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Capsulized Mastery Learning: An Experimental and a Correlational Study of a Mastery Learning Strategy

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CAPSULIZED MASTERY LEARNING:

AN EXPERIMENTAL AND A CORRELATIONAL STUDY

OF A MASTERY LEARNING STRATEGY

by

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of Doctor of Philosophy

THIS PAPER IS DEDICATED TO

WILLIAM R. CAPONIGRI
(1925-1972)

WHO SACRIFICED MUCH SO THAT I

MIGHT CONTINUE MY EDUCATION, FOR

WHICH I WILL BE FOREVER GRATEFUL.

ACKNOWLEDGMENTS

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CHAPTER I

INTRODUCTION

STATEMENT OF THE PROBLEM

The term "accountability" is being used with increasing frequency in the field of education. Accountability (according to Webster) may be defined as the responsibility to discharge a task and the liability for failure to do so. As accountability relates to education, it conveys the idea that "professional educators should be held responsible for educational outcomes." (Barro, 1970). Barro (1970) proposes that:

> ..."Each participant in the educational process should be held responsible only for those educational outcomes that he can affect by his actions or decisions, and only to the extent that he can affect them."

If the current emphasis on accountability and performance contracting continues, the classroom teacher will become increasingly more responsible for the achievement of his students. In comparison to high school and elementary classes, college classes tend to be more homogeneous. College students are usually more mature and motivated, and college teachers are more autonomous. For these reasons, it would seem that college and university teachers should be held more accountable for student achievement than teachers at lower levels. This relationship between accountability and outcomes crystalizes the question of determining what outcomes are possible.

Barro (1970) states that the extent to which teachers can affect educational outcomes must be determined empirically. It is surprising to note in this context, the paucity of controlled research bearing on the subject. In other words, what methods, techniques or strategies of learning are best in a given situation. Stated generally, the purpose of this study is to determine which of three selected learning strategies produces the best results in a given learning situation.

The three strategies selected for and analyzed in this study are: traditional learning (TL), Mayo's Mastery Learning (MML), and Capsulized Mastery Learning (CML). Convenient operational definitions of these strategies are as follows:

1. Traditional learning (TL) refers to the lecture-demonstration approach with large-sized classes. It affords little individualization in helping students overcome their difficulties with subject matter, and generally inhibits classroom discussions.

2. Mayo's Mastery Learning is best described by an exerpt from a paper presented at the annual meeting of the National Council on Measurement in Education in 1969:

> A variety of learning experiences was made available. Dittoed orientation notes describing the purpose of the study were handed out on the first day of class. The senior author lectured nearly every day for part of the period. Tutoring was offered, indeed encouraged, either individually or in small groups. A workbook was available for each student as well as an extensive specialized departmental library in statistics. A syllabus assigned particular numerical problems on particular dates. These were collected on the days assigned, corrected overnight, and returned the next day when an explanation of the solutions was given in class

and students were allowed to ask questions. Weekly quizzes
served as formative evaluation. The quiz papers were
returned the next day with answers, and students were
allowed to keep their papers. An alternate form of the
midterm was offered optionally with the stipulation that
the student would have the higher of the two grades earned.
A review examination, which had been the final examination
in a previous section, permitted comparison with a non-
mastery situation. (Mayo, Hunt & Tremmel, 1969).

3. Capsulized Mastery Learning is a learning technique. It incorpor-
ates all the basic characteristics of MML as described above, with the addi-
tion of several other variables. During the first week of class, the students
are given specifically stated overall course objectives. (Page 325). There-
after daily lesson objectives are presented in hierarchical form according to
Bloom's taxonomy (1953). In order to clarify what the student is to learn on
that day, specially prepared lessons are also used daily as adjuncts to the
textbook. These "capsule" lessons present the daily lesson material in varied
form. Regular instruction is further supplemented with diagnostic procedures
(daily and weekly quizzes termed "formative evaluations"). Both students and
teacher receive immediate feedback from the formative evaluations. Finally,
tutors are made available to students who require additional instruction.

Historically, the traditional learning (TL) method is as old as
organized schooling. It has much in common with the early Indian, Egyptian,
Chinese and Roman systems. These systems had pre-set class times in which
a specific amount of material was to be covered. In those days, students
learned at different rates. What they did to adjust the differential in
learning rates is not clear. Today, however, the difference in learning
rates is usually reflected by the letter grade a student receives. We say

"reflected" because there is at least one other factor which is probably operative. That factor is the amount of information which students have on the objectives for the course. To put it another way, some individual differences variance may result from differences in students' perception of objectives.

There also is another option to consider in relation to differential rates of learning. The amount of material to be learned can be kept constant, and the time to learn it can be adjusted to the learning rate of the individual student. This concept is not new, as Washburne (1922, 1925) experimented with it some fifty years ago.

The notion of time as a flexible variable was revived by Carroll (1963) in an important article entitled "A Model of School Learning." This model provided the theoretical framework for MML and CML. Conceptually, Carroll's model states that learning is a function of two variables: (1) time spent in learning, and (2) time required to learn. These two variables can be further differentiated into five factors.

1. aptitude or learning rate

2. ability to understand instruction

3. perseverance--the time one is willing to spend in active learning.

4. opportunity--time allowed for learning

5. quality of instruction

Of the five factors, the first three are related to the learner; and the last two are related to the learning environment. The meaning of each of these five factors will be amplified and clarified in the review of the literature in Chapter II.

Bloom (1968) suggests that Carroll's learning model could be employed to achieve subject matter mastery. He states that if students are normally distributed with respect to aptitude, and the kind and quality of instruction and the amount of time available for learning are made appropriate to the characteristics and needs of each student, the majority of students may then be expected to achieve mastery of the subject. Bloom feels that there are many alternative strategies for mastery learning, and that each must deal with individual differences in learning through some means of relating the instruction to the needs and characteristics of the learner. He states that each strategy must include some way of dealing with the five factors of learning described in Carroll's model. Bloom also outlines some preconditions, operating procedures and methods to evaluate the outcomes of a particular mastery learning strategy. These will be developed more completely.

Following Bloom, Mayo (Mayo, Hunt & Tremmel, 1969) developed and experimentally validated a mastery learning strategy. In this study, it is referred to as Mayo's Mastery Learning (MML). Mayo's mastery learning classroom was in contrast to a non-mastery learning situation which used what has been defined as traditional learning (TL). By implementing the mastery learning strategy, Mayo's study resulted in a skewed distribution of grades (predominately A's and B's), in comparison to a previous year's class taught according to the traditional technique which yielded a roughly symmetrical distribution of grades. (See Appendix F).

The success of Mayo's strategy seemed impressive. Nearly 90% of the students exposed to his mastery learning strategy either achieved mastery (a grade of "A"), or near mastery (a grade of "B"). These results stimulated this writer to reevaluate the findings already available from the comparison of TL and MML and to contrast these findings with data collected from a trial of CML. An elementary course in statistics (consisting of a majority of graduate students) was used as the vehicle to test the effectiveness of TL, MML, and CML. Table (1) should serve to clarify the differences among these three techniques: (TL), (MML), and (CML).

Since Capsulized Mastery Learning is the mastery learning strategy that is primary in this investigation, a list of its possible advantages over traditional learning technique (TL) would seem appropriate:

1. Subject matter mastery for all students as the primary objective.

2. Instruction which employs explicitly stated objectives in behaviorial terms.

3. A pledge of success which raises the aspirations of both students and teachers.

4. An opportunity for the poorer students, who have experienced humiliation and frustration in past learning situations, to gain confidence and satisfaction.

5. Utilization of instant feedback to reinforce newly learned principles or to highlight areas of weakness.

6. Tutors who provide varied amounts of attention required by individual students to achieve subject matter mastery.

7. A possibly more efficient technique than the traditional teaching technique as measured in terms of greater output (learning) versus input (money).

8. A feasible method of overcoming the cumulated deficit which retards performance at higher levels.

Capsulized Mastery Learning is an extension and refinement of the already successful Mayo's Mastery Learning strategy. Therefore, many of the attributes of CML are possessed by MML. The most important differences between CML and MML are that CML has the following:

1. Explicitly stated and hierarchically classified course and lesson objectives

2. Especially prepared supplementary materials

3. Immediate feedback on formative evaluations

CML and MML both used tutorial assistance, formative and summative evaluations.

TABLE I

VARIABLES AVAILABLE TO THE THREE GROUPS

WHO EXPERIENCED TRADITIONAL LEARNING, MAYO'S

MASTERY LEARNING AND CAPSULIZED MASTERY LEARNING

Variables	T.L.	M.M.L.	C.M.L.
Orientation notes-Course syllabus	x	x	x
Lecture presentation by Dr. S. T. Mayo	x	x	x
Specifically assigned homework	x	x	x
Midterm examination	x	x	x
Final examination	x	x	x
Homework corrected and returned		x	x
Pre-midterm and pre-final examinations		x	x
Six weekly quizzes		x	x
Tutors		x	x
Specifically stated overall course objectives			x
Specifically stated daily lesson objectives			x
Hierarchical classification of objectives			x
Daily formative evaluations			x
Immediate feedback on formative and summative evaluations			x
Especially prepared supplementary materials			x

PURPOSE OF THE STUDY

The primary purpose of this study was to test the following hypotheses: (1) whether Capsulized Mastery Learning (CML) produces significantly better results than Mayo's mastery learning strategy in an elementary statistics course; and (2) whether CML produces significantly better results than does the traditional teaching technique in an elementary statistics course. Significantly better results is defined as superior performance on the criterion examinations (summative evaluations) administered during and at the conclusion of the statistics course.

A secondary purpose was to explore the interrelationships of 42 variables such as age, attitude, mathematical and reading ability, etc., (a complete listing can be found on page 319) by a correlational analysis. This correlational analysis was expected to yield a pattern of the variables related to success in CML, and the knowledge of how this relatedness can improve subject matter mastery.

SIGNIFICANCE OF THE PROBLEM

Eisner (1969) states that a crisis exists at every level of education. The influx of knowledge and information in every field has increased the numbers and levels of difficulty of the concepts that must be learned by students. He also states that teachers often complain that their students are ill-equipped to assimilate the material, the thought, and the concepts required to meet the course objectives.

In light of these and other obstacles, some teachers may relent by claiming that they teach students, and not material; or that it is more important to teach the process rather than the content. Nevertheless, in a society that is becoming more complex each day, it is necessary to transmit knowledge in its broadest sense and in the most efficient way.

Rather than stating behavioral changes which the students should be exhibiting, it has been written (Tyler, 1950; Eisner, 1967; Atkin, 1968) that some teachers either disregard course objectives or have replaced them with vague descriptions of what they themselves are trying to accomplish. Specifically stated objectives of Capsulized Mastery Learning focus the attention of both teachers and students on what is to be accomplished. This tends to overcome the problems precipitated by vaguely stated objectives. In addition, the immediate feedback provides for realistic assessment of whether or not the objectives have been achieved. In this writer's opinion, the aspects of specifically stated objectives and immediate feedback would be especially helpful in "tough" teaching situations. These can be exemplified at any level where the students are either ill-prepared, the subject matter is particularly difficult, or the students possess a built-in bias toward the subject. It is in these situations that cumlative deficit (Ausubel, 1964) is likely to occur and that CML may serve to reverse the deficit.

The ill-prepared student would most likely be found in the inner city where cultural and environmental conditions have retarded his educational progress in the traditional classroom setting. Capsulized Mastery Learning

affords assistance in overcoming these classroom learning problems by its inherent specification of daily lesson objectives, and through daily formative evaluations.

Some authors (Eisner, 1967; La Gaipa, 1968) have found that many students encounter much difficulty in the areas of science and mathematics, with mathematics incurring the greatest negative bias. Since these subjects require an accretive learning process, it is the belief of this writer that CML will promote learning and reduce negative bias through the attainment of the daily lesson objectives. This will not only give the students a feeling of success, but will also reduce their negative feelings toward the subject matter.

Ausubel (1964) found that a tendency exists for developmental deficits to become cumulative in nature, since current and future rates of intellectual growth are always conditioned or limited by the attained level of development. He feels that the student who has an existing deficit in growth incurred from past deprivation is less able to profit developmentally from new and more advanced levels of environmental stimulation. Therefore, a student's past success or failure pattern tends to affect his future rate of growth. Ausubel contends that the "optimal" mastery learning environment can arrest and reverse these deficits. He defines the environment as stimulating, geared to the individual's readiness and skill, as well as providing for remediation. Conversely, if the environment is inadequately stimulating, the student's functional capacity is impaired.

It can be inferred from Ausubel's work that in situations where students have not had the opportunity to obtain the proper background, learning should be stimulated by the use of realia, which he terms "concrete-empirical props," when presenting abstract ideas. After students become familiar with the existence of abstract ideas, they can move to a more abstract level of functioning.

SCOPE OF THE STUDY

In its broadest sense, this study of the comparative effectiveness of Capsulized Mastery Learning as contrasted to Mayo's Mastery Learning strategy and the traditional teaching technique, can have broad implications. The sample used for this study consisted of college students, and was, in this respect, strictly limited to a population of college students. Capsulized Mastery Learning, however, does not require specific characteristics of its students. There is nothing evident to this writer which would prohibit its adoption at different educational levels and in varied social environments. In this respect, its scope may be far-reaching.

In keeping with experimental theory, some may wish to restrict the generalizability of the results to the smallest population, which, in this case would be all college students (mostly graduate students) enrolled in an elementary statistics course during the summer. This study, however, is another in a chain of researches which have been producing significant and positive results in several different experimental situations (Bloom, 1968; Carroll and Spearritt, 1969; Mayo, Hunt & Tremmel, 1969).

In summary, while the scope of this study is admittedly narrow, the techniques used have broad application. Tools such as formative and summative evaluations, objectives stated in behavioral terms, immediate feedback, etc., can be applied to most classroom situations.

The question of motivation can be legitimately raised at this point, since the sample was comprised exclusively of college students. The fact that college students are self-motivated may restrict the generalizability. This may have either positive or negative aspects, depending on what is tacitly assumed by the reader. If one assumes that success in a learning situation is a powerful motivational force, as does this writer, then Capsulized Mastery Learning is generalizable to other levels of education. However, if this premise is not acceptable, then the applicability to other levels must be viewed in terms of the assumptions or theories one holds about learning at a particular level. If one believes that students are motivated by different factors at the elementary or secondary level, than they are at the college level, then the results of this study must be restricted to college level students. However, restricting the results of this study to the college population should not decrease its potential value, considering the present college enrollment.

CHAPTER II

REVIEW OF THE LITERATURE

A search of the literature reveals that the concept of mastery learning is not new. A mastery technique or strategy is one which attempts to control the effect of individual differences by experimental manipulation of the variables involved in learning subject matter.

Bloom (1968) suggest that Carroll's "Model" (1963) contains the major variables one must consider for the attainment of subject matter mastery. These variables are specified as follows:

1. Aptitude for particular kinds of learning

2. Ability to understand instruction

3. Quality of instruction

4. Perseverance

5. Time allowed for learning

Since the investigations of Bloom and Carroll, there has been an increase of articles on mastery learning and related topics. The writer chose to add to the above division of variables, the concept of mastery and cognitive/affective results of learning models to serve as a topical outline to review the literature.

It should be remembered that these variables overlap and are not clear-ly differentiated from one another. In cases in which a study could be classi-

fied under several variables, the study was placed where it seemed most appropriate.

APTITUDE FOR PARTICULAR KINDS OF LEARNING

Kim (1968) found that certain aptitudes were more strongly related to certain learning tasks than others. For example, memory is related to German; reasoning and number facility are related to statistics; spatial relations are related to logic. This intimates that perhaps subject matter can be structured to fit the individual's aptitudes; i.e., students who have a high aptitude in spatial relations, would be taught German in a logical fashion, emphasizing structure rather than memory.

Similar results were obtained from the research of Behr (1967) and Davis (1967). Behr found that by varying the amount of figural and verbal material in a program, students who possessed strong verbal aptitudes did well on that material; those who had strong figural aptitudes did better on the figural material. Davis' results almost paralleled those of Behr. According to Guilford's structure of intellect classification, students who had high semantic ability also exhibited high achievement on material structured to utilize that ability. The high symbolic group did well on highly symbolic material. In addition, Davis found that maximum achievement occurred when the content form was congruent with the individual's pattern of ability factors.

Two studies which exhibit similar results are those of Gagné and Paradise (1961) and another by Gagné (1968). Gagné and Paradise found that

basic abilities were predicitive of the learning rate of the skills to which they were logically relevant; however, these abilities were more highly related to the learning rate for the more simple skills. The learning rate for the more complex skills depended increasingly upon the acquisition of subordinate capabilities. Again the fact is established that mastery of lower level tasks is a necessary condition for the learning of higher order tasks.

Implicit in Carroll's model (1963) as viewed by Bloom and others, is the aptitudes are predictive of the learning rate of various learning tasks. If Gagné's hierarchical structure of task learning can be generalized (1968), it reveals that aptitudes are highly predictive of the rate of learning lower-level skills. It can be conceived that after these lower level skills are mastered, the skills of a higher level can also be learned. Implicit in the hierarchical structure is that the mastery of the lower level skills is a necessary, but not sufficient condition to learning the higher level skills.

Carroll (1963) utilizes time as the variable which bears the greatest relationship to aptitude. The spectre of this defintion of aptitude has been in education for a long time. It has been generally accepted that a poor student was a "slow" learner, not an incapable one. Carroll formalized what many educators had been aware of: given enough time, most (up to 90%) of the students could master the material presented to them.

Factors other than ability effect learning. Duncanson (1964) claims that performance in a learning task is related to measured abilities and to

performance in other learning tasks; more importantly, there are learning factors which are not related to abilities measured. It was suggested that factors such as interest, motivation and anxiety affect the limit of learning.

The writings of Bloom (1968) and Jensen (1969) support this idea. They found that except for the extremely talented or extremely deficient, students can learn to master most materials, provided that they are exposed to the proper kinds of stimulation.

Other studies giving support for the same general theory are those by Bloom (1964) and Hunt (1961). They found that aptitudes for a particular learning may be proper environmental conditions or learning experiences in the school and home. Finally, Cronbach and Snow (1969) contend that general ability does correlate with learning outcomes.

ABILITY TO UNDERSTAND INSTRUCTION

Bloom (1968) and Carroll (1963) define the ability to understand instruction as the ability of the learner to understand the nature of the task he is to learn, and the procedure he is to follow in the learning of the task. This also can be considered as the product of the interaction of the student's abilities, the instructional materials and the teacher's abilities.

Since the ability to understand instruction has been defined as the interaction of the learner, the teacher, and the instructional materials, it is expected that the composition of these reactants will differ in each situation (Bloom, 1968). The same student may need different instructors and instructional materials at different times.

Yates and Pidgeon (1957), in a study of admissions and predictability of success in the secondary schools of England, found that a verbal test or an intelligence test was the best single predictor of success. This may mean that the traits measured by these tests interact most profitably with the prevailing system of education in England which requires high verbal intelligence.

Airasian (1968) found that a necessary condition of learning topics of a higher order is mastery of the lower order components. In other words, the ability to understand instruction of a higher order necessitates the mastery of instruction of a lower order.

QUALITY OF INSTRUCTION

Carroll (1963) claims that the quality of instruction is the most elusive variable. He defines the quality of instruction in terms of the degree to which the presentation, explanation, and ordering of elements of the task to be learned approach the optimum for a given learner. By definition this must be considered in terms of the individual learner, and not of a group of students. It is a variable that is difficult to manipulate, and even if this were possible, the generalizability of such manipulation in an experimental setting would be difficult to accomplish in a typical classroom situation.

In Behr's (1967) study, it was demonstrated that it was possible to construct instructional materials to fit the strength and weaknesses of the

individual. The same author found that persons who are low in certain abilities may actually be at a disadvantage if the mode of presentation stresses these abilities. A similar result was found by Davis (1967). He discovered that the forms in which the subject matter is taught will give an advantage to students with aptitudes congruent to the mode of presentation, while it will place other students (low in these relevant aptitudes) at a disadvantage.

Included in the quality of instruction are the activities of learning that are best suited to the individual learner. Dave (1963) found that with the aid of a tutor, students were able to reach achievement levels that bore no relation to aptitude scores. This is empirical verification of one of Bloom's hypotheses-that a student may achieve mastery regardless of initial differences in aptitude.

One would also expect the quality of instruction to be influenced by the quality of the teacher. Some studies supporting this thought in particular are those by Dressel (1960), Campbell (1963), Martin (1963), Coleman and others (1966). Dressel (1960) defines instruction as a matter of bringing students in contact with an organized body of knowledge. It also requires assisting students in achieving mastery of his field. A good teacher must arouse the interest of his students and motivate them to learn. A teacher should keep in mind that learning implies a change in the individual and that much of the problem of interest and motivation can be related to the

need for clarifying what change is desired. Students also need assistance and guidance in the learning process.

Another study emphasizing the need for a good teacher in improving the quality of instruction is Campbell's report (1963). He concluded that the caliber of teachers was the single most important school factor in predicting achievement scores. According to Martin (1963), good teaching can be defined through subject matter analysis and empirical research. It is Martin's contention that a good teacher can be defined by analyzing the subject matter which is being taught and by analyzing what the student has learned. This argument, while tenable, needs the fortifications of experimental evidence.

The quality of instruction reflected by the teacher's verbal ability had the greatest effect on the achievement of students, especially those students at the lower ability level, according to Coleman (1966).

Much can be said about the use of programmed learning and computers on the quality of instruction. Atkinson (1968) reports that computers can be programmed to fit the strengths and weaknesses of the individual by use of a system that can provide similar feedback to teachers. Teachers also can adjust their methods to improve the quality of their instruction.

Schramm (1964) reviewed the literature on programmed instruction. Of thirty-six studies comparing programmed versus conventional methods of instruction, he found that: seventeen favored programmed instruction; no difference was found in eighteen; and one favored conventional (traditional) methods.

In addition to finding programmed instruction more effective than the conventional mode, La Giapa's studies (1968) showed that there was a significant interaction between subject matter difficulty and the quality of the instructor. That is, programmed instruction led to differentially higher achievement when the teachers were poor and the subject matter difficult. This also lends support to research done by Davis (1967) and Kim (1968).

Campbell (1963) failed in his attempt to establish "bypassing" or "branching" as a means of adapting self-instruction programs to individual differences. One should not conclude that the same paradigm is doomed to failure if employed by a teacher or a tutor.

Individual differences is the keynote of Roberts' study (1968). He suggests that materials should be constructed to fit the strengths and weaknesses of the individual. Implicit in this statement is that instruction itself can be improved by structuring it to conform to the strengths and weaknesses of the class. Hunt (1961), Cronbach and Snow (1969), and Jensen (1969) share the opinion that scholastic achievement can be improved and individual differences in performance can be minimized by making use of subjects and instruction interaction.

Environment is an important variable in two studies. Using observational and interview techniques, Anthony (1967) attempted to determine what aspects of the classroom environment affected achievement. In this study conducted with a representative sample of 21 classes at the fifth grade level, Anthony found that kind of instruction and type of materials could be the

general classification of a group of variables that positively affect achievement. Wittrock (1969) claims that instruction can be evaluated by quantifying several learners' intellectual and social characteristics where the environmental characteristics are measured, and the interactions of the learner and environmental characteristics to student learning are statistically determined.

Cronbach and Snow (1969), in an exhaustive, highly technical study, criticize most previously conducted studies on the basis of inadequate design for provision of valid conclusions. However, their study did show that certain methods of teaching interacted with specific abilities. Both authors contend that modes of instruction can be identified which will maximize learning. Improving the quality of instruction therefore, can optimize learning for selected groups.

Finally, Carroll and Spearritt (1967), basing their study on Carroll's "Model of School Learning," found that poor quality of instruction is detrimental to good as well as poor students.

PERSEVERANCE

Carroll (1963) defines perseverance as the time the learner is willing to spend in learning. He further specifies this time as time spent in active learning. The view that success implies perseverance is held by several researchers. Bloom (1968) feels that as a student finds the effort rewarding, he is likely to spend more time on a particular learning task. This view is supported by Lawson (1965) who found that frustration leads to a reduction in

time allotted to, or abortion of the task. Bruner (1966) contends that learning in many school situations has provided many students with frustration rather than success. He points out that if learning is to be optimal, the students must experience success rather than frustration.

A study proposing the same concept is that of Seashore and Bavelas (1942). These authors found that a decrease in the amount of time spent on a task is inversely related to the feeling of frustration toward it. In other words, the more frustration one experiences the less he will persevere in continuing to perform the same task. Bloom (1968) makes a point of diminishing the value of perseverance as an important variable with the statement "endurance and unusual perseverance may be appropriate for long distance running--they are not great virtues in their own right." He also feels that improvement of the other variables of the mastery learning model would reduce the concern and importance of this variable.

