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A CRITICAL EXAMINATION OF THE EFFECT ON ACHIEVEMENT OF STUDENTS USING PROGRAMMED INSTRUCTION (PI) IN SHORT CONCENTRATED MANAGEMENT COURSES

by

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requirements for the degree of Doctor of Philosophy
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CERTIFICATE OF APPROVAL

PH. D. THESIS

This is to certify that the Ph. D. thesis of

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has been approved by the Examining Committee for the thesis requirement for the Ph. D. degree in the College of Education at the May, 1973 graduation.

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I. THE PROBLEM

INTRODUCTION

Education Administration, at all levels, has been challenged continually to develop and implement policies, procedures and practices which will yield the highest quality students at a minimum expenditure of resources. In recent years, this challenge has been magnified by the growing public pressures to reduce educational funds and to examine critically the allocation of educational resources throughout the community. At the same time, there has been no diminution in the need for upgrading the skill and knowledge capabilities of the graduates of educational institutions. To respond to this challenge, Education Administration is forced to innovate and test new methods so as to maintain an acceptable level of efficiency and effectiveness in the institutions under its control.

In any educational or training endeavor, the key element of success is the faculty; it is also the most expensive.

In The Administration of Academic Affairs in Higher Education, Williams (29) notes:

> "The expenditures for teacher's salaries in a college or university normally constitute the largest single item in the entire budget. In many institutions, this item will represent approximately half of the total budget."

Clearly then, any effort to deal with the problem of reduced resources, leads one to carefully and conscientiously examine the role and methodology of the teacher. Since there can be no reduction in the quality of output, the effectiveness of any proposed changes must be accompanied by a high degree of reliability.'

As Williams (30) points out:

> "It is strongly urged that the final decision regarding the method of instruction and the use of teaching manpower in the several faculty grades should be based on the outcome that is desired rather than solely upon the cost that is involved."

A great deal of the ferment which characterizes American education today is the result of the revolution in instructional technology. Accompanying this revolution, has been a deep concern by teachers and administrators alike that the technology will turn education into a completely automated, robot-directed process with all the personal, human qualities removed. Finn (6) in his article, "Take Off to Revolution," says:

> "Now it may be that all these events will come to pass. If they do, however, it will be for social reasons - not because of the existence of a technology of instruction. For technology obviously includes machines, but it also includes systems and organization patterns, plus both an attitude toward problems and a method of solving them."

Given the experience of the last several years, there can be little doubt that certain of the new technologies, if effective, could do much to alleviate our singular dependence upon the time of a teacher to provide instruction. One of these technologies that not only allows for less individual input on the part of the teacher to a student, but also permits him to control the content through his impact on the program is programmed instruction(PI).

Managers in Government and industry realize that the training and development of their people are essential to the long run health and success of their organizations. What is more, the training and development may be accomplished in several ways depending upon the educational objectives, costs and availability of educational resources. One way is through the use of short, concentrated courses of instruction in which the course meets from six to ten hours a day, each day for from three to fifteen days.

Increasingly, this type of program is being utilized to meet certain training needs of business, Government and industry. Examples may be found in the Department of Defense, The University of Michigan, The University of California, Los Angeles, Massachusetts Institute of Technology and the American Management Association.

Costs in this type of program are high because they include not only development and presentation costs but also facilities and student costs, including student salaries. It is incumbent therefore, on administrators and teachers alike, to seek out ways to improve the efficiency and effectiveness of this type of training.

The purpose of this investigation is to examine the effect on subsequent achievement of students using programmed instruction (PI) to provide prerequisite concepts in a concentrated course and to develop and test hypotheses regarding these factors in order to provide a basis for the improvement of educational practices and a consequent reduction in the costs associated with such courses.

STATEMENT OF HYPOTHESES

Effect on Achievement of Students Using Programmed Instruction (PI)

The normal practice in conducting short, concentrated management courses is for a single instructor to be responsible for the entire course. He may use a variety of teaching methods: lecture, slide presentations, films, video-tape, etc., to achieve the course objectives, but they all tend to be instructor-centered.

In certain courses, it is necessary to provide a degree of refresher training to bring all of the students to a given point of understanding in preparation for presentation of the subject matter material in a given course. This phase of the course is also entirely instructor-centered. If a teaching method were available to provide the same degree of learning without requiring the same amount of instructor time and effort, a saving in faculty resources could be realized. The nature of the training and the investment in the training is such that there could be no reduction in learning on the part of the student. Any method used to reduce instructor time and effort would have to be as effective as the instructor-centered method now being used.

Such a substitute method may be the use of programmed instruction (PI) in place of the current lecture method used by the instructor. Operational definitions of these two modes of instruction are provided in Appendix 1. The major hypothesis tested in this study then was:

1. There is no significant difference in achievement on the part of students who learn by the programmed instruction (PI) method and those who learn by the lecture method of instruction.

Other Factors and Their Effects on Achievement

An adult who is enrolled in a short, concentrated course of instruction possesses a number of characteristics and has had a number of experiences that might be expected to affect his achievement. A knowledge of these effects would benefit the manager and the training institution in identifying and structuring course content, establishing pre-requisite conditions for attendance and predicting performance of individuals and groups. It is also possible that the effect of some or all of these characteristics interact with achievement in one or the other of the modes being studied. This part of the problem was to identify and test the effect of the following variables on the achievement of the individual under the lecture method and the programmed instruction (PI) method to determine whether or not they interacted.

1. Age
2. Education
3. Work Experience
4. Reasons for Attendance

Hypotheses tested were:

2a. There is no significant difference in the level of achievement on the part of students as a function of age.

b. The effect of age does not interact with the lecture method or the programmed instruction (PI) method of instruction employed.

3a. There is no significant difference in the level of achievement on the part of students as a function of educational background.

b. The effect of educational background does not interact with the lecture method or the programmed instruction (PI) method of instruction employed.

4a. There is no significant difference in the level of achievement on the part of students as a function of differences in the amount of work experience.

b. The effect of work experience does not interact with the lecture method or the programmed instruction (PI) method of instruction employed.

5a. There is no significant difference in the level of achievement on the part of students as a function of their reasons for attending the course.

b. The effect of the reasons for attendance does not interact with the lecture method or the programmed instruction (PI) method of instruction employed.

Effect of Previous Experience in Using Programmed Instruction (PI) on Student Achievement

Some students who were trained through the programmed instruction (PI) method had no previous experience with this teaching method. What is the effect on achievement from having had previous training through the programmed instruction (PI) method?

The hypothesis tested was:

6. There is no significant difference in level of achievement on the part of students as a function of having had previous experience in the use of programmed instruction.

II. RELATED LITERATURE REVIEW

The research literature on the two primary areas involved in this study: (1) effect on achievement of the lecture method of instruction versus programmed instruction (PI), and (2) effect of other factors on achievement, was reviewed and sorted to retain only that which would have implications for the study.

EFFECT ON ACHIEVEMENT OF THE LECTURE METHOD OF INSTRUCTION VERSUS PROGRAMMED INSTRUCTION (PI)

Research is not at all definitive at the present time, as to whether one instructional system is better than the other. A great deal of the research is devoted to an investigation of the feasibility of use of new methods rather than the quality of the outcome produced. Bruner (3), in discussing the "New Educational Technology," decries the lack of a Theory of Instruction that would be complementary to a Theory of Learning. His reason is that, "Not until we have developed a theory of instruction will we be able to test propositions about the best way of teaching something."

In spite of the absence of a theory of instruction, the enthusiasm for new teaching methods can be detected through the literature. As Margolis (17), in 1963, wrote:

> "For many, programmed instruction has become a glittering symbol of America's supremacy in the so-called 'education race' with Russia. One educator has termed it, 'the most important breakthrough in the field of education since the printed textbook.' Another has prophesied that it will ultimately replace teachers. A famous psychologist has asserted flatly that 'teaching machines can teach twice as much in half the time.'"

While the most superficial review of the literature points to differences of opinion regarding the use of programmed instruction (PI), one cannot but be impressed by the special study on programmed instruction (PI) conducted by Schramm (23) in which he observes:

> "Research leaves us in no doubt that programs do teach.... A great deal of learning seems to take place, regardless of the kind of program or the kind of student. Even a bad program is a pretty good teacher."

The 1954 article published by B. F. Skinner (39), while it signaled the birth of programmed instruction (PI), also provided the basis of its principal criticism. Skinner's research on learning was conducted using pigeons and his ideas on rewards for learning or "reinforcement" are central to his theories about programmed instruction (PI). In the case of human learning, the reward for learning is the encouragement that comes from knowing instantly that ones answers to questions about the learning material are correct. Most programs being produced today still follow the rules formulated in Skinner's laboratory in the fifties. The rigid application of laboratory theory to classroom practice disturbs many educators and in at least one instance evoked the remark: "People aren't pigeons." As Margolis (17) points out:

> "The critics warn that the new technique contains a number of serious defects. They can be briefly summarized: (1) Programmed instruction discourages critical thinking. (2) Programmed instruction fosters only rote learning and memorizing of facts, but prevents the student from exploring a discipline on his own and from discovering basic principles. (3) Programmed instruction is both mechanical and monotonous: it is a joyless and uninspiring way to learn."

Some variations on the precise Skinner approach have addressed the criticisms directed at the "tedious, cut-and-dried, mechanical and monotonous" teaching method. Crowder (31), an Air Force psychologist, has written programs for programmed instruction (PI) that are chattier and more informal and has created a program in which it may be just as rewarding to answer a question incorrectly as to answer it correctly.

On one point, the literature is perfectly clear - programmed instruction (PI) is not equally suitable for all types of learning. It appears to be relatively more effective in teaching mathematics, science and fact-oriented materials than it does in teaching philosophy, English and the more qualitative - oriented subjects.

O'Day (20), in 1971, in his study on techniques and trends in programmed instruction (PI) concluded:

> "In the future, programs will become more adaptive to the learner.... Efficacy of technique will, of course, be found to vary with learner characteristics and instructional objectives."

In a 1970 publication, Instructional Technology and the School Administrator (14), we find the following support for both the process and the psychology of programmed instruction (PI):

> "What is called programmed instruction (PI) or learning is a way of thinking about the learning process. It is an approach based on breaking down a complex learning task into meaningful and related bits or units, and implies a psychology of learning. Programmed learning is as valid or effective

> in promoting learning as is the psychology on which it is based. It can be coupled with other means, such as a piece of computer hardware or a printed volume. Immediate reinforcement is one of its most vital aspects."

McKeachie (37), in his investigation into research on teaching compared the lecture method of instruction with programmed instruction (PI) as follows:

> "It seems that the teaching machine (programmed instruction (PI)) should have advantages over the lecturer, for the sequence can be carefully planned to utilize research on the method of successfive approximations, on concrete to abstract sequences in problem solving, and on building up generalizations from varying specifics. Lecturers, on the other hand, vary greatly in the degree to which they organize their materials systematically. Probably few lecturers use optimal sequences of presentation."
>
> "Moreover, the learner in a lecture is largely passive, while the learner using a teaching machine is continually active. Many studies of different types of learning and concept formation demonstrate that active learning is more effective than passive learning (e.g., Ebbinghaus, 1913; Wolfle, 1935)."

Effect of Other Factors on Achievement

In any study on educational achievement of adults, research regarding the effect of age on achievement is relevant. In recent years, there has been a great deal of research dealing with this subject.

Some of the early research in adult learning was conducted by Thorndike (26, p. 177), during the period 1924 - 1928, which led to the publishing of the first substantive research report in this area. In this report, Thorndike concluded:

> "In general, teachers of adults of ages 25-45 should expect them to learn at nearly the same rate and in nearly the same manner as they would have learned the same thing at fifteen to twenty. What that rate and manner will be depends upon the general intelligence and special capacities of the individual."

Thorndike went on to suggest that the best age for learning is in the twenties and any age below forty-five is better than ages ten to fourteen. He pointed out specifically that:

> "Childhood was emphatically not the best age for learning, in the sense of the age when the greatest returns per unit of time spent are received."

A key study on adult learning ability was conducted by Conrad and Jones (12), in 1933, using the Army Alpha Test of World War I. This investigation provided evidence that intelligence, defined as the ability to learn, increased up to age 21 and then gradually declined until age 60. In 1939, the

Wechsler - Bellevue Scale portrayed peak performance between ages 20-24. In the 1955 version of the Wechsler Adult Intelligence Scale (27), (WAIS), the performance peak in-increased to ages 25-29 and declined even less noticeably. A longitudinal study by Owens (21), in a subsequent testing of former Iowa State College students who had been tested 30 years earlier with the World War I Army Alpha Test, reported an increase in scores of .55SD.

An associate of Thorndike's, Irving Lorge (16), believed that the ability to learn did not deteriorate with age, but that attitude or perception of the learning situation, in terms of goals and values of the adult student, were more important than chronological age:

> "Learning is the power to learn, while learning performance is a function of the circumstances under which a person performs. If a person thinks the assigned learning task is silly, or if he conceives that the primary objective is accuracy, or if he has developed a personal tempo for working on tasks in general... then regardless of his potential ability to learn, his learning performance, when measured by amount accomplished per unit of time, must show a decrement."

Lorge, also believed that investigators confused slower speed of reaction with a decline in the capacity to learn.

The University of Nebraska has done considerable research on adults enrolled in university evening courses in order to determine the effect of age, education, and extent of previous adult education on achievement. Three major findings are reported by Knox and Sjogren (35):

> "In the learning experiments, age was never significantly related to achievement, while there was a consistent, positive relationship between achievement and level of education. . . ."
>
> "There was no significant difference between the subjects who had engaged in adult education in the previous five years and those who had not, in terms of such variables as age, intelligence, level of formal education, proportion of men and women, interest, etc. The subjects who had participated in adult education (recently) achieved significantly better in the learning units all the way through the project, than those who had not been active in adult education in the previous five years. . . ."
>
> "The third finding concerned pace of learning. . . . When allowed to proceed at their own rate, the slowest performance was by the older, those with less formal education, and those who had not recently participated in adult education. In general, those who set a faster learning pace, were those who achieved significantly better."

McAreavy (18), on the other hand, in the investigation of the effect of age on achievement, using 102 Government employees who were attending a short, intensive course in Data Processing, reported a significant difference in achievement between those subjects under 46 years of age and those 46 years of age and older. Those under 46 achieved at a higher level on the average than those over that age.

The bulk of the evidence seems to indicate that age per se is not critical to achievement. Such factors as changes in attitude, motivation, goals, values, and physical condition in relation to age would seem to be more important.

In a study conducted for the National Opinion Research Center, Johnstone and Rivers (10) concluded that the more education an individual had the more likely that individual would continue to pursue his education. This was based on their conclusion that in the process of obtaining an education, people learn that education is a continuing life experience and the means of acquiring new skills and knowledge in life.

In his study of factors affecting adult education, Jensen (9) stated:

> "The single factor that was found to have a significant level of achievement was educational background. Subjects who were college graduates demonstrated a significantly higher level of achievement than subjects who were not college graduates."

A study to identify the attitudes and interests characteristic of learners was conducted by Deane (32) in 1950. He studied three distinctly different adult education programs: a Great Books reading and discussion group, a non-credit evening school group, and a college credit group. Specific investigation of the college credit group indicated that the majority attended because of employer pressure. Attendance was frequently made a requirement for promotion. These individuals were also interested in the practical aspects of the course material and openly expressed how they used it on the job. The long-term goal for this group was vocational success and financial security. Deane concluded that:

> "One very significant difference between those who completed courses and those who did not, concerned their statements of their purposes in entering the programs. Those who completed definite semester units, and in many cases went on to take more work, almost invariably cited vocational reasons for enrollment."

Both McAreavy (18) and Jensen (9) concluded that there was not enough evidence to indicate that the reason for a subject's attendance at a short, intensive management course affects his level of achievement. In considering the literature on this point, however, it might be assumed that a subject who was required to attend a course by his supervisor rather than by his own individual motivation, would achieve at a lower level.

III. DESIGN OF EXPERIMENTS AND EXPERIMENTAL METHODOLOGY

THE EXPERIMENTAL SETTING

In order to test the hypotheses stated in Chapter I, a setting where adult students would participate in short, concentrated management courses of instruction was required. The Department of Army has established and maintains an Agency at Rock Island Arsenal, Illinois, whose mission, in part, is to develop and conduct short, concentrated management courses for military and civilian employees of the Federal Government. The United States Army Management Engineering Training Agency (AMETA) has been conducting courses in management engineering and associated areas over the last twenty years. At the present time, the curriculum consists of 66 courses ranging in length from three days to nine weeks.

The courses are developed in response to stated training needs of civilian employees of the Department of Defense. The curriculum consists of seven basic subject areas:

1. Automatic Data Processing
2. Business Administration
3. Statistics

4. Operations Research
5. Quality Control
6. Reliability Engineering
7. Industrial Engineering

The course titles and lengths are included as Appendix 2. Each of these courses has specific educational objectives with subject matter documentation and appropriate methods of instruction to achieve these objectives. They are developed and conducted by civilian employees, each of whom is a college graduate and who, because of education and experience is classified as a mathematician, industrial engineer, general engineer, management analyst or computer systems analyst.

The training program participants are military and civilian personnel from throughout the world. Personnel from other Federal Agencies and Departments, plus selected Foreign Nationals are accommodated as resources and class space permits. Students represent virtually every occupational category in the Federal Service and range from GS-5 to GS-18 in Civil Service Grade and Lieutenant to General in military rank. Approximately 5,000 people are trained annually at the AMETA campus in Rock Island and 2,500 are trained at various off-campus locations throughout the world.

The AMETA facility in Rock Island contains thirteen classrooms, each classroom approximately 35' by 60' in size. The classroom will accommodate up to thirty students and the seating arrangement is designed to accommodate lecture, seminar and individual study activities. A diagram of the classroom layout is provided in Appendix 3.

