab demonstrated the statistical option appropriate for the topic covered in the lecture in the same format presented above. The topics covered on each exam are listed on the course outline presented in Appendix D.

Spreadsheet Experience

The spreadsheet CAI group used an Apple Macintosh microcomputer with a spreadsheet program entitled Microsoft Multiplan. The program was available to students in the microcomputer lab located within the IRC.

The spreadsheet is a standard spreadsheet with about 20 functions. The user could also build his/her own mathematical functions. The user could enter data or formula into a cell referencing other data or cells. Labels for columns or rows could be placed adjacent to cells containing data. Upon entering the program a blank series of cells fills the screen with a menu bar across the top of the screen.

The process of working with the data and statistical formulas with a spreadsheet to produce an answer required each student in the treatment to learn how to operate the Macintosh, and the Multiplan software. The Spreadsheet user decides on the arrangement of data and formula to direct the spreadsheet in the computation of the desired statistics. Once the model or template is entered into the computer spreadsheet, the user can change the data and the computer automatically recalculates and updates the calculations.

In the first lab experience for the spreadsheet group, the researcher presented the process of booting the software, an overview of the Macintosh microcomputer, and instruction on the options contained in the various menus across the top of the screen. The capabilities of the Multiplan program were demonstrated. Students were instructed in the process of entering a sample problem. Students were instructed to use the blank cells as if they were doing the problem by-hand, with a different process used for calculations. By loading data in each cell, he/she could combine the information in various ways to compute different statistics.

The students built their own spreadsheet template in lab and saved it on the disk provided by the researcher. An example of a student's first spreadsheet appears in Appendix E. The student was in charge of the arrangement and calculation sequence for the problem. Instructions on where they could find a reference manual for the Multiplan software and Macintosh microcomputer were provided. During the second lab, questions were addressed regarding the operation of the Macintosh and the spreadsheet. Instruction was provided on calculation of the statistics of mean, variance and standard deviation for a population and an estimate of the population statistics from the sample. In Appendix E, a copy of a typical second lab experience spreadsheet is provided. Each additional lab provided instruction on the statistical concepts being presented in the lecture.

Questions Addressed by the Study

The study will address the following questions: (1) Will the students in the spreadsheet group receive a higher average score than students in the traditional group on the total points on the four exams when statistically controlling for anxiety and differences on a pretest mathematical ability? (2) Will the students in the spreadsheet group receive a higher average score than students in the traditional group on the total points of the multiple choice questions on the four exams when statistically controlling for anxiety and differences on a pretest of mathematical ability? 3) Will the students in the spreadsheet group receive a higher average score than students in the traditional group on the total points of the mathematical questions on the four exams when statistically controlling for anxiety and differences on a pretest of mathematical ability? and 4) Will the students in the spreadsheet group receive a higher average score than students in the traditional group on the total points of the essay questions on the third and fourth exams when statistically controlling for anxiety and differences on a pretest of mathematical ability? For the purposes of this study, these questions were stated as null hypotheses in Chapter 1.

Independent Variables

The independent variable in this study were the experimental treatments of lab experience using (a) spreadsheet and (b) preprogrammed statistical package learning methods.

Dependent Variables

The dependent variables for this study are the sum of the standardized scores on all four exams, the sum of the standardized scores on the essay questions, the sum of the standardized scores on the mathematical calculation questions, and the sum of the standardized scores on the multiple choice questions.

Control Variables

The pretests of statistical anxiety and mathematical ability were used as covariants in the analysis of the four hypotheses. The research presented in Chapter 2 referred to the high correlations found between scores in a statistics courses with measures of level of mathematics ability at the beginning of the course.

Research Design

Since human subjects were used for the study purposes, the human subjects committee at Iowa State was consulted. A copy of the human subjects form approved by the committee can be found in Appendix F. Subjects were informed in writing on the cover sheet of the pretest of statistical anxiety and verbally with a statement on the first day of class. Students were informed that a research study was being conducted on the laboratory part of the course and that they could withdraw from or transfer to the experimental group at any time without prejudice to him or her on this account.

A posttest control-group design is presented with covariance on the measures of statistical anxiety and math ability. This original design defined in Borg and Gall (1983, page 670), and is represented below in Figure 2. The design was chosen over a pretest-posttest control group design. The researcher felt that due to the complexity of the subject matter in the course students would not score well on concepts that were yet to be presented; however, students would be familiar with those concepts by the end of the course. The design as presented does not control for the individual levels of statistical knowledge held at the beginning of course. The premeasures used assess subject's ability to use simple mathematics manipulations and his/her level of anxiety in approaching statistics. In order to determine if differences among individuals existed that might affect the this study, data were collected on the information sheet on the first day of class to judge the equivalency of the groups.

$$\begin{array}{lll} & & O_1 \\ & & O_2 \\ R\ O_{p1}\ O_{p2} & X_1 & O_3 \\ & & O_4 \end{array}$$

$$\begin{array}{lll} & & O_1 \\ & & O_2 \\ R\ O_{p1}\ O_{p2} & X_2 & O_3 \\ & & O_4 \end{array}$$

where

R is the stratified random assignment
O_{p1} is the mathematical pretest
O_{p1} is the statistical anxiety test
X_1 is the treatment group, spreadsheet
X_2 is the traditional treatment (control group)
O_1 through O_4 are the four planned exams

Figure 2. Research design

All students were given a mathematical calculation assessment, statistical anxiety measure, and an information sheet to complete, Appendix G. Students were asked to complete the mathematical assessment without the use of a calculator. The statistical anxiety assessment was distributed next, followed by the information sheet. Students were given one hour to complete all three items. There were no statistically significant differences found on premeasures of mathematical ability, anxiety level, or demographics between members in the treatment groups using the t statistic.

The instruments used to measure the covariates in the study were analyzed for reliability and criterion-related validity. The mathematical test was analyzed using the Crombach Alpha as a subprocedure of reliability command and the Regression procedure on Statistical Package for Social Sciences (SPSSx).

The mathematical pretest instrument had a .771 reliability. As a criterion predictor of the dependent variable it had an adjusted R^2 value of .256, accounting for about 26 percent of the variability with the dependent measure.

The statistical anxiety instrument was evaluated using the same procedures and found to have a 0.96 reliability as compared to the original of 0.94 reported by Wisieniski (1970). The computed reliability is quite high for a sample size of 19. However, the anxiety measure was found to have an adjusted R^2 of negative 0.027. The conclusion by this researcher is that the instrument is highly reliable at measuring some aspect of anxiety; yet, the instrument is not a predictor of the criterion of total points in the course. Based on this analysis of the covariates for the study, the anxiety premeasure was withdrawn from the analysis in the hypotheses.

The four exams used during this study were administered, one approximately every two weeks, over an eight week period. Tests one and two were less extensive in format than tests three and four, which included essay questions over statistical concepts. The exams were not comprehensive, but covered only the classroom material presented following the preceding exam. The reliability Alpha of .7710 for the four exams was found to be significant at .05 level. This alpha statistic for repeated measures is a method of stating the level of consistency for subjects across the four examinations (Table 1).

Table 1. Summary of scores received on the four exams by subject.

Subjects Groups	df	F	Alpha	Probability
19	4	3.58	.77	.02

Time Line of Events for the Study

The order and dates of the labs and testing are provided on the syllabus. The syllabus presented in Appendix H lists the dates established prior to the study. Several changes in the schedule were made to accommodate the sharing of lab facilities and the need for more teaching time on concepts in the lecture as requested by the students. Homework assignments given to both treatment groups were not established before the study. The assignments were determined on a weekly basis by the instructor.

Summary

The CAI program used in this study provided an environment for students to manipulate statistical problems through the use of an electronic spreadsheet in the tutee mode. The students used an elaboration technique to interact with his/her own view of the statistical problem held in their memory and the computer.

The subjects in the study were 19 students of a course in Basic Educational Statistics at Iowa State University, during the summer session of 1987. The study used a posttest only statistical design with covariance on mathematical ability. The study addressed whether the experimental group would score higher on the average than the control group in terms of total standardized points received on the sections of the four exams and the exam totals.

This chapter provided a description of the treatment CAI program used in the study, a description of the study sample, the data analysis measures and the steps taken in carrying out the research.

CHAPTER IV: FINDINGS

In this chapter, the findings of this study are presented. In the first section, the results of comparing the groups on the preexperimental measures are presented. Data were collected for comparison of the two groups on the measures recorded at the beginning of the experiment. The findings are reported to establish the equality of the two groups prior to the beginning of the experiment. In the second section, each of the four formal hypotheses is presented and relevant findings discussed. Findings of this research that were not included in the hypotheses are presented in a section titled auxiliary findings. The final section of the chapter provides a summary of the study results.

Analysis of Preexperimental Measures

As stated in Chapter 3, the mathematical ability and anxiety tests were given to test whether or not differences existed between the experimental and control groups prior to the treatment. The number of prior math and statistical courses taken by the subjects was also recorded. A t statistic was calculated to determine if differences on the selected measure existed. No statistically significant differences were found between the two groups (Table 2).

Table 2. Means on preexperimental measures by treatment group

Measure	Mean	N
Mathematical Ability		
Experimental group	21.5	10
Control group	19.5	9
Statistical Anxiety		
Experimental group	117.1	10
Control group	112.5	9

As determined in Chapter 3, the measure of statistical anxiety was removed from the hypotheses and statistical analyses. The anxiety measure had a predictive criterion validity of negative 0.027. The hypotheses are listed in Chapter 4, therefore, without the statistical anxiety measure and the analyses preformed without covarying on anxiety.

Transformation of the Data

In order to sum the scores received on the four exams by individuals, the researcher converted the raw scores received by the students to standardized scores with a mean of 50. This procedure took into account the difficulty of each exam and places the scores on a common scale. The means for each group with respect to the four hypotheses are reported in terms of unstandardized points. The total number of raw points of the four exams was 400. The amount of each component of the exams, expressed as a percentage was 74 % for mathematical questions, 16 % for multiple choice questions, and 10% for essay questions.

Hypotheses

Hypothesis 1

Hypothesis 1 was stated as follows: The subjects in the spreadsheet learning method will receive a higher average score than the students in the traditional group on the total points on the four exams when statistically covarying for differences in mathematical ability.

The sum of the nonstandardized scores on the four exams ranged from 169 to 326 out of 400 possible on all four exams. The mean for the sum of the control group was 235.33 and the mean score of the sum for the treatment group was 279.10. Therefore, the experimental group scored 43.77 points higher on the average than the students in the control group.

An F statistic from an analysis of covariance (ANOVA) was calculated to determine if a statistically significant difference existed. An F value of 4.57 was calculated for treatment effect with 1,16 degrees of freedom. The data show that a statistically significant difference existed between the experimental and control groups. The researcher rejects the null hypothesis that there is a statistically significant difference between the two groups and accepts the alternative hypothesis on the total points received in the course (Table 3).

Table 3. Test for differences on the average total points on the four exams while covarying on mathematics scores

Source of Variation	Sum of Squares	df	Mean Square	F	Probability
Covariate					
Math ability	4163.45	1	4163.45		
Main Effects					
Treatment	2869.36	1	2869.36	4.57	0.048
Residual	10056.93	16	628.56		
Total	17089.75	18			

Hypothesis 2

Hypothesis 2 was stated as follows: The subjects in the spreadsheet learning method will receive a higher average score than the students in the traditional group on the total of the multiple choice questions on the four exams when statistically controlling for differences on mathematical ability.

Total points scored on the multiple choice questions ranged from 27 to 56 out of 65 possible. The mean for the control group was 42.11 and the mean score for the treatment group was 45.10. Therefore, the experimental group scored 2.99 points higher on the average than the students in the control group. An F statistic was calculated to determine if a statistically significant difference existed. An F value of 0.36 was observed. The data showed that no statistically significant difference existed between the experimental and control groups. The researcher fails to reject the null hypothesis and can not accept the alternative hypothesis, that there are statistically significant differences between the two groups on the total of the multiple choice scores (Table 4).

Table 4. Test for differences on the average total points on the multiple choice questions on the four exams while covarying on mathematics scores

Source of Variation	Sum of Squares	df	Mean Square	F	Probability
Covariate					
Math ability	2358.38	1	2358.38		
Main Effects					
Treatment	281.64	1	281.64	0.36	0.58
Residual	12548.21	16	784.26		
Total	15188.22	17			

Hypothesis 3

Hypothesis 3 was stated as follows: The subjects in the spreadsheet learning method will receive a higher average score than the students in the traditional group on the total points of the mathematical calculation questions on the four exams when statistically controlling for differences in mathematical ability.

Total points scored on the mathematics questions on the four exams ranged from 109 to 239 out of 295 possible. The mean for the control group was 169.33, and the mean score for the treatment group was 204.60. Therefore, the experimental group scored 35.27 points higher on the average than the students in the control group. An F statistic was calculated to determine if a statistically significant difference existed. An F value of 4.30 was calculated. The data did not show that a statistically significant difference existed between the experimental and control groups. The researcher was unable to reject the null hypothesis and accept the alternative hypothesis. The data did not show that there were statistically significant differences between the two groups (Table 5).