White (1959) argues that it is necessary to make competence a motivational concept. He claims that competence in an area would promote increased learning in that area. Bruner (1966) says, "We get interested in what we get good at." Both writers are aware of the positive effects that success has on subsequent learning. The aim of mastery learning is to promote students' success, therefore utilizing success motivation.

Carroll and Spearritt (1967), in a two-way classification of I.Q. and quality of instruction, found that students with a higher I.Q. tend to exhibit more perseverance than those who have low I.Q.'s. Also, there was

the implication that poor quality of instruction leads to reduced perseverance. This supports White's claim (1959). Students having higher I.Q.'s are generally more competent and therefore, more persevering.

Weiner (1965) found that students who were highly motivated toward achievement persisted longer when they experienced failure, and those students who were not highly motivated persisted longer when they experienced success.

TIME AS A VARIABLE IN ATTAINING MASTERY

An extremely important study supporting time as a variable in attaining mastery is Carroll's (1963) "Model of School Learning". The most crucial variable in the "model" is time allowed for learning. He believes that aptitude is actually a learning rate and that most students can master most subject matter, providing that their ability, aptitude and perseverance and the quality of the instruction have been taken into consideration.

Other research by Bugelski (1962), Carroll and Spearritt (1967), Goodlad and Anderson (1959), and Woodrow (1946), support the theory relating learning rate to aptitude. Also, Jensen (1969) and Gulliksen (1968) showed that learning in some tasks was independent of mental test scores and of social or ethnic background. This may be another indication that regardless of past performance, students may achieve mastery in a given subject matter area.

There appears to be considerable support for the mastery concept in studies involving time as a variable in attaining mastery. Atkinson (1968),

with the aid of a computer utilizing a branching program, determined that
students could achieve mastery, and did so at a variable time rate. He found
that the time required to reach mastery varied, and that the fastest students
require one-fifth the time required by the slowest students. Skinner (1954)
agrees with Atkinson, as do some other disciples of programmed learning.
They generally support the notion that given the proper experience and time,
"most" anyone can learn "most" anything.

In a recent study of the rate of learning in a mathematics curriculum,
Glaser (1968) found that students can, in general, achieve mastery, but do so
at different rates. In fact, the ratio is similar to the one in Atkinson's
study. There is a five to one variation in time to achieve mastery.

Wright (1967) found that:

1. A large percentage of students eventually attained the pre-defined
   mastery level.

2. A majority eventually reached mastery, with some reaching it
   faster than others.

3. The time which it took for a majority of students to reach mastery
   varied for the different subject matter sub-tests.

Here again the Carroll "Model" finds support.

Gagné and Paradise (1961) found that when a hierarchy of skills is
required for subject matter mastery, the adequate learning of subordinate
skills reduces the time required to master the more complex skill. Again this

supports Carroll's contention that aptitude and learning rates can be considered as synonymous measures.

Airasian (1967) found a slight negative correlation between hours of study and achievement which he attributed to the effectiveness of the feedback system. This study seems to support Carroll's model, with the exception of learning rate variable.

Sjogren (1967), when investigating Carroll's concept, found a significant positive relationship between the ratio of time spent on learning a particular task to the time needed to master the performance of the task and the ratio of achievement test scores to aptitude scores. Sjogren seems to be proposing that the following mathematical relationship holds true:

$$\text{time spent} \quad \propto \quad \text{achievement}$$
$$\text{time needed} \quad \propto \quad \text{aptitude}$$

Since the eta coefficients were not found to be significantly larger than the Pearson coefficients, the degree of learning can be considered a linear function.

Two other studies relating to the "time" variable are by Smith and Eaton (1939) and Congreve (1965). Smith and Eaton support the contention that time required to learn different types of material varies with the individual and the task. More importantly, they found that retention was not significantly related to learning speed. In this study, different materials promoted more learning in some of the learners than in others. Also, if the learning rate is increased, no reduction of retention occurs. Congreve disclosed that

given equal time, students with greater ability did better in situations where they could independently choose the learning environment, whereas those with less ability did better in situations where the environment was structured for them.

Finally, Smith and Eaton (1939), Congreve (1965) and Carroll (1963) agree that different instructional conditions call upon different kinds of aptitude, that is, a person's learning rate will be different in different circumstances. More specifically, the person who learns fast under one condition, may be a laggard under another condition.

THE CONCEPT OF MASTERY AND COGNITIVE/AFFECTIVE RESULTS OF LEARNING "MODELS"

The review of the literature of the sixth variable begins with an investigation by Carroll and Spearritt (1967). They found a somewhat surprising result when investigating Carroll's "Model of School Learning" in that interest in a task was not found to be significantly correlated with performance on that task. The authors, therefore, contended that interest does not have to be considered in the "Model."

Ausubel (1964) investigated the problem of cultural deprivation and found that students from culturally deprived areas were deficient in abstract thinking and vocabulary skills. Also, they were not highly motivated. He suggests that mastery learning of the rudimentary skills at the lower levels would improve the results at the higher levels. Ausubel points out that

learning tasks should be arranged sequentially, and that each of these tasks should be mastered before moving to the next.

Feather (1966) found that positive results on prior tasks increased the individual's success expectations and also improved performance, whereas negative results or failure on initial trials resulted in an expected failure on subsequent tasks. Furthermore, those students whose expectations were low, performed more poorly than those who had high expectations. In a study somewhat related to Feather's is that of Brookover, Shailer, and Paterson (1964). In an investigation of an individual's self-concept they found it to be significantly related to academic performance. This would seem to indicate that other objectives in the affective domain might serve to predict academic achievement. Also, if one's affective values are raised, a resulting increase in academic achievement could be expected. The results of Brookover, Shailer, and Paterson (1964) also indicate that a person's self-concept is in part due to what he believes others think of him.

Washburne (1922) and some others found that students learned more rapidly and were able to outperform other students where instruction was structured to meet their individual differences. Individualized instruction had long term effects which were exhibited by the significantly improved achievement at the high school level. Moreover, the effects in the affective domain were significantly better when instruction was individualized than in the traditional classroom setting.

Today, some forty-three years later, individual differences are still an important aspect of school learning, and will probably be an even more important one in the future. Domino (1968) found that "a student's academic performance reflects a variety of factors, including personality aspects that can enhance or interfere with optimal functioning in settings where <u>conformity</u> or <u>independence</u> are differentially rewarded." (Writer's emphasis) This finding has significance for the classroom. Both kinds of classes exist in colleges and universities. The importance is that some students can benefit form an environment where conformity is rewarded and others where independence is rewarded. It would seem appropriate to specifically define Domino's terms of conformity and independence.

A course was deemed as rewarding conforming behavior if it was characterized by emphasis on: (a) memorizing of technical terms, definitions, poems, etc.; (b) presentation of material through lectures; (c) objective type examination; (d) keeping of attendance records; (e) discipline and adherence to regulations (e.g., no smoking, absences justified by written medical reasons); (f) clearly defined and frequent homework assignments emphasizing convergent thinking; (g) rare use of visual aids, outside speakers, little variation in class routine; (h) close correspondence between lecture material and textbook; (i) identical assigned readings for all class members; and (j) course grade determined by proportional weighting of various course requirements.

A course was deemed as rewarding independent behavior if it was characterized by emphasis on: (a) ideas rather than facts; (b) seminar discussions, student presentations, or question-answer format; (c) no examinations, or examinations involving essay questions; (d) little concern for attendance; (e) little explicit emphasis on discipline and adherence to school regulations; (f) no homework assignments, or assignments demanding divergent thinking; (g) variety of presentation, as indicated by use of visual aids, tape recordings, outside speakers, or other material; (h) little direct overlap between class discussions and textbook content; (i) suggested readings individually tailored to a student's interests; and (j) grade determined by consultation with student or by global evaluation of student's performance.

"Conforming" as it is used here should not be taken in the pejorative sense. This may happen since current usage has unbalanced the connotation of this word.

Mastery Learning rejects the theory that because students differ in ability the result must be a difference in achievement. It replaces this theory with the following: Most students can master what is taught them.

Many prominent authors in the field of learning have proposed conceptual models of learning. To develop a creditable strategy for mastery learning one must become familiar with a variety of these learning theories and the models suggested by these theories. Those familiar with the work of researchers cited below will recognize the synopsis of their models and theories relevant to the Mastery Learning principle.

Osgood (Silberman and Coulson, 1964, p. 28) holds that learning involves the modification of the mediation process elicited by a stimulus pattern, or the modification of the instrumental sequence elicited by a mediator, or both. Mediation processes are modified by the regular association of a sign with a stimulus pattern, so that the sign becomes the stimulus for certain of the reactions previously elicited by the original stimulus pattern. Instrumental sequences are modified by the reinforcement of certain reactions to a sign. Thus, through the contiguity of signs and stimulus patterns the signs may acquire stimulus properties, and, through reinforcement, certain reactions to signs may come to be elicited regularly by the signs.

In the usual experimental situation with which Osgood is concerned, the learner is given sufficient trials to reach a specified criterion. Assuring mastery could be interpreted as either the use of sufficient associations between sign and stimulus pattern to bring about mediational modification; or, the use of sufficient reinforcements of reactions to a sign to bring about instrumental modification; or, a combination of the two.

Skinner (Silberman and Coulson, 1964) holds that learning is the reassortment of responses in a complex situation. Thus, a given stimulus acquires control over an operant response (or pattern of operant responses) through the processes of discrimination and shaping. Discrimination takes place when the operant is reinforced in the presence of other stimuli. Shaping takes place when operant responses are selectively reinforced so that behavior successively approximates the desired behavior.

Skinner maintains that a stimulus acquires control over an operant only after the operant is reinforced in the presence of the stimulus on a sufficient number of occasions. Therefore, assuring mastery would mean that numerous occasions for reinforcement must be included in a program. Skinner advocates providing a large number of occasions for reinforcement of the operant in the presence of the stimulus to insure stimulus control over the responses of even the slowest learner.

Hull (Silberman and Coulson, 1964, p. 32) believes that general reinforcement theory of behavior emphasizes that the stimulus is likely in all cases to be an exceedingly complex compound of events. He states that

the reaction which will adapt an organism to a given environmental situation depends, as a rule, not upon any single element of that situation, but upon a certain combination of elements.

His mastery principle could be described as follows. The excitatory potential depends on habit strength, which is built up through reinforced practice. Insufficient practice will result in low habit strength, and hence, low excitatory potential. If some component responses are deleted from the larger behavior pattern, subsequent responses will suffer, since component responses are greatly altered by virtue of their combination with other responses.

Bruner (Silberman and Coulson, 1964) does not discuss in any detailed, operational fashion, the manner in which human behavior can be effectively controlled. His discussions of the educational process are expressed at the level of general policy and over-all curriculum design. The point that Bruner makes most strongly is that education can be made to have the most lasting impact by giving students an understanding of the fundamental structure of whatever subjects we choose to teach. He does not, however, specify the educational procedures by which the basic principles, once identified, can most effectively be taught.

In his theoretical formulations, Bruner is primarily concerned with the ways in which people categorize the things and events that they encounter. This concern has led him to focus on the experimental situation in which a person is exposed to a series of stimulus patterns (e.g., drawings of people,

symbols, or scenery), and attempts to put each of the patterns into one or more categories. Bruner's emphasis is on what the subject himself does with the materials presented. He views the learner not as a passive receiver whose responses simply reflect his physiological limitations and his previous conditioning history, but rather as an active organizer of every event that he encounters. Little or no guidance is given to the instructor who might wish to prepare and sequence educational materials so as to produce systematic changes in a student's behavior. Bruner states that "learning often cannot be translated into a generic form until there has been enough mastery of the specifics of the situation to permit the discovery of lower-order, more generic coding systems." By extrapolation to the programmed learning situation, this statement might be construed to mean that all the preliminary topics and concepts must be specifically covered in the program, as well as the subsequent, logically dependent topics. It would seem to argue, also, that the learner should be required to show mastery of the earlier topics before he is allowed to move ahead in the program.

Ausubel (1964) has written a book on meaningful verbal learning that is quite relevant to programmed instruction, being specially directed toward school learning of subject-matter disciplines. He suggests the following teaching strategy:

1. Materials geared to the existing state of readiness.

2. Mastery of tasks before new ones are introduced so as to provide the necessary foundation for successful sequential learning, and to prevent unreadiness for future learning tasks.

3. The use of structured learning materials optimally organized to facilitate efficient sequential learning.

Ausubel (Silberman and Coulson, 1964) states that:

"New material in the sequence should never be introduced until all previous steps are thoroughly mastered. Perhaps the chief pedagogic advantage of the teaching machine lies in its ability to control this crucial variable in sequential learning."

Ausubel does not state operational techniques by which the principle of mastery should be implemented in an actual instructional situation. He appears to believe that the mere use of a teaching machine is sufficient. In fact, most teachning machine applications simply insure that the learner is exposed to one step before going to the next, not that he actually masters the earlier step.

Gideonse (1968), who is affiliated with the U.S. Office of Education, suggests that objectives in education must become more specific. He reports that progress toward objectives must be made available, and that objectives must be stated in terms of educational outputs. Since this article was oriented toward future developments, it would seem that the impetus of the U.S.O.E. would be toward learning strategies like C.M.L.

Carroll and Spearritt (1967), two of the more popular authors in this area, re-examined the five variables Carroll suggested in 1963, which are as follows:

1. Quality of instruction (adequacy with which the task is presented)

2. Opportunity (time allowed for learning the task)

3. Student aptitude for learning the task (measured in terms of the time the student needs to learn the task to a specified criterion of learning, but also in many cases predictable from measures of ability and prior achievement that can be obtained before the student begins learning the task)

4. Student ability to understand instruction (a combination of general intelligence and verbal ability)

5. The student's perseverance (the time he is willing to spend in learning)

This study, which was of sound design, revealed that poor quality instruction depressed the performance of children at all intelligence levels, and led to reduced perseverance on the part of children of higher intelligence. Learning was also shown to be highly inefficient when students had insufficient opportunity for learning.

In mathematical terms, Carroll's model (1963) can be expressed as follows:

In amount of learning expressed in percent of criterion reached is a function of how much time the learner actually spends in learning in relation to the amount of time he needs to learn; this latter quantity being a complex function of the quality of instruction, the student's aptitude, and his ability to understand instruction. The efficiency of learning, expressed as a percentage, is a function of the relation between the students' optimal rate of learning and the rate at which he actually learns. The product of the amount and efficiency of learning can be used as an overall measure of achievement from the standpoint of the school's success in promoting learning.

In mathematical symbols:

1. $L = f(t_s / t_n)$

2. $t_n = f(Q, A, U)$

3. $E = f(R_a/R_o)$

4. $S = f(L, E)$

where L is the amount of learning in terms of proportion of criterion reached

t_n is the time needed to learn the material

t_s is the actual time spent in learning the material

Q is the quality of instruction

A is the student's aptitude for the particular task

U is the student's ability to understand instruction

E is the efficiency of learning

R_o is the optimal learning rate

R_a is his actual learning rate

S is the school's success in promoting learning

Finally, it is informative to investigate what Hilgard (1960) believed to be the principles in learning that could be put into practice in the classroom. These principles come from three categories: S-R theories, cognitive theories, and motivation and personality theories. These are listed so the reader can objectively evaluate which of these are employed in C.M.L.

A. Principles emphasized within S-R theory

1. The learner should be an active, rather than a passive listener or viewer. The S-R theory emphasizes the significance of the learner's responses, and "learning by doing" is still an acceptable slogan.

2. Frequency of repetition is still important in acquiring skill, and in bringing enough overlearning to guarantee retention. One does

not learn to type, or to play the piano, or to speak a foreign language without some repetitive practice.

3. Reinforcement is important; that is, repetition should be under arrangements in which desirable or correct responses are rewarded. While there are some lingering questions over details, it is generally found that positive reinforcements (rewards, successes) are preferred over negative reinforcements (punishments, failures).

4. Generalization and discrimination suggest the importance of practice in varied contexts, so that learning will become (or remain) appropriate to a wider (or more restricted) range of stimuli.

5. Novelty in behavior can be enhanced by imitation of models through "cueing" and "shaping," and is not inconsistent with a liberalized S-R approach to learning.

B. Principles emphasized within cognitive theory

1. The perceptual features according to which the problem is displayed to the learner are important conditions of learning (figure-ground relations, directional signs, "what-leads-to-what", organic interrelatedness). Hence, a learning problem should be structured and presented in a manner in which the essential features are open to the inspection of the learner.

2. The organization of knowledge should be an essential concern of the teacher or educational planner. Thus, the direction from simple to complex is not from arbitrary, meaningless parts to meaningful wholes, but instead from simplified wholes to more complex wholes.

The part-whole problem is, therefore, an organizational problem, and cannot be dealt with apart from a theory of how complexity is patterned.

3. Learning with understanding is more permanent and more transferable than rote learning or learning by formula. Expressed in this form the statement belongs in cognitive theory, but S-R theories make a related emphasis upon the importance of meaningfulness in learning and retention.

4. Cognitive feedback confirms correct knowledge and corrects faulty learning. The notion is that the learner tries something provisionally and then accepts or rejects what he does on the basis of its consequences. This is, of course, the cognitive equivalent of reinforcement in S-R theory but cognitive theory tends to place more emphasis upon a kind of hypothesis testing through feedback.

5. Goal-setting by the learner is as important as motivation for learning, and his successes and failures are determiners of how he sets future goals.

C. Principles from motivation and personality theory

1. The learner's abilities are important, and provisions have to be made for slower and more rapid learners, as well as for those with specialized abilities.

2. Anxiety level of the individual learner may determine the beneficial or detrimental effects of certain kind of encouragements to learn. The generalization appears justified that with some kinds

of tasks high-anxiety learners perform better is <u>not</u> reminded of how well (or poorly) they are doing, while low-anxiety learners do better if they <u>are</u> interrupted with comments on their progress.

3. The same objective situation may tap <u>appropriate motives</u> for one learner, but not for another. For example, one can contrast those motivated by affiliation and those motivated by achievement.

4. The <u>organization of motives</u> and values within the individual is relevant. Some long-range goals affect short-range activities. Thus college students of equal ability may do better in courses perceived as relevant to their majors than in those perceived as irrelevant.

5. The group atmosphere of learning (competition vs. cooperation; authoritarianism vs. democracy; individual isolation vs. group identification) will affect satisfaction in learning as well as the products of learning.

The preceding was an attempt to inventory the models and theories that relate directly and indirectly to the Mastery Learning principle. In general, they suggest that in situations where students are normally distributed with respect to aptitude, and, if the kind and quality of instruction and the amount of time available for learning were made appropriate to the characteristics and needs of each student, the majority of students can be expected to achieve mastery of the subject. The review of the literature suggested to this writer that the key features of the mastery concept are as listed below.

1. Most students can master what is taught to them.

2. The task of the instructor is to find ways to enable students to master the subject.

3. Given enough time, nearly all students can attain mastery.

4. The learner must understand the nature of the task he is to learn and the procedure he is to follow in learning it.

5. It may be profitable to provide alternative learning opportunities.

6. The teacher should provide feedback on the learner's particular errors and difficulties.

7. Frequent feedback to the learners and specific instruction is effective in helping the learner to achieve.

8. The teacher must find ways to alter the time individuals need for learning.

9. Formulation of specific objectives for the learning task is an important precondition of mastery.

10. It is useful to break a course or subject into small units of learning and to test at the end of each unit.

11. Student effort is increased when small groups of two or three students meet regularly for as long as an hour to review their test results and to help one another overcome the difficulties identified by means of the test.

SUMMARY OF REVIEW OF THE LITERATURE

Since the review of the literature is quite extensive, a summary seems appropriate at this point. Following are the salient principles gleaned from this review:

1. Optimal learning occurred when the content form was congruent with the individual's aptitudes.

2. A necessary condition for learning was that the learner have the ability to understand the instructions and the procedure he is to follow in learning the specific task. Also, the learner must have the proper prerequisites: learning tasks should be sequentially arranged; if the lower order tasks are mastered, success at the higher levels would be improved; that is, where possible, tasks should be arranged in a hierarchical structure.

3. If the quality of instruction i.e., the presentation, explanation and order of elements to be learned, was to be most effective, it had to conform to the individual's cognitive strengths and weaknesses.

4. Unanimous support for the value of perseverance could not be found; however, this variable is positively linked with success in the learning situation. In general, it was found that those who experience success persevered longer than those who experienced failure.

5. No serious opposition was mustered against the theory which proposes that aptitude can be defined as learning rate. This

indicates that by varying the amount of time the learner can achieve the desired level of subject matter mastery.

6. In several studies investigating cognitive and affective areas, it was found that interest was not related to task mastery. Also, classes can be conducted to reward conforming or independent behavior, and better performance can be expected from those students whose personalities are congruent with the classroom atmosphere.

7. Instructional materials must be geared to the individual's existing state of readiness.

8. There should be mastery of lower order tasks through repetition and the use of different modes of presentation.

9. To facilitate learning in highly structured situations, the instructional materials must be optimally organized.

10. Feedback and reinforcement are essential features to the learning process.

11. Learning must be generalized, i.e., learning with understanding rather than rote learning.

12. The learner must have pre-set goals to be attained.

13. The group atmosphere should be cooperative rather than competitive.

CHAPTER III

RATIONALE OF THE CAPSULIZED MASTERY LEARNING STRATEGY

The review of the literature in the preceding chapter was a detailed discussion of the studies relating to the five factors of Carroll's Learning Model (1963) and the studies relating to Bloom's Mastery Learning Strategy. This chapter is devoted to five components of Capsulized Mastery Learning and the findings in the literature that support their inclusion into this particular mastery learning strategy. These components are:

1. Daily lesson objectives

2. Daily lesson supplement

3. Daily and Weekly formative quizzes

4. Criterion examinations (summative evaluation)

5. Tutorial assistance

DAILY LESSON OBJECTIVES

Daily lesson objectives provide the structure which students need in focusing their thought processes. Specifically, they are statements of the behavior modifications which the students must undergo before proceeding to higher levels. It is the view of this writer that a more active response will be elicited from students, if they know specifically what is expected of them; furthermore, they must know this prior to the experience from which they are to extract a behavior change.

Since formal education consists of purposeful activities, the conduct of the classroom must be purposeful also. With this end in mind a statement of objectives in behavioral terms should be distributed at the beginning of each class. These objectives cause both the teacher and the students to dwell on the specific purposes of the class. Further, they can be used as cues to focus the students' attention of certain concepts which the teacher intends to help the students learn. In addition, these objectives provide the student with the underlying structure of the subject matter to be mastered and stress the fact that certain areas require greater emphasis and scrutinization. The Taxonomy of Educational Objectives: Cognitive Domain (Bloom,1 953) provides such a hierarchical structure which helps the students concentrate their efforts to master the material at the specified level. It is obvious that lower ordered tasks must be learned, if success is expected on the higher ordered tasks. Gagné (1968) found that the acquisition of learning sets at successively higher states of the hierarchy was found to be dependent upon prior mastery of subordinate learning sets and proportions of achievement of the higher learning sets. The daily lesson objectives help insure that pre-requisties are mastered before moving on to more difficult concepts.

A list of the objectives which were specifically devised for this course are contained in the Appendix D page 325. These objectives were derived by analyzing the items on the 1967 and 1968 final examinations. This was done to ascertain the objectives related to the items on these examinations. This method assured a congruency between objectives and items.

DAILY LESSON SUPPLEMENT

The second component constituting the reationale of Capsulized Mastery Learning is the daily lesson supplement. These supplements are condensations of the material assigned from the textbook. Basically, they present the same material as in the textbook, but from a different point of view. The main purpose of the daily lesson supplement is to provide the student with an added source of positive reinforcement.

The development of the daily lesson supplements can be inferred from a study of programmed textbooks by Ausubel (1964). He suggests that the traditional textbook format or oral didactic exposition that follows a programming principle, supplemented by frequent self-scoring and feedback-giving tests, is far superior to the teaching machine approach for the actual presentation of subject-matter content. The work of Feldman (1965) would indicate that the difficulty of test items is greatly reduced by the use of graphs, diagrams and workbook type exercises. Information is sufficiently carried by these adjuncts so that differences in the level of reading makes no significant difference in learning. Many of these devices were used in developing the materials used in the study.

As can be ascertained from a survey of the materials in the Appendix, a great deal of emphasis was placed upon relating language to concept. Bruner's (1964) writings had the greatest affect in this direction. He said: "Language permits productive combinatorial operations in the absence of what is represented." Therefore, in the materials used in this study a

concentrated effort was made to have the student draw increasingly clearer connections between the verbal symbols and their meanings. The quizzes, feedback and reinforcement were the means used to promote the ideational connection between verbal symbols and actual concept.