Population and Sample

The "Management Statistics" course was chosen from among the sixty-six courses in the curriculum to provide subjects for the experiment. The course is two weeks in duration and five to eight classes are conducted in this course annually. Students are selected for these classes in the following manner:

An annual comprehensive survey of training needs is conducted throughout the Federal Government and from this survey, AMETA receives overall requirements for its courses. For the period July 1, 1972 to June 30, 1973, 370 requests for spaces in the Management Statistics course were received. Due to limitation of instructors and classrooms, only 27 students were accepted in each of the six classes, for a maximum of 162 students. Spaces are allocated to the requesting activities in direct proportion to their expressed requirements. The spaces are also allocated evenly over the year to allow for some flexibility in planning at the requesting activity. No consideration is made in the allocation process of any student characteristics, such as age, sex, work experience or education.

The sample then, consists of those individuals in Federal Service who have been sent to AMETA by their organizations to acquire the knowledge provided in the Management Statistics course. This sample could be thought of as adults from a population, who require short, intensive training in management-oriented subjects in order that they might achieve a higher level of performance in accomplishing their assigned work tasks.

Four classes of the Management Statistics course were chosen as the sample of this population. The classes were conducted by AMETA at Rock Island, Illinois on the following dates:

Class 1	11 - 22 September 1972
Class 2	6 - 17 November 1972
Class 3	11 - 22 December 1972
Class 4	8 - 19 January 1973

Since students are assigned to the six classes in a random fashion, i.e., all of the six are constituted in the same manner, it was not necessary to randomly select four classes from the six being offered. If there were some reason to think that composition of classes was different, for example, from September to June, a random selection of four classes from the six would be required. A check on this factor was made by tabulating the ages and job position ranks of the students enrolled in the five classes conducted in Management Statistics during the period, September 1971 through June 1972. There were no significant differences in these two student variables in the five classes.

Even though the requesting activities are allocated spaces in specific courses, in some instances, they do not send the students who were originally nominated because of such factors as sickness, higher work priorities or lack of training funds, therefore, class sizes vary. In the classes used in this study, 29 students completed Class #1, 27 students completed Class #2 and 26 students completed Classes #3 and #4 respectively. Total sample size for the four classes examined was 108.

Administration of Course of Instruction

The Management Statistics course is a two-week course designed to provide the enrollee with a basic understanding of methods used in the collection, presentation, analysis interpretation and evaluation of data for management purposes. The major topics include:

1. Role of Statistics in Management (PI vs. Lecture)
2. Descriptive Statistics (PI vs. Lecture)
3. Normal Distribution
4. Sampling for Estimation and Control
5. Correlation - Regression
6. Testing of Hypotheses

The educational objectives developed for this course are given in Appendix 4.

The course material consists of:

Summary Outline: This brief outline identifies topics to be covered in each half-day session. This summary outline is included in Appendix 5.

Course Book: A general introductory text developed and maintained by the AMETA Department of Applied Mathematics and Statistics to:

a. Provide continuity to the course material covered by lecture and discussion.

b. Provide additional examples of principles and methods discussed.

Programmed Instruction Material: Statistics and Measurement: A Programmed Instruction , (22).

Vu-Graph Slides: Transparency slides are used to present the most significant concepts, principles and methods to the class.

Instructor Guide: The guide is prepared by the instructor in conformance to the material indicated above, but it is individualized to take advantage of the instructor's personal experience and knowledge.

The instructor does not present a prepared script to the class, but he is expected to adhere to the overall outline and the prepared course material. He is also expected to assure that all students who attend the Management Statistics course are exposed to essentially the same content and course material and achieve the prescribed educational objectives.

The instructors who teach this course are classified as Mathematicians or Engineers. They have college degrees and work experience in statistics. After they are hired, they spend three to six week becoming acquainted with course content and presentation method in order to develop their individual Instructor Guides. They also audit a class in Management

Statistics to obtain experience in the use of course material and class management. After another three to six week period of short presentations, they conduct their first class.

The regular daily class schedule for Monday through Friday of the two-week period is as follows:

8:00 - 10:00	Class
10:00 - 10:20	Coffee Break-outside classroom
10:20 - 11:45	Class
11:45 - 1:00	Lunch
1:00 - 3:00	Class
3:00 - 3:20	Coffee Break-outside classroom
3:20 - 4:30	Class
4:30	Dismissed

This two-week schedule yields approximately 60 hours of class time. Students are expected to spend from one to two hours daily outside of class on reading, homework assignments or class projects.

Teaching methodology incorporates lecture, discussion, individual and group projects and testing. The same instructor conducts the total two-week class period.

On the last day of class, a 1 1/2 hour test is administered covering the material presented during the two weeks of class. Course grades are assigned as follows:

College Equivalent	
0	A
S+	B
S	C
S-	D
U	F
I	Incomplete

The assignment of grades is an instructor decision based upon his assessment of test grades and other objective evidence such as homework assignments and class projects. These grades are forwarded to each student's supervisor and become a part of his official record.

RESEARCH DESIGN

Experimental Variables

The dependent variable identified in the hypotheses stated in Chapter I was the level of achievement of subjects. The level of subject achievement was the criterion measure used in all hypotheses.

The independent variables used were:

1. Programmed Instruction (PI) and Lecture Method of Instruction - Hypotheses 1 - 6
2. Subject's Age - Hypothesis 2
3. Subject's Educational Background - Hypothesis 3
4. Subject's Work Experience - Hypothesis 4
5. Subject's Reason for Course Attendance - Hypothesis 5
6. Subject's Previous Use of Programmed Instruction (PI) - Hypothesis 6

Final Examination

The subject's level of achievement was measured by the score on the AMETA Management Statistics Final Examination taken by each subject on the last day of class. This test is a sixty-item, four-choice, multiple-choice test developed by the AMETA instructional staff in conformance with procedures identified in Educational Measurement (15) edited by E. F. Lindquist. The test was initially utilized by Jensen in "An Analysis of the Effect of Instructor Authoritarianism and Democracy Upon Adult Achievement," (9).

Test objectives are included as Appendix 6. The test blueprint was prepared in the matrix format specified by

Thorndike and Hagen (27) and is presented in Appendix 7.

Test items were originally developed by Jensen (9) in sufficient quantity to provide the numbers of items needed to fill the percentages in each element of the test blueprint and to assure a reliable and valid instrument of approximately 1 1/2 hours.

The Tryout Test of 112 items was completed in January, 1969 at AMETA. The results of Jensen's (9 , p. 38) analysis of these are presented in Table 1.

TABLE 1

RESULTS OF TRYOUT TEST

Number of items	112
Number of students taking the test	25
Mean score	64.16
Standard deviation	15.40
Split-half reliability(odd-even items)	.8340
Spearman-Brown Prophesy Reliability . . .	.9095

Jensen summarized his item analysis as follows:

> "Item analysis of this test was conducted by dividing the students into upper third total test scores and the lower third total test scores, then recording the performance of each group on every item. By considering the difficulty and discrimination of each item, a test of 60 items was constructed as the end-of-course achievement test in "Management Statistics." The reliability of this achievement test was determined by splitting

> the test into odd item, even item scores for the total score of each subject and computing the Spearman-Brown Prophesy reliability coefficient.

In the current experiment, the Final Examination was administered to all subjects at the conclusion of each course by the course instructor. One and one-half hours were allowed for the subject to take the test. The Final Examination is presented as Appendix 8.

Pre-Test

Subject's incoming skill level was measured by a score on a four-choice, multiple-choice item test administered at the start of each of the four classes. The items for the Pre-Test were selected from among the 112 items on the Tryout Test that were not used in the Final Examination. In addition, these items were chosen according to the same blueprint and the analysis of test items used in the Tryout Test.

Schedule constraints required that the Pre-Test not utilize more than 45 minutes of class time, consequently the Pre-Test consisted of thirty items. The Pre-Test is presented as Appendix 9.

Student Survey

A multiple-choice, initial student survey was prepared to obtain the following data:

1. Age
2. Highest Level of Formal Education
3. Primary Reason for Class Attendance
4. Previous Use of Programmed Instruction(PI) Material

The Student Survey form is Appendix 10. The reliability of this instrument was determined by comparing responses to Items 1. and 4. to responses obtained for the same items on the enrollment request forwarded to AMETA five weeks prior to the beginning of class. Inasmuch as analysis indicated a significant degree of uniformity of responses, it was concluded that responses to other items were also reliable.

The Student Survey form was completed at the beginning of class. The subject was allowed approximately fifteen minutes to complete the Student Survey form.

End-of-Course Evaluation

Each student who attends AMETA is asked to complete a course evaluation sheet prior to graduation.

Two special forms of this evaluation sheet were prepared that would provide the information required by AMETA as well as that information needed for this research. The two special forms contained certain elements of common data, such as:

1. Subject's belief concerning the <u>logical organization</u> of the class.
2. Subject's belief in his ability to <u>apply training</u> to his job.
3. Average daily <u>non-class time</u> devoted to the study of course materials.
4. Availability of <u>course related assistance</u> within the classroom.

In addition to the elements of common data shown above, the special form prepared for those subjects who received the programmed instruction (PI) method treatment provided the following data:

1. Subject's evaluation of the use of programmed instruction (PI) as a teaching method.
2. Subject's belief as to whether he applies himself to a greater degree when using programmed instruction (PI).
3. Subject's preference between programmed instruction (PI) and the lecture method as a teaching method.

The End-of-Course Evaluation is in Appendix 11. No reliability analysis was performed, however, the subjects were asked to be honest since the information obtained would be used by the instructor to make further improvements in the Management Statistics course. To assure objectivity, the subjects were instructed not to identify themselves.

Instructor Selection

Seven instructors were available who had at least two years experience in teaching the Management Statistics course at AMETA and who were regularly assigned to this teaching function. Two instructors were randomly selected to participate in this experiment.

An instructor questionnaire was constructed and administered by the experimentor through personal interview in order to generate instructor factual and attitudinal data associated with programmed instruction (PI) and lecture method modes of instruction. The Instructor Questionnaire is Appendix 12.

Summary List of Instruments

1. Final Examination - Appendix 8
2. Pre-Test - Appendix 9
3. Student Survey - Appendix 10
4. End-of-Course Evaluation - Appendix 11
5. Instructor Questionnaire - Appendix 12

Design of Experiment

The treatment involved in each hypothesis is the factor A. There were two levels of this factor. Treatment A_1 consisted of lecture method of instruction and Treatment A_2 consisted of programmed instruction (PI) method.

In order to allow for variation between instructors, another factor I, was introduced in the design to test the major hypothesis.

There were seven qualified instructors capable of assisting in the experiment; two were randomly selected to participate. Each selected instructor taught one course in the lecture method treatment mode and one in the programmed instruction (PI) treatment mode. Therefore, there were two levels of factor I: I_1 represents one instructor and I_2 represents the other instructor.

Four classes were selected for the experiment, two using the lecture method of instruction and two using the programmed instruction (PI) method. Two classes, one in each treatment mode, were randomly assigned to each of the two instructors. The design resulted in four treatment combinations assigned to the four classes as follows:

Class	Dates	Treatment Combinations		Sample Size
1	11 - 22 Sep 72	A_1	I_1	29
2	6 - 17 Nov 72	A_1	I_2	27
3	11 - 22 Dec 72	A_2	I_1	26
4	8 - 19 Jan 73	A_2	I_2	26

For each treatment combination, a subject generated two test scores, X_1 , the measure of incoming skill level (Pre-Test) and Y_1 , the Final Examination test measure. The design matrix is presented in Table 2.

The design constructed to test Hypotheses 2 through 6 consisted of two factors: Factor A with two levels, A_1 and A_2 , lecture method and programmed instruction (PI) respectively, and a second factor related to the variable specified. In the individual hypotheses, these were:

Hypothesis 2: Two levels of factor B, Age

B_1 - Subjects 35 years of age and under

B_2 - Subjects over 35 years of age

TABLE 2

EFFECT OF LECTURE VERSUS PROGRAMMED INSTRUCTION (PI) ON ACHIEVEMENT

Research Design Matrix

Treatment
A

Instructors I	A_1 Lecture Method		A_2 Programmed Instruction (PI)	
I_1	x_{111}	y_{111}	x_{121}	y_{111}
	x_{112}	y_{112}	x_{122}	y_{112}
	.	.	.	.
	.	.	.	.
	.	.	.	.
	x_{ijk}	y_{ijk}	x_{ijk}	y_{ijk}
	.	.	.	.
	.	.	.	.
	.	.	.	.
	x_{1123}	y_{1123}	x_{1123}	y_{1123}
I_2	x_{211}	y_{211}	x_{221}	y_{221}
	x_{212}	y_{212}	x_{222}	y_{222}
	.	.	.	.
	.	.	.	.
	.	.	.	.
	x_{ijk}	y_{ijk}	x_{ijk}	y_{ijk}
	.	.	.	.
	.	.	.	.
	.	.	.	.
	x_{2124}	y_{2124}	x_{2224}	y_{2224}

Hypothesis 3: Two levels of factor C, Educational Background

C_1 - Subjects who were college graduates

C_2 - Subjects who were not college graduates

Hypothesis 4: Two levels of factor D, Work Experience

D_1 - Subjects with ten years work experience and under

D_2 - Subjects with over ten years of work experience

Hypothesis 5: Two levels of factor E, Reasons for Attending Course

E_1 - Subjects who were required to attend course by immediate supervisor

E_2 - Subjects who requested to attend course

Hypothesis 6: Two levels of factor F, Previous Experience in a Course Using Programmed Instruction (PI)

F_1 - Subjects who had previous experience in a course using programmed instruction (PI)

F_2 - Subjects who have had no experience in a course using programmed instruction (PI)

Significance Level

The significance level utilized in this experiment was .05 for all statistical tests.

Instructor Procedure

Each of the selected instructors was given one lecture method class and one programmed instruction (PI) method class. They were each given the same guidance in conducting the classes in the experiment. This guidance consisted of:

1. Utilize appropriate outline and course material.
2. Maintain a log on daily class hours.
3. Prepare a classroom layout.
4. Note any changes in normal routine between two treatments being used.

The instructor was advised not to inform his classes that an experiment was in progress. Each instrument was disguised as a standard AMETA form. The subjects were informed that these instruments were utilized in all AMETA Management Statistics classes during the 1972 - 1973 school year in order to improve the effectiveness of the training program.

Test Procedure

The instructor administered the Student Survey,

Appendix 10 and Pre-Test, Appendix 9, indicating that the data secured would be used by him to improve the effectiveness of the course. Each instructor collected the completed instruments and forwarded them to this experimentor for analysis. Results were tabulated by subject identification number. The Final Examination, Appendix 8, was administered on the last day of class. Subjects were allowed one hour and thirty minutes to complete this test. The tests were then forwarded for grading and tabulation of the results by subject identification number.

The End-of-Course Evaluation, Appendix 11, was administered one hour prior to graduation. The subjects were asked not to identify themselves. The procedure used to identify each sheet by subject is included at Appendix 13. These forms, upon completion, were forwarded to this experimentor for analysis.

IV. DATA ANALYSIS

RELIABILITY AND VALIDITY OF INSTRUMENTS

Pre-Test

An estimate of the reliability of the Pre-Test of thirty items was obtained by splitting the test into odd-even halves and then recording and correlating the odd-even scores. The odd-even scores for the Pre-Tests administered to the 108 subjects are given in Appendix 14. The split-half correlation coefficient was calculated as $r_{1/2\ 1/2} = 0.374$. The Spearman-Brown Prophesy correlation coefficient was calculated as

$$r_{11} = \frac{2\ (0.374)}{1 + 0.374} = 0.544.$$

The validity of the Pre-Test was established by the method of test construction used and outlined in Chapter III.

Final Examination

An estimate of the reliability of the Final Examination of sixty items was obtained by splitting the test into odd-even halves and then recording and correlating the odd-even scores. The odd-even scores for the Final Examination administered to the 108 subjects are given in Appendix 15. The split-half correlation coefficient was calculated as $r_{1/2\ 1/2} = .771$ and the Spearman-Brown Prophesy correlation coefficient was calculated as $r_{11} = \frac{2\,(.771)}{1 + .771} = .871$.

The validity of the Final Examination was established by the method of test construction used and outlined in Chapter III.

Student Survey

The sixteen-item, multiple-choice, Student Survey instrument was designed to obtain biographical information about the subjects. The subjects were informed that the results of this survey would be of benefit to the instructor during the class so it would be in their best interests to answer the questions truthfully. As a check, the results obtained from Item 1 (Age) and Item 4 (Education) were compared to the data submitted in answers to the same two questions on the student enrollment request. The data on this form is submitted to AMETA four to eight weeks before the start of class. In every case, the information given by the subjects on the two items in the survey matched that on the student enrollment request. Therefore, it was inferred that the reliability of the other items was high enough to utilize the results in the analysis for this study.

End-of-Course Student Evaluation

The reliability and validity of the End-of-Course Student Evaluation was verified by making certain the subjects were free to answer the questions as objectively as possible by telling them that they did not have to put their names on the completed forms. The subjects were also informed that the data on these forms would be used by the instructional staff in making decisions regarding the need for new course materials and course content.

Subjects Personal Data Profile

Subject data was obtained from the Student Survey forms and cross-checked with the student enrollment request forms. There were 108 subjects. They were divided into four classes: Class #1 contained 29 subjects, Class #2 contained 27 subjects, Class #3 contained 26 subjects and Class #4 contained 26 subjects. Sixty-four percent of the subjects were between the ages of 26 and 45, with 33 percent of the subjects between the ages of 26 and 35. Fifty-two percent of the subjects were not college graduates. Within the subject sample, 53 percent had 11 or more years work experience in the Federal Government and 61 percent had no previous experience with the use of programmed instruction (PI)

Subjects Personal Data Profile is presented in Table 3.