Table 5. Test for differences on the average total points on the mathematical questions of the four exams while covarying on mathematics scores

Source of Variation	Sum of Squares	df	Mean Square	F	Probability
Covariate					
Math ability	4496.14	1	4496.14		
Main Effects					
Treatment	2517.07	1	2517.07	4.30	0.055
Residual	9375.28	16	585.96		
Total	1638.50	18			

Hypothesis 4

Hypothesis 4 was stated as follows: The subjects in the spreadsheet learning method will receive a higher average score than the students in the traditional group on the total points of the essay questions on the four exams when statistically controlling for differences in mathematical ability.

The sum of the scores on the two essay questions ranged from 12 to 33 out of 40 possible. The average for the control group was 23.67, and the mean score for the treatment group was 28.8. Therefore, the experimental group scored 5.13 points higher on the average than the students in the control group. An F statistic was calculated to determine if a statistically significant difference existed. An F value of 2.22 was calculated. The data did not show that a statistically significant difference existed between the experimental and control groups. The researcher fails to reject the null hypothesis and cannot accept the alternative hypothesis, due to the fact that data did not support that there were statistically significant differences between the two groups (Table 6).

Table 6. Test for differences on the average total points total points on the essay questions of the four exams while covarying on mathematics scores

Source of Variation	Sum of Squares	df	Mean Square	F	Probability
Covariate					
Math ability	32.84	1	32.84		
Main Effects					
Treatment	600.24	1	600.24	2.22	0.156
Residual	4325.84	16	270.37		
Total	4958.92	18			

Auxiliary Finding

In conducting the analysis of the data gathered for this experiment, the researcher discovered several unanticipated findings. The researcher has already acknowledged the limitation of 19 subjects; thus, the findings presented represent a trend in the data and may not be statistically founded.

This researcher was interested in examining if there were differences between the treatment groups on total points scored on the four exams when the groups were analyzed by high and low math ability. Members in both treatment groups were separated into low and high math scores by splitting the groups at the median score of 20.5 on the math measure. The averages for the treatment group were 19.00 on the average for low math ability and 23.16 for the high math group. The control group had an average score of 16 for the low math ability group and 25.25 for the high math group. The number of individuals in each group were five and four for the control group and five and five for the treatment group respectively. An ANOVA was calculated to test the significance of the effect of mathematics level on treatment level.

The ANOVA of treatment level by math level with total points as the dependent variable was computed. The data in the table below show a significant main effect for treatment and a two-way interaction of treatment by math level (Table 7). The effect of belonging to a particular treatment group influenced the subjects point total. The math ability reflected on the math preexperimental measure did not significantly determine the subjects point total. The subjects in the spreadsheet groups performed higher than would have been suggested by their math score and previous research (Miller, 1987; Elmore and Vasu, 1980). However, the interaction of treatment and math score seems to reflect a lessening of the importance of the math level when the subject is in the spreadsheet experimental group. The expected outcome of a subject having a low math ability, from the review of the research, is to perform at a level similar to his/her math ability (i.e. correlated values of .4 to .6).

Table 7. Mathematics level by treatment on total point in the course

Source of Variation	Sum of Squares	df	Mean Square	F	Probability
Main Effects					
Treatment	3299.76	1	3299.76	5.89	0.028
Mathematics	1363.02	1	1363.02	2.43	0.140
two-way Interaction					
Treatment * Math Level	3224.06	1	3224.06	5.75	0.030
Residual	8411.13	15	560.74		
Total	17089.75	18			

Figure 3, shown below, listing the means of the two experimental groups is presented by math level, using raw total points on the four exams as a dependent variable. The graph suggests that the members of the spreadsheet group who were measured as having a lower math ability seem to score higher while using the spreadsheet while learning statistics . In contrast, the low math ability individuals in the control group seem to score lower than anyone else when using the traditional approach. The high math ability students in both groups seem to score about equally.

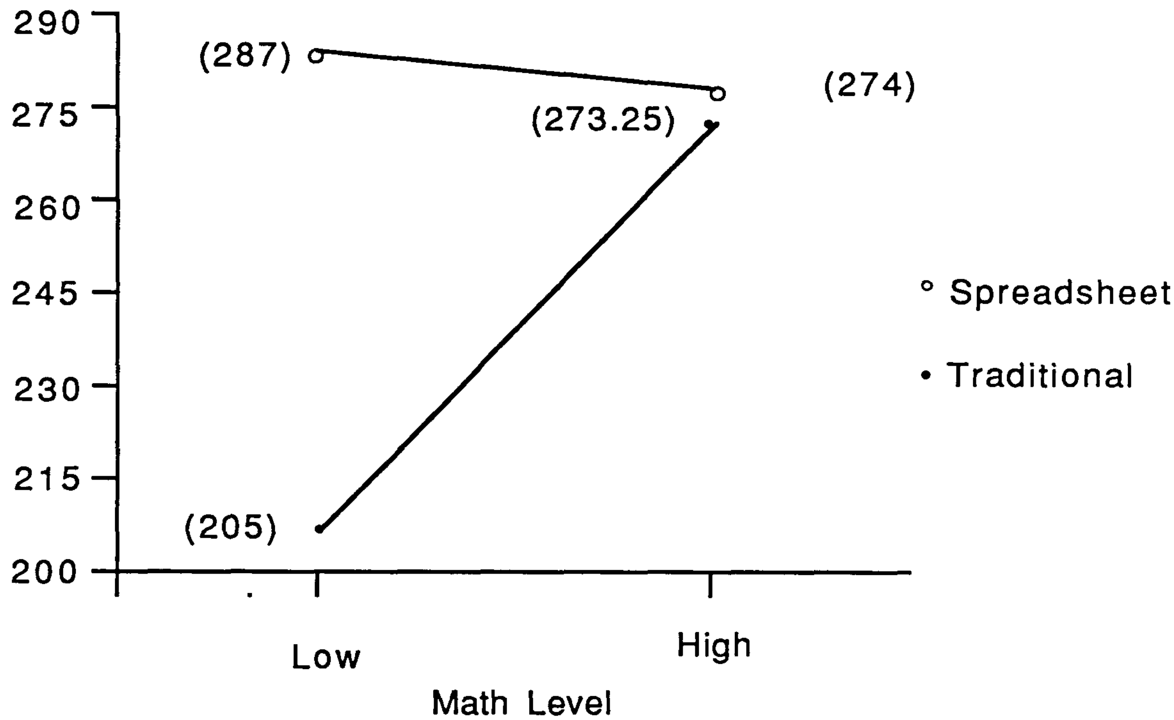


Figure 3. Graph of the interaction of treatment level by math level

Summary

Based on statistical analysis of the preexperimental measures and demographic measures, the researcher noted that there were no statistically significant differences between the two groups detected on the first day of class. The t tests conducted on these measures between the treatment groups did not allow the researcher to document possible interactions between these variables.

The four research hypotheses of this study have been addressed, and the results of the statistical analyses have been presented. The spreadsheet group received a higher average point total on four individual exams. The exams measured the student's understanding of the material covered in the two weeks prior to each exam.

On all four exams, the multiple choice questions were to test the student's understanding of statistical concepts in written form. Although the subjects in the experimental group scored on the higher on the average, this difference was not significant.

On the total mathematical calculation points received on the four exams, the spreadsheet groups scored higher on the average. The mathematical questions were scored in three parts: (a) approach to the problem, represented by identifying and using the correct statistical formula for calculation; (b) calculation of the mathematical formulas; and, (c) interpretation of the problem in regard to the the statistical conclusion and layman's conclusion. The correction of the problems was judged by the instructor for the course. The observed differences were not statistically significant. The observed F for mathematical questions was close to being significant with a probability of 0.055.

The average score received on the essay questions on the third and fourth exams did not show a statistically significant difference in the level of understanding between the treatment groups. The essay questions were designed to measure the student's level of abstract reasoning on statistical concepts. The questions presented were asking the student to explain relationships among statistical concepts that the students might have come to understand while working with data and statistical procedures. An example of a question given on the fourth exam was "what changes in the F distribution occur as the sample size exceeds 400." This concept was not presented in any lab or lecture. The effects of sample size, criterion for rejection, error in measurement, and critical values, which are components of the the concept of the F distribution, were presented in lectures and labs. Students were asked to present their thoughts on the effect of a large sample size on an F Statistic in layman's terms.

The results of the hypotheses presented in Chapter 1 have been addressed and the statistical conclusions stated. An auxiliary finding was also presented, and the relevance of it will be discussed in Chapter 5.

CHAPTER V: SUMMARY, CONCLUSIONS AND IMPLICATIONS

As stated in the introduction to Chapter 1, using the computer in the teaching of educational statistics will reduce the time necessary to compute answers and reduce computational errors. The type of computer usage and the amount of control on the part of the student may have an effect on the amount of student learning. As educators and psychologists investigated the use of the computer in the teaching of statistics (Stockburger, 1980), the inquiry of the researchers was directed toward determining how it could increase student learning. In order to stimulate student learning Brown (1983) suggests that the process of how the student uses the computer may be more important than the output of a student generated computer program. Studies must be conducted which document the effectiveness of the amount and type of student control over his/her interaction with the computer and the effects on student learning.

This chapter presents a summary of the purpose of this study, a brief outline of the research design features, a list of the major findings, an outline of the conclusions relative to these findings, and discussion of the implications of the study. The information presented in this chapter provides a brief summary of the study, and suggestions for further research.

Purpose of the Study

The purpose of this study was to conduct a preliminary investigation into the effects of student usage of a computer spreadsheet in the tutee mode in the teaching of educational statistics. The study was based on the underlying belief that students might learn statistics in a more comprehensive way by being in charge of the computer usage. Thus, the way in which the student integrates the information being taught into his/her working schemata of statistics may be increased.

The treatment administered in this study by the use of the spreadsheet program provided a system for student interaction with the statistical problems and his/her self held schemata on statistics. The treatment program provided an environment for active student assimilation of the material by his/her elaboration (Mayer, 1980) of his/her understanding of statistics onto the computer spreadsheet. The cycle of information was completed when the student received information from the spreadsheet that they had programmed. The information would be in the form of testing his/her model to see if it produced the desired calculations the student anticipated. The cycle could continue until the student felt like the spreadsheet was completed.

The spreadsheet reflects the student's unique understanding of the problem. Once the spreadsheet was completed by the student, the spreadsheet was a working model of his/her understanding of the calculation process of the statistic and a calculation tool for more problems. The amount of student learning, according to Brown (1983) and Andre (1987), was determined by the student's interaction with the material and his/her schemata of the statistical concept, and not the product of his/her effort. Since the more elementary topics were taught in the beginning of the semester, the complexity of the spreadsheet grew as the students learned more advanced statistical techniques. The instruction to the students on how to develop a statistical technique on the spreadsheet was primarily conducted after the students received instruction on the statistical technique.

Study Design

A posttest only control group design with covariance on the measure of mathematical ability was used for this study. The sample consisted of nineteen graduate students enrolled in a basic educational statistics course in the Professional Studies in Education department at a large land-grant university in the midwest. Treatment groups were assigned to the subjects using the stratified random assignment technique. All subjects were given a mathematical pretest to determine their level of mathematical ability at the beginning of the study. The treatment group received the laboratory instruction during the same instructional time period in separate labs. The spreadsheet that was produced by the subjects was to reflect the material covered in the lectures. Since the use of the spreadsheet was to reflect the actual calculation process, only automated, this researcher felt that the students would not benefit from receiving instruction on a technique unknown to them before the lecture. The spreadsheets constructed by the students were modified and expanded as the semester progressed. The study was designed to compare the results of student usage of two different teaching techniques of using a microcomputer to learn statistics.

Major Findings

Based upon the stratified random assignment of treatment groups to subjects, an evaluation of the demographic attributes and mathematics pretest scores, the researcher considered subjects in experimental treatment groups to be equivalent in terms of knowledge and background statistics prior to the study. Though subject groups were determined to be equivalent prior to the study, subjects in the experimental group scored higher on all sections of the four exams. The experimental group scored higher on the totals of the four exams, mathematical sections, multiple choice sections, and essay sections. Table 8 presents a comparison of the mean scores on the exams in raw points. While the mean score for the experimental group was higher in each instance, the calculated ANCOVA statistic for each hypothesis demonstrated only a statistically significant difference on the totals of the four exams while covarying for individual differences differences in mathematical ability. The study involves a small sample size (9 in the control group, 10 in the experimental group and a total study sample of 19).

Table 8. Comparison of mean scores on exam sections and totals

Exam Sections	Control Group Mean Score	Experimental Group Mean Score	Mean Score Difference
Multiple Choice	42.1	45.1	3.0
Mathematical Problems	169.3	204.6	35.3
Essay Questions	23.7	28.8	5.1
Exam Totals	235.3	279.1	43.8

While a statistically significant difference between groups was observed only on the totals of the exams, the means on the mathematical, multiple choice, and essay sections of the individual exams were higher for the experimental group. As a result of these findings, the null hypothesis for the exam totals was rejected. The null hypothesis for the multiple choice, essay and mathematical sections, was retained. There was a statistically significant difference on average on exam score totals between students who received the spreadsheet lab experience and those who received the traditional lab experience. When the researcher examined the mathematical, multiple choice, and essay sections on the exams individually, the researcher found that there was no statistically significant difference between students who used the treatment lab experience and those who received the traditional lab experience.