DAILY AND WEEKLY FORMATIVE QUIZZES

Short quizzes were administered on a daily and weekly basis. Daily formative quizzes tested the objectives which were to be achieved during a particular class and were administered immediately following the lecture. The weekly formative quizzes tested the cumulative objectives for a given week, and were administered on the last day of the school week (Friday). All tests were distributed with carbon copies, so that the student was able to keep a copy.

These quizzes fulfilled three purposes. First, they provided immediate feedback for the students. Second, they provided the teacher with information regarding student achievement of pre-stated objectives. And, third, the quizzes pointed out the areas of strength and weakness to the student, and allowed him to utilize his study time more meaningfully.

The method used to develop these quizzes is outlined on page 112.

Two educators who support this rationale of daily quizzes are Ausubel (1964) and Dressel (1960). Ausubel holds the theory as many others do that frequent testing and provision of feedback, especially with test items

demanding fine discrimination among alternatives, varying in degree of cor--
rectness, also enhance consolidation by confirming, clarifying and correcting
previous learning." Dressel (1960) comments that one of the strongest motiva-
tions to learning is found in the provision of satisfaction for the student
through recognition and reward of his efforts. The daily quizzes also serve
as mathemagenic material in that they faciliatate learning through a focus
effort (Frase, 1967). The positioning of this test at the end of the period
serves as an "organizer" which enhances learning (Barman, Glass and Harrington,
1969).

The weekly formative quizzes, in addition to fulfilling the same func--
tions as the daily quizzes, also serve the function of increasing retention
and concept formation by reintroducting through testing some of the previously
learned material.

Since Cronbach (1963) formally introduced the concept of "formative
evaluation", many curriculum specialists and other writers in the area of
course and teacher improvement have advocated its use. Specifically, forma-
tive evaluations are those evaluative activities that occur during the
carrying out of the instructional activities. Of course from this definition,
it is clear that formative evaluations cannot be separated from the feedback
upon which they depend. Cronbach (1963) suggests that evaluation be used to
identify aspects of the course where revision is desirable. He felt that
evaluation used to improve the course, while it is still fluid, contributes
more to improvement of education than evaluations used to appraise a product

already placed on the market. This, among others, is the reason for formative evaluations such as daily quizzes and weekly quizzes.

CRITERION EXAMINATIONS

Summative evaluation, the evaluation of the final product, is accomplished by criterion examinations given at the midterm and at the conclusion of the course. It is from these examinations that judgments must be made as to the degree to which the pre-set objectives were achieved.

From the study by Blatt (1963) based on work by Rimoldi (1962), an unexpected reward stems from the extensive number of quizzes. Blatt found that students who were highly anxious operated at reduced efficiency levels when confronted with complex problems. (See page 19). However, familiarity with the situation and format facilitated cognitive functioning. This finding seems to support the use of a large number of quizzes as was done in the formative evaluation, thereby increasing the efficiency of cognitive functioning on the summative evaluation.

An intricate part of Capsulized Mastery Learning is that learning hierarchies can be developed through the Taxonomy. When searching for a hierarchy, Gagné's (1968) advice was to begin with the final task or goal and then ask, "What would the student already have to know to learn this new task?" Then, by successively working backward toward the knowledge that the student possesses, one would be able to provide for learning experiences that direct the student toward the specified goal. Gagné also suggested that

these hierarchies can be established empirically. However, hierarchies are not the complete answer, since it is known that there is more than one learning route, and there is no guarantee that the hierarchy determined is of the most efficient design. Perhaps, tutors can be utilized to discover the proper route for the individual student.

TUTORIAL HELP

An important phase of this study is the tutorial service. All students had the opportunity, and, in fact, were encouraged to take advantage of the tutorial service offered. The tutors also attempted to handle problems in the affective domain when they arose. These problems generally took the form of negative feelings toward the subject matter and fear of not doing well in a graduate course. An awareness of the work of Doty and Doty (1964) served as a guide to the proper role of the tutors in the affective domain. This study found that learning was significantly affected by social need. As an operational definition, social needs were taken to mean needs in any other area except the area of subject matter needs. Initially, it was hoped that the tutors would assume the role of facilitators described by Morris, Pflugrath and Emery (1969), who sought to establish something other than typical classroom situations. Tutors, short of being involved in sensitivity-training, should attempt to deal with whatever difficulties students have either in the cognitive or affective domains. It is expected that many students will have difficulties that stem from the affective areas (Mayo, Hunt, Tremmel, 1969). Although tutors attempt to allay any fears and

anxieties that may exist, it is beyond the scope of this study to conduct an extensive search in this area except to use tutoring time in the affective areas as one of the variables.

CHAPTER IV

DESIGN OF THE EXPERIMENT

In order to explore the efficacy of Capsulized Mastery Learning (CML) versus Mayo's Mastery Learning (MML) versus Traditional Learning (TL) in an elementary statistics course, the performance of the students in three classes was compared. The data from the Traditional and Mayo's Mastery classes were collected by Dr. Samuel T. Mayo and his assistants and were made available for the purpose of comparison with (CML). All classes were summer sessions taught by Dr. Mayo as follows:

> 1967 - Traditional Learning
>
> 1968 - Mayo's Mastery Learning
>
> 1969 - Capsulized Mastery Learning

The experimental design can be divided into two separate parts, each having its own purpose: (1) an inter-group study (which will be referred to as the experimental study), in which each of these sessions serves as one of three treatment samples; (2) an intra-group, or correlational study, using intercorrelational methods to examine the relatedness among variables.

Undoubtedly, the writings of Cronbach (1963, 1967) had the greatest impact in determining the experimental design of this study. The following are statements paraphrased from Cronbach's work.

1. The greatest service evaluation can perform is to identify aspects of the course where revision is desirable.

2. Evaluation, used to improve the course while it is still fluid, contributes more to improvement of education than evaluation used to appraise a product already placed on the market.

3. Evaluation should be used to understand how the course produces its effects and what parameters influence its effectiveness. It is important to learn, for example, that the outcome of programmed instruction depends very much upon the attitude of the teacher.

4. Evaluation should help us understand educational learnings.

5. Evaluation studies should generate knowledge about the nature of abilities that constitute educational goals.

6. Evaluation should not only compare one course with another but should also determine the post-course performance of a well described group with respect to pre-set objectives.

7. The follow-up study comes closest to observing ultimate educational contributions but the competition of such studies is so far removed in time from the initial instruction that it is of minor value in improving the course or explaining its effects.

8. I would emphasize departures of attained results from the ideal, differences in apparent effectiveness of different parts of the course, and differences from item to item: all these suggest places where the course could be strengthened.

9. Attitude questionnaires have been much criticized because they are subject to distortions, especially where the student hopes to gain by being less than frank. While students may give reports more favorably than their true beliefs, this distortion is not likely to be greater one year than another, or greater among students who take an experimental course than among those who do not. In group averages, many distortions balance out. Questionnaires insufficiently valid for individual testing can be used in evaluating curricula, both because the student has little motive to distort and because the evaluator is comparing averages rather than individuals.

10. In course evaluation, we need not be much concerned about making measuring instruments fit the curriculum. In an ideal evaluation, measures of all types of proficiency in the area in question, not just selected outcomes should be given direct substantial attention. If the curriculum developers deliberately planned to sacrifice some of the conventional attainments, they have nothing to fear from this measurement completely interpreted.

11. Evaluation is a fundamental part of curriculum development, not an appendage. Its job is to collect facts the course developer can and will use to do a better job, and facts from which a deeper understanding of the educational process will emerge.

12. Formally designed experiments putting one course against another are rarely definitive enough to justify their cost.

The preceding statements provided the basis for the major formulation of the experimental design used in this study.

The experimental portion of this study employed a slight variation of the simple randomized design as described by Lindquist (1953). Since it was not possible to draw the subjects at random from the same population, two statistical techniques were employed to remove doubts of Type S error. Chi square and the analysis of variance were used to compare the profile data available for each of the three groups. Also, every criterion score was adjusted for the effects of one or more covariates. The analysis of covariance technique was utilized to determine whether or not the treatment group were significantly different. By using these statistical techniques, three fundamental questions were investigated:

1. Do students who are exposed to Mayo's Mastery Learning master statistics to a higher degree than those taught by Traditional Learning methods?

2. Do students who are exposed to C.M.L. master statistics to a higher degree than those taught by Mayo's Master Learning method?

3. And most importantly, do students who are exposed to C.M.L. master statistics to a higher degree than those taught by Traditional Learning method?

When action research is conducted in the classroom, it is seldom possible to structure situations to conform to classic laboratory conditions. However, through the proper use of statistics, one can begin to approximate laboratory exactness. Experiments conducted in a laboratory usually consist of control and treatments matched on some criterion and measured for an anticipated gain. Walker (1956) feels that the era of person to person matching appears to be over, since analysis of covariance achieves the same results without the tedium of matching pairs. In other words, it is possible to statistically control variation in the treatment and control groups by adjusting the treatment means to compensate for the lack of equivalency between the treatment and control groups on a particular variable. The following variables singularly and in combination were used to adjust the criterion scores of the three groups:

1. Mathematics pretest

2. Nelson Denny vocabulary scores

3. Nelson Denny comprehension scores

4. Nelson Denny total scores

5. Pre-mathematics opinionnaire

6. Post-mathematics opinionnaire

7. Pre-statistics opinionnaire

8. Post-statistics opinionnaire

In statistical terminology the above variables are called covariates. These eight variables were used in various combinations as the covariates in the 43 different tests listed in condensed form on page 67.

The analysis of covariance requires the assumption that the individuals be randomly assigned to treatments. In this case, this was impossible. Although this is the most prevalent problem in all action research conducted in the classroom, the literature does not give a satisfactory solution. However, this writer felt by using chi square and the analysis of variance tests with the following variables (1) sex, (2) academic status, (3) immediate degree goals, (4) course history; the equivalence of the annual groups could be tested.

CONTROL GROUP--1967

This 1967 class, as described by Mayo, Hunt and Tremmel (1969), was taught in traditional fashion. That is, large group instruction was utilized, with little opportunity for student-teacher or student-student interaction. For the most part, this type of instruction was conducted in the lecture demonstration mode, where students typically take notes and/or listen to the lecture. Student involvement appears at the minimal level, as it generally does in most courses that are taught in the traditional manner.

Personal data sheets similar to the one in Appendix E, page 332 were used to collect biographical information on the student who enrolled in this introductory statistics course during the summer of 1967. In addition to the biographical data, data were also available from the mathematics pre-test, three quizzes and the final examination. All of these data were collected and made available to this writer by Dr. Samuel T. Mayo. Each of these variables will be considered in the analysis. Throughout this study, these quizzes and the final examination will be referred to as '67 quizzes and '67 final.

EXPERIMENTAL GROUPS

This study actually incorporates two experimental groups, the '68 group and the '69 group. The '68 group was composed of students who enrolled in the introductory statistics course in the summer of 1968. The '69 group similarly was composed of students who enrolled in the introductory statistics course in the summer of 1969.

'68 Group

For the purpose of distinguishing between the two experimental groups, this writer named the method used with the '68 group Mayo's Mastery Learning. As previously stated, Mayo followed the work of Bloom (1968) closely and perhaps the best description of Mayo's Mastery Learning is the following excerpt from a paper read at the NCME annual meeting in 1969 by Mayo, Hunt and Tremmel (1969).

> A variety of learning experiences were made available. Dittoed orientation notes describing the purposes of the study were handed out on the first day of class. The senior author lectured nearly every day for part of the period. Tutoring was offered, indeed encouraged, either individually or in small groups. A workbook was available for each student as well as an extensive specialized departmental library in statistics. A syllabus assigned particular numerical problems on particular dates. Those were collected on the days assigned, corrected overnight, and returned the next day when an explanation of the solutions was given in class and students were allowed to ask questions. Weekly quizzes served as formative evaluation. The quiz papers were returned the next day with answers, and students were allowed to keep their papers. An alternate form of the midterm was offered optionally with the stipulation that the student would have the higher of the two grades earned. A review examination, which had been the final examination in a previous section, permitted comparison with a non-mastery situation.

'69 Group

The '69 group consisted of 22 students. They received the most structured instruction of the three groups. The name "Capsulized Mastery Learning" was given to this learning technique or strategy so as to distinguish it from the treatment the '68 group received.

INSTRUMENTS--DATA COLLECTING DEVICES

A specimen of the personal data sheet used to collect biographical data from each of the three groups can be found in Appendix E page 332. Data were also collected from quizzes and exams given to each of the three groups. These examinations were constructed by Dr. Samuel T. Mayo, who, in some cases, was assisted by Ruth Hunt and Fred Tremmel, both of whom worked on the 1968 Mastery Learning experiment. It is through their efforts that the data of the 1967 and the 1968 groups were made available. The 1967 final was given to the '67 and '68 and the '69 classes as a final examination. A specimen of the 1967 final examination is in Appendix A page 288; a specimen of the 1968 final is in Appendix A page 278; and a specimen of 1967 quizzes can be found on pages 301 to 309. These quizzes were given to the '67 and the '69 classes only. A specimen of the 1968 quizzes can be found on pages 258 to 273. These quizzes were given to the '68 and the '69 classes. Specimens of the 1968 midterm and final examinations can be found on pages 244 to 257 and 274 to 297. These tests were given to the '68 and the '69 classes. It might be well to note that the quizzes provided data for formative evaluations and the examinations provided data for summative evaluations.

DEVELOPMENT OF THE ESPECIALLY
PREPARED SUPPLEMENTARY MATERIALS

An important phase of this study was the design and development of the especially prepared supplementary materials that was used in CML.

Creating these materials was essentially a six step process.

1. Each item of the 1967 and 1968 summative evaluation instruments, that is, the midterms and finals, was analyzed to determine the overall course objectives.

2. An attempt was made to classify these items using the hierarchical classification system of the Taxonomy of Educational Objectives. This was accomplished by having the four tutors (C. Breslin, R. Bushong, B. Przywara and R. Caponigri) independently classify each of the items. Where differences in classification arose, a form of arbitration was utilized until a specific classification was agreed upon.

3. Each of these items and their respective objectives were then placed in one of twenty-two separate categories. This was done on the basis of the content of the item and its objective. In other words, the items on the 1967 and 1968 midterms and finals were grouped so that all of the items relating to a single topic were together. For example, all items relating to the concept of Central Tendancy were grouped; each item of the group was analyzed to determine its related objective. These objectives were used as a guide for the development of the especially prepared supplementary materials. From this process lessons 5, 6, 7 and 8 evolved (See pages 112,113). The table of contents contains a list of the twenty-two daily lesson supplements that were developed in this manner.(See iii-iv)

4. After these items and objectives were separated into the twenty-two categories, a related set of items which would be used for formative evaluation was developed. These items were given as a quiz at the end of each lesson. From these quizzes, it was determined if additional exposure to specific concepts was necessary before mastery could be attained.

5. The objectives were used as a guide for the development of the work sheet part of the daily lessons. Armed with these objectives, several texts were reviewed to determine which approach would be most likely to help the students achieve the aforementioned objectives.

6. The objectives that the students were expected to achieve would be specifically stated at the beginning of each lesson. The coding system of the Taxonomy of Educational Objectives: Cognitive Domain was used to inform the student of the learning level that he should attain.

This concludes the description of the design of the primary (experimental) part of this study.

The secondary purpose of this study was to perform a correlational analysis of variables available from the treatment group exposed to Capsulized Mastery Learning. As previously stated, this portion of the study was designed to reveal the relationships among the forty-two variables measured. The knowledge of the interrelatedness between variables should provide important information about variables that influence learning in the Capsulized Mastery Learning situation. These variables are listed on page 319 and the intercorrelational matrix of the correlation coefficients

is in Appendix B, page 322. The method used to generate this intercorrela-
tional matrix was the Bio-Medical Computer Program. This program yields all
possible intercorrelations among the 42 variables.

Since the program used yielded Pearson product moment correlation
coefficients, the usual assumptions were made as follows:

1. Each pair of variables was linearly related.

2. Each variable was measured on a continous scale.

3. Each variable was normally distributed and,

4. Each variable was homoscedastic.

There is a divergence of opinions on how rigorously these assumptions
must be adhered to in order to obtain valid results. Two assumptions
knowingly violated were the inclusion in the set of variables of ordinal data
and categorical data, such as rank of working time on the quizzes and sex.
Aside from these aberrations, (within the limits of its robustness) the
remainder of the variables adhere to the four conditions required by the
Pearson r.

For the sake of clarity, it should be stressed that the correlational
study deals only with variables collected from the group exposed to
Capsulized Mastery Learning. Data for Mayo's Mastery Learning (1968) and
Traditional Learning (1969) situations were not used in the correlational
analysis.

CHAPTER V

ANALYSIS OF DATA

CHI SQUARE AND THE ANALYSIS OF VARIANCE

In the preceding chapter, it was stated that chi square and the analysis of variance tests would be performed to determine if the groups could be differentiated on the basis of the variables of (1) sex, (2) academic status, (3) immediate degree goal, and (4) course history. The name of each of the variables is self-explanatory with the exception of course history. Course history, as it is defined here, is the mean number of hours earned in the areas of education, psychology, mathematics and science.

The tables beginning on page 63 indicate the composition of the three groups with respect to the four variables mentioned above. The results of the chi square tests indicated that the groups are essentially the same with respect to the variables of sex, academic status, and immediate degree goals. However, the results of the analysis of variance test on the course history variable indicated that there existed a significant difference (Table 5B) among the groups. This suggested a further investigation of the course history data. A correlational analysis was performed and the results

are summarized in Table 5C. This was done to determine whether or not it would have been appropriate to use course history as a covariate to adjust the criterion in determining the differences among the treatment groups. From Table 5C, it can be seen that no consistent pattern of significant correlation coefficients existed. When this information was combined with the results shown in Tables 2, 3, 4 and 5C, it decreased the importance of the results shown in Table 5B. Thus although Table 5B indicated that there was a statistically significant difference among the three groups, it was not of practical importance. The remainder of the analysis proceeded on the basis that the three groups have essentially the same biographical composition. This would potentially be a more serious violation of good experimental design if the analysis of covariance were not used to test for the differences among the three treatments. It should be noted that these data were collected at the beginning of the course. The discrepancies in the totals, as shown in these tables (74), and the total number of students in the study (69) was due to the fact that some students withdrew from the course before it was completed. In 1967 and 1968, two students withdrew; in 1969, one student withdrew. The discrepancy in the 1968 and 1969 immediate degree goals exists, since one student in each of the classes was not pursuing a degree.

TABLE 2

SEX

Sex	1967	1968	1969	Total
Male	8 (25.0%)	8 (42.0%)	9 (39.0%)	25 (33.8%)
Female	24 (75.0%)	11 (58.0%)	14 (61.0%)	49 (66.2%)
Total	32(100.0%)	19(100.0%)	23(100.0%)	74(100.0%)

x^2 = 2.53   (df = 2)

$x^2_{.05}$ = 7.4   ∴ no significant difference in number of males and females

TABLE 3

ACADEMIC STATUS

Status	1967	1968	1969	Total
Graduate	28 (87.5%)	15 (78.9%)	22 (95.7%)	65 (87.9%)
Undergraduate	4 (12.5%)	4 (21.1%)	1 (4.3%)	9 (12.1%)
Total	32(100.0%)	19(100.0%)	23(100.0%)	74(100.0%)

x^2 = 2.9   (df = 2)

$x^2_{.05}$ = 7.4   ∴ no significant difference in the academic status of three groups

TABLE 4

IMMEDIATE DEGREE GOAL

Goal	1967	1968	1969	Total
M. Ed.	20 (62.5%)	8 (44.4%)	14 (63.6%)	42 (58.3%)
Other	12 (37.5%)	10 (55.6%0	8 (36.4%)	30 (41.7%)
Total	32(100.0%)	18(100.0%)	22(100.0%)	72(100.0%)

$x^2 = 1.9$ (df = 2)

$x^2_{.05} = 7.4$ no significant difference in the immediate degree goals of the three groups

TABLE 5A

COURSE HISTORY

History	1967 (N=30)	1968 (N=17)	1969 (N=22)	Total (N=69)
Education	18.0*	17.3	28.0	63.3
Psychology	7.2	10.4	12.1	29.7
Mathematics	4.9	3.2	10.6	18.7
Science	6.2	5.5	10.6	22.3
Total	36.3	36.4	61.3	134.0

*The numbers in the table above represent the mean number of credit hours earned in the specified field by the students in each of the three years.

TABLE 5B

ANOVA SUMMARY OF TABLE 5A

Source	df	SS	MS	F	$F_{.05}$	$F_{.01}$
Treatments	2	2402.13	1201.07	9.212	3.04	4.71
Levels	3	9665.20	3221.73			
(Cells)	(11)	(12576.02)				
Treatment x Levels	6	508.69	84.78			
Within-Subgroups	264	34420.69	130.38			
Total	275	46996.71				

TABLE 5C

Correlational Table of the Number of Credit Hours In Education, Psychology, Mathematics and Science Versus The Scores on 1967 Final Examination

CRITERION: 1967 FINAL EXAMINATION

		TREATMENT GROUPS		
		1967 N=30	1968 N=17	1969 N=22
Credit Hours	Education	.35	-.06	.26
	Psychology	.11	.05	.26
	Mathematics	.29	.53	.24
	Science	.11	.08	.49
	$P < .01$	.46	.61	.54

ANALYSIS OF COVARIANCE

As indicated in the previous discussion, the analysis proceeded as though the three groups were randomly drawn from the same population while this is a defensible assumption and is often necessary when conducting educational research, it was not true in this case. Because of this, it was decided to use the analysis of covariance rather than the analysis of variance.

Essentially, the analysis of covariance is a procedure which does two things: (1) reduces the possible bias in treatment comparisons due to differences in the covariates and, (2) increases precision in the treatment comparisons by reducing the variability in the criterion scores due to the variability in the covariate.

Table 6 on page 67 is a condensed table containing covariates, criterion variables, F ratios obtained by the analysis of covariance, the appropriate F ratios at the .05 and the .01 levels of significance, and the acceptance or rejection of the null hypothesis. Perhaps the following example will clarify the use of the table.

Regarding Test 1: There is no significant difference at the .01 level among the three treatment means on the 1967 final examination, when adjusted with the mathematics pre-test as the covariate.