Analysis of Covariance

Analysis of Covariance procedures were utilized throughout the experiment to test the various hypotheses since it was considered that the experiment would have more precision with the use of the Analysis of Covariance approach than without its application.

Assumptions

Lindquist (15,p. 323) has identified several assumptions under which the ratio $F = \frac{ms'A}{ms'W}$ is distributed as F. Two of the following conditions, 1 and 2, are necessary, "if in a controlled experiment, one is safely to conclude from a significant F that the experimental treatments have different effects."

1. Subjects in each treatment group were originally drawn at random from the same parent population.

This condition has been satisfied by the approach for selecting the subjects identified in Chapter III.

2. The X-measures are unaffected by the treatments.

This condition has been satisfied because the Pre-Test scores (X) were obtained prior to the start of each class.

TABLE 3

PERSONAL DATA PROFILE

Total Experiment

(Source - Student Survey, N = 108)

	FREQUENCY	PER CENT
Age (Item 1)		
25 or under	15	14
26 - 35	36	33
36 - 45	33	31
46 - 55	21	20
over 55	3	2
Educational Level (Item 4)		
High School	16	15
College Work	40	37
College Graduate	26	24
Graduate Work	26	24
Work Experience (Item 2)		
Under 3 years	18	17
3 - 10 years	32	30
11 - 20 years	51	47
over 20 years	7	6
Previous Experience With Programmed Instruction (Item 11)		
Yes	42	39
No	66	61

3. The criterion measures for each treatment group are a random sample from those for a corresponding treatment population.

4. The regression of Y on X is the same for all treatment populations.

5. The regression of Y on X is linear.

6. The distribution of adjusted scores for each treatment population is normal.

7. These distributions have the same variance.

Concerning the validity of these conditions, Lindquist (15, p. 330) states:

> "Linearity of regression, normality of distribution and homogeniety of variance must generally represent judgments based on a priori considerations since available statistical tests of the validity of these assumptions are both low in power and difficult to apply."

Correlation Between Control and Criterion Measures

The correlation between the concomitant variable Pre-Test scores (X) which is the control measure and the criterion measure Final Examination (Y) is determined by:

$$r_{xy(w)} = \frac{spw}{\sqrt{ss_{wx} \cdot ss_{wy}}}$$

Substituting the within values from the Summary Table of Analysis of Covariance from Table 5:

$$r_{xy(w)} = \frac{1509.31}{\sqrt{1125.50 \cdot 6827.50}}$$

$$r_{xy(w)} = .5445$$

This correlation is large enough to produce a significant advantage for the use of Analysis of Covariance. Since $1 - r_w^2 = .704$ is approximately equal to the ratio $ms'_w / ms_{wy} = 48.52/68.28 = .711$, it can be concluded that this experiment would have more precision with the use of the Analysis of Covariance approach than without its application.

Other Factors and Their Effect on Achievement

In each of the subsequent analyses, it was necessary to omit on a random basis, subjects in some levels of the factors considered, in order to achieve the proportionality requirement of the Treatment by Levels design. Even though each of the following designs permit the test of Hypothesis 1, the tests are not made because:

1. The test has already been made.

2. The primary interest in the subsequent designs is on the other factors specified in each case.

3. Some of the subjects in the subsequent designs are omitted to achieve proportionality among the levels of the factors considered.

EFFECT OF METHOD OF TEACHING ON ACHIEVEMENT

The initial analysis was performed to test Hypothesis 1: There is no significant difference in achievement by students who learn by the programmed instruction (PI) method as compared to those who learn by the lecture method of instruction.

The design used also provided for a determination of instructor effect.

Pre-Test (X) and Final Examination (Y) scores were obtained and the data organized in the format required in a factorial design. A_1 included subjects who were taught by the lecture method, A_2 those who were taught, in part, by the programmed instruction (PI) method. I_1 represented subjects taught by Instructor #1 and I_2 represented subjects taught by Instructor #2. The data is portrayed in Appendix 16.

In terms of the statistical procedure employed, Hypothesis 1 can be divided into three hypotheses stated as follows:

1a. There is no difference between A_1 lecture method and A_2 programmed instruction (PI) method on variable Y (Final

Examination) after adjusting for the concomitant variable X (Pre-Test score).

1b. There is no difference between I_1 and I_2 (Instructor 1 and Instructor 2) on variable Y after adjusting for the concomitant variable X.

1c. There is no interaction between A and I as they affect the variable Y after adjusting for the effect of the concomitant variable X.

The results of the analyses are presented in Tables 4 and 5. The data in Table 4 is a summary of detailed information on treatment and treatment combination means that appears as Appendix 17 and 18.

The critical F ratio for each of the three hypotheses is $F(.05; 1, 99) = 3.94$.

The major hypothesis cannot be rejected at the .05 level of significance. The instructor effect was significant. The interaction between method and instructor was not significant.

The design of the experiment provided for each instructor to teach an equal number of classes under each of the two methods considered so as to balance any possible instructor effect equally between the two methods being studied. For this

TABLE 4

TABLE OF TREATMENT AND TREATMENT COMBINATION MEANS (HYPOTHESIS 1)

	A: A_1	A: A_2	
I_1	n = 26 $\bar{Y}$ = 40.8846 adj. $\bar{Y}$ = 41.7227	n = 26 $\bar{Y}$ = 40.4231 adj. $\bar{Y}$ = 40.2812	n = 52 $\bar{Y}$ = 40.6538 adj. $\bar{Y}$ = 41.0020
I_2	n = 26 $\bar{Y}$ = 36.4615 adj. $\bar{Y}$ = 36.0102	n = 26 $\bar{Y}$ = 32.8077 adj. $\bar{Y}$ = 32.5627	n = 52 $\bar{Y}$ = 34.6346 adj. $\bar{Y}$ = 34.2865
	n = 52 $\bar{Y}$ = 38.6731 adj. $\bar{Y}$ = 38.8665	n = 52 $\bar{Y}$ = 36.6154 adj. $\bar{Y}$ = 36.4220	

Treatments

A_1 - Subjects who participated in the lecture method treatment condition.

A_2 - Subjects who participated in the programmed instruction (PI) method treatment condition.

I_1 - Instructor I

I_2 - Instructor 2

TABLE 5

SUMMARY TABLE OF ANALYSIS OF COVARIANCE

(HYPOTHESIS 1)

Source	df	ss_x	sp	ss_y	ss'_y	df	ms'_y	F
Method(A)*	1	2.16	-15.43	110.09	115.07	1	155.07	3.20
Instructors (I)	1	7.01	-81.26	942.01	1165.30	1	1165.30	24.02
Interaction (AI)	1	5.09	18.36	66.24	26.04	1	26.04	.54
Within	100	1125.50	1509.31	6827.50	4803.50	99	48.52	
Total	103	1139.76	1430.98	7945.84	6149.91	102	$F_{(1, 99).05} = 3.94$	

* Lecture Method/Programmed Instruction (PI)

reason, the instructor variable can be collapsed under the lecture method (A_1) and the programmed instruction (PI) method (A_2) treatments. This collapsing was done in all subsequent analyses.

Effect of Age on Achievement

Pre-Test scores (X) and Final Examination scores (Y) were sorted and arranged in the format required for a 2 x 2 covariance factorial design. A_1 consisted of those subjects taught by the lecture method and A_2, those taught by the programmed instruction (PI) method. B_1 consisted of those subjects who were less than or equal to 35 years of age and B_2 consisted of those subjects greater than 35 years of age. The raw data is presented in Appendix 19.

In terms of the statistical procedure employed, Hypothesis 2 can be divided into two hypotheses stated as follows:

2a. There is no difference between B_1 and B_2 on the variable Y after adjustment for the concomitant variable X.

2b. There is no interaction between A and B as they affect the variable Y after adjustment for the effect of the concomitant variable X.

Results are presented in Table 6, Table of Means, and

TABLE 6

TABLE OF TREATMENT AND TREATMENT COMBINATION MEANS (HYPOTHESIS 2)

A

	A_1	A_2	
B_1	n = 24 $\bar{Y}$ = 43.1250 adj. $\bar{Y}$ = 42.7269	n = 24 $\bar{Y}$ = 41.1250 adj. $\bar{Y}$ = 39.4827	n = 48 $\bar{Y}$ = 42.1250 adj. $\bar{Y}$ = 41.1048
B_2	n = 25 $\bar{Y}$ = 36.8800 adj. $\bar{Y}$ = 37.3475	n = 25 $\bar{Y}$ = 33.3200 adj. $\bar{Y}$ = 34.8113	n = 50 $\bar{Y}$ = 35.1000 adj. $\bar{Y}$ = 36.0794
	n = 49 $\bar{Y}$ = 39.9388 adj. $\bar{Y}$ = 39.9823	n = 49 $\bar{Y}$ = 37.1429 adj. $\bar{Y}$ = 37.0993	

Treatments

A_1 - Subjects who participated in the lecture method treatment condition.

A_2 - Subjects who participated in the programmed instruction (PI) method treatment condition.

B_1 - Subject Age - less than or equal to 35 years of age.

B_2 - Subject Age - greater than 35 years of age.

TABLE 7

SUMMARY TABLE OF ANALYSIS OF COVARIANCE

(HYPOTHESIS 2)

Source	df	ss_x	sp	ss_y	$ss_{y'}$	df	$ms_{y'}$	F
Methods(A)*	1	0.16	-5.59	191.52	203.60	1	203.60	3.70
Age (B)	1	86.10	322.58	1208.59	572.17	1	572.17	10.38
Interaction (AB)	1	27.69	20.31	14.90	2.99	1	2.99	.05
Within	94	1063.40	1134.03	6333.33	5123.98	93	55.10	
Total	97	1177.35	1471.33	7748.34	5902.74	96	$F_{(1, 93) .05} = 3.95$	

* Lecture Method/Programmed Instruction (PI)

in Table 7, Summary Table of Analysis of Covariance. Raw data on treatment and treatment combination means is presented in Appendices 20 and 21.

Hypothesis 2a is rejected at the .05 level of significance. By referring to Table 6, the Table of Means, it is noted that subjects in the B_1 category, those less than or equal to 35 years of age, achieved at a higher level on the average than subjects in the B_2 category, those greater than 35 years of age.

Hypothesis 2b, however, could not be rejected at the .05 level of significance on the basis of the results of this experiment. There is not sufficient indication to support the premise that there is an interaction between age and lecture method or programmed instruction (PI).

Effect of Educational Background on Achievement

Pre-Test scores (X) and Final Examination scores (Y) were sorted and arranged in the format required for a 2 x 2 covariance factorial design. A_1 consisted of those subjects taught by the lecture method and A_2, those taught by the programmed instruction (PI) method. C_1 consisted of those subjects with college degrees and C_2 consisted of those subjects without college degrees. Raw data is presented in Appendix 22.

In terms of the statistical procedure employed, Hypothesis 3 can be divided into two hypotheses stated as follows:

2a. There is no difference between C_1 and C_2 on the variable Y after adjustment for the concomitant variable X.

2b. There is no interaction between A and C as they affect the variable Y after adjustment for the effect of the concomitant variable X.

Findings are presented in Table 8, Table of Means, and in Table 9, Summary Table of Analysis of Covariance. Detailed data on treatment and treatment combination means is presented in Appendices 23 and 24.

Hypothesis 2a is rejected at the .05 level of significance. By referring to Table 8, Table of Means, it is noted that subjects in the C_1 category, those who are college graduates, achieved at a higher level on the average than subjects in the C_2 category, those who are not college graduates.

Hypothesis 2b, however, cannot be rejected at the .05 level of significance on the basis of the results of this experiment. There is not sufficient indication to support the premise

TABLE 8

TABLE OF TREATMENT AND TREATMENT COMBINATION MEANS (HYPOTHESIS 3)

	A: A_1	A: A_2	
C_1	n = 25 $\bar{Y}$ = 43.4800 adj. $\bar{Y}$ = 43.5275	n = 25 $\bar{Y}$ = 38.8800 adj. $\bar{Y}$ = 37.8619	n = 50 $\bar{Y}$ = 41.1800 adj. $\bar{Y}$ = 40.6947
C_2	n = 19 $\bar{Y}$ = 35.5263 adj. $\bar{Y}$ = 35.5717	n = 19 $\bar{Y}$ = 32.7368 adj. $\bar{Y}$ = 33.9686	n = 38 $\bar{Y}$ = 34.1316 adj. $\bar{Y}$ = 34.7701
	n = 44 $\bar{Y}$ = 40.0455 adj. $\bar{Y}$ = 40.0920	n = 44 $\bar{Y}$ = 36.2273 adj. $\bar{Y}$ = 36.1807	

Treatments

A_1 - Subjects who participated in the lecture method treatment condition.

A_2 - Subjects who participated in the programmed instruction (PI) method treatment condition.

C_1 - Subjects who were college graduates.

C_2 - Subjects who were not college graduates.

TABLE 9

SUMMARY TABLE OF ANALYSIS OF COVARIANCE

(HYPOTHESIS 3)

Source	df	ss_x	sp	ss_y	ss'_y	df	ms'_y	F
Methods(A) *	1	0.18	-7.64	320.73	336.50	1	336.50	5.94
Educational Background(C)	1	25.98	166.92	1072.64	738.09	1	738.09	13.02
Interaction (AC)	1	26.08	-21.48	17.69	86.76	1	86.76	1.53
Within	84	970.63	994.56	5723.30	4704.22	83	56.68	
Total	87	1022.87	1132.36	1134.36	5865.57	86	$F_{(1,83).05} = 3.96$	

* Lecture Method/Programmed Instruction (PI)

that there is an interaction between educational background and the lecture method or programmed instruction (PI) method.

Effect of Work Experience on Achievement

Pre-Test scores (X) and Final Examination scores (Y) were sorted and arranged in the format required for a 2 x 2 covariance factorial design. A_1 consisted of those subjects being taught by the lecture method and A_2 , those taught by the programmed instruction (PI) method. D_1 consisted of those subjects whose work experience was less than or equal to ten years, and D_2 consisted of those subjects whose work experience was greater than ten years. The raw data is presented in Appendix 25.

In terms of the statistical procedures employed, Hypothesis 4 can be divided into two hypotheses stated as follows:

4a. There is no difference between D_1 and D_2 on the variable Y after adjustment for the concomitant variable X.

4b. There is no interaction between A and D as they affect the variable Y after adjustment for the effect of the concomitant variable X.

Findings are presented in Table 10, Table of Means, and in Table 11, Summary Table of Analysis of Covariance. Raw

TABLE 10

TABLE OF TREATMENT AND TREATMENT COMBINATION MEANS (HYPOTHESIS 4)

	A: A_1	A: A_2	
D_1	n = 27 $\bar{Y}$ = 43.333 adj.$\bar{Y}$ = 42.6420	n = 27 $\bar{Y}$ = 38.7407 adj.$\bar{Y}$ = 37.1634	n = 54 $\bar{Y}$ = 41.0370 adj.$\bar{Y}$ = 39.9027
D_2	n = 25 $\bar{Y}$ = 33.8800 adj.$\bar{Y}$ = 35.1290	n = 25 $\bar{Y}$ = 34.3200 adj.$\bar{Y}$ = 35.5212	n = 50 $\bar{Y}$ = 34.1000 adj.$\bar{Y}$ = 35.3251
	n = 52 $\bar{Y}$ = 38.7885 adj.$\bar{Y}$ = 39.0300	n = 52 $\bar{Y}$ = 36.6154 adj.$\bar{Y}$ = 36.3739	

Treatments

A_1 - Subjects who participated in the lecture method treatment condition.

A_2 - Subjects who participated in the programmed instruction (PI) method treatment condition.

D_1 - Subject Work Experience - less than or equal to ten years.

D_2 - Subject Work Experience - greater than ten years.

TABLE 11

SUMMARY TABLE OF ANALYSIS OF COVARIANCE

(HYPOTHESIS 4)

Source	df	ss_x	sp	ss_y	$ss_{y'}$	df	$ms_{y'}$	F
Methods(A)*	1	4.24	-22.82	122.78	182.72	1	182.72	3.43
Work Experience(D)	1	101.02	355.26	1249.33	497.92	1	497.92	9.35
Interaction (AD)	1	3.19	-22.89	164.38	223.04	1	223.04	4.19
Within	100	1091.39	1305.42	6831.27	5269.84	99	53.23	
Total	103	1199.84	1614.97	8367.76	6173.52	102	$F_{(1, 99).05} = 3.94$	

* Lecture Method/Programmed Instruction (PI)

data on treatment and treatment combination means is presented in Appendices 26 and 27.

Hypothesis 2a is rejected at the .05 level of significance. By referring to Table 10, Table of Means, it is noted that subjects in the D_1 category, those with less than or equal to ten years experience achieved at a higher level on the average than subjects in the D_2 category, those with work experience greater than ten years.

Hypothesis 2b, also is rejected at the .05 level of significance on the basis of the results of this experiment. There is sufficient indication to support the premise that there is an interaction between years of work experience and the lecture method or programmed instruction (PI) method.

Effect of Reasons for Course Attendance on Achievement

Pre-Test scores (X) and Final Examination scores (Y) were sorted and arranged in the format required for a 2 x 2 covariance factorial design. A_1 consisted of those subjects taught by the lecture method and A_2, those taught by the programmed instruction (PI) method. E_1 consisted of those subjects who were required to attend the course by their supervisors and E_2 consisted of those subjects who requested to attend the course themselves. The raw data is presented in Appendix 28.

In terms of the statistical procedure employed, Hypothesis 5 can be divided into two hypotheses stated as follows:

5a. There is no difference between E_1 and E_2 on the variable Y after adjustment for the concomitant variable X.