Conclusions

The following conclusions are presented on the basis of the results of this study. The number of subjects in this study was small and this fact should be alert the reader to interpret the following results with caution.

This study has been an investigation into the use of computers in the teaching of statistics to promote student learning. Since the student places the statistical problem on the computer spreadsheet, the spreadsheet can be utilized to help the student organize the information in a process that promotes high interaction with the material. The result of the high interaction with the statistical process, i.e., having the student direct his/her learning using the spreadsheet in the tutee mode, may have lead to an increase in understanding. The measure of the student understanding is the increase in points received by students on exams.

When the spreadsheet experience was used for the understanding of statistics, statistically significant results were observed on the total of the measures of student learning. In all experimental studies, the observed scores result form some combination of true score and error. In this study, a statistically significant result for the spreadsheet group was observed on total points scored. The researcher is led to believe that the student use of a spreadsheet may influence student performance in an educational statistics course, especially for lower math ability students. The average score on all exams, however, was greater for the experimental group throughout the study.

Another trend discovered in the analysis of the data was the finding that the students with low math ability at the beginning of the course scored higher than anticipated after receiving the spreadsheet treatment. Previous research by Miller (1987) and Elmore and Vasu (1980) found correlations of .6 and .4, respectively, between math ability on a pretest and success in the course. Those results suggest that a student's success in a statistical course was related to his/her mathematical ability at the beginning of the course. By examining the analysis in Chapter 4 of the 2 X 2 ANOVA of treatment by math ability and Figure 3 (scores of treatment by math level), it is evident that the subjects in the low math, spreadsheet group, performed at a higher level than would have been anticipated from previous research.

Implications and Suggestions for Future Work

The experimental treatment in this study was a comparison of two different styles of computer usage by students in the learning of statistics. The study compared the use of the spreadsheet in the tutee mode versus the traditional lab experience of using a preprogrammed statistical package.

The results of this study seem to provide an indication of a positive influence on student understanding of statistical problem solving from the use of the treatment spreadsheet experience. The positive effects of the experimental treatment on increased understanding was reflected in higher average score across the four exams. The spreadsheet group had greater control (Hewett, 1986) over its interaction with the computer and more frequent feedback from this interaction during the problem solving process (Wells and Berger, 1985/86). The issue of student control over his/her interaction with the material was proposed to increase student learning and facilitate student understanding by Papert (1980), Mayer (1980), Goetzfried and Hannafin, (1985), Andre and Phye (1986), Tennyson et al. (1987), Andre (1987), and Cooper and Sweller (1987). The spreadsheet group may have interacted more with their mental representation of the problem while trying to describe or elaborate the statistical problem to the spreadsheet (Orzech and Shelton, 1986; Mayer, 1980). The completed spreadsheet contained the student's interpretation of the statistical process versus the interpretation given to the the student in the traditional group by the programming skills of Freedman F. Elzey.

The analysis of differences between the groups on mathematical questions in the exams, hypothesis 2, was almost significant. It would be interesting to assess the effect of the use of the spreadsheet with a higher sample size to assess how the use of a spreadsheet may benefit student understanding of the mathematical computations of statistical problems.

In reviewing the literature, the predictors of student success in an educational statistics course could be viewed as static characteristics (Elmore and Vasu, 1980; Miller, 1987). A partial list of the characteristics includes gender, level of degree sought (Ph.D. or M.S.), MMPI femininity/masculinity subtest scores, spatial visualization, and some measure of prior math and statistics courses. The implication was that a student's innate characteristics at the beginning of course were strong indicators of performance in the class.

Students with lower math premeasure scores would have been predicted to obtain lower point totals in the course. As reported in the Auxiliary Findings section in Chapter 4, the lower math ability students seemed to benefit more from the use of the spreadsheet approach than those students with a higher math ability score at the beginning of the semester. The use of an interactive spreadsheet for the learning of statistics may have assisted these students with a lower mathematics ability. The interaction reported in Figure 3, Chapter 4, illustrates the differences observed between students in the two treatments.

Other measures that assess the process of how students benefit from the use of the spreadsheet would be helpful to document the learning process. Differences in the amount of time it took individuals to complete problems using the two different learning methods, if it had been measured, might have shed some additional insight into the processes that students used in solving statistical problems as the term progressed. Similar studies should be conducted with larger populations of high and low math ability students to assess the impact of this treatment process.

Future studies must be specific in describing the objectives of the use of the computer being made in the study, and in explaining the instructional approach of this use. In future studies, a high amount consideration should be given to increasing the number of participants in the study. The researchers who might consider this project for replication, may want to investigate similar student controlled environments with easier access for the students to manipulate and interact with their ideas. The benefit of the spreadsheet treatment seems to center in the allowing the student high interaction with the content area, statistics, and the students' mental representations of the content. In the interactive spreadsheet environment, with the student in control of the interaction, the student's learning was increased by their adjusting the model representing their understanding.

BIBLIOGRAPHY

Anderson, T. (1977). Computer assisted problem solving in an introductory statistics course. Technical Report N. 56. Bolt, Beraned, and Newman, Inc., Center for the Study of Reading, Illinois University, Urbana.

Andre, T. (1987). Expert-Novice Differences and the Role of the Student Response in Acquiring Schemata in Science Learning. Unpublished manuscript. Dept. of Psychology, Iowa State University, Ames, Iowa.

Andre, T. and Phye, G. (1986). Cognition, Learning, and Education. Orlando: Academic Press, Inc.

Arganbright, D. (1985). Mathematical Applications of Electronic Spreadsheets. New York: McGraw Hill.

Bar-On, E. (1986). A programming approach to mathematics. Computers and Education, 10(4), 393-401.

Becker, M. (1986). Interactive spreadsheet computing for engineering problems. Engineering Education, 76(5), 290-292.

Boettcher, E. G., Alderson, S. F., and Saccucci, M. S. (1981). A comparison of the effects of computer-assisted instruction versus printed instruction on student learning in the cognitive categories of knowledge and application. Journal of Computer Based Instruction, 8(1), 13-17.

Borg, W. R. and Gall, M. D. (1983). Educational Research: An Introduction. (4th ed). New York: Longman.

Brown, J. M. (1986-87). Spreadsheets in the classroom. The Computing Teacher, 14(1), 8-10.

Brown, J. S. (1982, August). Learning-by-doing revisited for electronic learning environments. The Future of Electronic Learning Conference. Paper presented at the meeting of Teachers College, Columbia University, New York.

Brown, J. S. (1985). Process versus product: A perspective on tools for communal and informal electronic learning. Journal of Educational Computing Research, 1(2), 179-201.

Brown, R. (1933). Mathematical difficulties of students of educational statistics. New York: Columbia University Press.

Burns, P. K., and Bozeman, W. C. (1981). Computer-assisted instruction and mathematics achievement: Is there a relationship? Educational Technology, 28(10), 32-39.

Catterall, P. and Lewis, R. (1985). Problem solving with spreadsheets. Journal of Computer Assisted Learning, 1, 167-179.

Clements, D. H. (1987). Longitudinal study of the effects of LOGO programming on cognitive abilities and achievement. Journal of Educational Computing Research, 3(1), 73-94.

Cooper, G. and Sweller, J. (1987). Effects of schema acquisition and rule automation on mathematical problem-solving transfer. Journal of Educational Psychology, 79(4), 347-363.

Dillbeck, M.C. (1983). Teaching statistics in terms of the knower. Teaching of Psychology, 10(1), 18-20.

Elmore, P. B. and Vasu, E. S. (1980). Relationships between selected variables and statistical achievement: Building a theoretical model. Journal of Educational Psychology, 72, 457-467.

Emond, W. J. (1982). Some benefits of micro-computers in teaching statistics. Computers and Education, 6(1), 51-54.

Evans, J. St. B. T. (1982). The psychology of deductive reasoning. London: Routledge and Kegan Paul.

Fong, G. T., Krantz, D. H. and Nisbett, R. E. (1986). The effects of statistical training on thinking about everyday problems. Cognitive Psychology, 18, 253-292.

Gaynor, P. (1981). The effect of feedback delay on retention of computer-based mathematical material. Journal of Computer Based Instruction, 8(2), 28-34.

Gibson, L. M. (1984). Electronic spreadsheet packages for microcomputers. Drexel Library Quarterly, 20 (4), 64-73.

Glass, G. and Stanley, J. (1970). Statistical Methods in Education and Psychology. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Goetzfried, L. and Hannafin, M. J. (1985, Summer). The effect of the locus of control of CAI control strategies on the learning of mathematics rules. American Educational Research Journal, 22(2), 273-278.

Goodman, T. (1986, March). Using the microcomputer to teach statistics. Mathematics Teacher, 79(3), 210-215.

Gordon, T. J. and Hunt, D. N. (1986). Teaching statistics with the aid of a microcomputer. Teaching Statistics, 8(3), 66-72.

Hart, A.E. (1983). The non-standard deviation. Teaching Statistics, 5, 16-20.

Hays, W. L. (1963). Statistics New York: Holt, Rinehart and Winston

Hewett, T. T. (1986). Using an electronic spreadsheet to teach neural modeling of visual phenomena. Collegiate Microcomputer, 4(2), 141-151.

Hinkle, D. E., Wiersma, W. and Jurs, S. G. (1979). Applied Statistics for the Behavioral Sciences Boston: Houghton Mifflin Company

Hsiao, F. S. T. (1985a). A statistical method of grading--theory and practice. Computers in Education, 9(4), 227-233.

Hsiao, F. S. T. (1985b). Micros in mathematics education--Uses of spreadsheets in CAL. International Journal of Education Science and Technology, 16(6), 705-713.

Hsiao, M. W. (1985c). A CAI framework of multiple regression analysis on spreadsheets. Collegiate Microcomputer, 3(3), 239-248.

Kemp, B. (1977). Statistics for the non-specialist. International Journal of Mathematical Education, 8(4), 407-409.

Kleiman, G. M. (1984). Brave New Schools: How computers can change education. Reston, Virginia: Reston Publishing Co. Inc.

Lahey, G. F. (1981). The effect of instructional sequence on performance in computer-based instruction. Journal of Computer-Based Instruction, 7(4), 111-117.

Lamaison, H. J. (1986). The use of micro-computer software packages in teaching economics and statistics. International Journal of Education Science and Technology, 17(1), 67-69.

Levey, S. (1984, November). A spreadsheet way of knowledge. Harpers, 269, pp 58-64.

Lohnes, P. R. and Cooley, W. W. (1968). Introduction to Statistical Procedures: with Computer Exercises. New York: John Wiley and Sons, Inc.

Luehrmann, A. W. (1972). Should the computer teach the student, or vice versa? A paper presented at the Joint Computer Conference, Spring, 1972, Montvale, N.J.

Luehrmann, A. W. (1986, April). Spreadsheets: More than just finance. The Computing Teacher, 13(7)pp. 24-28.

Lyczak, R. (1980). Statistics By Computer: Elementary Fortran and Basic Programming for Statistical Analysis. New York: Duxbury, 1980.

Magnello, M. E., and Spies, C. J. (1984). Using organizing concepts to facilitate the teaching of statistics. Teaching of Psychology, 11(4), 220-223.

Maher, C. A., and Pace, J. P. (1985). Success with statistics through planned experiments. Mathematics and Computer Education, 19(2), 93-98.

Mayer, R. E. (1980). Elaboration techniques that increase the meaningfulness of technical text: an experimental test of the learning strategy hypothesis. Journal of Educational Psychology, 72(6), 770-784.

Mayer, R. E. (1981). The psychology of how novices learn to program. Computing Surveys, 13(11), 121-141.

Miller, W. G. (1987). Predictors of success in a graduate educational statistics course. Unpublished manuscript. Dept. of Professional Studies, Iowa State University, Ames, Iowa.

Nisbett, R. E., Krantz, D. H., Jepson, C., and Kunda, Z. (1983). The use of statistical heuristics in everyday inductive reasoning. Psychological Review, 90, 339-363.

O'Dell, J. W. (1977, summer). Statistics students' mathematical difficulties. Improving College and University Teaching, 25(3), 157-158.

O'Neil, H. F., Jr., and Spielberger, C. D. (1969). Effects of state anxiety and task difficulty on computer-assisted learning. Journal of Educational Psychology, 60(5), 343-350.

Orzech, Z. and Shelton, F. A. (1986). The electronic spreadsheet as a didactic learning enhancement. Computer Education, 10(4), 429-437.

Papert, S. (1980). Mindstorms: Children, Computers and Powerful Ideas. New York: Basic Books, Inc.

Roth, K. J. (1985). Conceptual change learning and student processing of science texts. Paper presented at the annual meetings of the American Educational Research Association, Chicago.

Schiffman, S. S. (1986, May). Productivity tools in the classroom. The Computing Teacher, 13(8), 27-31.

Silvert, W. (1984). Teaching ecological modeling with electronic spreadsheets. Collegiate Microcomputer, 2(2), 129-133.

Squires, D., and McDoougal, A. (1986). Computer-based microworlds-- A definition to aid design. Computer Education, 10(3), 375-378.

Steinberg, E. R. (1977). Review of student control in computer-assisted instruction. Journal of Computer-Based Instruction, 3(3), 84-90.