TABLE 6

CONDENSED FORM OF THE RESULTS OF ANALYSIS OF COVARIANCE

Test number	Covariate	Criterion variable	F	$F_{.05}$	$F_{.01}$	Accept	Reject
1.	Mathematics pretest	1967 final examination	7.177		7.04		x
2.	Mathematics pretest	1967 quiz scores	11.930		7.18		x
3.	Nelson Denny vocabulary	1967 final examination	10.734		7.39		x
4.	Nelson Denny reading comprehension scores	1967 final examination	11.713		7.39		x
5.	Nelson Denny total scores	1967 final examination	12.175		7.39		x
6.	Pre-course mathematics opinionnaire	1967 final examination	7.539		7.39		x
7.	Post-course mathematics opinionnaire	1967 final examination	8.247		7.39		x
8.	Pre-course statistics opinionnaire	1967 final examination	7.554		7.39		x
9.	Post-course statistics opinionnaire	1967 final examination	3.987	4.11		x	
10.	Mathematics pretest & Nelson Denny vocabulary scores	1967 final examination	11.985		7.42		x

TABLE 6--Continued

Test number	Covariate	Criterion variable	F	$F_{.05}$	$F_{.01}$	Accept	Reject
11.	Mathematics pretest & Nelson Denny comprehension	1967 final examination	11.569		7.42		x
12.	Mathematics pretest & Nelson Denny total	1967 final examination	13.021		7.42		x
13.	Mathematics pretest, pre-course mathematics opinion-naire, & pre-course statistics opinionnaire	1967 final examination	8.014		7.44		x
14.	Mathematics pretest, post-mathematics opinionnaire & post-statistics opinionnaire	1967 final examination	4.304	4.13			x
15.	Mathematics pretest, Nelson Denny total, pre and post-mathematics opinion-naire, pre and post-statistics opinionnaire	1967 final examination	5.916	4.16			x
16.	Mathematics pretest	1968 midterm	4.601	4.11			x
17.	Nelson Denny comprehension	1968 midterm	4.150	4.11			x
18.	Nelson Denny vocabulary	1968 midterm	4.197	4.11			x
19.	Nelson Denny total	1968 midterm	4.046	4.11		x	

TABLE 6--Continued

Test number	Covariate	Criterion variable	F	$F_{.05}$	$F_{.01}$	Accept	Reject
20.	Post-course mathematics opinionnaire	1968 midterm	6.253	4.11			x
21.	Pre-course statistics opinionnaire	1968 midterm	4.279	4.11			x
22.	Post-course statistics opinionnaire	1968 midterm	10.528		7.39		x
23.	Mathematics pretest & Nelson Denny vocabulary	1968 midterm	4.131	4.12			x
24.	Mathematics pretest & Nelson Denny comprehension	1968 midterm	3.657	4.12		x	
25.	Mathematics pretest & Nelson Denny total	1968 midterm	3.831	4.12		x	
26.	Mathematics pretest, pre-course mathematics opinionnaire, & pre-course statistics opinionnaire	1968 midterm	4.232		4.13		x
27.	Mathematics pretest, post-course mathematics opinionnaire & post-course statistics opinionnaire	1968 midterm	11.374		7.44		x

TABLE 6--Continued

Test number	Covariate	Criterion variable	F	$F_{.05}$	$F_{.01}$	Accept	Reject
28.	Mathematics pretest, Nelson Denny total, pre and post-mathematics opinionnaire, & pre and post-statistics opinionnaire	1968 midterm	10.502		7.55		x
29.	Mathematics pretest	1968 final examination	13.691		7.39		x
30.	Nelson Denny vocabulary	1968 final examination	14.878		7.39		x
31.	Nelson Denny comprehension	1968 final examination	17.247		7.39		x
32.	Nelson Denny total	1968 final examination	16.559		7.39		x
33.	Pre-course mathematics opinionnaire	1968 final examination	11.835		7.39		x
34.	Post-course mathematics opinionnaire	1968 final examination	11.978		7.39		x
35.	Pre-course statistics opinionnaire	1968 final examination	11.972		7.39		x
36.	Post-course statistics opinionnaire	1968 final examination	6.445	4.11			x
37.	Mathematics pretest & Nelson Denny vocabulary	1968 final examination	16.696		7.42		x

TABLE 6--Continued

Test number	Covariate	Criterion variable	F	$F_{.05}$	$F_{.01}$	Accept	Reject
38.	Mathematics pretest & Nelson Denny comprehension	1968 final examination	17.462		7.42		x
39.	Mathematics pretest & Nelson Denny total	1968 final examination	17.917		7.42		x
40.	Mathematics pretest, pre-course mathematics opinionnaire & pre-course statistics opinionnaire	1968 final examination	14.158		7.44		x
41.	Mathematics pretest, post-course mathematics opinion-naire & post-course statistics opinionnaire	1968 final examination	7.447		7.44		x
42.	Mathematics pretest, Nelson Denny total, pre and post-mathematics opinionnaire & pre and post-statistics opinionnaire	1968 final examination	10.800		7.55		x
43.	Mathematics pretest, Nelson Denny vocabulary, Nelson Denny comprehension, pre-mathematics opinionnaire, & pre-statistics opinionnaire	Post-course mathematics opinionnaire	1.644	4.15		x	

The reader should recall that the purpose of all of these tests was to determine which of the three methods of teaching statistics produced the greatest proficiency in statistics. With this in mind, the following is an attempt to summarize and report in abstract form.

Test 1

The most important of the tests was the analysis of covariance performed on the three groups using the 1967 final examination as the criterion measure. These scores were adjusted on the basis of scores received on comparable forms of a mathematics pre-test. This analysis yielded a significant F ratio which necessitated further exploration. Subsequent t-tests were performed and the total analysis can be summarized as follows: Students exposed to the C.M.L. strategy demonstrated a superior knowledge of statistics over those students exposed to either the Mastery Learning strategy or the traditionally taught class. Furthermore, Mastery Learning was found to be superior to traditional learning. In other words, C.M.L. was an improvement on Mastery Learning which was an improvement on traditional learning.

Test 2

This test was a comparison of the 1967 traditional learning group and the 1969 C.M.L. group using the 1967 quiz scores as the criterion variable. The criterion variable was adjusted on the basis of scores received on comparable forms of a mathematics pre-test, and it was found that the C.M.L. group did significantly better than the traditionally taught class.

Tests 3-15

In tests 3 through 15 the dependent or the criterion variable was the 1967 Final Examination with the covariable(s) designated on the particular test. In each case, with the exception of test 9 where the post course statistics opinionnaire was used as the covariable, the null hypothesis was rejected. This is strong evidence that regardless of how the criterion variable was adjusted, C.M.L. was found to be significantly better than the Mastery Learning strategy of the previous year. The test 9 results may be explained as follows: since all students were constantly aware of their relative standing due to the frequent feedback, perhaps those who did not do as well as their classmates bore slight resentment toward the subject. However, it should be noted that if the level of significance was chosen at .10 instead of at .05, test 9 would have shown C.M.L. significantly better. This result prompted test 43, which was an attempt to detect if C.M.L. produced a negative attitude toward statistics.

It should be noted that while one final examination was given to the 1967 group, the 1968 group received a warm-up examination (1967 Final Examination) on Wednesday with another especially prepared final examination administered two days later (1968 Final Examination). However, another procedure was used with 1969 group. On Wednesday one-half of the class received the 1967 Final Examination and the other one-half of the class received the 1968 Final Examination. This procedure was reversed on Friday. This counterbalancing technique was utilized to control for any bias that might have accrued on the scores of the later administered examination due to the practice effect of the first administered examination.

Tests 16-28

In tests 16 through 28, the 1968 midterm was the criterion or dependent variable with the covariable(s) designated on the individual test. In all tests except 19, 24, and 25, a significant difference was found. Noting these exceptions when adjusting with the covariables, C.M.L. was found to be significantly better than the Mastery Learning of the previous year. Although the differences were not significant in tests 19, 24 and 25, they were in the direction indicating the superiority of C.M.L. These tests can be used as evidence to support the contention that superior performance can be expected from C.M.L. midway through the course. In this way the consistency of the method can be examined.

Tests 29-42

In tests 29 through 42, the 1968 final examination was used as the criterion or dependent variable. The results on all tests were the same. Regardless of the covariables used to adjust the criterion variable, C.M.L. was determined to produce individuals who scored better on the 1968 final than did the Mastery Learning technique employed the previous year.

Test 43

After adjusting with the following covariates: the mathematics pre-test, the Nelson-Denny vocabulary test, the Nelson-Denny Comprehensive, the pre-mathematics opinionnaire, and the pre-statistics opinionnaire, no significant difference was found in the criterion variable - the post-course

mathematics opinionnaire. This test was made for two reasons: first, because of the results of test 9; and, second, because of the suspicions among some of those acquainted, but not directly associated with the project, that negative feeling might be produced by the fact that C.M.L. is an extremely structured teaching/learning technique. It might also be noted that the students involved were accustomed to far less structure in most of their courses, since a majority of the students came from a social science or educational background where there is far less structure.

This completes the summary of the results of the experimental study. The reader should be cautioned not to confuse the preceding study with the correlational study which is to follow. The fact that an analysis of covariance was employed forty-three times in the experimental study, and that forty-two variables are used in the correlational study is merely a coincidence.

THE CORRELATIONAL STUDY

The following list of 42 variables and a Bio-Medical Computer program (Dixon, 1968) was used to generate an intercorrelational matrix. The number to the left of the variable corresponds to the row and column number in Appendix B, page 319. For example, the Correlation between variable 1 (age) and variable 18 (computation on the final examination, 1967 version) is given in Appendix B as .21. The reader should note that, counting from left to right in row 1, .21 is the eighteenth r. A further aberration is in the

inclusion of variables 13, 17, and 20, which are variables pertaining to rank ordering and, consequently, violate the necessary assumption that the data be, at least, of the interval level of measurement when calculating Pearson's r. However, this treatment is recommended by Kelley, (Kelley, T.L., Statistical Method, The MacMillan Company, 1923, p. 194.) rather than contend with the loss of accuracy by transforming score data into ranked data.

List of variables

1. Age: biographical data sheet--(See Appendix E, page 332.)

2. Score on mathematics pretest: This instrument was contructed by Mayo, Hunt, and Tremmel for the purpose of determining what basic math skills the student possesses when he enters the course.

3. Nelson-Denny vocabulary score.

4. Nelson-Denny total scores.

    Note: These scores are derived from the Nelson-Denny Reading Test published by Houghton-Mifflin Company, Boston, 1960. This test was administered to examine whether or not reading skills bear any relation to success in learning statistics.

5. Nelson-Denny reading comprehension scores.

6. Pre-course mathematics attitude scores: An opinionnaire given at the beginning of the course.

7. Post-course mathematics attitude scores: The same opinionnaire as in (6) only given at the end of the course.

8. Pre-course attitude score: An opinionnaire pertaining directly to statistics administered at the beginning of the course.

9. Post-course attitude score: Same opinionnaire as in (8) only given at the end of the course.

10. Midterm computation first version: This part of the examination dealt with the computational aspects of statistics.

11. Midterm total first version: This was a composite score made of the computation and multiple choice parts.

12. Midterm multiple choice first version.

13. Rank of working time on the first midterm.

    Note: The first version of the midterm was devised by Dr. Mavo and used first with the 1967 group.

14. Midterm computation second version.

15. Midterm multiple choice second version.

16. Midterm total second version.

    Note: The second version was devised by Mayo, Hunt and Tremmel to be used with the 1968 group.

17. Rank of working time on the second version.

18. Computation final 1967 version.

19. Multiple choice final 1967 version.

20. Rank of working time on 1967 version of final.

21. Sum of quizzes I, II, and III 1967 version.

22. Final total score on 1967 version.

    Note: The 1967 final was devised by Dr. Mayo and first used with the 1967 group.

23. Total score on the 1968 version of the final examination. (Page 278).

24. Sum of the total scores on the 1967 and 1968 final examination. (Page 288).

25. Total amount of tutoring time in minutes spent with the student discussing subject matter (cognitive).

26. Total amount of time spent with the tutors discussing anything but subject matter (affective).

27. Total time spent with tutors in both cognitive and affective areas. (Page 322).

28. Percentage of daily quizzes $\dfrac{\text{total points}}{\text{total possible}}$ x 100.

29. Percentage of weekly quizzes $\dfrac{\text{total points}}{\text{total possible}}$ x 100.

30. Score on weekly quiz I.

31. Sum of weekly quizzes I and II.

32. Sum of weekly quizzes I and II and III.

33. Sum of weekly quizzes I + II + III + IV.

34. Sum of weekly quizzes I + II + III + IV + V.

35. Sum of weekly quizzes I + II + III + IV + V + VI.

36. Weekly quiz II.

37. Weekly quiz III.

38. Weekly quiz IV.

39. Weekly quiz V.

40. Weekly quiz VI.

41. Sex.

42. Grade point average.

INTERPRETATION OF THE CORRELATIONAL MATRIX

Guilford (1965), Edwards (1967), and Snedecor (1946), all contain good accounts of how to determine which of the correlation coefficients indicate a significant relationship between the two variables. Without going into specific detail, the null hypothesis ($H_0: \rho = 0$) that the population Pearson Product Moment correlation coefficient is equal to zero can be rejected at the .05 level if $r \geq .423$, and at the .01 level if $r \geq .547$ (N = 22). In Appendix B, page 319, those coefficients significant at .05 level are underlined. The determination of those variables that are significantly correlated is a straight statistical procedure. The interpretation of the statistic requires a familiarity with the data and the situation from which the data were collected.

As Glaser (1968) suggests, studies all too often have been conducted with rigid experimental design to compare two or more different procedures. Some have not been carried out in a way useful for building an organized body of information about the variables that influence learning. In this study, there is an attempt to build an organized body of information by interpreting the correlational matrix to ascertain the variables pertinent to learning. The following ten conclusions follow from my evaluation generated by this experiment. It should be clear that someone operating from a different frame

of reference may come to conclusions other than those presented here. Only many replications will yield clear cut relationships among the variables.

1. The men of the class were older than the women, but age did not correlate with any of the other measures.

2. The score on the mathematics pretest was found to correlate positively with computational parts of the subsequent examination, but not necessarily with the multiple choice parts. Also, those who did well on the pretest required less time with the tutors.

3. The scores on the Nelson Denny reading tests were positively correlated with the scores on the computation parts of the various examinations, and were not significantly correlated to the total or multiple choice portions of the examinations. Also, the students with better reading capabilities did not, in the beginning or the end, have the best attitudes of the course. These students spent significantly less time in the cognitive domain with the tutors.

4. In general, the attitudes remained the same throughout the course, and those with the better attitudes did better at the midterm and on the quizzes but not so on the finals.

5. The scores on the midterm generally correlate positively with the mathematics pretest, the attitude tests, the finals, and the quizzes. However, they are not related to the Nelson Denny tests, and are negatively related to time spent with the tutor.

6. One can observe in general, that those who completed the examinations more quickly received better scores.

7. The separate scores and the sum of the '67 and '68 finals vary directly with the mathematics pretest, with the Nelson Denny tests, with the midterms, and with weekly and daily quizzes. However, they bore a negative relation to the attitude and tutoring time.

8. Time spent with the tutors discussing matters in the cognitive domain is negatively correlated with the mathematics pretest, the Nelson Denny total, the midterm, and the '67 and '68 finals, but positively correlated with the '67 multiple choice. In the affective domain tutoring time is negatively related to the attitude measures. The more time spent with the tutors, the more improved scores there were on the '67 multiple choice, but not on the other multiple choice exams.

9. The average percentage-of-perfect score on the daily and weekly quizzes correlated with the mathematics pretest and all subsequent statistics tests, but not with the time spent with the tutors and not with the Nelson Denny tests. They also correlated positively with the pre-attitude but not with the post-attitude.

10. An analysis of the cumulative weekly quizzes, the midterm and the final examination showed that although the students achieved mastery, they maintained the same rank order position as the course progressed, however this study did not investigate the changes in variability of the scores throughout the course.

CHAPTER VI

SUMMARY, DISCUSSION, RECOMMENDATIONS, CONCLUSION

SUMMARY

This study was introduced with the concept of accountability. It was stated that the meaning of accountability must be related to teachers, their classroom performance and the achievement of their students. Further, the most appropriate methods, techniques and strategies for accountability must be determined empirically. This was the primary purpose of this study: to determine empirically which of three learning methods produced the highest degree of subject matter mastery.

The three learning methods used in this study were Traditional Learning, Mayo's Mastery Learning and Capsulized Mastery Learning. The subjects were college students (a majority of graduate students), enrolled in an elementary statistics course at Loyola University during the summers of 1967, 1968 and 1969. These students experienced Traditional Learning, Mayo's Mastery Learning, and Capsulized Mastery Learning respectively in 1967, 1968 and 1969.

Traditional Learning (TL) was defined as large group instruction using the lecture demonstration technique. The most important aspects of Mayo's Mastery Learning (MML) was the use of tutors, formative quizzes, and the

reduction of anxiety about the final examination. The following is a summary of the components that comprised Capsulized Mastery Learning (CML).

1. Each lesson starts with a specific statement of objectives in behavioral terms. These objectives are stated in hierarchical form utilizing Bloom's Taxonomy structure as a guide. They are communicated in writing to students.

2. Specifically prepared supplementary materials are constructed with the aid of the results of the formative evaluations.

3. The lecture is traditional (but results in more class participation due to the students' knowledge) of the objectives. Also questions are promoted by any misunderstanding of the prepared materials.

4. Following the lecture a formative quiz, which is designed to measure the degree to which the students have mastered the subject, is administered. Subsequent lessons will, in part, be based on the results of this quiz. Also, tutorial help would be given to those students whose quiz scores indicate a need of it.

5. Finally, a summative evaluation test is given to define those who have met the pre-set objectives. This test will determine those students who have mastered the subject.

Data for the Traditional Learning and Mayo's Mastery Learning classes were made available to this writer by Dr. Samuel T. Mayo, so that a comparison could be made with Capsulized Mastery Learning. In addition, a correlational analysis of the forty-two variables measured in the Capsulized Mastery Learning treatment was performed. (These variables are listed on page 319.)

Using a chi square analysis on the biographical data collected from the three groups, no significant differences were found among the groups. Nonetheless, it was appropriate to use analysis of covariance to adjust the criterion scores on the basis of one or more of the covariables as a means of equating the groups, since random assignment of students was impossible.

Forty-three separate covariance analyses were performed by using various combinations of the covariates. This procedure was used to state with as much confidence as possible that the groups were not different originally, and that the differences in the criterion variables was attributed to the differences in the treatment among the groups.

The covariates used in this study were the mathematics pretest, the Nelson Denny reading tests and pre-course opinionnaires. These produced a total of eight scores which were used to adjust the criterion variables. The criterion variables were the 1967 and the 1968 final examinations, the 1968 midterm and the 1967 combined quiz scores. In one case the post-course statistics opinionnaire was used as a criterion variable.

By utilizing analysis of covariance to compare the three groups, it was found that:

1. The (CML) class performed significantly better than the (MML) class.
2. The (MML) class performed significantly better than the (TL) class.
3. The (CML) class performed significantly better than the (TL) class.

In other words, (CML) was found to produce students who showed greater capabilities in statistics, as measured by the quizzes, midterm and final examinations than those who experienced Mastery Learning or those who were exposed to Traditional Learning.

The correlational analysis performed on the forty-two variables (listed on page 319) from the group exposed to C.M.L. revealed a significant positive correlation between the mathematics pretest and the computational parts of the subsequent criterion examination. This suggests that those students whose pretest performance was poorest could have been given special attention by the tutors with the objective of improving their computational skills, which might have enhanced their chances for mastery of statistics. In other words, if mathematics computational skills could have been improved, a corresponding improvement in the probability for mastery of statistics might have been expected. We do not have empirical evidence from this study on the effect of such intervention. An additional study would be necessary for this.

The Nelson Denny Reading test showed no significant correlation with the total scores on the criterion examination. This is a confirmation of Carroll's hypothesis that the correlation of aptitude and achievement drops to zero by the end of the course. Perhaps this is the most important finding of all, since it is the basic assumption of C.M.L. that all students are capable of mastering the subject regardless of difference in initial ability.

The correlational analysis of the summed weekly quiz scores (variables 30, 31, 32, 33, and 34, Appendix B, page 319) disclosed that, as the course progressed, the students maintained the same relative position with respect to the total number of quiz points earned. It is illuminating and

interesting, while there was no significant change in relative position, that the performance of nearly the entire class was translated linearly into the mastery("A") range. This supports the notion that nearly all students, regardless of their initial competencies, can master the subject matter.

The investigation of student opinions of Capsulized Mastery Learning revealed that their opinions toward statistics and mathematics remained invariant as measured by the opinionnaires used. In itself, this result is difficult to interpret. Additional information of how opinions shift during and after more traditional courses would have to be analyzed to make valid comparisons and conclusions.

DISCUSSION

The primary purpose of this study has been accomplished, namely, the comparison of three types of classroom learning strategies. The value of the C.M.L. strategy under the conditions and restrictions of the study has been established. All twenty-two students achieved the pre-set level of mastery. This level is set prior to the beginning of the course by stating specific objectives. Twenty-one students earned grades of "A", while one received a grade of "B". These levels are commensurate with the "A" and "B" levels of the 1967 control group. The restrictions of sample size, intelligence level, maturity of the group and the mathematical type of subject matter (statistics) all must be removed before results can be generalized to any degree beyond the specifications of this study. Nonetheless, Capsulized Mastery Learning in its first trial has been found to be a viable learning strategy. If it withstands the test of replication, it can become an important tool in the hands of the educator. A combination of factors such as the presentation of

behavioral objectives utilizing Bloom's Taxonomy, the immediate feedback and reinforcement of results of the formative quizzes, the utilization of the tutors to provide individualization of instruction, all contributed to the success of the C.M.L. technique. Other factors, such as the self-confidence that the students developed as the course progressed, the positive effects that were experienced by the instructor, and the team support of students achieving mastery were less obtrusive and were not quantified; however, they surely contributed to the success of the experiment. Since there were multiple factors which could have affected the outcome, one cannot at this time isolate their separate effects.

In this writer's opinion, the forty-three million children and youth who attend American schools are entitled to encounter educational programs which produce such successful results. In the last ten years, the U.S. Federal Government has spent over one-hundred million dollars toward the goal of improved educational programs. Have the developed programs significantly improved the state of the educational art? The time has come to do away with grandiose programs that are designed to do everything, but in reality fail to produce positive results. Programs should specifically define what skills and ideas they are designed to develop, and then proceed to state to what degree these skills and ideas will be developed. Finally, these programs should have a built-in process which will enable the teacher to assess whether or not the students have achieved objectives of the program. C.M.L. is such a program.

The past and even the recent results of the Chicago Public School testing program have shown that students are becoming increasingly deficient

when compared to average age-grade national norms. That is, Chicago students start out equivalent to other first graders, but lose ground to national norms as they proceed to subsequent grades. C.M.L., because it requires that students achieve specific objectives before they progress to higher levels, would necessarily prevent this accumulated deficit. If C.M.L. were to become nationaly implemented, grades as we now know them would disappear. Replacing them would be a list of achieved objectives. This innovation could signifi-cantly improve the educational system by providing concerned teachers, students, parents, administrators, and taxpayers knowledge of how well the system is functioning.

One of the obvious dividends of a system such as this would be to make apparent those areas in which teaching techniques need to be improved. It would clarify which methods and teachers are succeeding, and those that are failing. It would spotlight weak areas and permit the educational researchers to concentrate their efforts wherever the problems arise.

Stating specific objectives and measuring their attainment is only a part of C.M.L. technique. Perhaps there are other learning schemes which can realistically use this method of listing accomplishments positively, rather than negatively, just as the prevalent practice of assigning grades of C,D, and F to most of the students.

In the past when educational techniques that were being employed met with failure, the instant remedy was to reformulate the goals, aims and objectives, rather than concentrate on the technique itself. The result of

this was the development of vague and general objectives which were meaning-less. This in turn resulted in further deterioration of classroom perform-ance. The only way to break the deterioration cycle is to retreat to specific objectives. Since education is our society's most important commodity, time spent in its pursuit must be meaningfully directed toward specific goals.

From the psychological point of view, C.M.L. has a great deal to offer. It is a learning technique which insures success and therefore precludes the frustration due to failure. From a middle class viewpoint, scholastic success is its own reward, and this alone should increase the learning rate. These all are in the plus column for the C.M.L. technique. However, one must admit that in situations where scholastic success is not valued, as in the ghetto schools, the logic used above does not hold. Nevertheless, C.M.L. might be an improvement over the existing conditions.

The economics of C.M.L. is a question which cannot be satisfactorily answered within the scope of this study. However, it is true that initial costs would far exceed the cost of the present methods. For example, the cost of the C.M.L. course considered in this study would have been approximately four to five times the traditional cost of the same course. Since the materials are now developed, subsequent courses using the C.M.L. technique would probably cost about one and a half times the traditional. Before considering this too costly, however, one must examine the quality of the product. To do this, one must consider the total number of quality points earned by the students exposed to C.M.L., and the same number of students

receiving the near-normal distribution of grades in a traditional class. In our experimental C.M.L. class the students received 21 A's and 1 B, compared to the 1967 control group in which only three students received an A. (See Appendix F page 333 for complete distribution of grades). If the normal curve were used to distribute grades in a traditional class of 22 students, the expected distribution would be as follows: 2-A's, 5-B's, 8-C's, 5-D's and 2-F's. From this it can be shown that C.M.L. produced approximately twice the total quality points as the traditional methods. More specifically, the '67 group received 3-A's, 17-B's, 9-C's and 1-D. This means that the '67 group earned, on the average, 2.73 quality points whereas the C.M.L. group earned 3.95 quality points. This means that C.M.L. yielded a 45% increase in production and would indicate that the cost of C.M.L. (while it could approach twice the cost of the traditional methods) would still be considered a better value. Therefore, on a fiscal basis alone C.M.L. can be feasible by staying within current expenditures. The preceding reasoning holds if one assumes that the quality point scale is a linear ratio scale, which never exists.

From an administrator's viewpoint, C.M.L. may cause a slight degree of uneasiness, especially if its understanding is incomplete. Administrators must realize that the "A" grade is what this technique is designed to produce. Any student who does not achieve mastery will be the exception under this strategy. It is this concept with which the administrator must become familiar. Although not a formal survey, this writer canvassed the opinion of several administrators and teachers regarding this subject. In general, they felt that C.M.L. would meet with suspicion initially, but would at least be given a fair trial.

RECOMMENDATIONS

For further explorations of Capsulized Mastery Learning, several aspects should be considered:

1. The significant correlation between the mathematics pretest and the final examinations indicates that the students' relative positions were not altered. In other words, there had been a linear translation into the "A" range.

2. In this study not all of the students who exhibited difficulties on the formative quizzes took every opportunity to meet with the tutors. In replication, provisions must be made to develop more effective means to urge students not exhibiting mastery on formative quizzes to spend more time with the tutors.

3. In this study the emphasis was on the cognitive aspects of learning. In replication, a more effective defintion of the affective objectives and the means and materials to achieve them should be developed. This type of investigation could reveal improvements which should be made in the C.M.L. strategy that would augment its effectiveness.