5b. There is no interaction between A and E as they affect the variable Y after adjustment for the effect of the concomitant variable X.

Findings are presented in Table 12, Table of Means, and in Table 13, Summary Table of Analysis of Covariance. The raw data on treatment and treatment combination means is presented in Appendices 29 and 30.

Hypothesis 2a is rejected at the .05 level of significance on the basis of results of this experiment. By referring to Table 12, Table of Means, it is noted that subjects in the E_1 category, those who were required to attend by their supervisors, did not on the average, achieve as well as those subjects in the E_2 category, those who requested to attend the course themselves. Hypothesis 2b cannot be rejected at the .05 level of significance on the basis of the results of this experiment.

TABLE 12

TABLE OF TREATMENT AND TREATMENT COMBINATION MEANS (HYPOTHESIS 5)

	A: A_1	A_2	
E_1	n = 18 $\bar{Y}$ = 36.6667 adj. $\bar{Y}$ = 35.9066	n = 18 $\bar{Y}$ = 33.3889 adj. $\bar{Y}$ = 34.4054	n = 36 $\bar{Y}$ = 35.0278 adj. $\bar{Y}$ = 35.1560
E_2	n = 16 $\bar{Y}$ = 40.1250 adj. $\bar{Y}$ = 40.7378	n = 16 $\bar{Y}$ = 39.5000 adj. $\bar{Y}$ = 38.5986	n = 32 $\bar{Y}$ = 39.8125 adj. $\bar{Y}$ = 39.6682
	n = 34 $\bar{Y}$ = 38.2941 adj. $\bar{Y}$ = 38.1801	n = 34 $\bar{Y}$ = 36.2647 adj. $\bar{Y}$ = 36.3787	

Treatments

A_1 - Subjects who participated in the lecture method treatment condition.

A_2 - Subjects who participated in the programmed instruction (PI) method treatment condition.

E_1 - Subjects who were required to attend the course by their immediate supervisors.

E_2 - Subjects who requested to attend the course.

TABLE 13

SUMMARY TABLE OF ANALYSIS OF COVARIANCE

(HYPOTHESIS 5)

Source	df	ss_x	sp	ss_y	$ss_{y'}$	df	$ms_{y'}$	F
Methods(A)*	1	0.94	8.12	70.01	55.10	1	55.10	1.00
Reasons for Attendance(E)	1	1.34	22.80	387.84	344.32	1	344.32	6.26
Interaction (AE)	1	48.84	38.15	29.80	1.62	1	1.62	.03
Within	64	776.94	744.17	4186.03	3464.90	63	55.00	
Total	67	819.06	813.24	4673.68	3865.94	66	$F_{(1,63).05} = 3.99$	

* Lecture Method/Programmed Instruction (PI)

Effect of Previous Experience Using Programmed Instruction (PI) on Achievement

Pre-Test scores (X) and Final Examination scores (Y) were sorted and arranged in the format required for a 2 x 2 covariance factorial design. A_1 consisted of those subjects taught by the lecture method and A_2 , those taught by the programmed instruction (PI) method. F_1 consisted of those subjects who had previous experience in a course using programmed instruction (PI) and F_2 consisted of those subjects who had no previous experience in a course using programmed instruction (PI). The raw data is presented in Appendix 31.

In terms of the statistical procedure employed, Hypothesis 6 can be divided into two hypotheses stated as follows:

6a. There is no difference between F_1 and F_2 on the variable Y after adjustment for the concomitant variable X.

6b. There is no interaction between A and F as they affect the variable Y after adjustment for the effect of the concomitant variable X.

Findings are presented in Table 14, Table of Means, and in Table 15, Summary Table of Analysis of Covariance. The raw data on treatment and treatment combination means is presented in Appendices 32 and 33.

TABLE 14

TABLE OF TREATMENT AND TREATMENT COMBINATION MEANS (HYPOTHESIS 6)

	A: A_1	A: A_2	
F_1	n = 17 $\bar{Y}$ = 37.7059 adj. $\bar{Y}$ = 36.9192	n = 17 $\bar{Y}$ = 35.1765 adj. $\bar{Y}$ = 35.3601	n = 34 $\bar{Y}$ = 36.4412 adj. $\bar{Y}$ = 36.1397
F_2	n = 33 $\bar{Y}$ = 39.2121 adj. $\bar{Y}$ = 39.2425	n = 33 $\bar{Y}$ = 37.4848 adj. $\bar{Y}$ = 37.7651	n = 66 $\bar{Y}$ = 38.3485 adj. $\bar{Y}$ = 38.5038
	n = 50 $\bar{Y}$ = 38.7000 adj. $\bar{Y}$ = 38.4526	n = 50 $\bar{Y}$ = 36.7000 adj. $\bar{Y}$ = 36.9474	

Treatments

A_1 - Subjects who participated in the lecture method treatment condition.

A_2 - Subjects who participated in the programmed instruction (PI) method treatment condition.

F_1 - Subjects who had previous experience in a course using programmed instruction (PI).

F_2 - Subjects who have had no experience in a course using programmed instruction (PI).

TABLE 15

SUMMARY TABLE OF ANALYSIS OF COVARIANCE

(HYPOTHESIS 6)

Source	df	ss_x	sp	ss_y	ss'_y	df	ms'_y	F
Methods (A) *	1	4.41	21.00	100.00	56.46	1	56.46	0.94
PI Experience (F)	1	3.37	-16.59	81.63	125.13	1	125.13	2.08
Interaction (AF)	1	2.10	2.75	3.61	0.04	1	0.04	0.00
Within	96	1432.87	1688.34	7715.76	5726.39	95	60.28	
Total	99	1442.75	1695.50	7901.00	5908.02	98	$F_{(1, 95) .05} = 3.94$	

*Lecture Method/Programmed Instruction (PI)

Neither Hypothesis 6a nor 6b can be rejected at the .05 level of significance on the basis of results of this experiment.

V. EVALUATION AND INTERPRETATION

STATEMENT OF HYPOTHESIS 1

There is no significance difference in achievement on the part of students who learn by the programmed instruction (PI) method and those who learn by the lecture method of instruction.

On the basis of the data generated in this experiment, there was not enough evidence to reject this hypothesis. The implications of these results are significant for short, intensive management courses where time and costs are factors. One may extrapolate from these results that since either method is equally effective, it does not matter, in terms of achievement, which method is used. One might generalize that where good programmed instruction (PI) exists, it would be cost-effective to use the programmed instruction(PI), thus reducing or eliminating the need for a teacher.

A part of the time in many of the courses taught at AMETA is required for a review and updating of the students prior to launching into the main subject matter material. This review and updating, where programmed instruction (PI) materials are available, could be accomplished by the use of such materials, thus freeing the teacher to concentrate on the main subject matter content. It may also be feasible to send these materials to the student in advance of his attendance at AMETA so that, through review and study, he may accomplish his own updating and be prepared to launch into the main subject matter material upon his arrival at AMETA for class. There may be additional advantages to having the entire class undergo the updating through the use of programmed instruction (PI) materials. In this way, they would all be at a common point of preparation for the main subject matter to follow.

While the data indicated no difference in achievement as a result of the method used, it did show a highly significant instructor effect on achievement. The instructor effect, while interesting and perhaps worthy of future study, does not effect the outcome of this experiment. The design of the experiment was such that each instructor taught an equal number of classes under each of the two methods considered so as to balance any possible instructor effect equally between the two methods being studied.

STATEMENT OF HYPOTHESIS 2

There is no significant difference in a) the level of achievement on the part of students as a function of age, b) nor does age interact with the method of instruction employed.

Age had a significant effect on level of achievement based on data generated in this study. The subjects who were 35 or younger performed at a higher level than those subjects who were older than 35 years of age. While this finding agrees with the study conducted by McAreavy (18), in which he found that subjects under 46 years of age achieved at a higher level than subjects 46 years of age and older, it does not agree with the Knox-Sjogren (35) finding that age was significantly related to achievement.

The Knox-Sjogren study (35) involved a learning project of approximately 40 hours over a six-month period, as contrasted to the learning period in this study of five consecutive days for two consecutive weeks. One must conclude from the evidence available that other factors associated with age, such as occupational status or years of experience, could combine to achieve the above experimental result. The present study findings show no interaction between method of instruction and age of the subject. Further study would be necessary to ascertain the effect of age on learning achievement.

STATEMENT OF HYPOTHESIS 3

There is no significant difference in a) the level of achievement on the part of students as a function of educational background, b) nor does educational background interact with the method of instruction employed.

This hypothesis must be rejected on the basis of the data in this study; educational level did have an effect on achievement. There was no interaction between method and educational background. Subjects who were college graduates achieved at a higher level than subjects who were not college graduates. Method appears as significant in this case, since college graduates achieved higher in the lecture method than in the programmed instruction (PI) method.

The findings in this study are in keeping with those found by Knox and Sjogren (35) which showed a positive relationship between education and level of achievement. Further support for this is found in Jensen's (9) report on the factor's influencing achievement of adults in a Management Statistics course. A study by Sorenson (25), found that the number of years of formal education which students have had is a general index to their ability to profit from instruction. Study habits, experience in test taking, listening, and note-taking, developed by college graduates would undoubtedly give them an advantage over non-college graduates and thus permit them to achieve at a higher level in a course in Management Statistics.

STATEMENT OF HYPOTHESIS 4

There is no significant difference in a) the level of achievement on the part of students as a function of differences in the amount of work experience, b) nor does work experience interact with the method of instruction.

Based on data generated in this experiment, the hypothesis must be rejected. Those subjects with ten or fewer years of experience achieved at a higher level than those subjects whose work experience was greater than ten years. The data also indicates an interaction between years of work experience and the lecture method or programmed instruction (PI) method of instruction. An analysis of the data shows that those with less than or equal to ten years of work experience are the younger members of the sample population. One might interpret the fact that they achieved higher in the course as a function of their age, (see Hypothesis 2), the fact that they tended to be more highly educated and had a greater over-all drive for achievement.

STATEMENT OF HYPOTHESIS 5

There is no significant difference in a) the level of achievement on the part of students as a function of their reasons for attending the course, b) nor does reason for attendance interact with the method.

This hypothesis must be rejected on the basis of the data in this study; reasons for attending did have an effect on level of achievement but there is no interation between reason for attending course and method of instruction. Those subjects who requested to attend the course achieved at a higher level than those who were required to attend the course by their immediate supervisor. This finding is inconsistent with the findings of McAreavy (18) and Jensen (9), who reported no significant difference in achievement based on reasons for course attendance. It is consistent however, with the view of many educators who generally support the notion that reason for course attendance is an important factor in adult level of achievement.

STATEMENT OF HYPOTHESIS 6

There is no significant difference in level of achievement on the part of students as a function of having had previous experience in the use of programmed instruction (PI).

There is no evidence in the data to reject this hypothesis. The very slight difference in achievement favoring those who had previous experience with programmed instruction (PI) over those who had no previous experience with programmed instruction (PI) is not significant. It may be interpreted from the evidence that lack of experience in the use of programmed instruction (PI) would be no impediment to its use. One might also generalize that it would be possible to send programmed instruction (PI) material to a subject in advance of his attendance at a course and expect a given level of achievement from his study efforts even though he had no previous experience with programmed instruction (PI) materials.

VI. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The purpose of this experiment was to determine the effect on achievement of the lecture method versus the programmed instruction (PI) method by adults in short, intensive management courses. Furthermore, the experiment was designed to develop and test hypotheses regarding the interaction between the method of instruction and the subject's age, education, work experience, reasons for attendance at course and previous experience with programmed instruction (PI).

Subjects in this experiment were 108 adults, enrolled in four classes of the two-week resident Management Statistics course conducted by the US Army Management Engineering Training Agency (AMETA). Two classes were taught using the lecture method of instruction and two were taught using, in part, the programmed instruction (PI) method of instruction. Two instructors taught the four classes, each instructor taught one course using the lecture method and one course using, in part, the programmed instruction (PI) method.

Achievement was measured by sixty-item, multiple-choice, Final Examination administered to subjects in all four classes. Other data collection instruments were a thirty-item Pre-Test, an incoming Student Survey, and an End-of-Course Student Evaluation sheet.

The results of this experiment indicated no significant overall difference in the achievement of subjects who were taught by the lecture method of instruction and those taught by the programmed instruction (PI) method of instruction.

Variables that were found to be significantly related to subject's level of achievement were:

1. Age - Subjects less than or equal to 35 years of age achieved at a higher level than those over 35 years of age.
2. Educational Level - Subjects who were college graduates achieved at a higher level than those who were not college graduates.
3. Work Experience - Subjects with less than or equal to ten years of work experience achieved at a higher level than those with more than ten years work experience.
4. Reason for Attending Course - Subjects who requested to attend the course achieved at a higher level than those who were required to

attend by their immediate supervisors.

Previous experience with programmed instruction (PI) materials did not have a significant effect on achievement.

The only variable which showed a significant interaction with method was work experience.

It is concluded from this experiment that there is no difference between the lecture method and programmed instruction (PI) in their effect on the achievement of adults in short, intensive, management courses. It can also be concluded that overall, regardless of method, younger students perform at a higher level than older students, that college graduates achieve at a higher level than non-college graduates, that those with lesser work experience achieve at a higher level than those with a longer period of work experience and that those students who attended because they requested to attend, achieve at a higher level than those who were required to attend by their immediate supervisors.

RECOMMENDATIONS FOR FUTURE RESEARCH

Additional research activities suggested as a result of the experiment are as follows:

This experiment should be replicated, using programmed instruction (PI) material as refresher training prior to a student attending a course at AMETA for which the training would be a pre-requisite.

A project should be undertaken using an experimental design capable of judging the interrelationship between age, work experience, educational background and time since last formal training course in order to determine the effect of these factors on the level of achievement of adults in short, concentrated management courses.

APPENDIX I

OPERATIONAL DEFINITIONS

Lecture/Programmed Instruction (PI) Treatment Conditions

Lecture

The term lecture refers to one of a number of general teaching methods which imply particular patterns of teacher behavior. For this experiment, lecture method is defined as a teacher-oriented method, wherein the teacher presents subject matter material by talking to a group of students who are presumably listening. The teacher may encourage questions on the part of students or he may ask questions of the students. He may use vu-graphs, films, or other audio-visual aids to reinforce what he says. However, whether questions are solicited or not, whether audio-visual aids are used or not, the teacher remains at the center of the teaching process.

The initial response to defining the lecture method would be that of a teacher talking to a group of students who are presumably listening. It is apparent however, that there are many variations. Other methods are the recitation method, the discussion method, the laboratory method and the problem-solving method. Evaluation of the lecture method has consisted almost entirely of comparison with the discussion method. While we find no clear-cut definition of the discussion method as contrasted with the lecture method, it does represent a greater degree of active participation on the part of the student than is found in the lecture method.

Programmed Instruction (PI)

Programmed Instruction (PI) is a teaching method which is essentially student-centered in that when the student is furnished materials, he may study the subject matter material, learn from it and be reinforced in that knowledge through the methodology of programmed instruction (PI). This methodology is built around a careful design of the instructional cycle in which an input of information calls for use on the part of the learner, response by the learner, followed by feedback in some form, such as the correct answer. Programmed instruction (PI) material may be either in pamphlet or book form or prepared for use with teaching machines.