Stockburger, D. W. (1980). Teaching statistical concepts using microcomputers simulations. Paper presented at the Southwestern Psychological Association Meeting, Oklahoma City, OK.

Strike, K. A. (1975). The logic of learning by discovery. Review of Educational Research, 45(3), 461-483.

Taylor, R. P. (Ed.). (1980). The Computer in the School: Tutor, Tool, Tutee. New York: Teachers College Press.

Tennyson, R. D. and Cocchiarella, M. J. (1986). An empirically based instructional design theory for teaching concepts. Review of Educational Research, 56(1), 40-71.

Tennyson, R. D., Thurlow, R. and Breuer, K. (1987). Problem-oriented simulations to improve higher-level thinking skills. Unpublished manuscript. Dept. of Psychology, University of Minnesota.

Thomas, R. A. and Boysen, J. P. (1984, May/June). A taxonomy for the instructional use of computers. Monitor, pp.15-26.

Thompson, E. A. (1988). Conversation with E. Ann Thompson, Professional Studies: Curriculum, Iowa State University, Ames, Iowa.

Vernot, D. (1986). Spreadsheets: How to calculate almost anything. Instructor, 95(7), 43-44.

Ward, E. F. (1984). Statistics Mastery: A Novel Approach. Teaching of Psychology, 11(4), 223-225.

Warren, R. D. (1988). Conversation with Richard D. Warren, Director of Research Institute for the Study of Education, Iowa State University, Ames, Iowa.

Wegman, E. J. and Gere, B. H. (1972). Some thoughts on computers and introductory statistics. International Journal Math. Education and Scientific Technology, 3(3), 211-221.

Wells, G. and Berger, C. (1985/86). Teacher/student- developed spreadsheet simulations: A population growth example. Journal of Computers in Mathematics and Science Teaching, 5(2), 34-40.

Wisnieski, G. J. (1970). Development and evaluation of self- instructional mathematics materials designed for students in educational statistics. Unpublished doctoral dissertation, Iowa State University, Ames.

Woodrow, J. E. J. (1986, Spring). Using the Apple Macintosh and MULTIPLAN spreadsheet to analyze tests. Journal of Computers in Mathematics and Science Teaching, 5(3)pp. 34-45.

ACKNOWLEDGMENTS

I would like to extend my appreciation to Dr. Ann Thompson, my major professor. Her support and encouragement of my completion of my thesis has been very inspirational. Her insight into education and educational computing has set a high mark for all of us to strive. I would also like to acknowledge the other members of my graduate committee, Dr. Tony Netusil and Dr. Rex Thomas. While having worked closely with Dr. Netusil this past year, I have learned a great deal about professionalism and friendship. In my conversations with Dr. Rex Thomas, I always left with more questions than answers, and a few of those questions were answered by the further research he inspired in my thesis.

I want to thank Joane McKay, Beth Ruiz and Linda Parker. For without their assistance, this document might have been completed in several years.

I wish to thank my lovely wife, Ann for her support given to me while I (we) completed this degree. She has denied herself many opportunities, so that I might complete my degree. Lastly, I thank my son David, who at two and one-half, asked everyday, "thesis done daddy?". Yes David, it is!

APPENDIX A

BLANK SPREADSHEET

	1	2	3	4	5	6	7
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							
32							
33							
34							
35							
36							
37							
38							
39							
40							
41							
42							
43							
44							
45							
46							
47							
48							
49							
50							
51							
52							
53							

APPENDIX B

EXAMS

Res Ev 552
TEST I
Summer 1987

NAME ____________________________

III. Multiple Choice (1 point each)

1. Which of the following commands should be followed by a file name?

   a. FETCH
   b. PURGE
   c. RELEASE
   d. SCRATCH
   e. all of the above

2. Given that a distribution of test scores is positively skewed, we can conclude that

   a. mean = median.
   b. mean > median.
   c. mean < median.
   d. mean = mode.

3. If a student scored a 75 on an achievement test and 85 percent of all students who took this test had lower scores, which of the following is correct?

   a. The student answered 75 percent of the test items correctly.
   b. The percentile rank of the student's score is 85.
   c. Eighty-five percent of the test takers scored at least a 75.
   d. The student answered 85 percent of the test items correctly.
   e. None of the above.

4. The range is used as a measure of

   a. relative position.
   b. skewness.
   c. variability.
   d. central tendency.

5. Mr. Sweetwater's biology class had a standard deviation of 2.4 on a standardized test, while Ms. Quincy's biology class had a standard deviation of 1.2 on the same test. What can be said about these two classes?

   a. Ms. Sweetwater's class is more homogeneous than Ms. Quincy's.
   b. Ms. Quincy's class is less heterogenious than Ms. Sweetwater's.
   c. Ms. Quincy's class did less well on the test that Ms. Sweetwater's.
   d. Ms. Sweetwater's class performed twice as well on the test as Ms. Quincy's class.

6. If a researcher wished to make a statement about the central tendency of students' hair color in a freshman astronomy course, which measure would be most appropriate?

   a. mean
   b. mode
   c. median
   d. It would depend upon the researcher's purposes.

7. If a distribution of test scores is negatively skewed, we can say that

a. there were more low socres than high scores on the test.
b. the distribution is leptokurtic.
c. a difference of five percentile points reflects a greater difference in raw score units at the lower end of the distribution.
d. none of the above.

8. If a score has a percentile rank of 68, this means that

a. 32 percent of the scores fall above it.
b. 68 percent of the scores fall above it.
c. this is an average score for this class.
d. the student answered 68 percent of the test questions correctly.

9. Population is to parameter as sample is to

a. random.
b. subset.
c. statistic.
d. X.

10. The standard deviation <u>cannot</u> be correctly described as

a. containing about 2/3 of all the original scores.
b. the square root of the variance.
c. a measure of dispersion.
d. having the same measurement units as the original scores.

11. For the mean to represent a meaningful measure of central tendency, it is necessary for the data to be measured on at least the

a. ratio score.
b. nominal scale.
c. ordinal scale.
d. interval scale.

12. In order to calculate an unbiased estimate of the population variance, divide the sum of the squared deviations from the mean by

a. the range.
b. the number of scores in the sample.
c. one less than the number of scores in the sample.
d. the total number of scores in the population.
e. none of the above.

13. If the mean and median are equal, the distribution is

a. symmetric.
b. a normal bell-shaped curve.
c. a rectangular (uniform) distribution.
d. not necessarily any of the above.

14. If each score in a distribution is divided by two, which measure would change by the greatest factor?

a. mean
b. mode
c. standard deviation
d. All would change by the same factor.

15. One measurement scale that includes the computation capabilities of the other three is the

a. ordinal scale.
b. interval scale.
c. ratio scale.
d. nominal scale.

16. To remove line 25 from an active file, which command do you enter?

a. DEL 25
b. MOVE 25
c. REP 25
d. SCRATCH 25
e. all of the above

17. Which of the following commands will allow you to modify lines from 15 to 20?

a. M 15/20
b. M 15-20
c. M 15-M 20
d. M 15 to M 20
e. all of the above

18. Which of the following commands will erase your active file?

a. FETCH
b. PURGE
c. RELEASE
d. SCRATCH
e. CLE ACTIVE

19. To display your disk file names, which command would you enter?

a. LIST
b. SHO CAT
c. SHO DIR
d. SHO LIB
e. SHO OUTPUT

20. To display current status of jobs with job numbers, which command would you enter?

a. LOC
b. SHO CAT
c. SHO DIR
d. SHO LIB
e. SHO OUTPUT

II. (40 points -- each question is worth 20 points)

The new Iowa State head coach held tryouts for a team punter yesterday. In order to get an accurate picture of each punter's ability, he had them kick 20 times after five warm-up kicks. He noticed that the better punters were fairly consistant on each of their punts. After two hours of tryouts, Coach Walden selected the following punter, thinking he had chosen the one with the highest ability. In order to help the coach describe the data about the punts: <u>show all work on the printouts, below or on additional paper</u>.

a. Provide three measures of central tendency.

b. Provide three measures of variability and one must be the variance.

37	45	42	38
40	41	39	48
35	32	39	44
43	42	40	34
45	38	39	40

III. (28 points)

A sample of delegates from a political convention were selected. Each was asked his age (REMEMBER HOW AGE IS MEASURED TO THE LAST WHOLE YEAR). The following table was tabulated from their answers.

AGE INTERVAL	FREQUENCY
80-84	1
75-79	1
70-74	1
65-69	4
60-64	4
55-59	7
50-54	6
45-49	6
40-44	6
35-39	3
30-34	0
25-29	1

You do NOT need to solve these problems for an answer — substitute into the correct formula and STOP -- don't calculate.

(a) Estimate of the population mean.

(b) Variance of the sample.

c. Percentile rank for an age of 36.

d. Estimate of the population standard deviation.

e. Median.

f. Third quartile.

g. Q.

IV.

given the following SPSSx program written for class:

```
1.    //TONY JOB E5223, NETUSIL
2.    //S1 EX   SPSSX
3.    TITLE EXAMINATION PROBLEM NUMBER FOUR
4.    DATA LSIT RECORDS = 1
5.    / ID 1/3 AGE 5-7  EDUCATION 9-10
6.    SCORE 11-13(1)
7.    VARIABLE LABEL  EDUCATION "YEARS OF FORMAL EDUCATION " SCORE
8.      "1ST  EXAMINATION SCORE"
9.    MISSING VALUES "999"
10.   FREQUENCIES VARIABLES    OLDAGE EDUCATION SCORE
11.     STATISTICS   ALL/
12.   BEGIN
13.   001 018 1515.4
14.   002  19 5616.9
15.   003 022 8017.0
16.   004  33 4518.5
17.   END
18.   FINISH
```

Please list each error you can identify in the program and then show your correction.

line #	Error	Suggested correcetion

Research & Evaluation 552
Test # 2
Summer 1987

The following test is worth 100 raw points. The points for each problem are recorded by the problem number. The test can be completed in one hour (60 minutes) but you may have 90 minutes to complete the test. Please arrange to take the test in one sitting so you can give the 90 minutes if you need it. You may use the GIGI terminals in room E116 of Lagomarcino Hall and or the mirco terminals located in E006 or the Mac Lab. Work all numeric problems rounded to two decimal place accuracy in the final answer and hand in any printouts that show how you arrived at your final answers. High light (circle) the answers you want graded on the numeric problems.

1. Eighteen (18) points

Two art judges were asked to rank five oil paintings from best to worst. Their results are as follows:

Judge I	Judge II
Paintings (from best to worst)	
African Sunset	African Sunset
Blue Mist	Lily of the Valley
Lily of the Valley	The Old Fisherman
The Old Fisherman	Blue Mist
Country Scene	Country Scene

WHAT IS THE RELATIONSHIP (APPROPRIATE CORRELATION) BETWEEN THEIR RANKINGS?

2. Eighteen (18) points

My electric bills have an estimated average of $60 a month with an estimated variance of $9. ASSUME BILLS ARE NORMALLY DISTRIBUTED AND MEASURED TO THE NEAREST WHOLE DOLLAR.

WHAT IS THE CHANCE (probability) THAT MY BILL MIGHT BE MORE THAN $64 FOR A GIVEN MONTH?

NINETY-FIVE (95) PERCENT OF THE TIME MY BILL WILL BE AT LEAST HOW MUCH?

3. Eighteen (18) points

A social studies teacher administered an attitude scale to a group of high schhol students and recorded the scores of the boys separately from those of the girls. The scale purports to measure student attitudes toward "going steady", and a high score is indicative of a favorable attitude toward this activity. The scores are as follows:

Boys: 4 9 1 2 5 8 9 5 3 4   Girls: 11 8 6 7 10 8 5 1 6 8

(A) RECORD THE SEX OF EACH STUDENT AS A BINARY VARIABLE HENCE AWARDING A TWO TO A BOY AND A ONE TO A GIRL ALONG WITH THE STUDENT ATTITUDE SCORE. YOU SHOULD THEN HAVE TWENTY PAIRS OF MEASURES, EACH PAIR HAVING A SEX "SCORE" AND AN ATTITUDE SCORE. CALCULATE THE PEARSON CORRELATION COEFFICIENT FROM THE PAIED VARIABLES.

(B) WHAT MEANING SHOULD BE ATTACHED TO THE SIGN OF THE CORRLEATION COEFFICIENT? PLEASE GIVE YOUR ANSWER IN LAYMANS LANGUAGE, NOT IN "EDUCATIONEESE".

4. EIGHTEEN (18) POINTS

IF THE SOCIAL STUDIES TEACHER IN PROBLEM #3 DECIDES TO CONSIDER THE TOTAL CLASS OF TWENTY STUDENTS AND WANTS TO RECORD T SCORES IN HIS GRADE BOOK FOR EACH STUDENT. WHAT T SCORE WOULD BE RECORDED FOR THE STUDENT WHO HAS A RAW SCORE OF 4?

5. Eight (8) Points

YOUR INSTRUCTOR GAVE YOU A SEVEN STEP ROUTINE TO USE WHEN TESTING HYPOTHESES. PLEASE GIVE EACH STEP IN THE SEQUENCE, EACH WITH A CLARIFYING PARAGRAPH (SO WE CAN TELL YOU KNOW WHAT THE STEP SAYS TO DO) AND MAKE SURE THE STEPS ARE IN THE PROPER ORDER.