4. In a larger study of C.M.L., personality, biographical and affective variables, in addition to cognitive variables, should be investigated. This would have as its ultimate objective a determination of how learning could be made more congruent to the learner with respect to his personality, background, affective and cognitive characteristics.

5. In future studies of this technique, trials must be made in other subject matter areas. C.M.L. should be developed for other mathematics

courses and other courses of study. It would not be surprising to find that in certain areas of the curriculum, C.M.L. in its present form would not be suitable.

6. Finally, in order to have complete knowledge of the C.M.L. strategies, a longitudinal study must be performed. Its purpose would be to determine the long range effects of the study. It may well be that while the short term effects are positive, some unpredictable, negative, long term effects may exist which a properly conducted longitudinal study would unearth.

CONCLUSION

It has been stated that the concept of teacher accountability depends upon empirical development of classroom methods. Capsulized Mastery Learning is such a method. In a classroom situation, it was found to be more successful in producing more students with a higher level of subject matter mastery than the other two methods investigated. While no single set of research findings hold all the answers to classroom learning problems, perhaps C.M.L. can provide a viable solution to some of them.

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APPENDICES

First Summer Session, 1969
Dr. S.T. Mayo

SYLLABUS

Elementary Statistics
(Education/Psychology 380)

Required Text: Tate, Merle, W.   Statistics in Education and Psychology.
                     New York: The Macmillan Company, 1965.

Optional Text: Walker, Helen, M.   Mathematics Essential for Elementary Statistics.
                     New York: Holt, Rinehart & Winston, 1951.

Date	Topic	Test	Reading reference	Homework problems
June 30	Orientation	Reading Comprehension		
July 1	Mathematics for Statistics Distribution of Course Objectives	Mathematics Pretest Mathematics Opinionnaire	Walker	
July 2	I. Introduction to Statistics A. Definition and history B. Uses		Tate: Ch. 1 pp. 1-20	
July 3	II. Variables and scales A. Types of variables B. Types of scales	Statistics Opinionnaire	Mimeographed Sheet	
July 4	Independence Day - No class			

Date	Topic	Test	Reading reference	Homework problems
July 7	III. Organization and presentation of statistical data A. Ranking B. Grouping 1. Advantages 2. Disadvantages 3. Assumptions 4. Class intervals	Quiz #1	Tate: Ch. 2 pp. 24-29	I
July 8	C. Graphical representations of statistical data 1. Histogram 2. Frequency polygon 3. Cumulative distributions 4. Other distributions		Tate: Ch. 2 pp. 29-39	II
July 9	IV. Characteristics of statistical series A. Central tendency		Tate: Ch. 3 pp. 42-45	
July 10	1. Mode a. Definition b. Computation c. Uses	Quiz #2	Tate: Ch. 3 pp. 45-47	III, IV
July 11	2. Median a. Definition b. Computation c. Uses		Tate: Ch. 3 pp. 47-50	VI, VII, VIII

Date	Topic	Test	Reading reference	Homework problems
July 14	3. Arithmetic Mean a. Definition b. Computation c. Uses		Tate: Ch. 3 pp. 50-59	IX, X, XI
July 15	B. Variability 1. Crude range 2. Interpercentile measures a. Percentiles b. Deciles, Quartiles, and Quintiles c. Semi-interquartile range	Quiz #3	Tate: Ch. 4 pp. 63-71	XIV, XV, XVI, XVII
July 16	3. Standard Deviation a. Computation with grouped and ungrouped data		Tate: Ch. 4 pp. 71-78	XVIII, XIX, XX, XXI, XXII, XXIII
July 17	Continuation of computation with grouped and ungrouped data			
July 18	Midterm Examination			
July 21	4. Properties and applications of measures of variability a. Skewness b. Kurtosis		Tate: Ch. 4 pp. 78-87	V, XII

Date	Topic	Test	Reading reference	Homework problems
July 22	V. Transformations of scores A. Percentile ranks 1. Measured data 2. Ordered data B. Cumulative percentage curve C. Standard scores 1. z scores 2. Z scores 3. Stanines		Tate: Ch. 5 pp. 99-103	XXIV, XXV, XXVI
July 23	VI. The Normal Curve A. Properties 1. Areas and frequencies under the normal curve 2. Proportions between given ordinates B. Fitting data to the normal curve	Quiz #4	Tate: Ch. 6 pp. 106-121	XXVII, XXVIII
July 24	C. T scores and Z scores D. Normalizing raw data		Tate: Ch. 6 pp. 121-122	
July 25	VII. Correlation and Regression A. Linear Correlation 1. Scatter diagrams 2. Correlation coefficients a. Pearson Product-Moment coefficient of correlation (xy)	Quiz #5	Tate: Ch. 7 pp. 126-142	XXIX a, b
July 28	b. Spearman rank difference correlation (r)		Tate: Ch. 7 pp. 161-163	XXX a

Date	Topic	Test	Reading reference	Homework problems
July 29	3. Uses and abuses of correlation		Tate: Ch. 7 pp. 153-161	
July 30	4. Other correlation coefficients		Tate: Ch. 7 pp. 163-176	XXX b, XXXI
July 31	Feast of St. Ignatius - No class			
August 1	B. Linear Regression 1. Regression equations 2. Standard error of estimate		Tate: Ch. 7 pp. 142-153	XXIV c, d, e
August 4	VIII. Testing hypothesis about attributes A. Contingency table B. Chi-square C. Testing independence in a contingency table	Quiz #6	Tate: Ch. 12 pp. 289-307	XXXII, XXXIII
August 5	D. Alternative hypotheses E. Median test F. Interpretation of interactions			
August 6	Review			
August 7	Review			
August 8	Final Examination			

KNOWLEDGE

1.00 Knowledge

Knowledge, as defined here, involves the recall of specifics and universals, the recall of methods and processes, or the recall of a pattern, structure, or setting. For measurement purposes, the recall situation involves little more than bringing to mind the appropriate material. Although some alteration of the material may be required, this is a relatively minor part of the task. The knowledge objectives emphasize most the psychological processes of remembering. The process of relating is also involved in tnat a knowledge test situation requires tne organization and reorganization of a problem such that it will furnish the appropriate signals and cues for the information and knowledge the individual possesses. To use an analogy, if one thinks of the mind as a file, tne problem in a knowledge test situation is that of finding in the problem or task the appropriate signals, cues, and clues which will most effectively bring out whatever knowledge is filed or stored.

1.10 Knowledge of Specifics

The recall of specific and isolable bits of information. The emphasis is on symbols with concrete referents. This material, which is at a very low level of abstraction, may be thought of as the elements from which more complex and abstract forms of knowledge are built.

1.11 Knowledge of Terminology

Knowledge of the referents for specific symbols (verbal and non-verbal). This may include knowledge of the most generally accepted symbol referent, knowledge of the variety of symbols which may be used for a single referent, or knowledge of the referent most appropriate to a given use of a symbol.

1.12 Knowledge of Specific Facts

Knowledge of dates, events, persons, places, etc. This may include very precise and specific information such as the specific date or exact magnitude of a phenomenon. It may also include approximate or relative information such as an approximate time period or the general order of magnitude of a phenomenon.

1.20 Knowledge of Ways and Means of Dealing with Specifics

Knowledge of the ways of organizing, studying, judging, and criticizing.
This includes the methods of inquiry, the chronological sequences, and
the standards of judgment within a field as well as the patterns of
organization through which the areas of the fields themselves are deter-
mined and internally organized. This knowledge is at an intermediate
level of abstraction between specific knowledge on the one hand and
knowledge of universals on the other. It does not so much demand the
activity of the student in using the materials as it does a more passive
awareness of their nature.

1.21 Knowledge of Conventions

Knowledge of characteristic ways of treating and presenting ideas and
phenomena. For purposes of communication and consistency, workers in
a field employ usages, styles, practices, and forms which best suit
their purposes and/or which appear to suit best the phenomena with
which they deal. It should be recognized that although these forms and
conventions are likely to be set up on arbitrary, accidental, or author-
itative bases, they are retained because of the general agreement or
concurrence of individuals concerned with the subject, phenomena, or
problem.

1.22 Knowledge of Trends and Sequences

Knowledge of the processes, directions, and movements of phenomena with
respect to time.

1.23 Knowledge of Classifications and Categories

Knowledge of the classes, sets, divisions, and arrangements which are
regarded as fundamental for a given subject field, purpose, argument,
or problem.

1.24 Knowledge of Criteria

Knowledge of the criteria by which facts, principles, opinions, and
conduct are tested or judged.

1.25 Knowledge of Methodology

Knowledge of the methods of inquiry, techniques, and procedures employed
in a particular subject field as well as those employed in investi-
gating particular problems and phenomena. The emphasis here is on the
individual's knowledge of the method rather than his ability to use the
method.

1.30 Knowledge of the Universals and Abstractions in a Field

Knowledge of the major schemes and patterns by which phenomena and ideas are organized. These are the large structures, theories, and generalizations which dominate a subject field or which are quite generally used in studying phenomena or solving problems. These are at the highest levels of abstraction and complexity.

1.31 Knowledge of Principles and Generalizations

Knowledge of particular abstractions which summarize observations of phenomena. These are the abstractions which are of value in explaining, describing, predicting, or in determining the most appropriate and relevant action or direction to be taken.

1.32 Knowledge of Theories and Structures

Knowledge of the body of principles and generalizations together with their interrelations which present a clear, rounded, and systematic view of a complex phenomenon, problem, or field. These are the most abstract formulations, and they can be used to show the interrelation and organization of a great range of specifics.

INTELLECTUAL ABILITIES AND SKILLS

Abilities and skills refer to organized modes of operation and generalized techniques for dealing with materials and problems. The materials and problems may be of such a nature that little or no specialized and technical information is required. Such information as is required can be assumed to part of the individual's general fund of knowledge. Other problems may require specialized and technical information at a rather high level such that specific knowledge and skill in dealing with the problem and the materials are required. The abilities and skills objectives emphasize the mental processes of organizing and reorganizing material to achieve a particular purpose. The materials may be given or remembered.

2.00 Comprehension

This represents the lowest level of understanding. It refers to a type of understanding or apprehension such that the individual knows what is being communicated and can make use of the material or idea being without necessarily relating it to other material or seeing its fullest implications.

2.10 Translation

Comprehension as evidenced by the care and accuracy with which the communication is paraphrased or rendered from one language or form of

communication to another. Translation is judged on the basis of faith-
fulness and accuracy, that is, on the extent to which the material in
the original communication is preserved although the form of the
communication has been altered.

2.20 Interpretation

The explanation or summarization of a communication. Whereas trans-
lation involves an objective part-for-part rendering of a communication,
interpretation involves a reordering, rearrangement, or a new view of
the material.

2.30 Extrapolation

The extension of trends or tendencies beyond the given data to deter-
mine implications, consequences, corollaries, effects, etc., which are
in accordance with the conditions described in the original communica-
tion.

3.00 Application

The use of abstractions in particular and concrete situations. The
abstractions may be in the form of general ideas, rules of procedures,
or generalized methods. The abstractions may also be technical prin-
ciples, ideas, and theories which must be remembered and applied.

4.00 Analysis

The breakdown of a communication into its constituent elements or parts
such that the relative hierarchy of ideas is made clear and/or the re-
lations between the ideas expressed are made explicit. Such analyses are
intended to clarify the communication, to indicate how the communication
is organized, and the way in which it manages to convey its effects, as
well as its basis and arrangement.

4.10 Analysis of Elements

Identification of the elements included in a communication.

4.20 Analyses of Relationships

The connections and interactions between elements and parts of a
communication.

4.30 Analysis of Organizational Principles

The organization, systematic arrangement, and structure which hold the
communication together. This includes the "explicit" as well as "im-

plicit" structure. It includes the bases, necessary arrangement, and the mechanics which make the communication a unit.

5.00 Synthesis

The putting together of elements and parts so as to form a whole. This involves the process of working with pieces, parts, elements, etc., and arranging and combining them in such a way as to constitute a pattern or structure not clearly there before.

5.10 Production of a Unique Communication

The development of a communication in which the writer or speaker attempts to convey ideas, feelings, and/or experiences to others.

5.20 Production of a Plan, or Proposed Set of Operations

The development of a plan of work or the proposal of a plan of operations. The plan should satisfy requirements of the task which may be given to the student or which he may develop for himself.

5.30 Derivation of a Set of Abstract Relations

The development of a set of abstract relations either to classify or explain particular data or phenomena, or the deduction of propositions and relations from a set of basic propositions or symbolic representations.

6.00 Evaluation

Judgments about the value of material and methods for given purposes. Quantitative and qualitative judgments about the extent to which material and methods satisfy criteria. Use of a standard of appraisal. The criteria may be those determined by the student or those which are given to him.

6.10 Judgments in Terms of Internal Evidence

Evaluation of the accuracy of a communication from such evidence as logical accuracy, consistency, and other internal criteria.

6.20 Judgments in Terms of External Criteria

Evaluation of material with reference to selected or remembered criteria.

SYNOPSIS OF THE DEVELOPMENT OF THE

ESPECIALLY PREPARED SUPPLEMENTARY MATERIALS

This writer is grateful to Richard Bushong, Carol Breslin and Barbara Przywara for their contribution to the development of these materials. They made an impossible task probable.

Creating these materials was essentially a six step process.

1. Each item of the 1967 and 1968 summative evaluation instruments, that is, the midterms and finals, was analyzed to determine the overall course objectives.

2. An attempt was made to classify these items using the hierarchical classification system of the Taxonomy of Educational Objectives. This was accomplished by having the four of us independently classify each of the items. Where differences in classification arose, a form of arbitration was utilized until a specific classification was agreed upon.

3. Each of these items and their respective objectives were then placed in one of twenty-two separate categories. This was done on the basis of the content of the item and its objective. These twenty-two categories eventually developed into the twenty-two daily lesson supplements presented in the following section. The Table of Contents contains a list of these lesson topics.

4. After these items and objectives were separated into the twenty-two categories, a parallel set of items which would be used for formative evaluation was developed. These items were given as a quiz at the end of each lesson. From these quizzes it was determined if additional exposure to

specific concepts was necessary before mastery could be attained.

5. The objectives were used as a guide for the development of the text-like part of the daily lessons. Armed with these objectives, several texts were reviewed to determine which approach would be most likely to help the students achieve the aforementioned objectives.

6. The objectives that the students were expected to achieve would be specifically stated at the beginning of each lesson. The coding system of the Taxonomy of Educational Objectives: Cognitive Domain was used to inform the student of the learning level that he should attain.

ORIENTATION NOTES FOR ELEMENTARY STATISTICS - EDUCATION/PSYCHOLOGY 380

First Summer Session 1968

In this course, you will be treated to something new and different--not only in terms of course material but in terms of ultimate goals and teaching methods as well. Because this class has been selected as part of a special research project in the teaching of statistics, special teaching aids and services will be available to each one of you to help you learn the material presented. Moreover, you will not be in competition with one another for grades, since no grading curve will be used.

WHAT THE LEARNING PROBLEMS ARE

The aim of this class is to achieve mastery learning. Now, what this means is that ideally each one of you should achieve mastery of the subject material and should thus receive a high grade. You all know that no two people learn any given thing at exactly the same rate of speed or in exactly the same way. There are probably as many rates of learning as there are people in this class. Moreover, some of you learn best by listening to the instructor explain the material, some by reading about the material, and still others by discussing the material with your colleagues or with an instructor.

You also differ from one another in two other attributes important to learning statistics: reading and computational skills. Despite these individual differences, all of you can achieve mastery, if you take advantage of the many aids which will be made available, for these aids are designed to meet the needs of individuals. Not all of you will require all of the special instructional materials and services available, of course, but all of you should seriously consider the help they offer.

There is no doubt that all of you have the ability to learn elementary statistics. You have proved this by your achievement in learning other college subjects. There are no untried freshmen in this class. Each of you is either an upper classman or a graduate student. It is possible, however, that you may handicap yourself unwittingly by your attitude toward simple mathematics in general and statistics in particular, or by your rusty reading and computational skills. But help is available even in these areas. In fact, an attempt will be made to diagnose problems in reading and computational skills as well as in attitude.

WHAT THE DIAGNOSTIC AIDS ARE

Early in this session, you will be given the following four tests which you may consider as diagnostic:

1. The Nelson Denny reading test
2. A mathematics pretest
3. An opinionnaire on mathematics
4. An opinionnaire on statistics

What these tests attempt to measure is obvious from their titles. Of course, none of these tests will determine any part of your final grade. Each is given in order to help the researchers determine where individual problems lie so that they can offer the corrective help necessary.

WHAT THE MATERIALS OF INSTRUCTION ARE

The materials of instruction are as follows:

1. Tate, Merle W. STATISTICS IN EDUCATION AND PSYCHOLOGY. (New York: The Macmillan Company, 1965).
2. Special mimeographed sheets.
3. Blomers, Paul and Lindquist, E.F. STUDY MANUAL FOR ELEMENTARY STATISTICAL METHODS. (Boston: Houghton Mifflin Company, 1960).
4. Walker, Helen M. MATHEMATICS ESSENTIAL FOR ELEMENTARY STATISTICS. (New York: Holt, Rinehart and Winston, 1951).

You have been asked to purchase Tate's STATISTICS IN EDUCATION AND PSYCHOLOGY as your textbook and also Blommer's and Lindquist's STUDY MANUAL FOR ELEMENTARY STATISTICAL METHODS as your workbook to give you practice in handling statistical problems. You will also be given the special mimeographed sheets as text material supplementing your textbook. Purchase of Walker's MATHEMATICS ESSENTIAL FOR ELEMENTARY STATISTICS is optional, since only some of you will need to refer to it in order to improve your computational skills. The library in Lewis Towers has three copies of this book on reserve for you to use, should you care to use it without purchasing it.

WHAT THE SPECIAL SERVICES ARE

The special services are provided by tutors who will work with either individuals or small groups by appointment. There are three tutors available, all of whom are competent to give you help in the subject of elementary statistics. Moreover, each can also be considered a specialist in one of these three fields: psychology, mathematics, or reading. These tutors offer their services to the members of this class free of charge. You should not hesitate to ask for their help whenever you have difficulty keeping up with the work or understanding it.

There is another service that you can and should perform for yourselves. Studies have shown that small study groups of students--three or four to be precise--can often help one another learn a subject with greater ease than can

an instructor or a tutor. All of you will find it to your advantage to form such groups. Since you will not be competing with one another for grades, you have nothing to lose and everything to gain in such groups.

HOW YOU WILL BE GRADED

Your final grade will be determined by the results of all of your achievement tests in statistics. These tests will be of three types: quizzes, a midterm, and a final examination. The quizzes and the midterm will each contribute one-fourth to your final grade, and the final examination will contribute one-half. Remember, none of the grades for any of these tests will be determined by a curve. In other words, your grade will not be determined by how well anyone else in the class did, and so it is possible for every member of this class to get an A. The criterion against which you will be measured will be last year's Summer School class in Education/Psychology 380. Now, this class did not have the special services available to you, and individual members were in competition with one another. You have a distinct advantage over members of that class. To achieve real mastery of statistics, you have but to pursue the learning tasks set before you, using all the skill you have and taking advantage of all the available help you need.

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N O T E:

      The attached study guide is designed to supplement - not replace - your textbook. These materials, which will be presented in textbook-workbook fashion, are being prepared specifically for this course, and the order of topic presentation will follow your course outline. The primary purpose of these study guides is to assist you in attaining the objectives specified for a particular lesson. (See Condensed Version of the Taxonomy of Educational Objectives)

      It is advisable that these study guides, together with the objectives and quizzes, be kept in a 3-ring notebook for easy reference.

      Any workbook portions of these handouts should be completed before the next lesson begins. (You are not required to submit these papers to the professor.)

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LESSON 1 - Objectives

The numbers at the left refer to the Taxonomy of Educational Objectives classification. These numbers represent the level to which you are to master the topics following the number. You must refer to the Taxonomy classification in order to understand the meaning of the number.

The objectives for the first lesson are as follows:

1.11   Three uses of the word "statistics"

1.23   Statistical Method
       A. Descriptive
       B. Inferential

1.23   Sample vs. Population

LESSON 1 - An Introduction

Statistics is a relatively new branch of mathematics. It had its beginnings in the seventeenth century when much of the work was done in the area of probability, searching for ways to win in a variety of card and dice games.

Knowledge and understanding of statistics is important today and becoming increasingly important every day. Its value increases with the complexity of our society. The "information explosion" which we are presently experiencing, makes it necessary to analyze large quantities of data in ways that are meaningful.

The word "statistics" presents a semantical problem in that it has three meanings which will probably cause beginning students some difficulty. The following statements identify the three meanings:

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1. "Statistics" refers to symbols and their meanings used to describe large quantities of data, i.e., M=mean, Mdn=median, Mde=mode, s=standard deviation, s^2=variance, etc.

2. "Statistics" refers to statistical methods used in a problem situation, i.e., the method of adding all the scores on a particular test and dividing by the number of persons taking the test in order to get the mean of the set of scores.

3. "Statistics" refers to the numerical facts collected from a given sample, i.e., a list containing the height, weight, and grade point averages of the members of this class.

Any confusion in this area will dissipate as one becomes more familiar with the subject.

It is possible to classify statistical methods into two broad categories, based on use or method. Statistics can be descriptive or inferential. Descriptive statistical methods are used to summarize and quantify collected data. Inferential statistical methods are used to infer what is characteristic of a population by studying the sample from that population.

A good sample is a small, but representative portion of the total population. A population is the source from which the sample is taken. For example, 100 randomly selected fourth-graders is a sample of the total population of fourth-graders. The underlying assumption of the sample is that whatever is true of the sample is within certain limits also true of the population from which it is drawn. A random sample, or more properly a random selection of a sample, is one in which every member of the population has an equal chance of being chosen.

In addition to the randomly selected sample, a stratified random sample is often useful. In this case the population is divided into strata or levels and then the members are randomly selected from each of these levels.

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LESSON 1 - Quiz

1,2. There is general agreement that statistics can be divided into the categories of _____ and _____ statistics.

3. _____ is concerned with the collection and summary of data.

4. _____ is concerned with drawing conclusions about the source of the data.

5,6. A _____ is always smaller than the _____ from which it is drawn.

7. T F Most samples are the same size.

8. T F One uses statistical inference to generalize from a sample to a population.

9. T F The mean and median are examples of statistics.

10. T F The methods used to calculate the mean and standard deviation are examples of statistics.

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LESSON 2 - Objectives

1.23   Types of variables
        A. Continuous and discrete
        B. Qualitative and quantitative

1.24,   Continuous - Discrete
3.00

1.24,   Measurement scales
1.32,   A. Nominal
3.00   B. Ordinal
        C. Interval
        D. Ratio

LESSON 2 - Variables and Scales

When collecting data in statistics, the term observation refers to each individual fact, and the term variable refers to the set of facts collectively. For example, by asking each person in this class to step on a scale, we can observe each individual's weight. The variable under consideration is weight, and the observation is the scale reading for each individual.

The variable "weight" has other characteristics which are typical of variables in this class and which define this class of variables. The two broad classes of variables are quantitative and qualitative. Examples of quantitative data are age, weight, scores on an achievement test, etc. Qualitative data would include variables such as color of hair and eyes, type of skin, attitudes, emotions, etc.

Variables can also be classified as continuous or discrete. A variable that can assume any value, such as hieght, weight and temperature, is called continuous. Variables which must be explained in terms of whole numbers, such

as the number of people in this classroom, are considered discrete. In some cases, however, discrete variables are treated as continuous. For example, the Government reports that the "average" family has 2.5 children. In this case the interpretation of the data is the key factor.

Before using any statistical method, one should be certain that the variables under consideration are of the proper type. Examine the following situation: Values of 1 and 0 are respectively assigned to the males and females in this class. A mean sex score of .59 is of little meaning in this case, whereas a mean weight of 135 for males and females would give us the average weight of persons in this room.

When two variables bear a causal relation (a change in one causes a change in the other), the variable effecting the change is called the inde-pendent variable, and the variable undergoing the change is called the dependent variable.

The operation of assigning numbers to variables is called measurement. There are four types of measurement scales: nominal (naming), ordinal (order-ing), interval (equidistant), and ratio (absolute zero point).

The nominal scale simply assigns arbitrary numbers to identify or distinguish classes or categories. The numbers assigned to players on a foot-ball team are included in this type of scale.

The ordinal scale places things in rank order. If A is taller than B and B is taller than C, we are not implying that B is twice as tall as A, but are merely stating that B is larger than C and smaller than A. In many

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cases in education and psychology, this is the highest level of classification
we have reached.