APPENDIX 2

COURSES CONDUCTED BY THE US ARMY MANAGEMENT ENGINEERING TRAINING AGENCY (AMETA)

Administrative Management

- Automatic Data Processing
- Business Administration

Top Management Seminar	2 weeks
Data Processing Profitability and Application Studies	2-1/2 days
Managerial Communication for Executives	2-1/2 days
Organization Concepts for Top Management	2-1/2 days
Real Time Systems	2-1/2 days
Computer Installation Management Seminar	1 week
Seminar for Middle Managers	2 weeks
Automatic Data Processing Appreciation	1 week
Fundamentals of Computer Programming	2 weeks
Data Collection & Transmission Appreciation	1 week
Financial Management for Managers	1 week
Managerial Communication Appreciation	1 week
Alpha Computer Systems Analysis (AMC)	2 weeks
Alpha Programming (AMC)	3 weeks
Alpha Software Programming (AMC)	2 weeks
Common Business Oriented Language(COBOL)	2 weeks
Advanced S/360 COBOL	1 week
IBM S/360 Basic Assembly Language	2 weeks
0S/360 COBOL Programming	2 weeks
Introduction to OS Functions	1 week
Computer Programming	3 weeks
Introduction to ADP System Analysis & Design	2 weeks
Organization Planning	2 weeks
Systems & Procedures Analysis	2 weeks
Automatic Data Processing Intern Program	18 months

Applied Mathematics & Statistics

- Statistics - Quality Control
- Operations Research - Reliability Engineering

Quantitative Decision Making	2-1/2 days
Reliability Program Management	1 week
Operations Research Appreciation	1 week
Design & Analysis of Experiments	3 weeks
Elements of Reliability & Maintainability	3 weeks
Management Statistics	2 weeks
Mathematical Programming	3 weeks
Probabilistic Methods in Operations Research	3 weeks
Seminar for Quality Managers	1 week
Product Assurance Appreciation	1 week
Designing Quality Programs	1 week
Evaluation of Producer's Quality Programs	1 week
Inspection Planning	1 week
Management of the Quality Function	2 weeks
Sampling Procedures for Reliability Testing	1 week
Statistical Quality Control I	2 weeks
Statistical Quality Control II	2 weeks
Quality Control Specialist Intern Program	12 months
Quality & Reliability Engineering Intern Program	18 months

Industrial Management

- Industrial Engineering

Managing Research & Development Activities	2-1/2 days
Managing the Value Engineering Program	2-1/2 days
Seminar for Chiefs of Management Engineering Functions	2 weeks
Numerical Control Orientation for Technical Middle Management (AMC)	2-1/2 days
Numerical Control Orientation for Non-Technical Middle Management	1-1/2 days
Numerical Control Orientation for Top Management	1-1/2 days
Work Methods & Standards Appreciation	1 week

Work Planning & Control Appreciation	1 week
Configuration Management	1 week
Economic Analysis for Decision Making	2 weeks
Managing with Contractor Performance Measurement Data	2 weeks
Methods-Time Measurement	3 weeks
Network Based Management Techniques	1 week
Numerical Control (APT) Part Programming	3 weeks
Principles & Applications of Value Engineering	2 weeks
Project Planning & Control Techniques	2 weeks
Standard Time Data	2 weeks
Systems Engineering	2 weeks
Work Planning & Control Systems	3 weeks
DIMES Analyst Basic Course	5 weeks
Seminar for Technical Data Package Management	1 week
Technical Data Package Development/ Preparation	3 weeks

APPENDIX 3

AMETA CLASSROOM LAYOUT

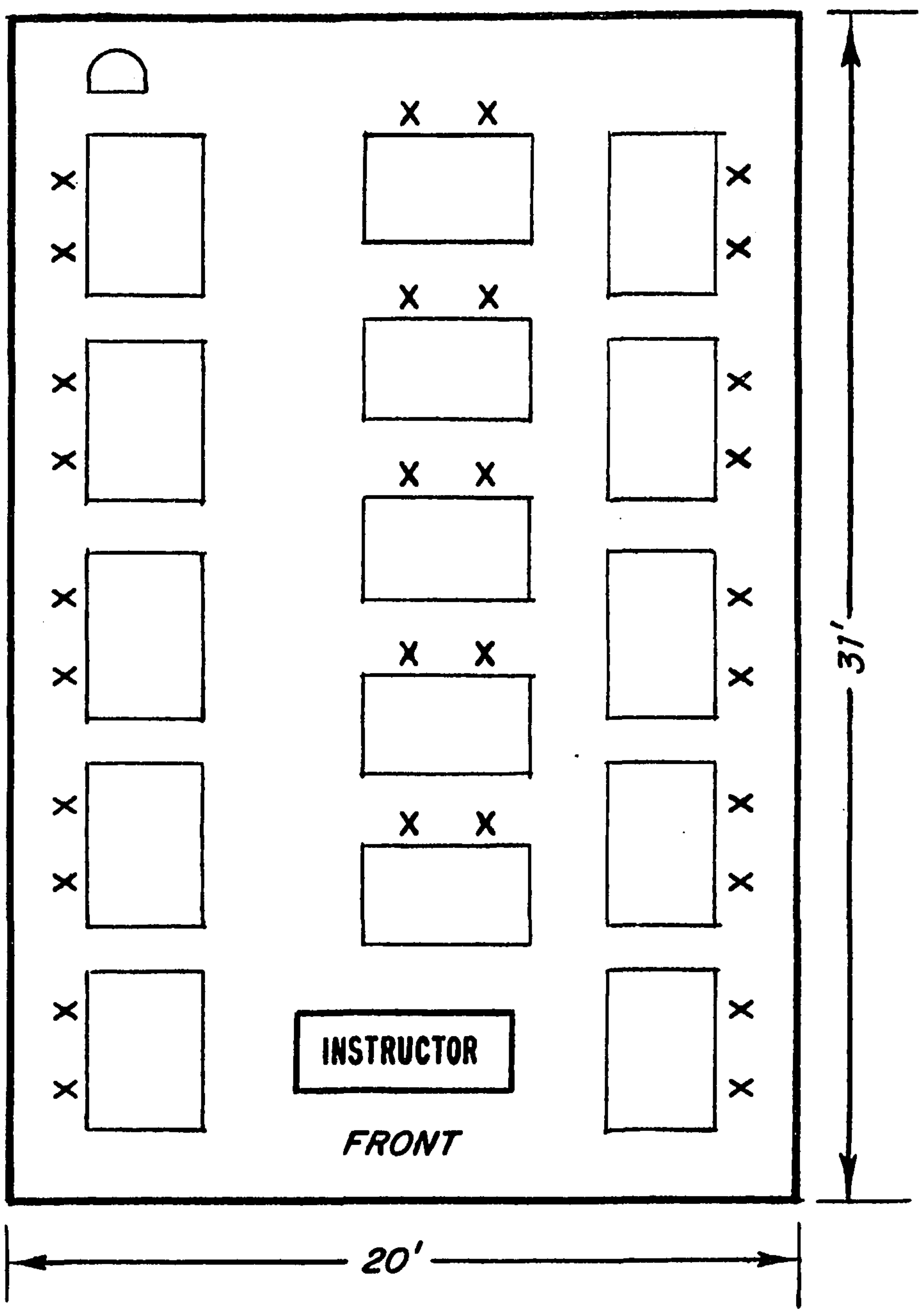


Figure 1

APPENDIX 4

EDUCATIONAL OBJECTIVES OF THE MANAGEMENT STATISTICS COURSE

Students who complete this two-week course of instruction should possess:

1. Comprehension of the role of statistics in the management process and the ability to interpret, translate and extrapolate management data employing statistical principles, methods and techniques.

2. Knowledge of fundamental statistical terminology concepts, principles, methods and techniques.

3. The ability to apply statistical concepts, principles, methods and techniques to a variety of management problems susceptible to statistical treatment.

The specific content of the course is identified in the Summary Outline in Appendix 4. Course content has been categorized in six basic subject matter areas:

Role of Statistics in Management
Descriptive Statistics
Normal Distribution
Sampling for Estimation and Control
Correlation - Regression
Testing for Hypotheses

APPENDIX 5

SUMMARY OUTLINE

MANAGEMENT STATISTICS COURSE

SESSION	SUBJECT	TOPIC
Monday AM	1	Orientation and Class Picture
	2	Introduction to Management Statistics A. Objective and Scope of the Course B. Definitions
	3	Role of Statistics in Management A. Nature of Administrative Problems B. Applications of Statistics in Business & Government
	4	Introduction to Data Presentation A. Types of Data Presentation B. Functions of Data Presentation C. Characteristics of Data Presentation
Monday PM	5	Narrative Presentation A. Definition & Purpose B. Advantages & Disadvantages C. Types of Narrative Analysis

SESSION	SUBJECT	TOPIC
	6	Tabular Presentation A. Definition & Purpose B. Advantages & Disadvantages C. Types & Applications
	7	Graphic Presentation A. Definition & Purpose B. Advantages & Disadvantages C. Types & Applications
	8	Exercise in Data Presentation I A. Problem in Tabular Presentation B. Discussion of Problem
Tuesday AM	9	Exercise in Data Presentation II A. Problem in Graphic Presentation B. Discussion of Problem
	10	Introduction to Descriptive Statistics A. Nature of Variability B. Definitions C. Functions
Tuesday PM	11	Methods of Organizing Numerical Data A. Tabular B. Graphic C. Frequency Distributions

SESSION	SUBJECT	TOPIC
	12	Measures of Central Tendency (Non-grouped Data) A. Mean B. Median C. Mode
Wednesday AM	13	Measures of Variability (Non-grouped Data) A. Range B. Average Deviation C. Quartile D. Standard Deviation
Wednesday PM	14	Measures of Central Tendency (Grouped Data) A. Mean B. Median C. Mode
Thursday AM	15	Measures of Variability (Grouped Data) A. Range B. Standard Deviation
Thursday PM	16	Exercises in Descriptive Statistics A. Enrollee Solutions to Assigned Problems B. Discussion of Problems
	17	Patterns of Variability

SESSION	SUBJECT	TOPIC
		A. General Forms B. Interpretation
Friday AM	18	The Normal Distribution I A. Definition & Description B. Standard Form of the Normal Variable C. Table of Normal Curve Areas
Friday PM	19	The Normal Distribution II A. Exercise B. Applications
	20	Review of First Week's Material A. Discussion B. Exercises
Monday AM	21	Sampling A. General Aspects of Sampling B. Parameter Estimation C. Sampling Demonstration
	22	Distribution of Sample Means A. Central Limit Theorem B. Standard Error of the Mean
Monday PM	23	Statistical Estimation A. Point Estimate B. Interval Estimate C. Confidence Interval

SESSION	SUBJECT	TOPIC
Tuesday AM	24	Control Charts for Variables A. Statistical Control B. Relationship to Sampling Distribution C. Development of an $\bar{X}$ & R Chart D. Interpretation of $\bar{X}$ & R Chart E. Exercises
Tuesday PM	25	Analysis of Attributes Data A. Definitions B. Central Tendency C. Variability D. Confidence Interval for Proportions
	26	Control Charts for Proportions A. Development of p Charts B. Interpretation of p Charts C. Exercises
Wednesday AM	27	Control Chart Applications A. Industrial B. Administrative
	28	Introduction to Correlation & Regression Analysis A. Definitions B. Concepts C. Scatter Diagram

SESSION	SUBJECT	TOPIC
Wednesday PM	29	Linear Regression Analysis A. Development of Line of Fit B. Methods of Calculation C. Exercise
	30	Correlation Analysis I A. Correlation Coefficient B. Product-Moment Method of Computation C. Exercise
Thursday AM	31	Correlation Analysis II A. Rank Correlation Method for Determining Correlation Coefficient B. Exercise
	32	Testing of Hypotheses A. Introduction B. Formulation C. Illustration
Thursday PM	33	Required Sample Sizes for Statistical Reliability A. Attributes B. Variables
	34	Examination

SESSION	SUBJECT	TOPIC
Friday AM	35	Review of Examination
	36	Topical Review of Course
	37	Critique of the Course
	38	Graduation

APPENDIX 6

MANAGEMENT STATISTICS
ACHIEVEMENT TEST OBJECTIVES

1.11 Knowledge of terminology
- To define statistics terms by giving their attributes, properties, or relations

1.12 Knowledge of specific facts
- To recall or recognize factual information about statistics

1.21 Knowledge of conventions
- To recognize correct forms, methods, techniques used in statistics

1.22 Knowledge of trends and sequences
- To specify the proper sequence of activities in statistical applications

1.23 Knowledge of classifications and categories
- To recognize the fundamental structure of statistics

1.24 Knowledge of criteria
- To specify proper criteria for judging the effectiveness and/or efficiency of statistical applications

1.25 Knowledge of methodology
- To recognize the techniques and methods used by statisticians in applying statistics to management problems

1.31 Knowledge of principles and generalizations
- To recall fundamental principles and generalizations involved in statistics

1.32 Knowledge of theories and structures
- To recognize fundamental theories and structures in statistics

2.10 Translation

- Demonstrate the ability to translate a problem given in technical phraseology into concrete or less abstract phraseology
- Demonstrate the ability to translate an abstraction, such as a general principle, by giving an illustration or sample

2.20 Interpretation

- Demonstrate the ability to distinguish among warranted, unwarranted, or contradicted conclusions drawn from a set of statistical data

2.30 Extrapolation

- Demonstrate the ability to deal with statistical conclusions of a management study in terms of inferences made from explicit statements

3.00 Application

- Demonstrate the ability to apply statistical principles, methods and techniques to new situations

APPENDIX 7

TABLE 16

MANAGEMENT STATISTICS TEST BLUEPRINT

	Data Display	Descriptive Statistics	Normal Distribution	Sampling	Correlation &Regression	Totals
Knowledge 1.00	3.24%	8.91%	2.97%	8.64%	3.24%	27%
Compre-hension 2.00	4.80%	13.20%	4.40%	12.80%	4.80%	40%
Application 3.00	3.96%	10.89%	3.63%	10.56%	3.96%	33%
Totals	12%	33%	11%	32%	12%	100%

APPENDIX 8

MANAGEMENT STATISTICS
FINAL EXAMINATION

DIRECTIONS: Select the best single answer for the following multiple choice questions and circle the appropriate letter. A normal curve table will be provided for your use.

Name: ____________________________________

Date: ____________________________________

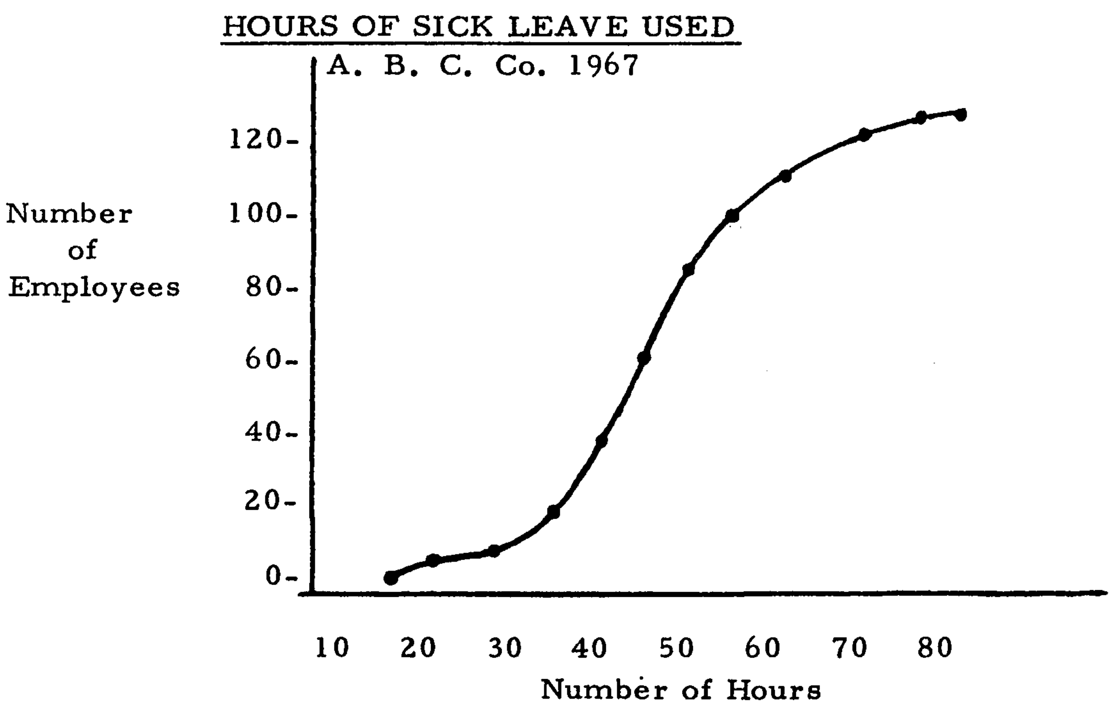
1. The best method for distinguishing between lines of a multiple chart is to:

   a. Use a different color for each line
   b. Use a different thickness for each line
   c. Use a different pattern design for each line (e.g., solid, dots, dashes, etc.)
   d. None of the above

2. The function (s) of data presentation:

   a. Is to reduce large volumes of data to important detail
   b. Is to bring attention to strengths and weaknesses
   c. Are both of the above
   d. Is neither of the above

3. Judging from the ogive below, the number of employees who used between 50 and 60 hours of sick leave was approximately:



   a. 30
   b. 100
   c. 45
   d. None of the above

4. It is easiest to compare differences in frequency between adjacent intervals in:

   a. An ogive
   b. A frequency polygon
   c. A histogram
   d. An array

5. A trend in data is most easily discerned from a presentation in the form of a:

   a. Table
   b. Column chart
   c. Surface chart
   d. Line chart

6. It is desired to prepare a single data presentation depicting the trend in total number of DoD employees in four career fields (contract specialists, engineers, management analysts, and quality and inspection) and the contribution each of the career fields makes to the total over a period of twenty years. Which one of the following types of presentations would probably portray this trend most clearly?

   a. Multiple curve chart
   b. Sub-divided surface chart
   c. Grouped column chart
   d. Sub-divided column chart

7. It is desired to prepare a single data presentation depicting the trend in a number of DoD civilian employees in each of four career fields (contract specialists, engineers, management analysts, quality and inspection) over a 20-year period. Which one of the following types of presentations would probably portray this trend most clearly?

   a. Multiple curve chart
   b. Sub-divided surface chart
   c. Grouped column chart
   d. Sub-divided column chart

8. Central tendency of a population can be estimated by using a sample estimate of the population.

   a. Skewness
   b. Variance
   c. Mode
   d. Extreme values

9. The expression $\frac{\sum_{i=1}^{n} x_i}{n}$ may be shown as:

   a. $\frac{x_{i=1} + x_n}{n}$

   b. $\frac{x_n - x_i}{n}$

   c. $\frac{x_1}{n} \times \frac{x_2}{n} \times \ldots \times \frac{x_n}{n}$

   d. $\frac{x_1 + x_2 + \ldots + x_n}{n}$

10. A continuous variable is a variable which is:

    a. Continuously varying
    b. Never varying
    c. Measurable
    d. Countable

11. Raw data is usually put into grouped data form when:

    a. Greater accuracy is desired
    b. There are more than ten pieces of data
    c. The data is widely dispersed.
    d. A large number of calculations must be done by hand

12. If plus and minus signs were not ignored in calculating the average deviation, its value would:

    a. Equal that of the standard deviation
    b. Equal zero
    c. Be greater than that of the standard deviation
    d. Be the average deviation, since signs are not ignored in its calculation

13. In calculating the mean for grouped data, the assumption is made that the mean of the values in each interval is:

    a. Greater than the mid-value of the interval
    b. Less than the mid-value of the interval
    c. Equal to the mid-value of the interval
    d. Greater than the mid-value of each interval in intervals below the mean and is less than the mid-value of each interval in intervals above the mean

14. Two events are said to be independent if:

    a. They are mutually exclusive
    b. Their marginal probabilities sum to one
    c. The occurrence or non-occurrence of one does not affect the other
    d. Their conditional probabilities sum to one