6. Twenty (20) Points
   One (1) point each

1) Which term represents the highest performance on a test with a normal distribution?

   a. z = +1.75.
   b. 85th percentile.
   c. T = 65.
   d. 1 standard deviation above the mean.

2) If every score in a standard normal distribution is multiplied by five, how will the distribution be changed?

   a. The mean will increase.
   b. The standard deviation will increase.
   c. Both the mean and standard deviation will increase.
   d. The variance will equal 5.

3) Which is not a property of the distribution of z-scores?

   a. It has the same range as the original distribution.
   b. It has the same shape as the original distribution.
   c. The mean is equal to zero.
   d. The variance is equal to one.

4) In the standard normal curve the area between two points does not equal

   a. A z-score.
   b. a probability.
   c. the number of scores between those points divided by the total number of scores.
   d. 1.0 minus the remaining area of the curve.

5) Scattergram is to Pearson r as histogram is to

   a. standardized normal distribution.
   b. z-scores.
   c. frequency distribution.
   d. normal curve.

6) All other things being equal, which situation would result in the smallest Pearson r?

   a. decreasing N
   b. decreasing the standard deviation
   c. making the group less homogeneous
   d. increasing N

7) The coefficient of determination equals the

   a. correlation coefficient squared.
   b. total variance of the Y-scores.
   c. correlation coefficient.
   d. proportion of variance attributable to random factors.
   e. none of the above.

8) Which of the following does not affect the value of r?

a. the number of paired scores
b. homogeneity on one variable
c. the slope of the points in the scattergram
d. linearity of the scattergram

9) If r = -.9, which statement is not necessarily correct?

a. As the scores on one variable increase, the scores on the other decrease.
b. Eighty-one percent of the variance in the two variables is shared.
c. A causal relationship between the variables is indicated.
d. There is a strong correlation.

10) Which is the most conservative alpha-level?

a. .05
b. .10
c. .01

11) If the population is assumed to be heterogeneous, the sampling technique that would be most appropriate is

a. cluster sampling.
b. stratefied sampling.
c. simple random sampling.
d. systemiatic sampling.
e. none of the above.

12) The standard error of the mean decreases as the

a. sample size decreases.
b. sample size increases.
c. mean increases.
d. mean decreases.
e. none of the above.

13) A logical alternate hypothesis for the null hypothesis H_0: $\mu = 60$ is

a. H_a: $\mu = 40$.
b. H_a: $\mu < 60$.
c. H_a: $\mu = 0$.
d. H_a: $\mu \neq 60$.
e. none of the above.

14) If a researcher has rejected a null hypothesis that in reality is true, the researcher has

a. committed a Type I error.
b. made a Type II error.
c. invoked a standard error.
d. actually made no error.

15) In hypothesis testing, the level of significance is

a. limited to .01 or .05.
b. determined by the researcher.
c. set by tradition.
d. of minor importance.
e. all of the above.

16) In a two-tailed test of a null hypothesis with 200 degrees of freedom, the critical values at the .05 level are about

a. +1.96 and -1.96
b. +2.58 and -2.58.
c. +1.65 and -1.65.
d. +3.58 and -3.58.
e. none of the above.

17) Which of the following is an acceptable research method?

a. proving the null hypothesis
b. disproving the null hypothesis
c. proving the alternate hypothesis
d. disproving the alternate hypothesis

18) Type I and Type II error rates are

a. directly related.
b. inversely related.
c. not related.

19) Changing the level of significance from .05 to .01

a. increases alpha and decreases beta.
b. increases beta and decreases alpha.
c. increases alpha and beta.
d. decreases alpha and beta.

20) As the level of confidence increases

a. alpha increases.
b. beta decreases.
c. level of significance increased.
d. beta increases.

Time out _____

Time in _____

Name ______________________________

Res Ev 552
Summer 1987
Test III

You will have 120 minutes (2 hours) available to complete this test. It is open book, open note and closed to communication with thy neighbor. If the test is not in the hands of either Stan or Dr. Netusil by the time marked on the test, a major point loss will occur!

All work leading to an answer must be clearly visible and turned in to be graded. This includes all printouts, scratch work and solutions. Clearly indicate the desired answer to be checked.

If you do not understand what the problem is asking you to do, seek clarification from either Stan or Dr. Netusil.

Good luck!

Multiple Choice (1 point each)

1. The hypothesized parameter $\rho = 0$ can be tested by

   a. the z-test.
   b. the t-test.
   c. both a and b.
   d. neither a nor b.

2. Which is not a consequence of increasing sample size?

   a. The significance level increases.
   b. Standard error decreases.
   c. The probability of rejecting a false null hypothesis is increased.
   d. Statistical precision is enhanced.

3. Statistical knowledge is least sufficient for

   a. analyzing data.
   b. testing for significant differences.
   c. interpreting results.
   d. adjusting statistical precision.

4. If a researcher uses the z-distribution when the t-distribution should be used (at the .05 level), a true null hypothesis will be rejected

   a. more than 5 percent of the time.
   b. less than 5 percent of the time.
   c. 5 percent of the time.
   d. if it is a one-tailed test.

5. The critical value of the test statistic is not dependent upon

   a. the level of significance.
   b. the directional nature of the alternate hypothesis.
   c. the degrees of freedom.
   d. the standard error of the statistic.

6. Random assignment of subjects to experimental groups is done to ensure

   a. equal Ns.
   b. maximum results in terms of the dependent variable.
   c. confounded results.
   d. equivalence of the groups at the beginning of the experiment.

7. A hypothesis is rejected when, for the statistic, the

   a. table value exceeds the calculated value.
   b. critical value exceeds the table value.
   c. calculated value exceeds the critical value.

8. When a one-tailed t-test is used rather than a two-tailed t-test, the researcher must change

   a. the degrees of freedom.
   b. the level of significance.
   c. the denominator of the observed t statistic.
   d. the critical value of the statistic.

9. Homogeneity of variance refers to

   a. equal population means.
   b. equal population variances.
   c. equal sample means.
   d. equal sample variances.

10. Which does not belong?

   a. z
   b. P
   c F
   d. t

Complete the following table. (1 point each)

11. $.01^{t}36$ =

12. $.90^{z}$ =

13. $.01^{X^2}_{4}$ =

14. $.25^{F}9,12$ =

15. $.99^{F}15,21$ =

(15 points)

16. Suppose an experimenter has correlated college grades and income 10 years after graduation for a random sample of 62 graduates of Lollipop Day-Care College. The sample estimate of the population correlation coefficient is 0.16. Construct a 95% confidence interval for the correlation and then interpret it for a layman.

(15 points)

116

17. A used-car dealer at first thought that on the average, car make A is traded in at the same age as make B. Having been in a dealership for some years, his experience makes him now believe that make A cars are traded in over one year older than make B. Test his belief using α = .05 and the data in the table. What do you conclude?
What would you tell a lay audience you have found?

Car Age At Trade-In

Make							
$A(X_A)$				$B(X_B)$			
3	3	4	5	2	3	3	4
5	5	6	6	4	4	4	4
7	8	8		4	4	4	5
					5	6	

(15 points) 117

18. The director of a secretarial school wants to measure the increase in typing speed for students who have completed their course. She selected a random sample of 10 students. Typing tests were taken at the end of the first week and at the end of the course (sixth week). She really believes that the average student will increase in typing speed by over 30 words per minute between weeks one and six. Working at the α of .05, what did she find?

Typing Speed Increase During Course

	Words per minute	
Student	Week 1	Week 6
1	15	51
2	21	63
3	20	55
4	36	68
5	12	48
6	9	38
7	17	54
8	42	73
9	26	49
10	18	57
Totals		

Also, make a 90% confidence interval for the average change in typing speed in the 6-week period.

(15 points)

19. From a sample of five grapefruit the 95% confidence limits for the mean weight of all grapefruit in shipment are calculated to be 12.89 and 17.11 ounces. Find estimates of the mean and standard deviation of the population using this sample of five grapefruit.

(15 points)

20. A study was conducted to compare the variabilities in strengths of one-inch-square sections of a synthetic fiber produced under two different procedures. A random sample of 9 squares from each process was obtained and tested. Use the data (psi) below to test the research hypothesis that the population variances corresponding to the two procedures are different. Use $\alpha = .05$.

Procedure 1	74	90	103	86	75	102	97	85	69
Procedure 2	59	66	73	68	70	71	82	69	74

Construct a 90% confidence interval for the ratio of the variances.

(5 points)

21. Your instructor kept saying -- "Degrees of freedom are like money in the bank!" There are two meaningful reasons for this. Please give them.

(5 points)

22. When you run an independent t test between two groups, what happens to the t statistic when the N's in both groups are the same? Explain.

    Are the critical values (rejection regions) the same? Explain.

RESEARCH & EVALUATION 552
TEST # 4
SUMMER 1987

This test has one hundred (100) points divided between two major sections. The first section is worth forty (40) points and is closed book, closed note. It has ten (10) multiple choice questions worth one (1) point each and some essay questions worth a total of thirty (30) points. When you finish the first section and hand it in to your instructor you may begin on the second section. The second section is worth sixty (60) points and is open book, open notes. It has four groups of problems. You are to select only one (1) problem from each group, work it and hand in all your work, printouts, etc. for all of the four problems you do. Each problem is worth fifteen (15) points and you have a total time limit for the entire test of 120 minutes. Please note this, you have only 120 minutes for the entire test, both closed book and open book parts. Budget your time accordingly.

Multiple Choice. (1 point each) 123

1. Considering the assumptions that underlie ANOVA, which would you expect to be true in the three group case?

   a. $\sigma e_1 2 = 0$

   b. $\overline{X}_1 = \overline{X}_2 = \overline{X}_3$

   c. $MS_{W_1} = MS_{W_2} = MS_{W_3}$

   d. $\mu_1 = \mu_2 = \mu_3$

2. In a one-way ANOVA, the between-groups viaration represents

   a. the variation due to the treatment.
   b. the variation due to random sampling.
   c. both a and b.
   d. neither a nor b.

3. In a study of five groups of fifteen subjects each, a one-way analysis of variance was used to analyze the data. How many degrees of freedom would be associated with the within-group variation?

   a. 75
   b. 74
   c. 15
   d. 70
   e. none of the above

4. A mean square is

   a. a parameter.
   b. a population variance.
   c. an F-ratio.
   d. a statistic.
   e. none of the above.

5. The more conservative the post-hoc test,

   a. the more likely you are to find statistically significant differences.
   b. the lower the alpha-level (.10 rather than .05).
   c. the less likely you are to find statistically significant differences.
   d. the greater the number of means you are comparing.

6. The most appropriate post-hoc comparison for five unequal sized groups is the

   a. Scheffé method.
   b. Tukey method.
   c. Newman-Keuls method.
   d. orthogonal contrasts method.

7. Which of the following is <u>not</u> characteristic of the Tukey post hoc test?

   a. the test statistic is Q.
   b. Equal group sample sizes are needed.
   c. It maintains the experiment-wise Type I error rate.
   d. It is the least powerful of all post hoc tests.
   e. None of the above.

8. The X^2-distribution differs from the t-distribution in that

   a. X^2-distributions are determined by 2 df values.
   b. the t-distributions are skewed unless N is very large.
   c. most of the X^2-distributions are symmetrical.
   d. most of the X^2-distributions are highly positively skewed.

9. The chi-square distribution

   a. is normal.
   b. is a family of distributions.
   c. is similar in shape to the t-distribution.
   d. approaches symmetry as the degrees of freedom decrease.

10. The degrees of freedom for a D × C contingency table are

   a. KC + 1 - K - C.
   b. 2KC - 1.
   c. $K^2 + C^2 - 2$.
   d. none of the above.

Essay. (6 points each)

1. Tell me the general steps in solving for a oneway classification of analysis of variance. Use words in essay format and not tables or charts.

2. In analysis of variance, what is the reasoning for using an a-priori contrast test when a post-hoc is easier to construct.

3. In a Chi-Square test, what does the expected value represent?

4. a) In layman's language, what does the mean square for the between treatments represent?

4. b) In layman's language, what does the mean square for the within treatments represent?

5. In a oneway analysis of variance test, what happens to the computed F as the n of each treatment grows larger than 120?

OPEN BOOK, OPEN NOTE PART OF 552 EXAMINATION # 4

Select one problem from each group to work completely.

GROUP I

1. THE FOLLOWING ARE ESTIMATED MEANS (IN TEN THOUSAND DOLLAR UNITS) OF PROFIT ON SPECIFIED TYPES OF FARMS. TEN (10) OBSERVATIONS WERE OBTAINED FOR EACH TYPE OF FARM.

		ESTIMATED MEAN
A.	TENANT OPERATED - DAIRY FARM	4
B.	TENANT OPERATED - CASH GRAIN FARM	2
C.	OWNER OPERATED - DAIRY FARM	6
D.	OWNER OPERATED - CASH GRAIN FARM	4

IT IS ALSO KNOWN THAT THE WITHIN MEAN SQUARE IS 4.

A. TEST THE HYPOTHESIS THAT THE FOUR GROUPS HAVE THE SAME POPULATION MEAN AT THE .05 LEVEL.

B. DESIGN AND TEST A <u>REASONABLE</u> SET OF MUTUALLY ORTHOGONAL COMPARISONS.

C. WHAT DID YOU LEARN?

Select one problem from each group to work completely.