The interval scale is an ordinal scale with the addition of equidistant
intervals. In this case the distance from 1 to 2 is the same as from 2 to 3,
etc. Each interval scale also has an arbitrary zero point. An example in this
category is the reading of a thermometer. If water boils at 100° C and freezes
at 0° C, then the distance between these two points is divided into 100° equal
parts called degrees. It is clear, however, that water at 2° C is not twice
as hot as water at 1° C.

In order to make the statement that 2 is twice as great as 1 or that
100 is twice as great as 50, we must use a ratio scale. This scale has all the
properties of an interval scale with the addition of an absolute zero point.
The Kelvin temperature scale is one in which 50° K is twice as hot at 25° K.
Distance, time, mass and force are all examples of ratio measures.

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LESSON 2 - Quiz

1-4. In order of increasing complexity, the four types of measurement scales
     are _____, _____, _____,
     and _____.

5-6. Variables can be classified into continuous or discrete; and _____
     or _____.

Which of the following are discrete and which are continuous?

7. _____ Number of words spelled correctly on a spelling test.

8. _____ Number of books read.

9. _____ Number of stocks traded on New York Stock Exchange.

10. _____ Grade point averages.

11. _____ Number of full pages read in a book.

12. _____ Number of people in U.S.

13. _____ Thickness of sheets of paper.

14. _____ Time needed to complete this test.

15. _____ Distance between the earth and moon.

State the measurement scale implied by the following information:

16. _____ License plate numbers.

17. _____ 72° C.

18. _____ Telephone numbers.

19. _____ 20 feet long.

20. _____ Continental-4; Thunderbird-3; Mercury-2; Ford-1.

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The following are extracts from the cited texts which were distributed to the '68 and '69 groups. These pages were not read in class, however, the students were encouraged to do so at their own leisure.

VARIABLES

A variable is an attribute or property that takes on different numerical values. Thus, a variable varies, which means that it is an attribute or property viewed in terms of quantity. Although that quantity may connote value, it may, at times, signify only number. In any case, the word "variable" implies the idea of quantity, while such words as "property" and "attribute" imply the idea of quality.

This does not mean that the idea of property or attribute are not important to measurement. Indeed, they must precede any idea of measurement. A property is anything which the mind of man can conceive of and then observe as being inherent within an object. Weight, height, and color, are all examples of physical properties. Intelligence and personality are two examples of psychological properties. An attribute is similar to a property. It is what someone or some group perceives either directly or indirectly to be inherent in an object. A property attributed to an object is an attribute.

Just how properties become the province of measurement is described by Irving Lorge* as follows: "The ascription of a property to a class of objects. ...requires that differences in other characteristics be ignored, while

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*Lorge, Irving, "The Fundamental Nature of Measurement", in EDUCATIONAL MEASUREMENT, ed. by E.F. Lindquist. (Wash. D.C.: Am. Council on Ed. 1951) p. 538.

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tne attention is given some main feature or quality. A property, broad or narrow, that can be seen, recognized, or classified only by a unique observer ...cannot be considered a property capable of measurement or enumeration. In science, at least, there must be an agreement among expert observers that the property does exist, and such observers must agree in excess of chance upon whether a particular reaction does or does not demonstrate the property...If judges perceive the same differences, then, the perceived differences may become the basis for classification and enumeration and, in some instances, measurement. Tne perception of resemblances and differences becomes the basis for measurement."

To understand more clearly the relationship between properties and variables, take the idea of intelligence as an example. Intelligence can be considered as an attribute or a property common to the certain animals, and especially man. As an attribute or property, intelligence is a qualitative entity, that is, it is defined and thought of in terms of non-measureable characteristics. But as soon as one decides to measure or classify by number the intelligence of an individual or of a species, the idea of quantity is added, and intelligence becomes a variable.

Variables themselves are also classified. Most often they can be categorized either by the role they assume as quantifiers or by their general function. As quantifiers, variables either express a specific point on a scale or they designate number that may or may not have value.

Continuous and discrete variables are examples of variables classified in terms of how they quantify. A continuous variable is a variable that can

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assume any value on a continuous scale. That means, that it can have theoreti-
cally, any one of the infinite number of values that are common to its scale.
Intelligence is such a variable. If we suggest, for example, that the scale of
intelligence ranges from 50 to 150, continually, then it is possible for a
measure of intelligence to take on any value between these two points. It
could be 50 or 50.3 or 69.75 or 149.9999999, for example.

A discrete variable, on the other hand, is a variable that cannot have
any one of an infinite number of values on a continuous scale. Take the case
of the number of students in a classroom. Even if the possible scale were in-
finite in range, this variable could not assume any value in the continuum. It
would have to assume a value given in terms of whole numbers. Thus there might
be 20 or 30 or 50 students in a classroom, but never 20.2 or 30.5 or 50.8.
Moreover, in some cases discrete variables may assume no value as such but only
number. Take the case of the researcher who wishes to classify a population
according to sex, using only number. He has only two classifications, male
and female. He may quantify his data by assigning the numeral 0 to the cate-
gory marked "male" and 1 to the category marked "female". This quantification
makes the attribute sex a variable. It does not assign value to the individual
cases, but it does assign number. However, number here operates only for
nominal purposes, that is, to name or categorize. The researcher could just as
well have called 1 "male" and 0 "female". In any event, the variable in this
case is discrete.

Sometimes the designations "qualitative" and "quantitative" variables
are used. In actuality, since the word "variable" presupposes quantity, the

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idea of a "qualitative" variable is a paradox and the term "quantitative" variable is a redundancy. But what is usually meant by "qualitative" variable is any variable to which a number is arbitrarily assigned without reverence to value. Thus any variable assigned a category only, such as sex in the example above, becomes a qualitative variable. All others are, in this sense, quantitative variables.

Examples of variables classified in terms of their functions are, among others, dependent and independent variables, and criterion and predictor variables. Independent and dependent variables go hand in hand. One does not exist without the other, since the independent variable is by definition that variable that causes the effect seen in the deptndent variable. For example, in the equation $y = x + 3$, y is the dependent variable and x is the independent variable, since the value of y is caused by or depends on the value of x. In experiments, tne independent variable is the variable which is manipulated by the experimenter and can thus cause the effect in the subject. An experimenter who is studying the effect of teaching methods on students manipulates those teaching methods, or the independent variable. The student responses then become the dependent variable.

A criterion variable is a standard to which a given variable may be compared, and a predictor variable is a variable which is used to foretell the outcome of an event. Just because both of these types of variables are used to judge something else by does not mean that they are necessarily better than the thing being judged or that they are even, for that matter, appropriate judges. The only thing you can tell from the terms "criterion variable" or "predictor variable" is how they function.

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The criterion variable functions merely as a standard. The predictor variable functions merely to foretell. An example of a criterion variable is a set of reading scores which is made by one class and against which the reading scores made by another class will be compared. An example of a predictor variable is a set of scores on an aptitude test that will be used to foretell success in a given field of business.

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STEVENS' TABLE OF FOUR BASIC TYPES OF SCALES

(Abridged from Stevens*)

Scale Type	Basic Empirical Operations	Permissible Statistics	Typical Examples
Nominative	Determination of equality	Number of cases Mode Contingency correlation	Numbering of football players or license plates Assignment of type or model numbers to classes
Ordinal	Determination of greater or less	Median Percentiles Rank-order correlation	Hardness of minerals Quality of leather, lumber, wool, etc. Pleasantness of odors Ranking of objects or people
Interval (Cardinal without absolute zero)	Determination of equality of intervals or differences	Mean Standard deviation Rank-order correlation Product-moment correlation	Temperature (F & C) Calendar dates "Standard scores" on achievement tests (IQ is used as though it belonged here)
Ratio (Cardinal with absolute zero)	Determination of equality of ratios	Coefficient of variation Logarithmic transformations	Length, width, force, Pitch scale Loudness scale

*Stevens, S.S. "On the theory of scales of measurement." Science, 1946, 103, 677-680.

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MEASUREMENT SCALES

In the discussion to follow, we will speak of a "scale" as denoting the procedure, or "yardstick," with which a particular measure is obtained. Measurement scales are part of everyday living: the ruler as a scale to determine length, the thermometer to indicate temperature, and the achievement test to measure success in school. We customarily place numbers along scales, such as inches, degrees Fanrenheit, and test scores. However, these are not the same kind of numbers; they mean different things about "how much," and they have different mathematical uses. Some of the major kinds of measurement scales will be discussed in the following sections.

Labels. Labels, or tags, are used to signify that one object or person is distinct from another. The numbers on the backs of baseball players are labels. They tell nothing at all about quantities. The player numbered 44 is not necessarily twice as good as 22. If we add the labels for these two, 66 is obtained. Does this sum have any meaning? Any other numbers would have served as well, or the players could be distinguished by different colors, alphabetical letters, or geometric designs. Labels have no mathematical properties and are not scales at all. Other examples of numbers used as labels are the numbers on theater seats, numbers used to designate highways, and the numbering of stamps in a collection. Not every set of numbers is necessarily a set of measures. The investigator must ensure that the numbers which he studies are really quantities rather than mere lables.

Categories. Categorization, or qualitative distinction, is the most elementary type of scientific datum. The biologist makes a distinction between insects that have wings and those that do not. The chemist classifies liquids into those that are acid and those that are alkaline. Mental patients are categorized into groups such as depressive and schizophrenic. Members of the general public are categorized in terms of their preferences for political candidates.

Categorization implies that the things in a category have something in common and that they differ in some characteristic from the objects in other categories. The difference can be illustrated with a geologist's collection of rocks. The geologist might first apply labels to his collection, numbering them from 1 to N, simply as a way of keeping tract of all the specimen. Later he might categorize the rocks as to whether they are sedimentary or igneous in origin.

It was said previously that no mathematical significance could be placed on labels. Although this is a humble beginning, there are complex mathematical systems that work entirely with categorical data.

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The number of categories used in particular problems may be only two, or, in some studies, the number of categories is large. An example of multiple categorization would be the description of people in terms of occupations: farmers, plumbers, lawyers, and so on.

When using categories, no distinction is made among the objects or persons within a category. We might think of the members of any category as being equated to the number one-one plumber, one schizophrenic, or one alkaline liquid. This would then give no information as to whether one plumber is better than another or whether one liquid is more alkaline than another. Also, from the categorizations alone, there would be no way of knowing that lawyers receive higher incomes than farmers and plumbers, or that any relationship exists among the categories.

The results of psychological studies are sometimes reported in terms of categories. There are a number of ways of statistically analyzing data of this kind, some of which will be mentioned in the chapters ahead. Chief among these procedures is the description of populations of people in terms of the frequencies that fall in various categories and the comparison of categories for the amount of overlap. Illustrating the former, mental patients can be characterized as schizophrenic, paranoid, manic-depressive, or other. The latter type of procedure might be used to show that the members of one category of mental patients more frequently come from home environments of a particular kind than do the members of other categories of mental patients.

Ordinal Scales. The ordinal scale relates persons or objects to one another by ordering or ranking them in respect to an attribute. Course marks are sometimes reported as ranks. The person who performs best is given a rank of 1, second-best receives a rank of 2, and so on to the person with the worst performance. As a convention the ordering is symbolized as 1, 2, 3,..., N, with the understanding that the numbers mean first, second, third,..., Nth.

The essence of the ordinal scale is the concept of "greater than" portrayed by the sumbol ($>$). Thus a b means that a is greater than b, or that b is less than a. To have an ordinal scale, it must be established that $a>b>c>d>e>...>N$ for N number of persons in respect to any particular attribute. The concept of "greater than" characterizing ordinal scales is a kind of information in addition to the concept of "different from" used with categories.

An ordering, or rank-ordering, constitutes a scale of measurement, but the use of such scales has definite mathematical limitations. The ordinary arithmetical operations of addition, subtraction, multiplication, and division make little sense with ordinal numbers. It is not sensible to add together the first and third man and equate this in any way with the fourth man, as the ordinary operations of arithmetic would lead us to expect.

Two important kinds of information are lacking in the ordinal scale. The first is that no information is provided as to how well the group performs as a whole. If there are six students and no ties in examination grades, there will be ranks 1, 2,...,6 regardless of how well or how poorly the whole group performs. The ranks might have been determined within a group of geniuses, or the ranks might as easily have been obtained within a group of only moderately capable students.

The second important information that is lacking in the ordinal scale is that of the dispersion of performance. That is, there is no way of telling from the ranks alone how closely the second man approaches the first man, or how much better the first man performs than the man who is ranked last. If there are two classes and thirty students in each class, there will be ranks 1 through 30 in each class. There is no way of telling from the ranks whether the dispersion of ability is larger in one class than in the other. The students in one class might have performed much the same, and the students in the other class might have varied widely from one another in performance.

The most important type of mathematical operation that can be applied to ranks is that of correlation. In this way, it can be determined to what extent persons are ordered alike in two circumstances. It could be determined whether the persons who make grades near the top in history also make high grades in mathematics and additionally, an over-all numerical index of agreement could be found over the extent of both orderings. The ability to correlate two sets of measures satisfies the most basic requirement for evaluating tests. Correlational analysis will be discussed in detail in Chapter 5.

Interval Scales. If, in addition to an ordering of persons, a knowledge is obtained of the interval or the distance between persons, then an interval scale is produced. The results of a foot race could be reported in the form of an interval scale. The customary procedure is, of course, to state the exact running time for each participant. To illustrate the characteristics of interval scales, assume that the results are reported in terms of the interval between the first and second man, the second and third man, and so on. It could be said that the second runner came in one second behind the first, the third runner came in two seconds behind the second man, the fourth came in one second behind the third, and so on for all intervals.

Like ordinal scales, interval scales also provide no information about how well the people perform as a group. Because the results of the race were reported only in terms of intervals, we have no information about the absolute running times for the men. If we learn later that the first runner took ten seconds, then we know that the second man took exactly eleven seconds, the third man thirteen seconds, and so on for the other runners; but if the first man had taken twenty seconds, then we learn that the second man took twenty-one seconds, indicating that the group as a whole is much slower.

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The important advantage of the interval scale over the ordinal scale is that knowing the interval allows for the determination of the dispersion, or spread, of the scores. The range of scores is the interval, or distance, between the person who stands highest and the person who stands lowest on the scale. Also, the standard deviation of a set of scores can be determined without a knowledge of the absolute level of measurements. (Measures of dispersion will be discussed in Chapter 3.)

The arithmetical operations of addition, subtraction, multiplication, and division can be used with interval scales only in respect to the differences between scores. For example, the interval between the men who finish the race first and second could be compared directly with the interval between those who finish third and fourth.

The ordinary Fahrenheit thermometer is an example of an interval scale. The zero point on the scale is arbitrary. It is not meaningful, for example, to say that 90 degrees is twice as warm as 45 degrees.

Ratio Scales. The final member in the hierarchy of measurement scales is the ratio scale. The ratio scale requires that the absolute measurement of each person be known. Then in the race that we used to illustrate interval scales, we might find that the first man took eleven seconds, the second man twelve seconds, the third man fourteen seconds, and so on for the remaining runners. Specifying the absolute level for running, or for any other attribute, is the same as saying that the zero point on the scale is known.

In addition to its own special virtues, the ratio scale has all the advantages of the less powerful scales. All of the operations of arithmetic as well as the tools of higher mathematics can be applied to ratio scales. As the name implies, one score can be divided by another, multiplied by another, subtracted from and added to any other.

Ratio scales are used quite frequently in everyday life. No simpler example is available than the weighing of two objects on a "scale." Comparisons of salaries, heights of individuals, numbers of rooms in buildings, and many, many other quantities are treated as ratio scales. It is so customary to deal with ratio scales that it is easy to make the mistake of assuming that all measures are of this kind. For example, it might be said that John is "twice" as handsome as Bill. It is difficult in this case to see how the ratio "twice" could be obtained, and it is reasonable to suspect that a ratio scale is being used where only an interval or even an ordinal scale is justified.

Test Scores as Scales. Most test scores are treated as though they are interval scales. Without such an assumption there would be no way of obtaining measures of dispersion. As will be shown later, the standard deviation and its companion statistic, the variance, are crucial to the gathering of test norms and to the determination of how well tests work.

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It is not justifiable to treat most test scores as though they constitute ratio scales. The absolute scores that people obtain are largely artifacts of the ways in which tests are constructed. For example, a class instructor might decide to give five points for each correct answer, or he might decide on ten points instead. Such decisions markedly affect the absolute size of scores. For example, suppose that persons a, b, and c make scores of 20, 15 and 12 on a test. Then, if we assume that a ratio scale is logical in this case, it could be said that a demonstrated 1.33 times as much of the particular ability as does b. Suppose that the test were revised by adding five items which are so easy that a, b, and c get them all correct. Now, the scores for a, b, and c would be 25, 20, and 17 respectively. This changes the ratio between the score of a and b to 1.25. We see in this way that ratios computed from test scores are not usually meaningful.

In some instances, psychological measures are justifiably treated as ratio scales. Some of these would be the number of trials needed to learn a particular task, the length of time taken to respond to a visual signal, and the amount of perceptual distortion induced by a visual illusion. There have been some interesting attempts to deduce ratio scales for certain types of psychological measures, particularly for measures of attitudes and for measures of human judgment.

SUMMARY

Whether or not it is recognized and designated as such, psychological measurement is an important ingredient of everyday life. Systematic measurement methods were rather late in coming, and only during the last one hundred years has the problem been carefully studied. A major drawback to the development of measurement methods has been the failure to distinguish the kinds of psychological phenomena that can and cannot be measured. Psychological science is concerned with human behavior, with the actions, words, judgments, and preferences of people--all of which are open to measurement. Psychological science is not concerned with purely subjective phenomena; until the individual does something about his feelings, there is nothing to measure.

We are so accustomed to measuring physical objects and assigning numbers to them on the basis of ratio scales that it is easy to assume that all measurements are of that kind. However, many measurements, and particularly those in psychology, must be made on a cruder basis. Consequently, it is important to specify the type of measurement scale which is in use. This will indicate the kinds of mathematical procedures that can be legimately employed.

Although we should be impressed with the need for measurement methods, this should not dim the importance of simple human observation and thought in the search for scientific lawfulness. Measurements are helpful to the scientist in explaining and exploring theories, but only the human observer can invent

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theories. No amount of elaborate measurement can make up for a lack of ideas on the part of the experimenter.

SUGGESTED ADDITIONAL READINGS

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Goodenough, Florence L. Mental testing. New York: Rinehart, 1949, chaps. 1-6.

Lorge, I. The fundamental nature of measurement. In E.F. Lindquist (Ed.), Educational measurement. Washington: American Council on Education, 1951, chap. 14.

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LESSON 3 - Objectives

1.11   Frequency distribution

1.23   Data

1.21   Indicated and real interval limits

1.25   Midpoint of interval

LESSON 3 - Frequency Distribution

Frequency distributions are used to represent large quantities of data in the form of a table. Two columns are used: one containing the scores, and tne other the number or frequency of that score.

Sometimes frequency distributions are classified according to the type of data they represent. Categorical or qualitative frequency distributions are those in which data is classified according to quality, such as sex, color, etc. Numerical or quantitative data can also be represented by a frequency distribution. It has been stated previously that data can be discrete or continuous. Likewise, distributions of this type can be described as discrete or continuous. Generally, the following rule can be applied:

Categorical $\longleftrightarrow$ Qualitative $\longleftrightarrow$ Discrete

Numerical $\longleftrightarrow$ Quantitative $\longleftrightarrow$ Continuous

To illustrate, suppose a die were thrown 24 times with the following results: 6, 2, 6, 6, 4, 1, 4, 6, 5, 4, 5, 2, 3, 5, 2, 3, 6, 3, 1, 4, 6, 4, 1, and 3. Note that this is a discrete variable with six classes:

Class	1	2	3	4	5	6
Frequency	3	3	4	5	3	6

This distribution is clearly more usable than a simple array of scores. Suppose further that we wish to know the proportion of times a number > (greater than) 3 occurred. The convenience of the frequency distribution is obvious in this elementary example.

The frequency distribution is also convenient in more complex situations. Consider the following array which was obtained from a die that could produce all possible values between 1 and 6:

2.6, 1.9, 3.9, 3.1, 5.9, 2.9, 4.4, 4.6, 1.2, 1.3, 3.5, 4.3, 5.3, 5.3, 2.4, 5.9, 0.6, 2.0, 3.8, 4.7, 1.4, 1.1, 6.0, and 2.3.

This variable is continuous; it can take on all values from 1 to 6, the indicated class limits, following the rule that the real class limits lie ½ unit above and below the indicated class limits. Check the following frequency distribution for agreement:

Class	1	2	3	4	5	6
Frequency	5	4	4	4	4	3

Table 3.2

In the preceding examples, 6 class intervals were used, each 1 unit wide. In most cases it will be more convenient to have larger size intervals. Many authors suggest choosing an odd integer for the interval width (this allows the interval midpoint to be an integer), and keeping the size of the interval small enough to produce 10 to 20 intervals. These are merely suggestions, however, and not rules which cannot be deviated from.

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In summary, it has been stated:

1. That a frequency distribution is a convenient way to represent data in meaningful, tabular form;
2. That the data represented could either be continuous or discrete;
3. That the real class limits are ½ unit above and below the indicated class limits;
4. That the interval width should be an odd number so that the interval midpoint is a whole number.

LESSON 3 - Quiz

1. Data represented in tabular form are called a _____.

2. Data can be divided into the following categories:

   a. Discrete and _____

   b. Qualitative and _____

   c. Categorical and _____

3. Answer the following questions using the intervals listed below:

		Real Class Limits	Indicated Class Limits	Midpoint
a.	31-35	_____	_____	____
b.	36-40	_____	_____	____
c.	41-45	_____	_____	____
d.	46-50	_____	_____	____

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LESSON 4 - Objectives

1.11   Horizontal and vertical axis;
Histogram, frequency polygon, cumulative

2.10   Data into graphical representation

6.20   Histogram, cumulative frequency polygons

1.23   Skewness, Kurtosis, normal, symmetrical

LESSON 4 - Graphing

Oftentimes we are afforded a better picture of a distribution if we represent the statistical data in graphical form. In graphing a frequency distribution, the frequencies are plotted on the vertical axis and the scale is plotted on the horizontal axis of two perpendicular lines:
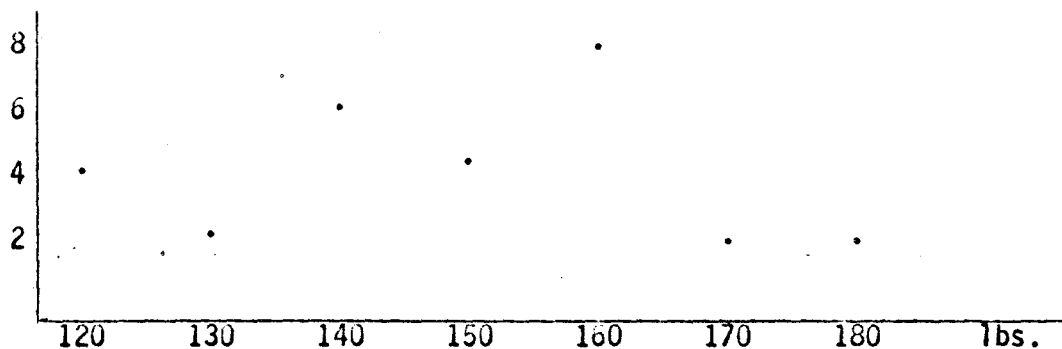
Figure 4.1. Graph of a frequency distribution

Refer to Figure 4.1 and answer the following:

1. How many people weigh 120 lbs? _____

2. What are the "real" interval limits of 130 lbs? _____

3. How many people are used in this set? _____

4. What is the average (mean) weight? _____

5. Which real interval has the most people in it (mode)? _____

6. Which weight interval has as many people above it as below it (median)?

HISTOGRAM

The histogram is an easily understood bar graph. Below is an example of a histogram based on the same data as in Figure 4.1:
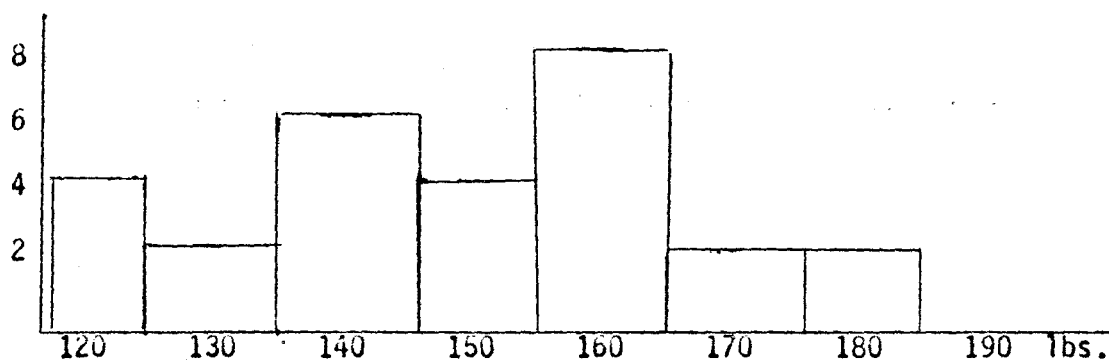
Figure 4.2. A Histogram

In a histogram the real interval limits are used with the midpoint of the interval shown. Also note that the area frequency times the width of the interval (represented by the bar) is the total weight of the individuals in that bar, and that the summation of these areas would equal the total weight of all the people represented in the histogram. Therefore, the total area under the histogram represents the total amount of the variable under consideration.