15. Events are said to be mutually exclusive if:

    a. The sum of their probabilities is one
    b. They never occur together
    c. One or the other always occurs
    d. The occurrence of one has no effect on the other

16. An example of mutually exclusive events is the occurrence of:

    a. A heart and a spade on a single selection from a 52-card deck
    b. A six and then a two on two successive rolls of a die
    c. A red bead on each of two successive draws without replacement from a bowl of ten beads, of which eight are red
    d. A nine and a diamond on a single selection from a 52-card deck

17. The mean of the data shown below is:

INTERVAL	FREQUENCY
21-23	3
24-26	7
28-29	9
30-32	15
33-35	22
36-38	18
39-41	14
42-44	8
45-47	4
	100

a. 34.6
b. 34.4
c. 34.2
d. None of the above

18. Of the events that can occur in a situation, the probability that event A will occur is 0.3 and the probability that event B will occur is 0.5. If A and B are mutually exclusive, what is the probability that A or B will occur?

a. 0.8
b. 0.5
c. 0.15
d. None of the above

19. The mean and median of the data below:

INTERVAL #	INTERVAL	FREQUENCY
1	5- 9	1
2	10-14	0
3	15-19	5
4	20-24	9
5	25-29	15
6	30-34	12
7	35-39	9
8	40-44	6
9	45-49	4

a. Fall into intervals 5 and 6, respectively
b. Both fall into interval 5
c. Both fall into interval 6
d. Fall into intervals 6 and 5, respectively

20. A die (singular of dice) is rolled twice. The rolls constitute:

a. Dependent events
b. Independent events
c. Mutually inclusive events
d. Mutually exclusive events

21. If an urn contains 5 red beads, 3 green beads, and 2 white beads, the probability of selecting a red bead on the first random selection and then a green bead on the second selection when sampling without replacement is:

a. 1/3
b. 15/64
c. 1/6
d. None of the above

22. The correct equation for calculating the standard normal deviate is:

a. $z = \frac{x - \sigma}{\mu}$

b. $z = \frac{x - \mu}{\sigma}$

c. $z = \frac{\mu - x}{\sigma}$

d. $z = \frac{x - x}{\mu}$

23. Which of the following is a characteristic of the normal distribution?

a. It is symmetrical about the origin
b. The total area under the curve is infinite
c. The two extremes of the curve are assymptotic to the horizontal axis
d. It is a discrete distribution

24. Approximately what percent of the area in a normal distribution lies between the mean and a point one standard deviation above the mean?

    a. 26
    b. 34
    c. 42
    d. None of the above

25. If x is a normally distributed random variable with mean of 0 and standard deviation of 1 and A is a value of the X scale that is greater than zero, the P (X > A) equals:

    a. P (X > -A)
    b. 1 - P (X < - A)
    c. P (X > 0) - P (X < -A)
    d. 1 - P (X > - A)

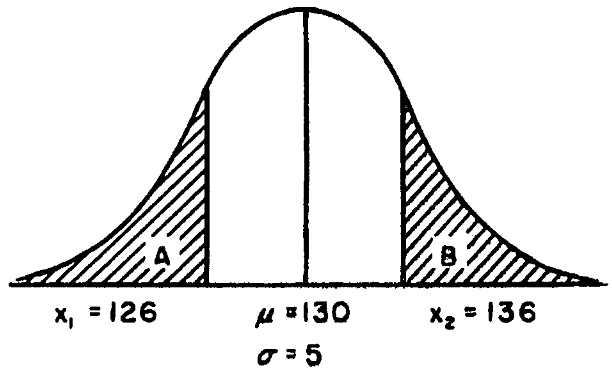
26. The area beneath the normal curve between points A and B is analogous to:

    a. The probability that a value in a normally distributed population will fall between A and B
    b. The proportion of normally distributed population values that will fall between A and B
    c. The relative frequency of occurrence of population values between A and B
    d. All of the above

27. In a normally distributed population, the probability that a single item will have a value exactly equal to the mean plus one standard deviation is:

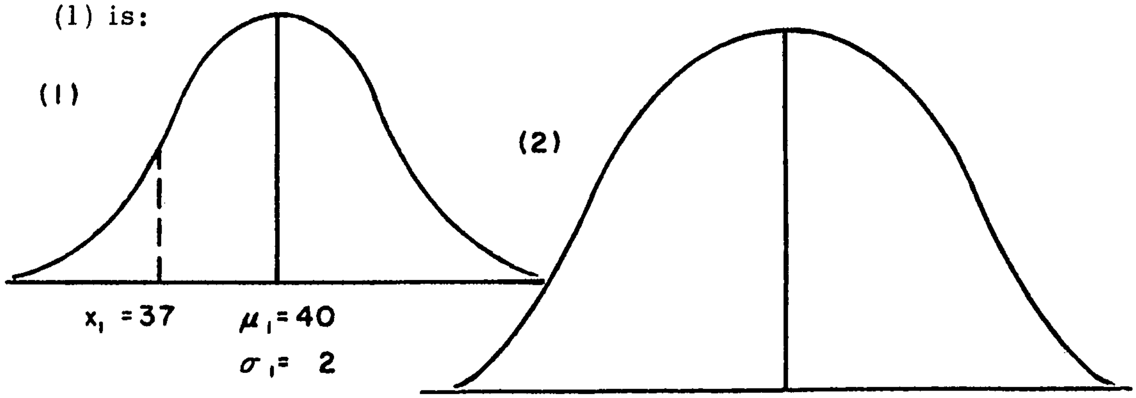
    a. 0.1586
    b. 0.5000
    c. 0.8414
    d. 0.0000

28. In the normal distribution shown below, which of the following relationships is true:



a. A < B
b. (A + B) = .05
c. (A + B) + 1 - (A + B)
d. P(126 < X < 136) + 1 - (A + B)

29. Shown below are two normal distributions with means and standard deviation as indicated. The value in (2) that will have the same proportion of area to its right that the value (37) has to its left in (1) is:



a. 375
b. 525
c. 453
d. None of the above

30. To find the percentage of values of a normal distribution included in the range $1/4\,\sigma$ above the mean to 1.00σ above the mean, the correct procedure is:

    a. To find the percentage included between the mean and $3/4\sigma$ above the mean
    b. To find 1/2 of the percentage included between the mean and $1\ 1/2\sigma$ above the mean
    c. To subtract the percentage included between the mean and $1/4\sigma$ above it from the percentage included between the mean to $1\,\sigma$ above it
    d. To subtract the percentage included between the mean and $1/4\sigma$ above it from the percentage included between $1\,\sigma$ above the mean and $+\infty$

31. The type of sample most likely to introduce bias is the:

    a. Area sample
    b. Judgment sample
    c. Simple random sample
    d. Stratified sample

32. Which of the following is true of assignable causes of variation:

    a. They are potentially identifiable
    b. They cannot be regulated
    c. They will always be present
    d. None of the above

33. When the sample mean is used as an estimator of the population mean, it is said to be:

    a. A biased estimate
    b. An exact estimate
    c. An interval estimate
    d. A point estimate

34. The statistics used in calculating a confidence interval for a population mean are:

    a. The sample average and the sample standard deviation
    b. The sample average and the population range
    c. The sample standard deviation and the sample percentile
    d. The sample average and the sample percentile

35. The sample size used to calculate the control limits for a p-Chart should be:

    a. The total of all past observations
    b. A number with an even square root
    c. The sample size used to collect the historical data.
    d. The sample size to be used in the future

36. Normal distribution probabilities may be used to estimate binomial probabilities if:

    a. p' is between 0.1 and 0.9, and np' is greater than 5
    b. p' is less than 0.1 or greater than 0.9, and np' is greater than 5
    c. p' is less than 0.5 and np' is less than 5
    d. p' is between 0.1 and 0.9 and np' is less than 5

37. The lower control limit of a control chart for proportion defective is:

    a. Never zero
    b. Always zero
    c. Sometimes zero
    d. Sometimes negative

38. A 90% confidence interval for the mean of a certain population is: $15.96 < \mu < 17.44$. This statement means that:

    a. 90% of all population means fall in the interval 15.96 to 17.44
    b. The probability is .90 that the interval includes μ
    c. The β risk is .10
    d. All of the above

39. A 95 percent confidence interval of <u>47.5 to 62.5</u> for a population mean indicates that:

    a. Ninety-five percent of the population means fall within the range 47.5 to 62.5
    b. Ninety-five percent of all sample means would fall within the range 47.5 to 62.5
    c. We are ninety-five percent confident that the range 47.5 to 62.5 encompasses the population mean
    d. All of the above

40. Two samples A and B are taken from a particular population. A and B both are of size 100. A 95% confidence interval for the population mean is calculated from each sample. The upper limits for the intervals would probably be:

a. Exactly equal
b. Different
c. Equal to the population mean
d. Greater than the highest value of the population

41. The advantage of an interval estimate of a parameter is that:

a. The estimate is exact
b. It shows how precisely the parameter is being estimated
c. The estimate is approximate
d. The population parameter will always be in the estimated interval

42. Two-sigma control limits might be used in place of three-sigma control limits when:

a. No out-of-control points have been observed for a relatively long period of time
b. It is relatively inexpensive to look for assignable causes of variation
c. Normal variation of the observed process is small
d. The process indicates good statistical control

43. If a random sample of 100 observations results in a sample mean of 42" and sample standard deviation of 3", a 95% confidence interval for the population mean will be approximately:

a. 36" to 48"
b. 41.4" to 42.6"
c. 40.2" to 43.8"
d. None of the above

44. A certain population is of size 100,000. Sample A of 100 units and sample B of 1,000 units are taken from the population. Ninety-five percent confidence intervals for the population mean are calculated from each sample. The confidence interval for sample A will be:

a. Larger than the confidence interval for sample B
b. Smaller than the confidence interval for sample B
c. The same size as the confidence interval for sample B
d. Less likely to include the population mean than would the confidence interval for sample B

45. An inspector samples a box of 100 bolts by the following procedure:

(1) Write the numbers 0 through 9 on ten slips of paper, one number per slip, (i.e., 0 on one slip of paper, 1 on another slip of paper, etc.)
(2) Prepare a table of two digit numbers by drawing one slip of paper from a hat, recording the number, replacing the slip of paper, shaking the hat, drawing a second number, recording and replacing. Repeat this cycle ten times, i.e. ten two digit numbers are determined)
(3) Line up the bolts on a bench and number them
(4) Inspect each bolt having a number corresponding to a number in the number table

What type of sample did the inspector take?

a. Stratified
b. Judgment
c. Simple random
d. Area

46. Approximately 100 of form #1719 are prepared each day. Entry A is very important. However, a certain number of erroneous "A" entries are expected. It is desired to determine when the number of erroneous "A" entries is significantly too large or too small. What statistical technique would be best for use on a repetitive or periodic basis:

a. A test of hypothesis
b. An attributes control chart
c. A variables control chart
d. A regression analysis

47. An urn contains an unknown proportion of red and green beads. A random sample of 50 beads selected with replacement from the urn included 35 (i. e., 70%) red beads. The sample size which will be necessary to provide 95% confidence that the sample proportion does not differ from the true proportion by more than 5% (absolute) is at least:

    a. 756
    b. 560
    c. 323
    d. None of the above

48. Certain electronic components manufactured by a firm have a mean lifetime of 800 hours and a standard deviation of 60 hours. The probability that a random sample of 100 of these components will have a mean lifetime of 770 hours or less is approximately:

    a. .69
    b. .00
    c. .09
    d. None of the above

49. The slope of a horizontal line is:

    a. One
    b. ∞
    c. 0
    d. Indeterminate

50. A graph showing the sets of Y values for each value of X is called a:

    a. Scatter diagram
    b. Regression line
    c. Frequency distribution
    d. Ogive

51. If b is negative in the equation $y = a + bx$, the line has a:

    a. Negative X intercept
    b. Negative slope
    c. Negative y intercept
    d. None of the above

52. The rank method of correlation considers the:

a. Values of the variables
b. Dispersion of the values of the variables
c. Neither of the above
d. Both of the above

53. When estimating the dependent variable (Y) from the independent variable (X) the value of Y is most reliable:

a. At the mean of X
b. At the extreme values of the range of X
c. Beyond the extreme values of the range of X
d. Uniformly throughout the range of X

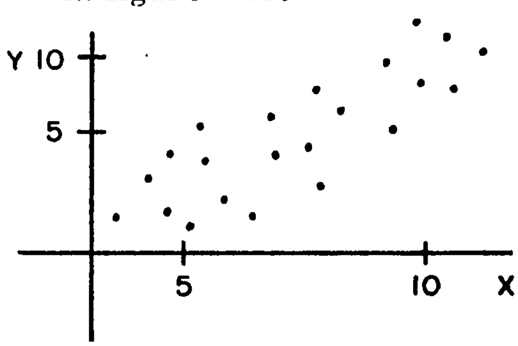
54. The relationship exhibited by the plotted points in the figure below is said to fit a higher order curve because:

a. Y increases with X
b. The best fitting curve is not a straight line
c. The values have considerable dispersion
d. None of the above

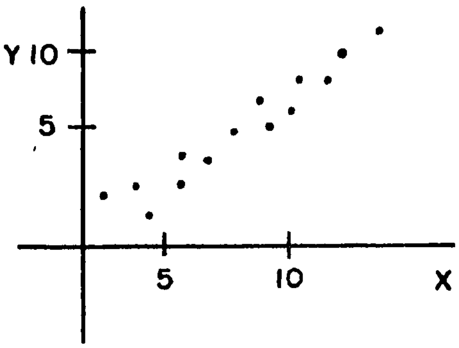
55. The graph of the equation (y = 3 - x) is:

a. A straight line through (0, 3) (3, 0)
b. A curved line with negative slope
c. A straight line that slopes up to the right
d. A straight line through the origin

56. The standard error of estimate displayed by the plotted points in figure A is:



(Figure A)



(Figure B)

a. Smaller than the standard error of estimate for the plotted points in figure B
b. Larger than the standard error of estimate for the plotted points in figure B
c. Less reliable than the standard error of estimate for the plotted points in figure B
d. More reliable than the standard error of estimate for the plotted points in figure B

57. in testing a given hypothesis, the maximum probability with which we would be willing to risk a Type I error is called the:

a. Level of significance
b. Critical region
c. Region of significance
d. Probability of acceptance

58. In testing the hypothesis that the mean of a population equals a particular value the statistics that are usually considered are the:

a. Sample average and sample range
b. Sample range and sample mode
c. Sample average and sample standard deviation
d. Sample standard deviation and sample mode

59. The means of a population truly equals C. A two sided test of hypothesis is performed. The hypothesis to be tested is that the mean equals C ($H_0 : \mu_0 = C$). The level of a significance is $\alpha = .05$. The $Z\frac{\alpha}{2}$ value for an $\frac{\alpha}{2}$ of .025 is 1.96 (taken from a table of cumulative probabilities of the normal probability distribution). The test statistic Z_t calculated from the sample is 1.90.

$$Z_t \quad \frac{\overline{X} - \mu_0}{\frac{\sigma}{\sqrt{n}}} \quad . \qquad H_0 : \mu_0 = C$$

$$Z\frac{\alpha}{2} = .05$$

$$Z_t = 1.96$$

$$= 1.90$$

What type of statistical error has occurred?

a. A true hypothesis has been rejected
b. A false hypothesis has been accepted
c. The sample size was too small
d. No error has occurred

60. It is desired to test the hypothesis that the mean of a particular population equals a given constant. The α risk is held constant. Two separate samples are taken. Sample A has a size of 100. Sample B has a size of 1,000. The β risks for Sample A are:

a. Less than the β risks for sample B
b. Greater than the β risks for sample B
c. The same as the β risks for sample B
d. Less variable than the β risks for sample B

END

APPENDIX 9

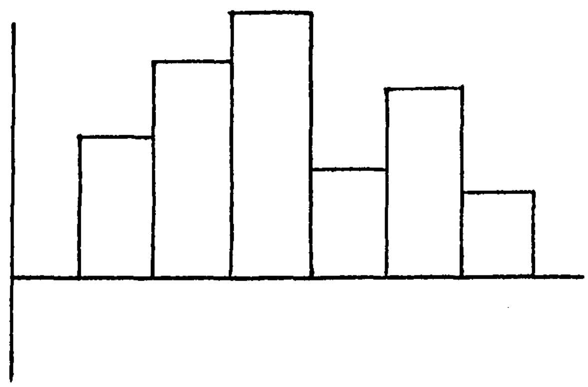
MANAGEMENT STATISTICS
PRE-TEST

DIRECTIONS: Select the best single answer for the following multiple choice questions and circle the appropriate letter.