GROUP II

1. THE FOLLOWING DATA WERE COLLECTED IN A SURVEY OF THE RELATIONSHIP BETWEEN AVERAGE NUMBER OF HOURS SPENT STUDYING PER DAY AND PERFORMANCE IN A GRADUATE LEVEL STATISTICS COURSE AT A PARTICULAR UNIVERSITY.

HOURS OF STUDY PER WEEK	PERFORMANCE	
	PASS	FAIL
< 1	2	7
2	58	25
3	65	13
4	25	5

ARE THE TWO CHARACTERISTICS INDEPENDENT? WHAT CAN YOU DISCOVER?

2. AN ENVIRONMENTAL PROCTECTION AGENCY WAS INTERESTED IN WHETHER THERE WAS A RELATIONSHIP BETWEEN AGE AND SPECIES FOR FOUR KINDS OF CETACEA OFF THE COAST OF BAJA CALIFORNIA. A RESEARCH TEAM OF MARINE BIOLOGISTS COLLECTED THE FOLLOWING DATA.

AGE	TYPE OF CETACEA			
	SPERM WHALE	BLUE WHALE	DOLPHIN	ORCA
1 MO TO 5 YR.	2	5	9	10
6 YR TO 10 YR.	2	7	7	8
MORE THAN 10 YR.	12	14	15	20

WHAT CAN YOU DISCOVER FROM THE DATA?

Select one problem from each group to work completely.

GROUP III

1. QUICKER OATS IS CONTEMPLATING CHANGING THE SHAPE OF ITS BOX FROM THE QUAINT CYLINDER PRESENTLY IN USE. DIFFERENT RANDOM SAMPLES WERE SELECTED FROM FIVE (5) STORES OF SIMILAR SIZE IN THE SAME REGION AND ONE OF THE THREE CANDIDATE BOXES WAS SUBSTITUTED FOR THE CYLINDER FOR SEVERAL DAYS. THE TOTAL NUMBER OF BOXES SOLD AT EACH STORE IS AS FOLLOWS:

	BOX SHAPE		
STORE	PYRAMID	RECTANGLE	CUBE
1	110	57	92
2	85	65	81
3	69	73	66
4	97	49	71
5	78	77	70

WHAT DO YOU RECOMMEND TO THE COMPANY?

2. PROFESSOR SPEED HAD DISCOVERED A NEW SERUM WHICH WOULD INCREASE A PERSON'S SPEED WHEN RUNNING. THE SUMMER OLYMPICS WAS APPROACHING AND THE PROFESSOR WANTED TO TEST HIS SERUM. HE RANDOMLY ASSIGNED TWENTY (20) INDIVIDUALS WHO WERE COMPETING IN THE 32 K RACE TO FOUR (4) GROUPS, FIVE (5) SUBJECTS TO A GROUP. EACH GROUP RECEIVED A DIFFERENT GRAM DOSAGE OF THE SERUM AND THEN RAN THE 32 K RACE. THE TIME FOR EACH PERSON TO RUN THE RACE FOLLOWS. (NOTE, THIS SITUATION IS HYPERBOLE. TO RUN 32 K IN ONE MINUTE ONE WOULD HAVE TO EXCEED THE SPEED OF SOUND.)

DOSAGE			
A	B	C	D
6	5	4	2
6	3	4	2
6	4	4	2
7	4	3	1
7	4	3	1

AT THE .01 LEVEL, WHAT DID YOU DISCOVER?

Select one problem from each group to work completely.

GROUP IV

1. AN INVESTIGATOR HYPOTHESES THAT HIGH SCHOOL GUIDANCE COUNSELORS TEND TO ADVISE BOYS TO PREPARE FOR PROFESSIONAL CAREERS MORE OFTEN THAN THEY ADVISE GIRLS TO PREPARE FOR PROFESSIONAL CAREERS. HE RANDOMLY DRAWS A SAMPLE OF ONE HUNDRED (100) STUDENTS WHO HAVE HAD CAREER COUNSELING, CLASSIFIES THE CARRER SUGGESTED BY THE COUNSELOR INTO PROFESSIONAL OR NON PROFESSIONAL. HIS DATA ARE AS FOLLOWS:

CAREER SUGGESTED	GENDER	
	GIRLS	BOYS
PROFESSIONAL	8	22
NON PROFESSIONAL	42	28

WHAT DID HE FIND OUT?

2. ONE WONDERS IF ONES PREFERENCE FOR POLITICAL CANDIDATES IS INDEPENDENT OF ONES MARITIAL STATUS. TO CHECK THIS OUT, SUPPOSE YOU ATTEND A DEMOCRATIC FUND RAISER AND ASK AS MANY PEOPLE AS YOU COME IN CONTACT WITH WHO THERE PRERENCE IS BETWEEN THE TWO FRONT RUNNERS. THERE RESPONSES ARE AS FOLLOWS:

	MARITIAL STATUS	
PREFERENCE	SINGLE	MARRIED
CANDIDATE A	20	10
CANDIDATE B	20	50

WHAT DID YOU FIND OUT?

APPENDIX C

MENU AND PRINTOUTS FROM ELZEY

ELZEY STATISTICAL PACKAGE

SELECT A LETTER AND PUSH RETURN

A - DATA FILE PREPARATION - # 1
B - DATA FILE PREPARATION - # 2
C - SAMPLE STATISTICS
D - PERSON CORRELATION (r)
E - REGRESSION
F - MULTIPLE REGRESSION -- TWO PREDICTORS
G - T-TEST -- INDEPENDENT SAMPLES
H - T-TEST -- DEPENDENT SAMPLES
I - ONEWAY ANOVA -- INDEPENDENT SAMPLES
J - TWOWAY ANOVA -- INDEPENDENT SAMPLES
K - ANALYSIS OF COVARIANCE
L - ONEWAY ANOVA REPEATED MEASURES
M- CHI SQUARE -- GOODNESS OF FIT
N - CHI SQUARE -- INDEPENDENT PROPORTIONS
O - SPEARMAN RANK CORRELATION (rho)
P - OTHER NON-PAREMETRIC TESTS

****

SAMPLE STATISTICS

****

N = 24

MAXIMUM VALUE = 9

MINIMUM VALUE = 1

SUM OF X = 124

SUM OF X SQUARES = 736

****

MEASURES OF CENTRAL TENDENCY

****

N = 24

MEAN = 5.167

MEDIAN = 5

****

MEASURES OF VARIABILITY

****

N = 24

RANGE = 8

VARIANCE = 4.145

STAN. DEV. = 2.036

STAN. ERROR = .416

****

CONFIDENCE INTERVALS

****

95% CONF. INT. 4.298 TO 6.035

99% CONF. INT. 3.982 TO 6.351

****

FOR 1ST SAMPLE N = 6

MEAN = 14.167

VARIANCE = 14.967

STAN. DEV. = 3.869

FOR 2ND SAMPLE N = 6

MEAN = 18.500

VARIANCE = 62.700

STAN. DEV. = 7.918

****

T TEST FOR DEPENDENT SAMPLES

****

T RATIO = -2.484

D. F. = 5

PROBABILITY = .028 (ONE-TAIL)

PROBABILITY = .055 (TWO-TAIL)

PEARSON R = .970

****

	VAR. #1	VAR. #2
SUBJ. #1	12	16
SUBJ. #2	13	18
SUBJ. #3	13	16
SUBJ. #4	16	19
SUBJ. #5	21	33
SUBJ. #6	10	9

FOR VARIABLE #1 N = 7

MEAN = 17.714

VARIANCE = 28.571

STAN. DEV. = 5.345

FOR VARIABLE #2 N = 7

MEAN = 19.714

VARIANCE = 8.571

STAN. DEV. = 2.928

****
PEARSON PRODUCT-MOMENT CORRELATION

****
PEARSON R = .622

DEGREES OF FREEDOM = 5

COEFFICIENT OF DETERMINATION = .387

T RATIO = 1.778

PROBABILITY = .067 (ONE-TAIL)

PROBABILITY = .134 (TWO-TAIL)

****

	VAR. #1	VAR. #2
SUBJ. #1	23	26
SUBJ. #2	12	18
SUBJ. #3	14	19
SUBJ. #4	13	17
SUBJ. #5	15	19
SUBJ. #6	23	19
SUBJ. #7	24	20

```
************************************
       ANALYSIS OF VARIANCE
************************************
BETWEEN GROUPS
------------------------------------
   SUM OF SQUARES     =   328.500
   DEGREES OF FREEDOM =       3
   MEAN SQUARE        =   109.500
WITHIN GROUPS
------------------------------------
   SUM OF SQUARES      =  1282.000
   DEGREES OF FREEDOM  =       20
   MEAN SQUARE         =    64.100


************************************
TOTAL SUM OF SQUARES = 1610.500
TOTAL DEGREES OF FREEDOM = 23

        F RATIO = 1.708
     PROBABILITY = .197
************************************
        SAMPLE MEANS
    SAMPLE NO. 1  MEAN =   14.500
    SAMPLE NO. 2  MEAN =   18.500
    SAMPLE NO. 3  MEAN =    9.500
    SAMPLE NO. 4  MEAN =   18.500


    TUKEY'S TEST--MULTIPLE SAMPLES
          EQUAL SAMPLE SIZES

FOR GROUP 1 VS. GROUP 2:  Q =    1.224
```

FOR GROUP 1 VS. GROUP 3: Q = 1.530

FOR GROUP 1 VS. GROUP 4: Q = 1.224

FOR GROUP 2 VS. GROUP 3: Q = 2.754

FOR GROUP 2 VS. GROUP 4: Q = 0.000

FOR GROUP 3 VS. GROUP 4: Q = 2.754

USE TABLE 4 WITH D.F. = 20 TO

EVALUATE EACH Q LISTED ABOVE.

FOR SAMPLE 1:

SUBJ. #1	12
SUBJ. #2	13
SUBJ. #3	14
SUBJ. #4	15
SUBJ. #5	16
SUBJ. #6	17

FOR SAMPLE 2:

SUBJ. #1	16
SUBJ. #2	17
SUBJ. #3	18
SUBJ. #4	19
SUBJ. #5	20
SUBJ. #6	21

FOR SAMPLE 3:

SUBJ. #1	7
SUBJ. #2	8
SUBJ. #3	9
SUBJ. #4	10
SUBJ. #5	11
SUBJ. #6	12

FOR SAMPLE 4:

SUBJ. #1	10
SUBJ. #2	0
SUBJ. #3	23
SUBJ. #4	45
SUBJ. #5	23
SUBJ. #6	10

APPENDIX D

SYLLABUS

RESEARCH AND EVALUATION

Res Ev 552-1

Basic Educational Statistics

2 Semester Hours

COURSE:

TIME: Daily 9:50 - 10:50 a.m.

PLACE: 203 Bessey

TEXTS:

Mandatory: Applied Statistics for the Behavioral Sciences
D. E. Hinkle, W. Wiessman, and S. G. Jurs
Rand McNally College Publishing Co., 1979

Through the Maze, Statistics with Computer Applications
M. P. Jendrek
Wadsworth Publishing Company

Suggested: SPSSx User's Guide, SPSS, Inc.,
Chicago, Illinois, 1983

INSTRUCTOR:

Dr. A. J. Netusil

Office - N247C Lagomarcino Hall
294-6216

Home - 1817 Roosevelt, Ames
232-6463

Office Hours - Daily 12:00 noon - 1:00 p.m.

GRADUATE ASSISTANT:

Stan Scheiding

Office - N247A Lagomarcino Hall, 294-1241

Home - 1304 Woodstock, Ames, 292-9601

CATALOG DESCRIPTION:

Statistical concepts and procedures for analyzing educational data. Descriptive statistics, correlation, t tests, simple ANOVA with Scheffee Post Hoc test and chi square with computer application.

STUDENT EVALUATION

The student's final course grade shall be arrived at as follows:

1) Eight(8) collections of work assigned [see * on content sections for days this will occur]. No excuses accepted. Each assignment shall be worth 10 points. The points for all 8 collections shall be totaled and converted to a single Z score. This Z score shall be 2/7 of the student's final grade.

2) Four(4) scheduled examinations (see content section for days scheduled). All students shall take all examinations on the day scheduled. Each examination shall be a combination of multiple choice problems, completion problems and numeric problems. The tests shall be closed book, closed note examinations but the students shall be free to utilize the mainframes and microcomputers located in Lagomarcino Hall to assist in solving the numeric problems. Each test shall be timed and the student shall have only one(1) hour for each examination. (Don't ask for more time!) Each examination will focus primarily on information provided in the main text (Hinkle) and the lecture/lab since the last examination. Each shall be worth 100 raw points. The points for each test shall be converted to a Z score and each Z score shall be 1/7 of the student's final grade.

3) The instructor, with the help of the graduate assistant, shall assign a Z score to each student based upon their class participation and attendance. The student's effort in the course as perceived by the instructor will also enter into this score. This Z score shall make up 1/7 of the student's final grade.