If the midpoints of the upper bases of each of the rectangles are connected, a frequency polygon is formed:
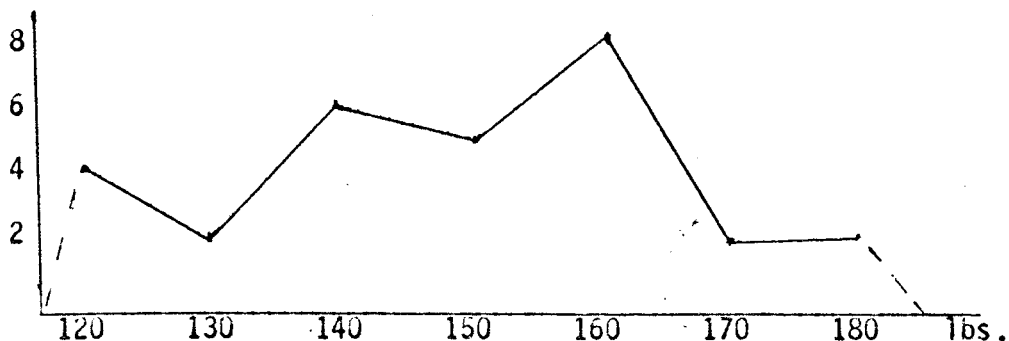
Figure 4.3. Frequency Polygon

Closing the polygon as indicated by the broken lines in Figure 4.3
produces a figure whose area is equal to the area of the corresponding histo-
gram. This can be proven by dividing the frequency polygon into triangles and
rectangles, and then summing the areas of these triangles and rectangles.
(The formula for the area of a triangle is A_t = ½base x height; for the area
of a rectangle A_r = base x height).

If the data used in the previous figures were expressed by a cumulative
frequency curve, it would take the following form:
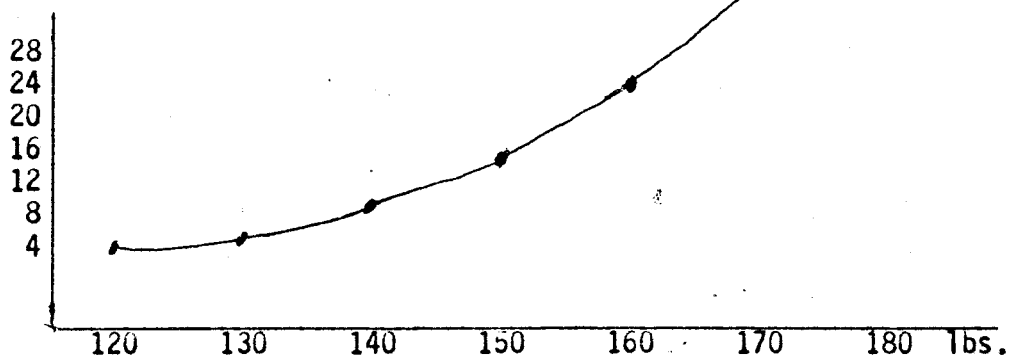
Figure 4.4. Cumulative Frequency Curve

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The data used to plot this curve is as follows:

lbs.	110	120	130	140	150	160	170	180
f	0	4	2	6	4	8	2	2
cf	0	4	6	12	16	24	26	28

Most students are familiar with the Cartesian Coordinate System where the y-axis is a vertical line (ordinate) and the x-axis is the horizontal line (abscissa). The intersection of these two lines is the origin, labeled 0,0. The directions to the left and down are negative; to the right and up are positive. To graph the point (-3,4) means going 3 units to the left and 4 units down.
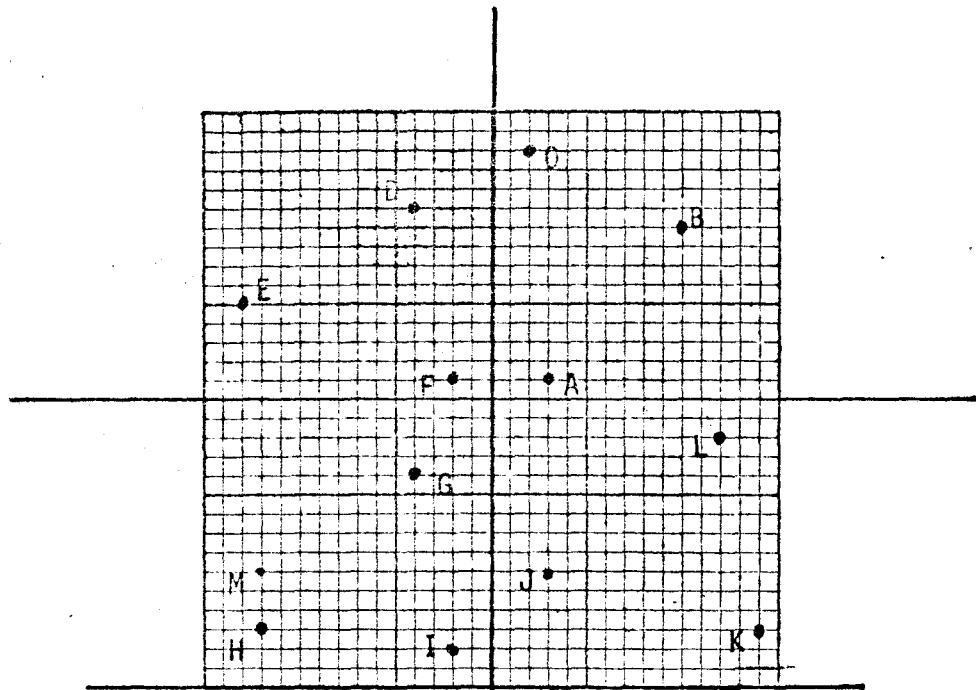
Figure 4.5

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From the graph on the preceding page, determine the coordinates which corre-
spond to the following letters:

A _____ B _____ C _____ D _____ E _____ F _____

G _____ H _____ I _____ J _____

On the axis below, plot the following pairs of points:

Y	0	.001	.004	.018	.054	.130	.242	.352	.399
Z	-4	-3.5	-3.0	-2.5	-2.0	-1.5	-1.0	-0.5	.0
Y	.352	.242	.130	.054	.018	.004	.001	0	
Z	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4	
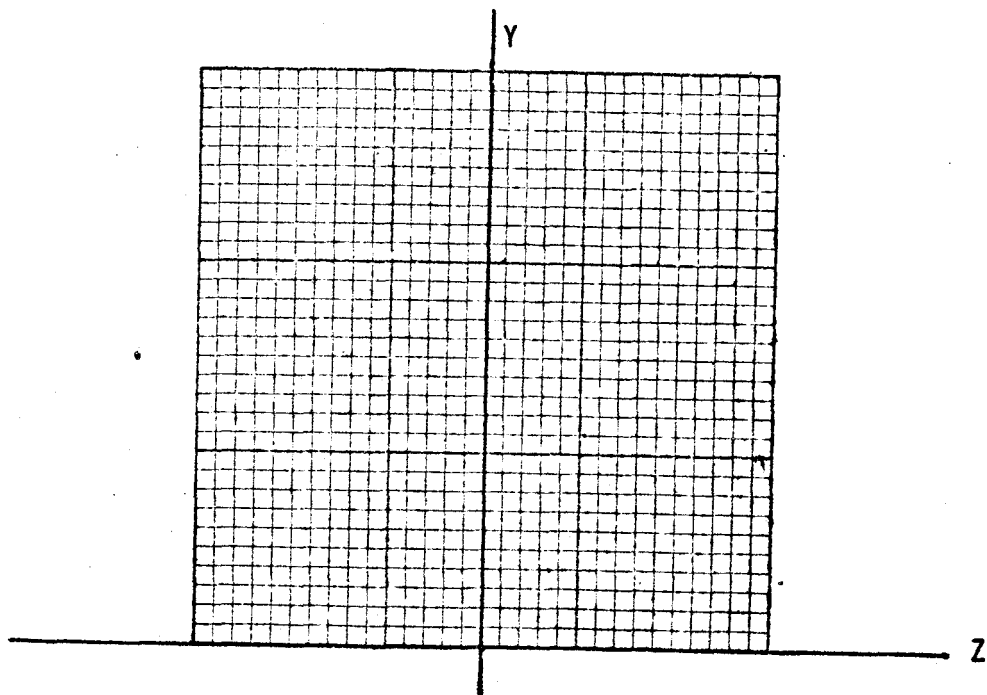
Figure 4.6.   Rough Graph of a Normal Distribution

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If these points are connected by a smooth curve, the result is a graph of the normal distribution. This distribution is symmetrical with respect to the y-axis; that is, the left side is a mirror image of the right side. Distributions that are not symmetrical are said to skewed. The following figures show skewed distributions:

Figure 4.7

Positively Skewed

Figure 4.8

Negatively Skewed

An easy way of differentiating between a positive and negative distribution is to remember that a positive distribution appears to "point" in the positive direction, and a negative distribution appears to "point" in the negative direction.

A distribution can be symmetrical and still not be normal. Those that are more peaked than normal are called leptokurtic; and those that are flatter than normal are called platykurtic.

LESSON 4 - Quiz

1. The _____ axis is horizontal and is called the _____.

2. The _____ axis is vertical and is called the _____.

3. On a graph the directions of right and up are _____; to the left and down are _____.

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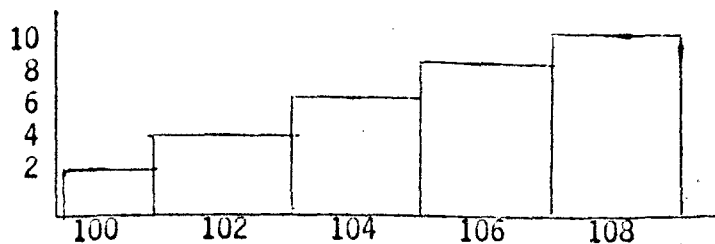
Figure A.
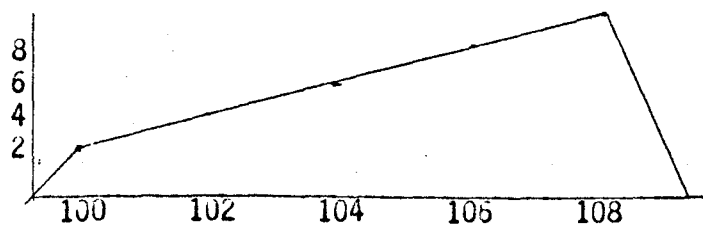
Figure B.
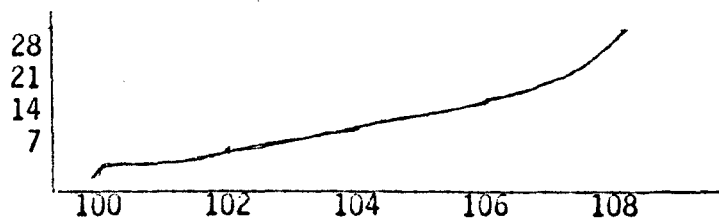
Figure C.

4. The above figures could be drawn from the same data:

    True _____ False _____

5. Figure A is called a _____.

6. Figure B is called a _____.

7. Figure C is called a _____.

8. In Figure A the frequency in the interval containing 104 is _____.

9. The total number weighing less than 104 lbs. is _____.

10. The most popular weight interval is _____.

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Which of these figures could be defined by the following terms:
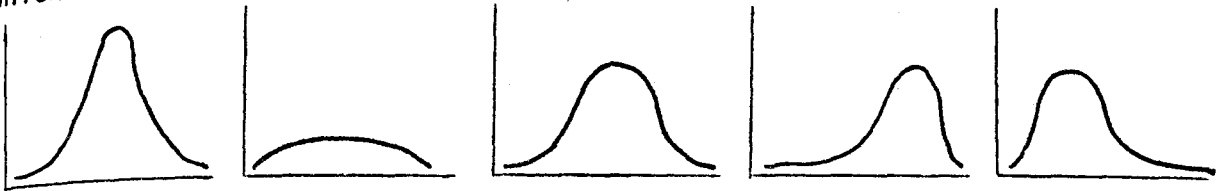
11. Platykurtic _____

12. Leptokurtic _____

13. Normal _____

14. Symmetrical _____

15. Positively skewed _____

16. Negatively skewed _____

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LESSON 5 - Objectives

1.12   Characteristics of a frequency distribution

1.12   Measures of central tendency

2.10   Types of kurtosis

LESSON 5 - Central Tendency

The frequency polygon allows us to represent many scores in a single graph. Another way of representing scores is to use the most typical score as a description of the whole distribution. The most typical score is the measure of central tendency of the distribution. In other words, the measure of central tendency is a method of summarizing a set of data.

Most students are familiar with the measure of central tendency known as the arithmetic mean. There are two other measures of central tendency commonly used: the median (middle score) and the mode (most frequently occurring score).

The graph of a frequency distribution is characterized by the following:

1. Measures of central tendency

   a. Mean

   b. Median

   c. Mode

2. Measures of variability (scatter)

   a. Standard deviation

   b. Variance

   c. Range

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3. Symmetry or skewness

4. Kurtosis

   a. Leptokurtic (high peaked)

   b. Platykurtic (flat topped)

   c. Mesokurtic (normal)

LESSON 5 - Quiz

1. The three most common measures of central tendency are: _____,

_____, and _____.

2. In addition to central tendency, the other characteristics of a graphical

distribution of data are: _____, _____, and

_____.

3. Match the following:

_____ Normal   a. Platykurtic

_____ High peaked   b. Mesokurtic

_____ Flat topped   c. Leptokurtic

                                  d. Skewed

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LESSON 6 - Objectives

1.11   Mode

1.21   Mode of a frequency distribution

1.24   Mode: Application to specific types of data

LESSON 6 - Mode

The mode is defined as the most frequent score. In the following set of scores: 3, 4, 4, 7, 9, 9, 9, 6, 6, 2, and 1; the mode is 9. Discrete variables were used in this example. In a frequency distribution, however, the midpoint of the interval containing the highest frequency is considered the mode. For example, consider the following:

Class	f
10-19	2
20-29	6
30-39	5

The mode in this case is 24.5 - the midpoint of the interval (20-29) containing the highest number of scores.

An approximation of the mode is given by the formula:

$$Mo = 3 \; Mdn - 2 \; M$$

Generally, the mode is used in the following cases:

- For a quick estimate of central tendency

- For a rough estimate of central tendency

- For a description of the most typical case

- For describing qualitative or categorical data

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Keep in mind that the mode is an unreliable measure of central tendency, since a few scores can radically change it. Further, it is not amenable to algebraic manipulation.

Among the other disadvantages of the mode are the fact that the mode may not exist in a given distribution. This is the case when all scores have the same frequency. A distribution may also be bimodal (two highest scores with the same frequency). When this occurs it may be that underlying qualitative differences exist which should be taken into account.

LESSON 6 - Quiz

1. What is the mode of the following set of scores:

   1, 2, 2, 3, 3, 3, 4, 4, 4, 4 _____

2. What is the mode of the following frequency distribution: _____

Class	f
20-24	6
25-29	12
30-34	18
35-39	12

3. True False The frequency distribution in problem #2 is bimodal.

4. True False The mode is a reliable measure of central tendency.

5. True False The mode is best used with qualitative rather than quantitative data.

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LESSON 7 - Objectives

1.20   Median

1.11   Mode

1.11   Median

1.10   Median of a histogram

1.10   Median of a polygon

2.10   Symbols of formula for median

3.00   Formula for median

LESSON 7 - The Median

The median is a point on the score scale above and below which half of the scores fall. Using different sets of data, the median is determined as follows:

I. A simple array of an odd number of scores:

3, 16, 12, 18, 11, 14, 5

First, the scores must be ordered: 3, 5, 11, 12, 14, 16, and 18. The middle score point is 12. A method of determining which score is the median can be expressed by $\frac{n + 1}{2}$, where n is the total number of scores.

II. A simple array of an even number of scores:

3, 16, 12, 18, 11, 14, 5, 7

After the scores are ordered: 3, 5, 7, 11, 12, 14, 16, and 18, the middle score point is not apparent as it falls between 11 and 12. The median in this case is 11.5 (the arithmetic average of 11 and 12)--the score point above and below which half of the scores fall.

III. A simple array of an even number of scores:

3, 16, 12, 2, 1, 11, 14, 5, 7, 18

Again, ordering the scores: 1, 2, 3, 5, 7, 11, 12, 14, 16, and 18, it becomes evident that the median falls between 7.5 and 10.5, providing we ascribe continuous characteristics to what appears to be discrete data. The score midway between 7.5 and 10.5 is 9 which would be the median of this distribution of scores.

IV. A simple array of scores (some repeated):

3, 16, 1, 7, 5, 7, 2, 7, 14, 10

Ordering the scores: 1, 2, 3, 5, 7, 7, 7, 7, 14, and 16. And if we again ascribe continuous characteristics for what seems to be discrete data, the median falls in the interval of 6.5 to 7.5. Then if one adds .25 to the lower limit, 6.50 + .25 = 6.75 which is the median.

The Median - Frequency Distribution

V. Consider the following frequency distribution.

Score	f	
3	1	
5	8	
7	5	21
11	7	
12	10	
14	4	
16	9	19
18	6	
	N=50	

Clearly, the median exists between the 25th and 26th scores. This is shown graphically on the next page.

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```
                    11.5                    ↓                   12.5
21 scores below    ←─| 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |──→   19 scores above
the median interval                     Mdn                                   the median
                                                                              interval
```
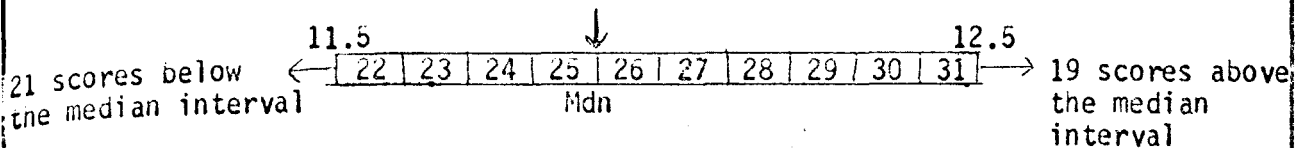
- 11.5 is the real lower limit of the median interval

- 12.5 is the real upper limit of the median interval

To find the median it is necessary to assume that the ten scores in the median interval are evenly distributed throughout the interval of 11.5 to 12.5. Twenty-one scores are below the median interval which is indicated by the arrow. Since each score occupies 1/10 of the interval, 4(1/10) = .4 must be added to the real lower limit to determine the value of the median, which would be 11.9. This was relatively easy to do because of the even number of scores in the distribution, however, examine the case of the distribution of an odd number of scores.

VI. Suppose a score of 18 was added to the preceding distribution, then N = 51 and the median would be as is indicated by the arrow in the figure below.

```
                    11.5                    ↓                   12.5
21 scores below    ←─| 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |──→   20 scores above
the median interval                     Mdn                                   the median
                                                                              interval
```
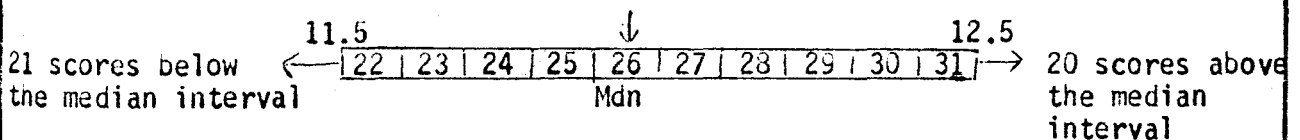
As before the real limits are 11.5 and 12.5 and there are 10 scores in the median interval. However, in this distribution there are 51 scores, therefore, the median is at the midpoint of the 26th score or 11.95. Notice that 25.5 scores are above and below 11.95 which complies with the definition of the median.

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VII. Now let us consider the preceding distribution where N = 50 and form the following grouped distribution.

Class	f
1-3	1 ⎫
4-6	8 ⎬ = 14
7-9	5 ⎭
10-12	17
13-15	4 ⎫ = 19
16-18	15 ⎭
	N=50

It is clear that the median interval is 10-12 and contains 17 scores. This is shown in the figure below.

9.5   12.5

| 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |

Mdn

14 scores below the median interval

19 scores above the median interval
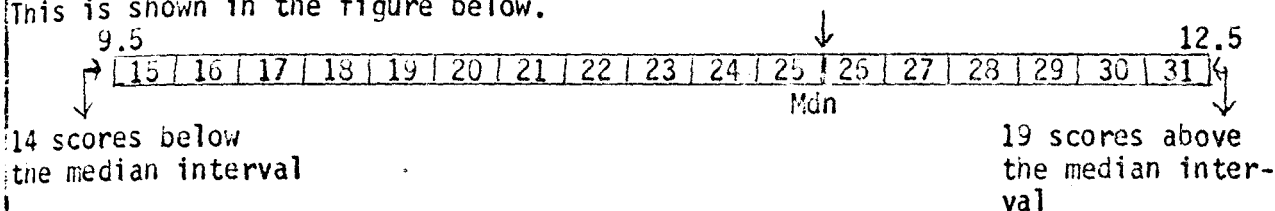
In this case the real limits of the median interval are 9.5 and 12.5. This interval has 17 scores which are assumed to be evenly distributed. Now to reach the median, 11 scores must be traversed and since each score occupied 3/17 of the median interval, 11(3/17) must be added to the real lower limit of 9.5 to determine the median which is 11.44.

VIII. An example of a distribution with an odd number of scores is the following:

Class	f
1-3	1 ⎫
4-6	8 ⎬ = 14
7-9	5 ⎭
10-12	17
13-15	4 ⎫ = 20
16-18	16 ⎭
	N=51

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```
9.5                                                    ↓              12.5
  | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
                                                      Mdn
14                                                                          20
```
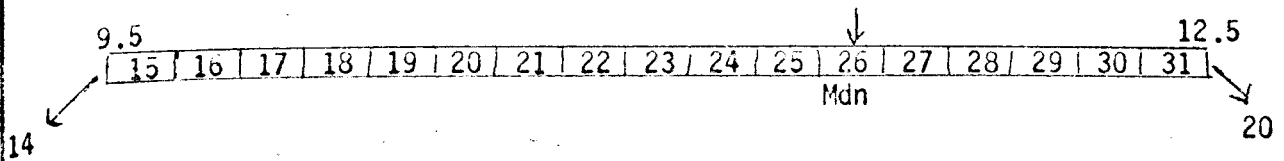
Again, the real limits of the median interval are 9.5 and 12.5 and it contains 17 scores which means each score occupies 3/17 of the interval, however, in this case 11½ scores are needed to reach the median. Therefore, 11.5(3/17) + 9.5 = 11.53. It may be of some interest to note that a vertical line drawn through the median divides a histogram or a frequency polygon into two parts, each having the same area.
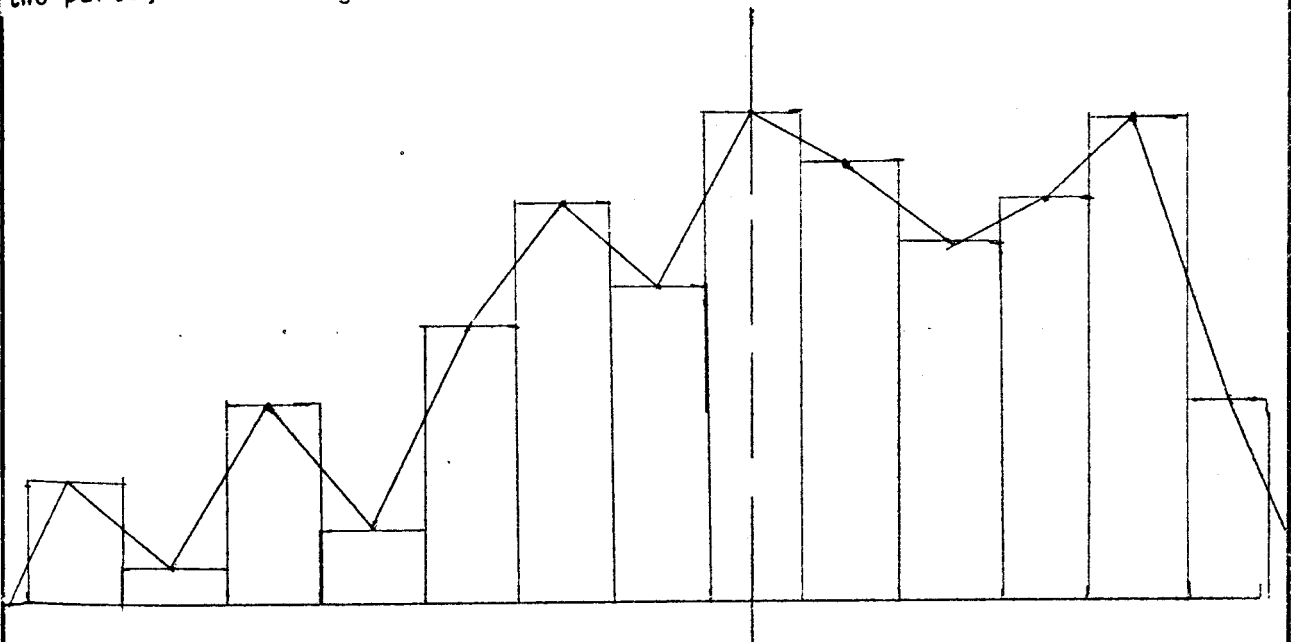
Characteristics of the median:

The median should be used when the distribution is skewed.