Name: ______________________________

Date: ______________________________

1. The chart below is an example of:



   a. A histogram
   b. An ogive
   c. A frequency polygon
   d. A bar chart

2. It is desired to prepare a single data presentation to compare the number of DoD employees in each of four career fields on a given date. Which one of the following types of presentations would probably portray this data most clearly?

   a. Line chart
   b. Column chart
   c. Bar chart
   d. Step chart

3. A portion of a routine periodic report for management is devoted to explanation of specific exception-type problems. What manner of presentation should be used for this portion of the report?

   a. Bar chart
   b. Narrative
   c. Tabular
   d. Surface chart

4. The mean of a set of values is:

   a. The middle value when arrayed
   b. The largest value
   c. The arithmetic average
   d. The mid-range

5. The middle value in an array of values is called the:

   a. Mean
   b. Median
   c. Mode
   d. All of the above

6. What is the effect upon the standard deviation of a set of data if each value in the set is increased by two units?

   a. Unaffected
   b. Doubled
   c. Quadrupled
   d. Halved

7. The measure of dispersion most affected by extreme values is the:

   a. Variance
   b. Range
   c. Standard deviation
   d. Average deviation

8. If $3x + \frac{y}{2} = 5$, then x equals:

   a. $2 - \frac{y}{2}$

   b. $5 - \frac{y}{6}$

   c. $15 - \frac{y}{2}$

   d. None of the above

9. The mean of the data below is:

   39
   38
   38
   36
   36
   36
   35
   34

32
31
30

a. 36.0
b. 35.5
c. 34.0
d. None of the above

10. For a single roll of a pair of dice, what is the probability that the sum of the spots on the upturned faces is either 5 or 6?

a. 20/1296
b. 1/4
c. 6/36
d. None of the above

11. The variable (x) considered in a normal curve analysis:

a. Can take on any value
b. Can take on any positive value
c. Is restricted to integers
d. Can take on any value between -3 standard deviations and +3 standard deviations from the mean

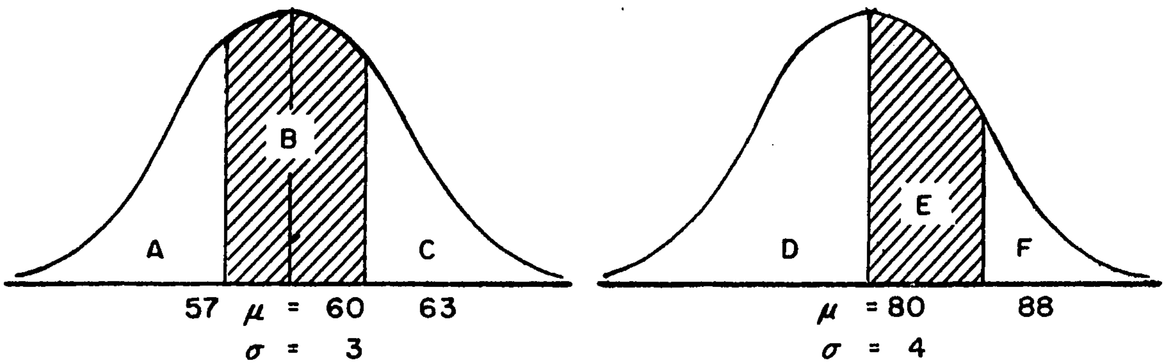
12. The normal distribution curve can be completely described if:

a. Its mean and standard deviation are known
b. The population size is known
c. The unit of measurement is known
d. The variable being measured is continuous

13. In any normal distribution the percentage of area lying between two points which are one standard deviation apart:

a. Will be approximately 34%
b. Will never exceed 34%
c. Will never be less than 34%
d. Will vary depending upon the two points

14. In the two normal distributions shown below, areas:



a. A + C = F
b. A + C + D = B
c. D - F = B
d. $A + \frac{B}{2} = D$

15. If the lifetimes of a particular type of tire are normally distributed with a mean of 25,000 miles and standard deviation of 3,000 miles, 97.5% of the tires can be expected to last longer than approximately:

a. 31,000 miles
b. 22,150 miles
c. 19,000 miles
d. 16,000 miles

16. A random sample is one in which:

a. All items in the sample are identical
b. Each item in the population being sampled has an equal chance of being selected in the sample
c. The population is normally distributed
d. Biased results are expected from the calculation of estimates

17. During the analysis of a control chart, the presence of an assignable cause of variabion may be indicated by:

a. Trends
b. Shifts
c. Extreme variation
d. All of the above

18. The minimum sample size required in estimating a population proportion is dependent upon:

    a. The required precision or tolerance
    b. The required confidence level
    c. An estimate of the proportion in question
    d. All of the above

19. The primary reason for sampling rather than making a complete check of the population is that sampling is:

    a. More economical
    b. The only alternative in most situations
    c. More accurate
    d. More scientific

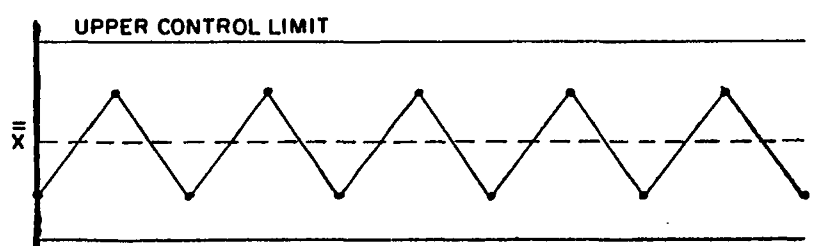
20. A process is said to be "in control" when variation is attributable to:

    a. Chance causes only
    b. Assignable causes only
    c. Either chance or assignable causes, but not both
    d. Neither chance nor assignable causes

21. A control chart is generally used to indicate:

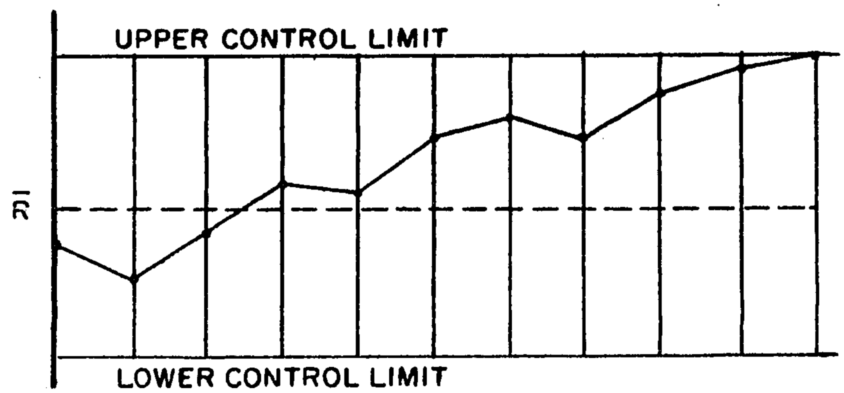
    a. When there are significant changes
    b. What has caused a change
    c. Both of the above
    d. Neither of the above

22. The pattern of variability shown below on the chart for sample averages most likely is an indication that:



    a. The process is extremely stable
    b. The process is out of control
    c. Assignable causes of variation are present
    d. Samples were improperly selected or results are being erroneously reported

23. The plotting of sample ranges shown below on the R-Chart most likely indicates that:



a. The process average is shifting upwards
b. The process is incapable of meeting requirements
c. The quality level of output is declining
d. The process variability is increasing

24. It is desired to determine when the time to perform a specific repetitive task is significantly too long or too short. What statistical technique would be best for use on a repetitive or periodic basis?

a. A test of hypothesis
b. An attributes control chart
c. A variables control chart
d. A regression analysis

25. In the equation y = a + bx, a represents the:

a. y intercept of the graph of the equation
b. x intercept of the graph of the equation
c. Slope of the graph
d. Minimum value of y

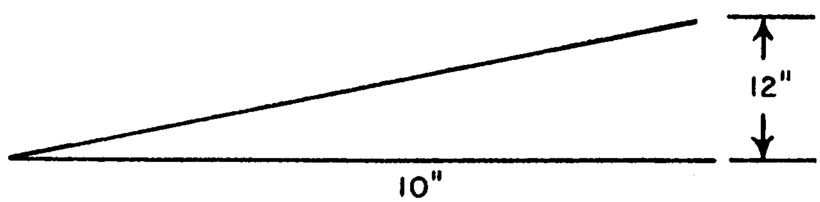
26. If all of the points of a scatter diagram fall exactly on a straight line, which is neither vertical nor horizontal, the correlation coefficient is:

    a. 0
    b. +1 or -1
    c. ∞
    d. Indeterminate

27. A correlation coefficient of -.9 indicates:

    a. A low relationship between the variables
    b. That the value of X has a large effect on the value of Y
    c. A high relationship between the variables
    d. That Y varies directly with X

28. If a straight rafter has a rise of 12 inches in 10 feet its slope is:



    a. 1.0
    b. .10
    c. 1.2
    d. None of the above

29. Tests of hypothesis may be used for the purpose of:

    a. Relating one variable to another
    b. Testing for a difference between the parameters of two populations
    c. Proving that the means of two populations are the same
    d. Determining the amount of variation within a population

30. Generally, the level of significance for a particular test of hypothesis is:

a. Determined by calculation of z
b. Chosen by the designer of the test
c. Dependent of sample size
d. All of the above

END

APPENDIX 10

MANAGEMENT STATISTICS STUDENT SURVEY

DIRECTIONS: Select the single best answer for the following multiple choice questions and circle the appropriate letter.

DATE:

____

1. Age

   a. 25 or under
   b. 26 - 35
   c. 36 - 45
   d. 46 - 55
   e. Over 55

2. Years in Federal service (military plus civilian experience)?

   a. Under three years
   b. 3 - 10 years
   c. 11 - 20 years
   d. Over 20 years

3. Years as a supervisor or manager in Federal service (military plus civilian experience)?

   a. None
   b. Under three years
   c. 3 - 10 years
   d. 11 - 20 years
   e. Over 20 years

4. Highest level of formal education?

   a. High school graduate
   b. College work but no degree
   c. College graduate
   d. Graduate degree

5. Highest level of formal mathematics training?

   a. High school mathematics
   b. One year college mathematics
   c. Two years college mathematics
   d. Over two years college mathematics

6. College courses taken for credit during the past three years?

   a. None
   b. One
   c. Two
   d. Three or more

7. The number of courses in 6. above to which the Government made a contribution, either time or money?

   a. None
   b. One
   c. Two
   d. Three or more

8. Short courses taken during the past three years (include only those courses that are work related and where a certificate or similar document was awarded upon completion)?

   a. None
   b. One
   c. Two
   d. Three or more

9. The number of courses in 8. above to which the Government made a contribution, either in time or money?

   a. None
   b. One
   c. Two
   d. Three or more

10. Are you familiar with the term Programmed Instruction (PI)?

    a. Yes
    b. No

11. Have you ever taken a course in which Programmed Instruction (PI) was one of the teaching techniques used?

    a. Yes
    b. No

12. If answer to 11. above is yes, what is your reaction to the use of Programmed Instruction (PI)?

    a. Effective
    b. Not effective

13. My attendance in this course is primarily the result of:

    a. My supervisor's recommendation that I acquire additional technique knowledge in Management Statistics
    b. My request to attend a course in Management Statistics
    c. My substitution for someone who was originally nominated for the course
    d. Factors of which I am unaware

14. The successful completion of this course will improve my opportunities for career advancement in my organization?

    a. Yes
    b. No
    c. Don't know

15. Now that I am enrolled in this course, my primary objective is to:

    a. Acquire as much Management Statistics technique knowledge and skill as possible in order to further my career
    b. Obtain an "outstanding" course grade
    c. Acquire as much Management Statistics technique knowledge and skill as possible in order to improve my work performance
    d. Acquire a certificate of successful completion

16. Have you previously attended a course conducted at AMETA?

    a. Yes
    b. No

APPENDIX 11

MANAGEMENT STATISTICS
END-OF-COURSE STUDENT EVALUATION

DIRECTIONS: Select the single best answer for the following multiple choice questions and circle the appropriate letter.

DATE:

____

1. Do you think the course is logically organized?

   a. Yes
   b. No

2. Do you think that the time devoted to each part of the course was adequate?

   a. Yes
   b. No

3. Do you think that the time devoted to each part of the course was:

   a. Fully and effectively utilized
   b. Not effectively utilized in a few instances
   c. Not effectively utilized in many instances

4. Training received in this course will be:

   a. A great help in my job
   b. Of some help in my job
   c. Of little help in my job

5. Were your primary objectives for attending the course achieved?

   a. Yes
   b. No
   c. For the most part

6. Have you ever taken a course before using Programmed Instruction (PI)?

   a. Yes
   b. No

7. How do you evaluate the use of Programmed Instruction (PI) now that you have used it in class?

   a. Effective
   b. Not effective

8. Do you feel that you apply yourself to a greater extent when you are required to use Programmed Instruction(PI)?

   a. Yes
   b. No

9. Which teaching method do you prefer, Programmed Instruction (PI) or Lecture-Conference?

   a. Programmed Instruction (PI)
   b. Lecture-Conference

10. When you individually required any kind of course related assistance within the classroom, was this assistance largely provided by:

    a. The instructor
    b. The group of fellow students in which you were working
    c. Individual fellow students

11. Average daily non-class time devoted to the study of course materials:

    a. None
    b. One hour
    c. Two hours
    d. Three or more hours

12. In comparison to other short courses you have taken in the Federal Government, would you rate this course as:

    a. Excellent
    b. Good
    c. Fair
    d. Poor

1. Do you think the course is logically organized?

   a. Yes
   b. No

2. Do you think that the time devoted to each part of the course was adequate?

   a. Yes
   b. No

3. Do you think that the time devoted to each part of the course was:

   a. Fully and effectively utilized
   b. Not effectively utilized in a few instances
   c. Not effectively utilized in many instances

4. Training received in this course will be:

   a. A great help in my job
   b. Of some help in my job
   c. Of little help in my job

5. Were your primary objectives for attending the course achieved?

   a. Yes
   b. No
   c. For the most part

6. Average daily non-class time devoted to the study of course materials:

   a. None
   b. One hour
   c. Two hours
   d. Three or more hours

7. In comparison to other short courses you have taken in the Federal Government, would you rate this course as:

   a. Excellent
   b. Good
   c. Fair
   d. Poor

8. When you individually required any kind of course related assistance within the classroom, was this assistance provided by:

   a. The instructor
   b. The group of fellow students in which you were working
   c. Individual fellow students

APPENDIX 12

INSTRUCTOR QUESTIONNAIRE

1. Age:

2. Years in Federal Service:

3. Years experience in teaching:

4. Years experience in teaching Management Statistics:

5. Educational background:

   Degree:

   Advanced degree:

6. Number of college level statistics courses completed:

7. I prefer to teach courses:

   . by the lecture method

   . by lecture plus programmed instruction (PI)

8. Were there any environmental or group conditions within the classroom that were different, or that affected teaching and learning as between the lecture method and programmed instruction (PI)?

9. Were you able to assign homework and class projects in a similar manner as between those classes employing the lecture method and those in the programmed instruction (PI) mode?

APPENDIX 13

METHOD FOR IDENTIFYING STUDENT SURVEY SHEETS

Each copy of the student survey sheet was coded by placing a small ink mark beneath a letter contained in the words of the "Directions." The first set of student survey sheets had an ink mark beneath the first letter of the first word, the second set of student survey sheets had an ink mark beneath the second letter of the first word, etc. The ordered sets of student survey sheets were distributed in such a way so as to identify which individual had a particular set.

APPENDIX 14

ODD-EVEN SCORES FOR 30 ITEM PRE-TEST

108 Subjects

ODD	EVEN	ODD	EVEN	ODD	EVEN
6	7	8	12	10	8
7	11	10	10	8	7
7	6	7	8	8	6
9	6	9	9	6	9
8	9	7	8	7	10
8	5	8	9	7	11
8	8	8	9	8	10
5	6	7	6	14	11
8	5	8	7	5	5
11	6	8	8	7	8
10	7	10	7	12	11
8	8	5	7	5	7
7	7	7	7	10	7
7	6	8	9	6	5
10	10	10	9	10	8
7	10	9	10	11	11
6	8	5	8	7	8
6	11	5	8	4	7
6	8	10	9	8	3
6	7	10	7	8	7
8	7	9	9	8	8
7	6	9	6	6	6
9	5	5	5	9	9
6	5	9	10	11	7
11	9	6	7	10	12
11	8	9	7	10	6
8	4	6	3	7	6
13	12	5	4	5	8
2	4	9	11	8	9
9	7	9	9	7	7
10	12	5	7	9	10
9	8	8	10	6	10
11	7	7	11	6	7
6	6	6	9	7	7
8	4	9	11	10	8
9	9	6	10	11	8

APPENDIX 15

ODD-EVEN SCORES FOR 60 ITEM FINAL EXAMINATION

108 Subjects

ODD	EVEN	ODD	EVEN	ODD	EVEN
28	27	21	23	23	15
26	27	20	24	22	16
27	26	17	25	18	20
25	25	18	22	18	18
24	25	18	22	16	20
24	25	16	23	14	21
22	26	19	19	16	19
24	24	18	19	14	20
22	25	18	18	16	18
22	23	18	17	14	12
22	22	14	20	29	29
22	22	13	21	25	27
22	20	11	22	21	26
20	21	11	20	20	26
16	24	14	17	24	20
19	18	13	17	20	22
16	22	9	16	17	21
17	21	9	14	17	20
15	21	8	15	16	20
15	20	9	13	17	19
17	17	25	27	16	19
15	18	24	27	16	18
16	17	26	25	15	19
13	20	23	27	17	16
12	20	19	26	17	15
15	16	23	22	12	18
14	17	22	23	12	17
13	14	24	20	13	15
8	11	20	24	10	18
26	28	23	20	11	16
26	27	19	24	10	16
25	27	20	22	12	14
24	23	17	24	12	11
22	24	20	20	10	13
22	23	17	22	10	8
23	22	19	20	6	9

APPENDIX 16

TABLE 17

PRE-TEST (X) AND FINAL EXAMINATION (Y) TEST SCORES OF SUBJECTS (HYPOTHESIS 1)

A_1 - Lecture Method, A_2 - Programmed Instruction (PI)
I_1 - Instructor 1
I_2 - Instructor 2

A_1 I_1		A_1 I_2		A_2 I_1		A_2 I_2	
X	Y	X	Y	X	Y	X	Y
12	53	17	29	9	37	19	45
17	48	12	32	9	34	18	42
25	53	12	39	20	44	14	25
13	41	18	31	18	50	13	27
14	40	15	40	12	41	16	31
13	33	14	50	18	39	19	35
14	47	16	23	18	50	14	28
13	31	16	24	15	38	17	32
17	50	12	37	20	46	13	22
15	34	17	33	16	43	13	27
13	35	15	36	18	43	16	35
18	43	15	33	15	42	22	51
17	33	17	52	14	40	18	29
13	38	20	43	15	36	18	33
20	55	17	31	17	35	12	15
17	27	19	35	18	40	16	43
11	44	13	22	18	51	15	27
19	44	19	44	25	50	11	17
14	36	12	23	10	38	11	22
16	31	16	41	15	39	15	37
13	49	20	45	18	44	22	57
17	38	18	44	15	24	18	33
15	49	17	46	10	36	11	25
16	46	13	33	19	34	17	36
14	32	18	43	13	35	23	46
6	33	19	39	16	42	12	33