SUMMARY

		Final Grade
1)	Eight collections of Daily Work 10 points each - total transformed to Z score	= 2/7
2)	Four one hour timed examinations 100 points each - transformed to Z score (1/7 each - 4 exams)	= 4/7
3)	Perception of participation, attendance and effort (Z score)	= 1/7
	Final Grade	7/7

Grades in the course usually run from A to C. Students receiving less than C will be encouraged to drop rather than receive a failing mark. The grade of I will not be used in place of a failing mark.

EXAMINATIONS

Each test will have both

a) Multiple choice questions
b) Problems to be worked out (mainframe, micro, hand, etc.)

HELP SESSIONS

Extra help sessions will be scheduled if so desired by the students prior to examination times. No new material shall be presented in these sessions and attendance at them shall be voluntary!

Res Ev 552
Summer 1987

Date	In Class	Preparation
June 9	Intro (20 minutes) Math Test (20 minutes) Att. Test (20 minutes)	H-1, 2
June 10	Introduction to Mainframe (a) Wylbur (b) SPSSx	
June 11	Introduction to Microcomputer (Stan & Tony)	Problem set
June 12*	Central Tendency Measures	H-3
June 15	iles, PR, Range, St. Dev, Variance	H-3
June 16	Microcomputer Lab (Stan & Tony)	
June 17	Review (Catch up)	
June 18	Mainframe (freq prog)	
June 19*	Test #I (1 hour - timed!)	
June 22	Test Results - Normal Curve Track	H-4
June 23	Normal Curve Problems Probability	
June 24	Correlation	
June 25	Mainframe-Correlation/Micro Correlation (Stan & Tony)	
June 26*	Correlation (Spearman Rank)	H-5
June 29	Intro-Inferential (7 steps)	H-7
June 30	Micro Computer Lab (Stan & Tony)	
July 1	Intro-Inferential (Type I-II errors)	H-8
July 2*	Test #II (1 hour - timed!)	
July 6	Test 1 mean, 1 variance, 1 correlation	H-9
July 7	Confidence Intervals	H-9
July 8	Microcomputer Lab (Stan & Tony)	
July 9	Test 2 means (t test groups)	H-10
July 10*	Test 2 means (t test pairs)	H-10
July 13	Mainframe t tests	

Date	In Class	Preparation
July 14	Microcomputer Lab (Stan & Tony)	
July 15	One Way ANOVA	H-11
July 16	Mainframe Oneway	
July 17*	Test III (One hour timed!)	
July 20	Test Results/Post Hoc	
July 21	Post Hoc Tests	H-12
July 22	Mainframe - Ranges	
July 23	Microcomputer Lab (Stan & Tony)	
July 24*	Chi Square	
July 27	Mainframe Chi Square	
July 28	Catch up	
July 29	Review	
July 30*	Test IV (1 hour - timed!)	
July 31	Review Tests Results	

* Days when homework will be collected.

On Reserve at the Library:

	Blalock	Social Statistics
QA294.7 D759b	Dowie	Basic Statistical Methods
HA29 E33 1973	Edwards	Statistical Methods for the Behavioral Sciences
QA294 F381s	Ferguson	Statistical Analysis in Psychology and Education
HA29 F685 1967	Freund	Modern Elementary Statistics
QA294.5 G192e	Garrett	Elementary Statistics
LB2846 G55	Glass	Statistical Methods in Education and Psychology
QA39 H369i	Helton	Introducing Mathematics
HA29 H85 1967	Huntberger	Elements of Statistical Inference
	Lapin	Statistics, Meaning and Method
QA286 Os7s2	Ostle	Statistics in Research
QA286 P431e	Person	Essentials of Mathematics
LB2846 P812e	Popham	Educational Statistics
QA291 St32p	Steel	Principles and Procedures of Statistics
QA291 W49s	Wert	Statistical Methods in Educational and Psychological Research

APPENDIX E

SPREADSHEET EXAMPLES

	1	2	3	4	5	6	7	8	9	10
1	Enter No. of	ANOVA:								
2	groups below	Group #1	Group #1	Group #2	Group #2	Group #3	Group #3	Group #4	Group #4	Group #5
3	4	X	X squared	X	X squared	X	X squared	X	X squared	X
4		3.2	10.24	3	9	7.2	51.84	3.1	9.61	5.3
5		4.1	16.81	3.9	15.21	7.1	50.41	2.8	7.84	4.3
6		5.3	28.09	5.2	27.04	8.2	67.24	2.4	5.76	4.7
7		6.7	44.89	6.4	40.96	6.8	46.24		0	5.2
8		4.8	23.04	5.1	26.01		0		0	6.7
9		3.9	15.21	3.7	13.69		0		0	
10		4.4	19.36	4.4	19.36		0		0	
11			0		0		0		0	
12			0		0		0		0	
13			0		0		0		0	
14			0		0		0		0	
15			0		0		0		0	
16			0		0		0		0	
17			0		0		0		0	
18			0		0		0		0	
19			0		0		0		0	
20			0		0		0		0	
21			0		0		0		0	
22			0		0		0		0	
23			0		0		0		0	
24			0		0		0		0	
25			0		0		0		0	
26	••••••••••	•••••••	•••••••	•••••••	•••••••	•••••••	•••••••	•••••••	•••••••	•••••••
27		32.4	157.64	31.7	151.27	29.3	215.73	8.3	23.21	26.2
28		Σ of X1	Σ of X1^2	Σ of X2	Σ of X2^2	Σ of X3	Σ of X3^2	Σ of X4	Σ of X4^2	Σ of X5
29	••••••••••	•••••••	•••••••	•••••••	•••••••	•••••••	•••••••	•••••••	•••••••	•••••••
30	Indiv. Groups									
31	X Bar	4.62857		4.5286		7.325		2.7667		5.24
32	N =	7		7		4		3		5
33	••••••••••	•••••••	•••••••	•••••••	•••••••	•••••••	•••••••	•••••••	•••••••	•••••••
34	TTL / Groups	5	•	Source	df	SS	MS	F		
35	Σ of X sq	688.45	•	•••••••	•••••••	•••••••	•••••••	•••••••		
36	Σ of groups	127.9	•	Between	4	39.23	9.8064	10.269		
37	total N =	26	•							
38	TTL Bar X	4.91923	•	Within	21	20.05	0.955			
39	df	25	•	•••••••	•••••••	•••••••	•			
40	••••••••••	•••••••	•	TOTAL	25	59.28				
41										
42	••••••••••	•••••••	•••••••	•••••••	•••••••	•				
43	Scheffe 1-2	0.00916	•	Tukey 1-2	0.2707	•		MSw/N =	0.1364	
44	Scheffe 1-3	4.84491	•	Tukey 1-3	-7.3	•				
45	Scheffe 1-4	1.9058	•	Tukey 1-4	5.0409	•		SQRT OF		
46	Scheffe 1-5	0.28544	•	Tukey 1-5	-1.655	•		MSw/N =	0.3694	
47	Scheffe 2-3	5.21093	•	Tukey 2-3	-7.571	•				
48	Scheffe 2-4	1.70658	•	Tukey 2-4	4.7702	•				
49	Scheffe 2-5	0.38645	•	Tukey 2-5	-1.926	•				
50	Scheffe 3-4	9.32476	•	Tukey 3-4	12.341	•				
51	Scheffe 3-5	2.52896	•	Tukey 3-5	5.6449	•				
52	Scheffe 4-5	3.00268	•	Tukey 4-5	-6.696	•				
53	••••••••••	•••••••	•••••••	•••••••	•••••••	•				

	VARIABLE X	VARIABLE Y	LITTLE x	LITTLE y	xy	x sq	y sq
	12	11	-1.6	-1.2	1.92	2.56	1.44
	14	14	0.4	1.8	0.72	0.16	3.24
	10	8	-3.6	-4.2	15.12	12.96	17.64
	14	15	0.4	2.8	1.12	0.16	7.84
	14	11	0.4	-1.2	-0.48	0.16	1.44
	17	14	3.4	1.8	6.12	11.56	3.24
	16	16	2.4	3.8	9.12	5.76	14.44
	11	9	-2.6	-3.2	8.32	6.76	10.24
	12	11	-1.6	-1.2	1.92	2.56	1.44
	16	13	2.4	0.8	1.92	5.76	0.64
SUM	136	122	0	0	45.8	48.4	61.6
mean	13.6	12.2					
Ho mean	0	0					
	N of X+Y/2	10	N of X	10	N of Y	10	
	pearson r	0.83879					
coef of	deter, r sq	0.70357					
			est of var	5.37778	est of st de	2.3190036	
prop of	variance		for X		for X		
in x that	can be attri						
to y		70.3566	est of var	6.84444	est of st de	2.6161889	
			for Y		for Y		
X-mu	1.4						Depend S.E.
DependT	3.09628					1.2222222	0.4521553
df	9					1.6775769	
independ	ent Tpooled	1.26635			48.4	0.7333333	
df	18			Seper S.E.	61.6	0.8273116	
independ	ent T sepera	1.26635		1.10554	18		
df	19.6877				0.2	Pooled S.E.	
WELSH		1.22222			1.22222	1.1055416	
		1.49383					
		0.02629		Confid Interval F test			
		0.04259		Small C.V.=	0		
IndepVar				Large C.V.=	0		
F test	0.78571		0	< <	0		INDEPEN C.I.
		DEPEND C.I.		INDEP C.I.			SEPARATE
BARX-Y	Critical val=	0		Pooled Est		Critical value	0
1.4		0	Criticalval	0			0
	1.4	1.4		0		1.4	1.4
				1.4	1.4		

	1	2	3	4	5	6	7	8	9	1
1					150					
2	Problem	2 X	X^2	x	|x|	x^2	z	z^3	z^4	
3		19	361	6.58	6.583	43.34	1.908	6.942	13.24	
4		18	324	5.58	5.583	31.17	1.618	4.235	6.851	
5		17	289	4.58	4.583	21.01	1.328	2.343	3.111	
6		16	256	3.58	3.583	12.84	1.038	1.119	1.162	
7		15	225	2.58	2.583	6.674	0.749	0.419	0.314	
8		15	225	2.58	2.583	6.674	0.749	0.419	0.314	
9		15	225	2.58	2.583	6.674	0.749	0.419	0.314	
10		14	196	1.58	1.583	2.507	0.459	0.097	0.044	
11		14	196	1.58	1.583	2.507	0.459	0.097	0.044	
12		14	196	1.58	1.583	2.507	0.459	0.097	0.044	
13		14	196	1.58	1.583	2.507	0.459	0.097	0.044	
14		13	169	0.58	0.583	0.34	0.169	0.005	8E-04	
15		12	144	-0.4	0.417	0.174	-0.12	0	2E-04	
16		12	144	-0.4	0.417	0.174	-0.12	0	2E-04	
17		12	144	-0.4	0.417	0.174	-0.12	0	2E-04	
18		11	121	-1.4	1.417	2.007	-0.41	-0.07	0.028	
19		10	100	-2.4	2.417	5.84	-0.7	-0.34	0.24	
20		10	100	-2.4	2.417	5.84	-0.7	-0.34	0.24	
21		9	81	-3.4	3.417	11.67	-0.99	-0.97	0.961	
22		9	81	-3.4	3.417	11.67	-0.99	-0.97	0.961	
23		8	64	-4.4	4.417	19.51	-1.28	-2.1	2.683	
24		8	64	-4.4	4.417	19.51	-1.28	-2.1	2.683	
25		7	49	-5.4	5.417	29.34	-1.57	-3.87	6.069	
26		6	36	-6.4	6.417	41.17	-1.86	-6.43	11.95	
27					63.58					
28		sum of scores	sum of sq	s		sum of dev		sum of z^	sum of z^	4
29		298	3986		∑x^2=	285.8		-0.9	51.31	
30		Bar X								
31		12.416667						Skewnes	Kurtosis	
32					St. Dev	3.451		∑z^3/N	∑z^4/N	
33		MD =	2.649					-0.04	2.138	
34					Variance	11.91				
35										
36		Est of Variance		12.4						
37										
38		Est. of St.Dev		3.53						
39										
40										
41										
42										
43										
44										
45										
46										
47										
48										
49										
50										
51										
52										
53										

	1	2	3	4	5	6	7	8	9	10
1	Enter No. of	ANOVA:								
2	groups below	Group #1	Group #1	Group #2	Group #2	Group #3	Group #3	Group #4	Group #4	Group #5
3	4	X	X squared	X	X squared	X	X squared	X	X squared	X
4		3.2	10.24	3	9	7.2	51.84	3.1	9.61	5.3
5		4.1	16.81	3.9	15.21	7.1	50.41	2.8	7.84	4.3
6		5.3	28.09	5.2	27.04	8.2	67.24	2.4	5.76	4.7
7		6.7	44.89	6.4	40.96	6.8	46.24		0	5.2
8		4.8	23.04	5.1	26.01		0		0	6.7
9		3.9	15.21	3.7	13.69		0		0	
10		4.4	19.36	4.4	19.36		0		0	
11			0		0		0		0	
12			0		0		0		0	
13			0		0		0		0	
14			0		0		0		0	
15			0		0		0		0	
16			0		0		0		0	
17			0		0		0		0	
18			0		0		0		0	
19			0		0		0		0	
20			0		0		0		0	
21			0		0		0		0	
22			0		0		0		0	
23			0		0		0		0	
24			0		0		0		0	
25			0		0		0		0	
26	••••••••••	•••••••	•••••••	•••••••	•••••••	•••••••	•••••••	•••••••	•••••••	•••••••
27		32.4	157.64	31.7	151.27	29.3	215.73	8.3	23.21	26.2
28		Σ of X1	Σ of X1^2	Σ of X2	Σ of X2^2	Σ of X3	Σ of X3^2	Σ of X4	Σ of X4^2	Σ of X5
29	••••••••••	•••••••	•••••••	•••••••	•••••••	•••••••	•••••••	•••••••	•••••••	•••••••
30	Indiv. Groups									
31	X Bar	4.62857		4.5286		7.325		2.7667		5.24
32	N =	7		7		4		3		5
33	••••••••••	•••••••	•••••••	•••••••	•••••••	•••••••	•••••••	•••••••	•••••••	•••••••
34	TTL / Groups	5	•	Source	df	SS	MS	F		
35	Σ of X sq	688.45	•	•••••••	•••••••	•••••••	•••••••	•••••••		
36	Σ of groups	127.9	•	Between	4	39.23	9.8064	10.269		
37	total N =	26	•							
38	TTL Bar X	4.91923	•	Within	21	20.05	0.955			
39	df	25	•	•••••••	•••••••	•••••••	•			
40	••••••••••	•••••••	•	TOTAL	25	59.28				
41										
42	••••••••••	•••••••	•••••••	•••••••	•••••••	•				
43	Scheffe 1-2	0.00916	•	Tukey 1-2	0.2707	•		MSw/N =	0.1364	
44	Scheffe 1-3	4.84491	•	Tukey 1-3	-7.3	•				
45	Scheffe 1-4	1.9058	•	Tukey 1-4	5.0409	•		SQRT OF		
46	Scheffe 1-5	0.28544	•	Tukey 1-5	-1.655	•		MSw/N =	0.3694	
47	Scheffe 2-3	5.21093	•	Tukey 2-3	-7.571	•				
48	Scheffe 2-4	1.70658	•	Tukey 2-4	4.7702	•				
49	Scheffe 2-5	0.38645	•	Tukey 2-5	-1.926	•				
50	Scheffe 3-4	9.32476	•	Tukey 3-4	12.341	•				
51	Scheffe 3-5	2.52896	•	Tukey 3-5	5.6449	•				
52	Scheffe 4-5	3.00268	•	Tukey 4-5	-6.696	•				
53	••••••••••	•••••••	•••••••	•••••••	•••••••	•				

CHAPTER 12, PROBLEM #2

GROUP 1 SQ	GROUP 2 SQ	GROUP 3 SQ	GROUP 4 SQ	GROUP 5 SQ
100	36	256	81	144
256	144	324	144	169
144	81	196	196	36
144	64	400	121	529
324	49	289	256	144
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
968	374	1465	798	1022

5 GROUPS - ANOVA TABLE

SOURCES	df	S.S.	M.S.	F
Between =	4	189.44	47.36	3.5824508
Within =	20	264.4	13.22	
TOTAL =	24	453.84		

MEAN	N	SUM = ?
0	0	0

MEAN	N = ?	SUM
0	#DIV/0!	0

APPENDIX F

HUMAN SUBJECTS FORM

INFORMATION ON THE USE OF HUMAN SUBJECTS IN RESEARCH
IOWA STATE UNIVERSITY
(Please follow the accompanying instructions for completing this form.)

154

1. Title of project (please type): ~~An Investigation into learning differeween educat~~ional ~~statistical students using a spreadsheet and pre-programmed computer software.~~

2. I agree to provide the proper surveillance of this project to insure that the rights and welfare of the human subjects are properly protected. Additions to or changes in procedures affecting the subjects after the project has been approved will be submitted to the committee for review.

Stanley K. Scheiding — Typed Named of Principal Investigator
July 20, 1987 — Date
Signature of Principal Investigator

Campus Address — Campus Telephone

3. Signatures of others (if any) — Date — Relationship to Principal Investigator

4. ATTACH an additional page(s) (A) describing your proposed research and (B) the subjects to be used, (C) indicating any risks or discomforts to the subjects, and (D) covering any topics checked below. CHECK all boxes applicable.

RECEIVED JUL 20 '87 ISU GRADUATE COLLEGE

- [ ] Medical clearance necessary before subjects can participate
- [ ] Samples (blood, tissue, etc.) from subjects
- [ ] Administration of substances (foods, drugs, etc.) to subjects
- [ ] Physical exercise or conditioning for subjects
- [ ] Deception of subjects
- [ ] Subjects under 14 years of age and(or) [ ] Subjects 14-17 years of age
- [ ] Subjects in institutions
- [ ] Research must be approved by another institution or agency

5. ATTACH an example of the material to be used to obtain informed consent and CHECK which type will be used.

- [ ] Signed informed consent will be obtained.
- [X] Modified informed consent will be obtained.

6. Anticipated date on which subjects will be first contacted: Month June Day 09 Year 1987

Anticipated date for last contact with subjects: July 31 1987

7. If Applicable: Anticipated date on which audio or visual tapes will be erased and(or) identifiers will be removed from completed survey instruments: August 10, 1987 (Month Day Year)

8. Signature ... on — Date 7/17/87 — Department or Administrative Unit
July 17, 1987 — Prof. Studies

9. Decision of the University Committee on the Use of Human Subjects in Research:

- [X] Project Approved
- [ ] Project not approved
- [ ] No action required

George G. Karas — Name of Committee Chairperson
7/22/87 — Date
Signature of Committee Chairperson

APPENDIX G

MATH AND ANXIETY PREMEASURE, INFORMATION SHEET

Computation Test

Name:____________________

In the exercises directly below, please perform the indicated operations <u>mentally</u>, and write the results in the blanks at the right.

1. $4 \times 36 =$ _____
2. $6 \times 7 \times 9 =$ _____
3. $32 + 38 + 133 =$ _____
4. $-8 \times 12 =$ _____
5. $-3 \times 4 \times (-6) =$ _____
6. $(-4)^2 \times 5 =$ _____
7. $36 \div (-9) =$ _____
8. $27 - 33 - 14 =$ _____
9. $5 + 2 + 3 =$ _____
10. $7 - 4 \times 12 =$ _____
11. $7(4 + 3) =$ _____
12. $\frac{6 - 3}{6} =$ _____

Properly locate the decimal point in the answers to the following exercises. Put in zeros where needed.

13. $253 \times .03 =$ 759
14. $4.5 \times .07 =$ 315
15. $(.065)^2 =$ 4225
16. $5 \div 39 =$ 128
17. $49 \div .007 =$ 7
18. $\sqrt{.00257} =$ 507

Below and to the right is a fragment of a table of squares and square roots. By means of this table find answers to the following exercises.

(figure in this space)

19. $\sqrt{54} =$ _____
20. $\sqrt{26} =$ _____
21. $\sqrt{52.5} =$ _____

No.	Square	Sq. Root
51	2601	7.141
52	2704	7.211
53	2809	7.280
54	2916	7.348
55	3025	7.416

Evaluate the following formuals, assuming that A= 124, S= 1888, C =-2, and N= 32. (figure in this space)

22. $M = \frac{A}{N} + C =$ _____

23. $Q = \sqrt{\frac{S}{N} - C^2} =$ _____

24. From the formula $\frac{b}{B} = \frac{1 - R}{1 - r}$, derive the formula R= ________________

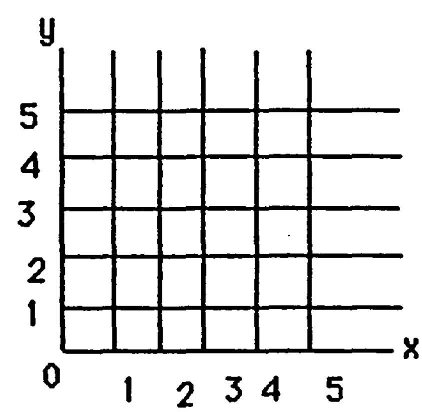
157

25. A procedure for finding the "standard deviation" of ungrouped measures is as follows:

Measure	Measure	
12	144	Step 1. Add the measures together.
9	81	Step 2. Devide the sum by number of measures. (Four in this model).
7	49	Step 3. Square the quotient obtained in step 2.
4	16	
$4\overline{)32}$	$4\overline{)290}$	Step 4. Square each of the measures.
8	72.5	Step 5. Add these squares together.
x 8	64	Step 6. Devide their sum by the number of measures
64	8.5	Step 7. From this quotient subtract the square obtained in step 3.
	$\sqrt{8.5} = 2.9$ Answer	Step 8. Take the square root of the difference.

By making use of the above method, find the standard deviation of the five measures given below.

Measure	Measure
8	
6	
5	
4	
2	



26. On the accompanying graph, draw a straight line through the points (x = 0, y = 3) and (x= 4, y=5)

27. What is the value of y when x = 2?. y = ______

28. Write the equation of the straight line you drew. y = ____________________

NAME ______________________________

ATTITUDINAL QUESTIONNAIRE

This is not an examination; it is part of a project to study the attitudes of students toward statistics. Please write your name in the upper right hand corner so that different groups of students can be compared; however, no results will be used in any way that will affect your grade in this or in any other course. We are interested in your feelings or opinion about each statement.

After you have read each statement, please circle the "A" (agree) if you agree with the statement or the "D" (disagree) if you disagree with the statement. Once you have made this decision, please indicate how strongly you agree or disagree with the statements by circling one of the numbers which appears to the right of each statement.

For example, consider the statement:

All men are created equal.

	slight				strong
A	1	2	3	4	5
D					

Do you agree or disagree with this statement? Circle "A"("D"). How strongly do you agree(disagree) with this statement? Circle the appropriate number.

Please be sure to circle both a number and a letter after each statement, unless you are completely undecided whether you agree or disagree with the statement. In that case, circle both "A" and "D", but do not circle any of the numbers. This response indicates that you neither agree nor disagree with the statement.

There are no right or wrong answers to the statements. The answers which will be most helpful to this project are the ones which best reflect your own feelings about each of the statements. Thank you for your cooperation.

		slight ... strong
1. It scares me to have to take statistics.	A / D	1 2 3 4 5
2. The feeling I have toward statistics is a good feeling.	A / D	1 2 3 4 5
3. Statistics can be made understandable to almost every college student.	A / D	1 2 3 4 5
4. I can't see where statistics will ever help me.	A / D	1 2 3 4 5
5. I don't think I can ever do well in statistics.	A / D	1 2 3 4 5
6. Only people with a very special talent can learn statistics.	A / D	1 2 3 4 5
7. Statistics is fascinating and fun.	A / D	1 2 3 4 5
8. I feel a sense of insecurity when attempting statistics.	A / D	1 2 3 4 5
9. I feel at ease in statistics.	A / D	1 2 3 4 5
10. Statistics is something which I enjoy a great deal.	A / D	1 2 3 4 5
11. When I hear the word statistics, I have a feeling of dislike.	A / D	1 2 3 4 5
12. I do not like statistics.	A / D	1 2 3 4 5
13. Statistics makes me feel secure.	A / D	1 2 3 4 5

	slight strong
14. Statistics is stimulating.	A / D 1 2 3 4 5
15. Very few people can learn statistics.	A / D 1 2 3 4 5
16. It makes me nervous to even think about having to do a statistics problem.	A / D 1 2 3 4 5
17. Statistics is enjoyable.	A / D 1 2 3 4 5
18. I approach statistics with a feeling of hesitation—hesitation from a fear of not being able to do statistics.	A / D 1 2 3 4 5
19. I really like statistics.	A / D 1 2 3 4 5
20. I wish I were not required to study any statistics.	A / D 1 2 3 4 5
21. Statistics makes me feel uncomfortable, restless, irritable, and impatient.	A / D 1 2 3 4 5
22. Any person of average intelligence can learn to understand a good deal of statistics.	A / D 1 2 3 4 5
23. I would like to study more statistics whether or not it is required for my program.	A / D 1 2 3 4 5
24. Statistics makes me feel as though I'm lost in a jungle of numbers and can't find my way out.	A / D 1 2 3 4 5
25. Almost anyone can learn statistics if he is willing to study.	A / D 1 2 3 4 5
26. Statistics is very interesting to me.	A / D 1 2 3 4 5

RESEARCH & EVALUATION 552 INFORMATION SHEET

Name:____________________ Semester F___ S___ SS___ 19___

Gender Female:___ Male:___

Local address:____________________ Phone: Home ____________

____________________ Work ____________

Hometown:____________________

Undergraduate College: ____________________ Major: ____________

Graduate Major: ____________________ Major Professor:____________

Projected Graduation date: ____________

What is your current position of employment:____________________

Research interest area (ifknown): ____________________

____

Degree sought: Masters, Doctorate or other ____________.

What area of employment will you seek after you leave Iowa State?____________

____

In order to help me assess your mathematical and statistical background for this course, please list the four most recent mathematical or statistical coures you completed.

Name:	Date Completed:	College:
1.____________	____________	____________
2.____________	____________	____________
3.____________	____________	____________
4.____________	____________	____________

Please list the Microcomputer(s) that you know how to operate:____________

____

Please list the computer software packages you know how to use (eg, Lotus 123, Appleworks):____________________

____