APPENDIX 17

TABLE 18

CALCULATION OF TREATMENT COMBINATION MEANS FROM DATA OF APPENDIX 16 (HYPOTHESIS 1)

($M_x = 15.7019$, $M_y = 37.6442$, $B = 1.3410$)

	Treatment Combinations			
	A_1 I_1	A_1 I_2	A_2 I_1	A_2 I_2
$\bar{X}$	15.0769	16.0385	15.8077	15.8846
$\bar{X} - M_x$	-0.6250	0.3365	0.1058	0.1827
$B(\bar{X}-M_x)$	-0.8381	0.4513	0.1418	0.2450
$\bar{Y}$	40.8846	36.4615	40.4231	32.8077
adj. $\bar{Y}$	41.7227	36.0102	40.2812	32.5627
n	26	26	26	26
Standard Error of $\bar{Y}$	1.37	1.37	1.37	1.37

APPENDIX 18

TABLE 19

CALCULATION OF TREATMENT MEANS FROM DATA OF APPENDIX 16 (HYPOTHESIS 1)

(M_x = 15.7019, M_y = 37.6442, B = 1.3410)

	Treatment Combination			
	A_1	A_2	I_1	I_2
$\bar{X}$	15.5577	15.8462	15.4423	15.9615
$\bar{X}-M_x$	-0.1442	0.1442	-0.2596	0.2596
$B(\bar{X}-M_x)$	-0.1934	0.1934	-0.3481	0.3481
$\bar{Y}$	38.6731	36.6154	40.6538	34.6346
adj. $\bar{Y}$	38.8665	36.4220	41.0020	34.2865
n	52	52	52	52
Standard Error of $\bar{Y}$	0.97	0.97	0.97	0.97

APPENDIX 19

TABLE 20

PRE-TEST (X) AND FINAL EXAMINATION (Y) TEST SCORES OF SUBJECTS (HYPOTHESIS 2)

A_1 - Lecture Method, A_2 - Programmed Instruction (PI)
B_1 - Subject 35 Years of Age or Less
B_2 - Subject Greater Than 35 Years of Age

A_1 B_1		A_1 B_2		A_2 B_1		A_2 B_2	
X	Y	X	Y	X	Y	X	Y
12	53	13	41	18	42	9	37
17	48	14	40	13	27	9	34
25	53	13	33	16	31	20	44
20	48	13	31	16	35	18	39
14	47	15	34	22	51	15	38
17	50	18	43	18	29	15	42
17	33	13	38	16	43	15	36
20	55	11	44	15	37	10	38
17	27	11	38	22	57	15	39
13	49	19	44	18	33	15	24
17	38	13	19	18	50	10	36
16	46	16	31	12	41	16	42
6	33	15	49	18	50	19	45
17	29	12	32	20	46	14	25
12	39	18	31	16	43	19	35
14	50	15	40	18	43	14	28
12	37	16	24	14	40	13	22
17	33	15	36	17	35	13	27
15	33	20	43	18	40	18	33
17	52	19	35	19	51	12	15
22	54	13	22	25	50	11	17
16	41	19	44	18	44	11	22
18	44	20	45	19	34	17	36
18	43	17	46	13	35	23	46
		19	39			12	33

APPENDIX 20

TABLE 21

CALCULATION OF TREATMENT COMBINATION MEANS FROM DATA OF APPENDIX 19 (HYPOTHESIS 2)

(M_x = 15.9184, M_y = 38.5408, B = 1.0664)

	Treatment Combination			
	A_1 B_1	A_1 B_2	A_2 B_1	A_2 B_2
$\overline{X}$	16.2917	15.4800	17.4583	14.5200
$\overline{X}-M_x$	0.3733	-0.4384	1.5400	-1.3984
$B(\overline{X}-M_x)$	0.3981	-0.4675	1.6423	-1.4913
$\overline{Y}$	43.1250	36.8800	41.1250	33.3200
adj. $\overline{Y}$	42.7269	37.3475	39.4827	34.8113
n	24	25	24	25
Standard Error of $\overline{Y}$	1.52	1.49	1.56	1.52

APPENDIX 21

TABLE 22

CALCULATION OF TREATMENT MEANS FROM DATA OF APPENDIX 19 (HYPOTHESIS 2)

(M_x = 15.9184, M_y = 38.5408, B = 1.0664)

	Treatment Combination			
	A_1	A_2	B_1	B_2
$\bar{X}$	15.8776	15.9592	16.8750	15.0000
$\bar{X}-M_x$	-0.0408	0.0408	0.9566	-0.9184
$B(\bar{X}-M_x)$	-0.0435	0.0435	1.0202	-0.9794
$\bar{Y}$	39.9388	37.1429	42.1250	35.1000
adj. $\bar{Y}$	39.9823	37.0993	41.1048	36.0794
n	49	49	48	50
Standard Error of $\bar{Y}$	1.06	1.06	1.09	1.07

APPENDIX 22

TABLE 23

PRE-TEST (X) AND FINAL EXAMINATION (Y) TEST SCORES OF SUBJECTS (HYPOTHESIS 3)

A_1 - Lecture Method, A_2 - Programmed Instruction (PI)
C_1 - Subject College Graduate
C_2 - Subject Non-College Graduate

A_1 C_1		A_1 C_2		A_2 C_1		A_2 C_2	
X	Y	X	Y	X	Y	X	Y
12	53	17	48	9	37	9	34
25	53	13	41	20	44	18	39
13	33	13	31	12	41	18	50
14	47	15	34	15	38	16	43
17	50	17	33	20	46	18	43
13	38	17	27	15	36	15	42
20	55	11	38	18	51	14	40
13	49	19	44	25	50	10	38
15	49	14	36	15	39	18	44
16	46	17	38	19	34	15	24
14	32	12	32	16	42	13	35
6	33	18	31	19	45	14	25
17	29	16	23	18	42	13	27
12	39	16	24	16	31	19	35
15	40	15	36	14	28	13	22
14	50	20	43	16	35	13	27
17	33	19	44	18	29	12	15
15	33	13	33	18	33	11	17
17	52	19	39	16	43	11	22
22	54			15	27		
16	41			15	37		
20	45			22	57		
18	44			11	25		
17	46			17	36		
18	43			23	46		

APPENDIX 23

TABLE 24

CALCULATION OF TREATMENT COMBINATION MEANS FROM DATA OF APPENDIX 22 (HYPOTHESIS 3)

(M_x = 15.8864, M_y = 38.1364, B = 1.0247)

	Treatment Combination			
	A_1 C_1	A_1 C_2	A_2 C_1	A_2 C_2
$\bar{X}$	15.8400	15.8421	16.8800	14.6842
$\bar{X}-M_x$	-0.0464	-0.0443	0.9936	-1.2022
$B(\bar{X}-M_x)$	-0.0475	-0.0453	1.0181	-1.2318
$\bar{Y}$	43.4800	35.5263	38.8800	32.7368
adj. $\bar{Y}$	43.5275	35.5717	37.8619	33.9686
n	25	19	25	19
Standard Error of $\bar{Y}$	1.51	1.73	1.52	1.75

APPENDIX 24

TABLE 25

CALCULATION OF TREATMENT MEANS FROM DATA OF APPENDIX 22 (HYPOTHESIS 3)

(M_x = 15.8864, M_y = 38.1364, B = 1.0247)

	Treatment Combination			
	A_1	A_2	C_1	C_2
$\bar{X}$	15.8409	15.9318	16.3600	15.2632
$\bar{X}-M_x$	-0.0455	0.0455	0.4736	-0.6232
$B(\bar{X}-M_x)$	-0.0466	0.0466	0.4853	-0.6386
$\bar{Y}$	40.0455	36.2273	41.1800	34.1316
adj. $\bar{Y}$	40.0920	36.1807	40.6947	34.7701
n	44	44	50	38
Standard Error of $\bar{Y}$	1.14	1.14	1.07	1.23

APPENDIX 25

TABLE 26

PRE-TEST (X) AND FINAL EXAMINATION (Y) TEST SCORES OF SUBJECTS (HYPOTHESIS 4)

A_1 - Lecture Method, A_2 - Programmed Instruction (PI)
D_1 - Subject With Ten Years or Less Work Experience
D_2 - Subject With More Than Ten Years Work Experience

A_1	D_1	A_1	D_2	A_2	D_1	A_2	D_2
X	Y	X	Y	X	Y	X	Y
12	53	13	41	9	37	9	34
17	48	13	33	18	50	20	44
25	53	13	31	12	41	18	39
14	40	15	34	18	50	15	38
20	48	13	35	20	46	16	43
14	47	18	43	18	43	15	42
17	33	13	38	14	40	10	38
20	55	11	38	15	36	15	39
17	27	19	44	17	35	18	44
11	44	13	19	18	40	15	24
13	49	14	36	18	51	10	36
17	38	16	31	25	50	13	35
16	46	15	49	19	34	16	42
14	32	12	32	18	42	19	45
6	33	15	40	14	25	13	27
12	39	16	23	16	31	19	35
14	50	16	24	17	32	14	28
17	33	12	37	16	35	13	22
15	33	15	36	22	51	13	27
17	52	17	31	18	29	12	15
22	54	19	35	18	33	16	43
19	44	13	22	15	27	11	17
16	41	12	23	15	37	11	22
20	45	13	33	22	57	23	46
18	44	19	39	18	33	12	33
17	46			11	25		
18	43			17	36		

APPENDIX 26

TABLE 27

CALCULATION OF TREATMENT COMBINATION MEANS FROM DATA OF APPENDIX 25 (HYPOTHESIS 4)

(M_x = 15.6442, M_y = 37.7019, B = 1.1961)

	Treatment Combination			
	A_1 D_1	A_1 D_2	A_2 D_1	A_2 D_2
$\overline{X}$	16.2222	14.6000	16.9630	14.6400
$\overline{X}-M_x$	0.5780	-1.0442	1.3187	-1.0042
$B(\overline{X}-M_x)$	0.6913	-1.2490	1.5773	-1.2012
$\overline{Y}$	43.3333	33.8800	38.7407	34.3200
adj. $\overline{Y}$	42.6420	35.1290	37.1634	35.5212
n	27	25	27	25
Standard Error of $\overline{Y}$	1.41	1.48	1.43	1.48

APPENDIX 27

TABLE 28

CALCULATION OF TREATMENT MEANS FROM DATA OF APPENDIX 25 (HYPOTHESIS 4)

(M_x = 15.6442, M_y = 37.7019, B = 1.1961)

	Treatment Combination			
	A_1	A_2	D_1	D_2
$\overline{X}$	15.4423	15.8462	16.5926	14.6200
$\overline{X}-M_x$	-0.2019	0.2019	0.9484	-1.0242
$B(\overline{X}-M_x)$	-0.2415	0.2415	1.1343	-1.2251
$\overline{Y}$	38.7885	36.6154	41.0370	34.1000
adj. $\overline{Y}$	39.0300	36.3739	39.9027	35.3251
n	52	52	54	50
Standard Error of $\overline{Y}$	1.01	1.01	1.01	1.06

APPENDIX 28

TABLE 29

PRE-TEST (X) AND FINAL EXAMINATION (Y) TEST SCORES OF SUBJECTS (HYPOTHESIS 5)

A_1 - Lecture Method, A_2 - Programmed Instruction (PI)
E_1 - Subject Required to Attend by Supervisor
E_2 - Subject Requested to Attend

A_1	E_1	A_1	E_2	A_2	E_1	A_2	E_2
X	Y	X	Y	X	Y	X	Y
25	53	12	53	12	41	9	37
13	33	20	48	18	50	20	44
17	50	18	43	15	42	15	38
13	35	17	33	15	36	20	46
17	27	13	38	10	36	25	50
16	31	11	44	19	34	10	38
12	39	19	44	18	42	18	44
18	31	13	49	16	31	15	24
17	33	15	49	19	35	16	42
15	33	16	46	14	28	13	27
20	43	12	32	17	32	22	51
17	31	15	40	13	27	16	43
19	35	16	23	16	35	18	33
13	22	16	24	18	29	17	36
19	44	12	37	15	27	23	46
18	44	19	39	11	17	12	33
13	33			11	22		
18	43			10	37		

APPENDIX 29

TABLE 30

CALCULATION OF TREATMENT COMBINATION MEANS FROM DATA OF APPENDIX 28 (HYPOTHESIS 5)

(M_x = 15.8824, M_y = 37.2794, B = 0.9690)

	Treatment Combination			
	A_1 E_1	A_1 E_2	A_2 E_1	A_2 E_2
$\overline{X}$	16.6667	15.2500	14.8333	16.8125
$\overline{X}-M_x$	0.7843	-0.6324	-1.0490	0.9301
$B(\overline{X}-M_x)$	0.7600	-0.6128	-1.0165	0.9014
$\overline{Y}$	36.6667	40.1250	33.3889	39.5000
adj. $\overline{Y}$	35.9066	40.7378	34.4054	38.5986
n	18	16	18	16
Standard Error of $\overline{Y}$	1.76	1.86	1.77	1.87

APPENDIX 30

TABLE 31

CALCULATION OF TREATMENT MEANS FROM DATA OF APPENDIX 28 (HYPOTHESIS 5)

(M_x = 15.8824, M_y = 37.2794, B = 0.9690)

	Treatment Combination			
	A_1	A_2	E_1	E_2
$\overline{X}$	16.0000	15.7647	15.7500	16.0313
$\overline{X}-M_x$	0.1176	-0.1176	-0.1324	0.1489
$B(\overline{X}-M_x)$	0.1140	-0.1140	-0.1283	0.1443
$\overline{Y}$	38.2941	36.2647	35.0278	39.8125
adj. $\overline{Y}$	38.1801	36.3787	35.1560	39.6682
n	34	34	36	32
Standard Error of $\overline{Y}$	1.27	1.27	1.24	1.31

APPENDIX 31

TABLE 32

PRE-TEST (X) AND FINAL EXAMINATION (Y) TEST SCORES OF SUBJECTS (HYPOTHESIS 6)

A_1 - Lecture Method, A_2 - Programmed Instruction (PI)
F_1 - Subjects With Programmed Instruction (PI) Experience
F_2 - Subjects Without Programmed Instruction (PI) Experience

A_1 F_1		A_1 F_2		A_2 F_1		A_2 F_2	
X	Y	X	Y	X	Y	X	Y
17	48	12	53	9	34	9	37
25	53	13	41	12	41	20	44
20	48	14	40	15	38	18	50
18	43	13	33	20	46	18	39
17	33	14	47	17	35	18	50
13	38	13	31	25	50	16	43
17	28	15	34	19	34	18	43
16	46	13	35	13	35	15	42
14	32	20	55	19	45	14	40
6	33	11	44	18	42	15	36
12	39	11	38	14	28	18	40
16	23	19	44	13	27	18	51
17	33	14	36	16	35	10	38
15	36	16	31	18	29	15	39
15	33	17	38	12	15	18	44
17	31	15	49	15	27	15	24
19	44	17	29	15	37	10	36
13	33	12	32	18	33	16	42
19	39	18	31	17	36	14	25
		15	40			13	27
		14	50			16	31
		16	24			19	35
		12	37			17	32
		17	52			13	22
		20	43			22	51
		22	54			18	33
		19	35			16	43

APPENDIX 31

TABLE 32

(Continued)

A_1 F_1		A_1 F_2		A_2 F_1		A_2 F_2	
X	Y	X	Y	X	Y	X	Y
		13	22			11	17
		12	23			11	22
		16	41			22	57
		20	45			11	25
		18	44			23	46
		18	43			12	33

APPENDIX 32

TABLE 33

CALCULATION OF TREATMENT COMBINATION MEANS FROM DATA OF APPENDIX 31 (HYPOTHESIS 6)

(M_x = 15.4500, M_y = 37.7000, B = 1.1783)

	Treatment Combination			
	A_1 F_1	A_1 F_2	A_2 F_1	A_2 F_2
$\overline{X}$	16.1176	15.4242	15.2941	15.2121
$\overline{X}-M_x$	0.6676	-0.0258	-0.1559	-0.2379
$B(\overline{X}-M_x)$	0.7867	-0.0304	-0.1837	-0.2803
$\overline{Y}$	37.7059	39.2121	35.1765	37.4848
adj. $\overline{Y}$	36.9192	39.2425	35.3601	37.7651
n	17	33	17	33
Standard Error of $\overline{Y}$	1.89	1.35	1.88	1.35

APPENDIX 33

TABLE 34

CALCULATION OF TREATMENT MEANS
FROM DATA OF APPENDIX 31 (HYPOTHESIS 6)

(M_x = 15.4500, M_y = 37.7000, B = 1.1783)

	Treatment Combination			
	A_1	A_2	F_1	F_2
$\bar{X}$	15.6600	15.2400	15.7059	15.3182
$\bar{X}-M_x$	0.2100	-0.2100	0.2559	-0.1318
$B(\bar{X}-M_x)$	0.2474	-0.2474	0.3015	-0.1553
$\bar{Y}$	38.7000	36.7000	36.4412	38.3485
adj. $\bar{Y}$	38.4526	36.9474	36.1397	38.5038
n	50	50	34	66
Standard Error of $\bar{Y}$	1.10	1.10	1.33	0.96

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