The median (and the mode) cannot be treated algebraically, whereas the mean can be.

The median can be used if it is necessary to divide the scores into two categories (upper and lower).

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The median can be useful if data for the distribution is incomplete.

The median should be used as a measure of central tendency when the range is used as the measure of variability.

LESSON 7 - Quiz

1. What is the median of the following set of scores: 9, 3, 1, 2, 4, 11 _____

2. The most frequent score in a frequency distribution is called the _____.

3. The middle score is called the _____.

4. True   False   A vertical line drawn through the mode divides a histogram into two parts, each having equal areas.

5. True   False   A vertical line drawn through the median would divide a frequency polygon into two parts, each having equal areas.

6. True   False   The median is used to describe the most typical dress size.

Fill in the blanks using the following symbols: L, Mdn, N_n, i, f

7. The median of a distribution _____

8. Number of cases in the median interval _____

9. Width of the interval containing the median _____

10. The real lower limit of the interval _____

11. The number of cases needed to get to the case that corresponds to the median _____

12. Using the above symbols, state the formula for the median _____

Answer the following questions regarding the frequency distribution on the next page.

13. The interval containing the median is _____.

14. The real limits of the interval in # 13 are _____.

15. The number of cases in the interval containing the median is _____.

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Class	f
20-24	2
25-29	4
30-34	6
35-39	8
40-44	10

16. The median is _____.

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LESSON 8 - Objectives

1.21   Mode, median, mean

3.00   Mean

3.00   Mean of grouped data

3.00   Coding

LESSON 8 - The Arithmetic Mean

The arithmetic mean (usually called the mean) is defined as the sum of all the scores divided by the number of scores. In symbolic form $M = \frac{\sum x}{N}$. This implies that if the scores are represented as X_1, X_2, X_3, ..., X_n, the mean would be $X_1 + X_2 + X_3 + ... + X_n$. The mean of the scores 4, 20, 12, and 14 equals 50/4 = 12.5. (Note that "$\sum$" is the symbol for summation.)

The mean from grouped data can be computed using the formula $M = \frac{\sum fX'}{N}$, where "f" is the frequency of the class whose midpoint is X'. In the example below, it is assumed that all the scores are at the midpoint of each of the intervals. Therefore, $\sum fX' = (4)(22) + (7)(27) + (6)(32) + (5)(37) + (1)(42) = 696$, and $\frac{\sum fX'}{N} = 696/23 = 30.3$. (assuming that the scores fall at the midpoint of the interval has the same effect as assuming that the scores are equally distributed throughout the interval.)

Class	Midpoint	f
20-24	22	4
25-29	27	7
30-34	32	6
35-39	37	5
40-44	42	1
		N=23

If the mean is to be calculated from scores that are extremely large and difficult to work with, a constant may be subtracted from each score. The mean of these reduced scores is then calculated. The mean of the original

scores is obtained by adding the constant to this mean. For example, to find the mean of 1012, 1017, 1081, and 1048, it would be feasible to first reduce each score by 1000. The reduced scores are 12, 17, 81 and 48; X = 158; $M = \frac{\sum X}{N} = 158/4 = 39.5$. Adding 1000 to the reduced mean gives us the mean of the original scores, or 1039.5. (This can be verified by adding the original scores and dividing by 4.)

The same results can be produced if we were to subtract any number other than 1000. The closer that number is to the mean, the simpler the computation. Suppose that in the preceding example we had subtracted 1039 from each score, rather than 1000. The results would be as follows: (1012-1039) = -27; (1017-1039) = -22; (1081-1039) = +42; and (1048-1039) = +9. After combining these numbers we have a +2. Dividing by 4 (that is 2/4), results in a .5. Now, we add this .5 to the number which we subtracted from each score (1039), and again come up with a mean of 1039.5. The principal advantage of choosing a number close to the mean is that the sum of the transformed scores is smaller. This method is called coding and in practice, the number to be subtracted should be as close to the mean as a quick estimate would allow.

It should be emphasized that the mode, median and mean are all measures of central tendency, but cannot be used interchangeably. The mode can be used with all the scales but most appropriately with the nominal scale. In fact, the mean and median cannot be used with the nominal scale. The median can be used with the ordinal, interval and ratio scales, whereas the mean is limited to the interval and ratio scales.

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Although the mean is the most difficult measure of central tendency to compute, it can be manipulated algebraically, and it is the most stable of the three measures. That is, the addition of a few scores to a large number of scores would not drastically change the mean.

LESSON 8 - Quiz

1. The best measure of central tendency to report when counting the number of blondes, brunettes, and redheads walking on Michigan Ave. between 12:00 and 1:00 is the _____.

2. Compute the mean of the following scores: 3, 97, 16, 12, 55, 84, 88, 45
   _____.

3. If you were asked to compute the mean in problem #2 by coding, which of the following numbers would be the best to use as the number to be subtracted from each score: 15, 45, 50, 55, 85 _____.

In the table below, assume that the mean is the midpoint of the 41-60 interval. Use this as a reference point, or arbitrary origin, and express the deviations of the midpoints of the other intervals from that origin in unit steps.

Score	Tally	f	d	fd
1-20	/////////////	14	d_1	$(fd)_1$
21-40	////////////	12	d_2	$(fd)_2$
41-60	////////	8	d_3	$(fd)_3$
61-80	///////////	11	d_4	$(fd)_4$
81-100	////	4	d_5	$(fd)_5$

4. d_1 _____   9. $(fd)_1$ _____

5. d_2 _____   10. $(fd)_2$ _____

6. d_3 _____   11. $(fd)_3$ _____

7. d_4 _____   12. $(fd)_4$ _____

8. d_5 _____   13. $(fd)_5$ _____

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14. $\sum (fd) =$ _____

15. $N =$ _____

16. $M =$ _____

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LESSON 9 - Objectives

1.20   Uses of the various measures of variability and measures of central tendency

1.11   Interpercentile measures

LESSON 9 - Variability

Variability is the extent to which the scores tend to scatter or spread above and below the average. There are three common measures of variability: the range, the quartile deviation, and the standard deviation. These measures represent distances rather than points, and the larger they are the greater the variability or scatter of the scores.

Range. The range is the distance between the lowest and highest scores. However, the range is usually not an accurate or trustworthy measure of variability since it can be greatly affected by a single score or by extreme scores. There are several measures of variability that are independent of the extremes.

Interpercentile Measures: Percentile Measures. Variability can also be described as a distance on the scale which includes 100% of the scores.

A percentile is the score or point on the scale of scores below which a specified percentage of the scores lie. Percentiles divide the scale into 100 parts and are sometimes referred to as centiles. The formula for finding the Pth percentile point, P_p, of any distribution is as follows:

$$P_p = L + \left(\frac{PN - F}{f}\right)i, \text{ where}$$

P_p = the point on the X scale where the Pth %ile can be found

L = the lower real limit of the class interval containing P_p

PN = the number of cases to be counted off to reach P_p

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F = the total number of cases in the class containing P_p

i = the class interval

Deciles, Quartiles and Quintiles. There are certain percentiles which are more commonly used than others. The percentile scale can be divided into 4 equal parts, thus producing the quartile scale. The 25th, 50th, and 75th percentiles are symbolically represented as P_{25}, P_{50}, and P_{75}, respectively. P_{25} is considered the first quartile and represented as Q_1; P_{50} is the second quartile and represented as Q_2; and P_{75} is the third quartile and represented as Q_3.

Dividing the percentile scale into 10 equal parts produces deciles. P_{10} is the first decile and P_{90} is the ninth decile.

When the percentile scale is divided into 5 equal parts, we obtain quintiles. P_{20} is considered the first quintile.

Semi-interquartile range. The interquartile range is the difference between P_{75} and P_{25}. The semi-interquartile range is ½ the interquartile range and is designated by : $Q = \dfrac{P_{75} - P_{25}}{2}$. The semi-interquartile range is also known as the quartile deviation.

The following list gives the uses of the various measures of variability.

1. Use the range when:
   a. The quickest possible measure of variability is wanted.
   b. Information is desired concerning extreme scores.

2. Use the semi-interquartile range, Q, when:
   a. The median is the only statistic of central value reported.
   b. The distribution is truncated or incomplete at either end.

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c. There are a few very extreme scores or there is an extreme skewness.
d. The actual score limits of the middle 50% of cases are needed.

3. Use the average deviation when:
a. There are extreme deviations, which, when squared, would bias estimation of the standard deviation.
b. A fairly reliable measure of variability is wanted without the extra labor of computing a standard deviation.
c. The distribution is nearly normal and we can, therefore, estimate the standard deviation from the average deviation.

4. Use the standard deviation when:
a. The greatest dependability of the value is desired.
b. Further computations that depend upon it are likely to be needed.
c. Interpretations related to the normal distribution curve are desired.

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LESSON 9 - Quiz

1. While examining a set of scores for variability, a researcher discovered a few very extreme scores. After graphing the scores he found extreme skewness. In this case the best measure of variability would be:

   a. the range
   b. the semi-interquartile range
   c. the average deviation
   d. the standard deviation

2. What would be the best measure of central tendency for the preceding problem?

   a. mean
   b. mode
   c. median
   d. harmonic mean

3. The most dependable measure of variability is the:

   a. range
   b. semi-interquartile range
   c. average deviation
   d. standard deviation

4. The extent to which the scores tend to scatter or spread above and below the point of central tendency is _____.

   a. variability
   b. central tendency
   c. significant difference
   d. reliability of measurements

Fill in the blanks with the following:

A. P_{50};   B. Percentile;   C. Q;   D. Quartile deviation;   E. P_{20};

F. P_{30}

5. _____ Score or point on the scale of scores below which a specified percentage of the scores lie

6. _____ The second quartile

7. _____ Symbol for the semi-interquartile range

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8. _____ Semi-interquartile range

9. _____ 3rd decile

10. _____ 1st quintile

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LESSON 10 - Objectives

1.20   Computing the standard deviation

2.20   Standard deviation

4.20   Standard deviation in a distribution of scores

LESSON 11 - Objectives

6.20   Standard deviation in a distribution of scores

3.00   Computing the standard deviation for grouped and ungrouped data

LESSONS 10 and 11 - The Standard Deviation

The average deviation, or AD, is the arithmetic mean of all the deviations when the algebraic signs are disregarded. The algebraic signs are not used in this situation because all we are looking for is the overall size of the deviations to describe the amount of variability. The formula for the average deviation is: $AD = \dfrac{\sum |x|}{N}$ where $x = (X - M)$, which is the deviation of a single original score or measurement (X) from the arithmetic mean (M).

(When the x's are summed, the signs are disregarded.)

The standard deviation is the most commonly used and most dependable source of estimation of variability within a given population. It is a simple value descriptive of a total population and can be very helpful in comparing different samples. The standard deviation also enters into many other statistical formulae. The general formula for the standard deviation is:

$s = \sqrt{\dfrac{\sum x^2}{N}}$ where x = deviation of each X from the mean of the sample and

N = size of sample

There are other formulae for "s" which are equivalent to this one, but which are more adaptable to calculators and computational techniques.

Computation of "s" for Ungrouped Data

The following formula for the standard deviation is used either when the number of measurements is not large; if the measurements are small numbers; or, if a good calculating machine is available:

$$\text{S.D.} = \frac{1}{N} \sqrt{N\sum x^2 - (\sum x)^2}$$

The following steps are involved when working with this formula:

Step 1: Square each score or measurement
Step 2: Sum the squared measurements to give $\sum x^2$
Step 3: Multiply x^2 by N to give $N\sum x^2$
Step 4: Sum the X's to find $\sum X$
Step 5: Square the $\sum X$ to find $(\sum X)^2$
Step 6: Find the difference $N\sum X^2 - (\sum X)^2$
Step 7: Find the square root of the number found in step 6.
Step 8: Divide the number found in step 7 by N, or multiply by $\frac{1}{N}$

This method is the most widely used since calculating machines are usually available and statisticians generally work with ungrouped data.

Computation of "s" for Grouped Data

If a calculating machine is not available, time and effort can be saved in computing the S.D. if the scores are grouped into a frequency distribution and the assumption is made that the midpoint of each interval is the score for that interval. The following formula can be used as a straightforward method for finding the standard deviation:

$$s = \sqrt{\frac{\sum fx'^2}{N}}$$

where f = the frequency in a class interval

x' = the deviation of the class midpoint from the mean

This formula is best to use when the class intervals are of unequal size. However, in most distributions the class intervals are equal, and there are more efficient methods for dealing with grouped data in these cases. The coded method is one such technique. In the coded method we attempt to put the data into a more convenient form. The formula is:

$$s = i \sqrt{\frac{\sum fx'^2}{N} - M_{x'}^2} = i \sqrt{\frac{fx'^2}{N} - \left(\frac{fx'}{N}\right)^2}$$

i = size of class interval
x' = deviation from the origin of coded values
$M_{x'}$ = mean of coded values

The following steps are involved in this formula:

Step 1: Set up a frequency distribution

Step 2: Choose a temporary origin, X_0. This is the midpoint of the interval which is either (a) near the center of the range, or (b) contains the median, or (c) is a compromise between the two.

Step 3: Assign new integral values to the class intervals, starting with zero at the origin, assigning positive values above the zero origin and negative values below it. These new values are called x'.

Step 4: Find the fx' product for each interval, and record all such values in a column.

Step 5: Sum the fx' products algebraically. This is $\sum fx'$.

Step 6: Divide the sum of fx' products by N, giving $M_{x'}$ which is the mean of the coded values.

Step 7: Find for every class interval the fx'^2 product. The most efficient way is to compute the product of x' times fx' for each interval. These products will all be positive.

Step 8: Sum the fx'^2 products.

Step 9: Divide this sum by N, carrying to at least 2 decimal places.

Step 10: Find M_x,^{2} to at least 2 decimal places.

Step 11: Deduct the number found in step 10 from the number found in step 9.

Step 12: Find the square root of the number found in step 11, keeping 2 decimal places.

Step 13: Multiply this number by the size of the class interval. If N is large, report 2 decimal places; if small, round to 1 decimal place.

Interpretation of the Standard Deviation

The S.D. is a kind of average of all the deviations about the mean of the sample. We look at a particular score and observe not only how it differs from the mean, but also how it stands in relation to the total range of scores in the sample.

The usual and most accepted interpretation of a standard deviation is in terms of the percentage of cases included within the range from one standard deviation below the mean to one standard deviation above the mean. This range on the scale of measurement includes 68.27% of the cases in the distribution. Since most samples yield distributions that depart to some degree from normality, we can say that about 2/3 of the cases in a distribution lie between one standard deviation above the mean and one standard deviation below the mean. This leaves 1/3 of the area to be divided between the two tails:
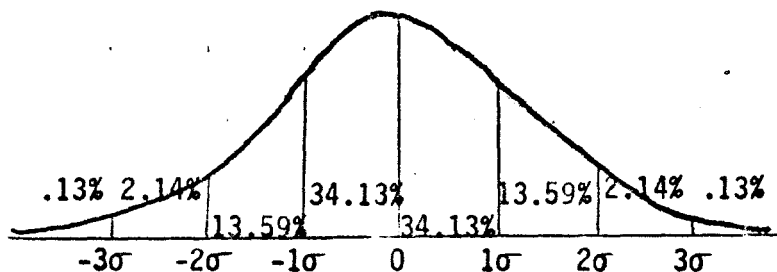
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LESSON 10 - Quiz

1. True   False   If the number of measurements is small or if a calculating machine is available, the best method for computing the standard deviation is by using the formula for ungrouped data.

2. True   False   The usual and most accepted interpretation of "s" is in terms of the percentage of cases included within the range from 1 S.D. below the mean to 1 S.D. above the mean.

3. In a representative sample of white urban children, the mean I.Q. was found to be 100 and the standard deviation was equal to 16. This means that approximately 33 1/3% of the cases have I.Q.'s between:

   a. 68 and 100
   b. 84 and 116
   c. 84 and 100
   d. 100 and 132

4. In most distributions of scores, about _____ of the cases will be between one standard deviation below the mean and one standard deviation above the mean.

   a. ½
   b. 2/3
   c. 5/8
   d. ¼

LESSON 11 - Quiz

1. Two classes with equal numbers of pupils were tested with the same group test of intelligence. The standard deviation of scores in class A was found to be 12: the standard deviation in class B was found to be 16. In which class would one expect to find fewer extremely bright or extremely dull chilren, assuming that the means are equal?

   a. Class A
   b. Class B
   c. There probably are no extremes in either class.
   d. The number of extremes will be about the same in both classes.

2. Approximately 2/3 of the middlemost scores on a test fall in the range 90-120. The S.D. of the test might be estimated to be:

   a. 8
   b. 10
   c. 15
   d. 20

3. What is the S.D. of the scores 3, 6, and 9?

   a. The square root of 3.
   b. 3
   c. The square root of 6.
   d. 6

4. Find the S.D. of the following frequency distribution:

Interval	f
93-95	1
90-92	2
87-89	7
84-86	9
81-83	13
78-80	15
75-77	11
72-74	8
69-71	4
66-68	3
63-65	2
	N=75

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LESSON 12 - Objectives

1.23   Skewness and Kurtosis

3.00   Skewness

6.20   Skewness

LESSON 12 - Properties and Applications of Measures of Variability

Skewness depends upon the way in which the scores are distributed. When the majority of scores cluster to the left and the distribution points to the right, the distribution is positively skewed. When the majority of scores cluster to the right of the distribution and the distribution points to the left, the distribution is negatively skewed.

Normal   Positively Skewed   Negatively Skewed
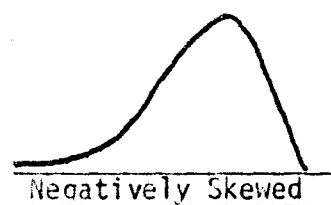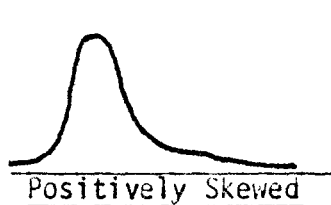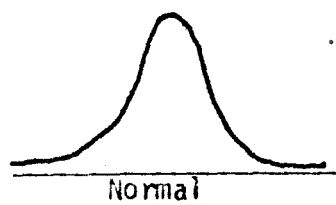
Since the mean is a measure of central tendency which is effected by extreme scores, in a positively skewed distribution the median lies to the left of the mean. In a negatively skewed distribution the median lies to the right of the mean.

Mdn   Mean   Mean   Mdn
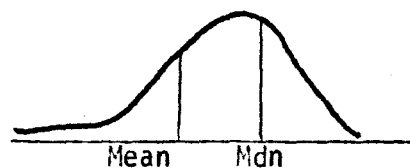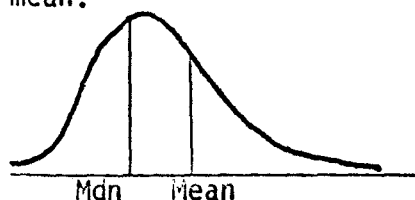
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Kurtosis is the degree of steepness in the middle part of the distribution. There are three types of kurtosis:

1. Mesokurtic curves are neither very peaked nor very flat across the top. A normal distribution is mesokurtic.

2. Platykurtic curves tend toward a rectangular form. They are lower and flatter across the top than the normal curve.

3. Leptokurtic curves are more peaked than normal curve.
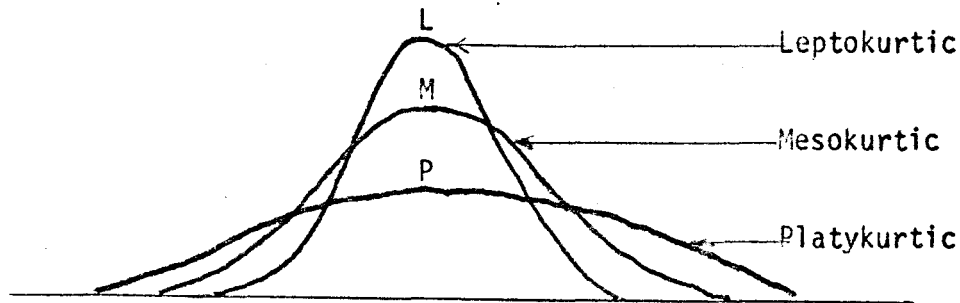
The skewness and kurtosis of a distribution are important to the statistician since the first step in a statistical analysis is to determine whether or not the distribution is normal. Examining a curve for skewness and kurtosis enables us to compare two or more distributions, and also gives some information concerning the way in which the scores are scattered.

Moments. In physics a moment is defined as a measure of the tendency of a force to cause rotation of an object about a point. It is the product of force times distance. When an object is in perfect balance, the sum of all the moments tending to cause rotation in one direction is equal to the sum of all the moments tending to cause rotation in the opposite direction.

In statistics we can think of a score in a distribution acting as a force at some distance - "x" - from the mean. We can think of the score in

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terms of moments of force. The sum of the negative deviations from the mean is equal to the sum of the positive deviations from the mean. The mean can therefore be thought of as the point of balance. Departures from the normal distribution can be measured precisely by moments. The formulae for the 1st, 2nd, 3rd and 4th moments are as follows:

First Moment: $m_1 = \dfrac{\sum x}{N} = 0$ where $x = (X - \bar{X})$

(This equation = 0 because it is the point of balance.)

Second Moment: $m_2 = \dfrac{\sum x^2}{N} = s^2$

(The second moment equals the variance.)

Third Moment: $m_3 = \dfrac{\sum x^3}{N}$

Fourth Moment: $m_4 = \dfrac{\sum x^4}{N}$

The measure of skewness, g, and the measure of kurtosis, g_2, are both derived from moments:

$g_1 = \dfrac{m_3}{m_2 \sqrt{m_2}}$ Measure of Skewness

$g_2 = \dfrac{m^4}{m_2^{\,2}}$ Measure of Kurtosis

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LESSON 12 - Quiz

1. True   False   A skewed distribution is a normal distribution.

2. True   False   Kurtosis is the degree of steepness of the middle part of
                     the distribution.

3. The following curve is an example of what type of distribution?

    a. Negatively skewed
    b. Positively skewed
    c. Normal
    d. Platykurtic
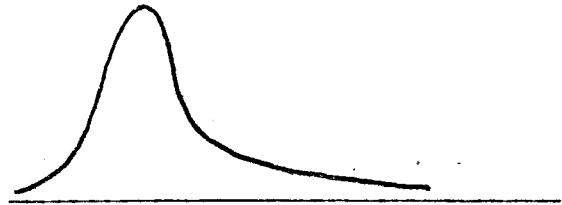
4. After performing a statistical analysis of the data, a researcher discovered
    that the mean of the sample distribution was 50 and the median was 30. The
    researcher could conclude that the distribution is:

    a. Negatively skewed
    b. Positively skewed
    c. Normal
    d. Platykurtic

5. The normal curve is an example of the following type of curve:

    a. Leptokurtic
    b. Platykurtic
    c. Mesokurtic
    d. Skewed

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LESSON 13 - Objectives

1. Know that a percentile is the ratio of a cumulative frequency (cf) over a total score (N)

2. Be able to apply the PR formula for grouped data

3. Be able to find the PR for ranked data

4. Be familiar with the cumulative percentage curve and its uses

5. Know how to find a z score

6. Know how to find a Z and Z' score

7. Be familiar with properties of z scores with regard to sign, median, s, and uses

LESSON 13 - Transformation of Scores

Percentile Ranks (PR). Finding a percentile rank of a score in un-grouped data is simple enough. All we have to do is form the ratio of the cf to that score over the total number of cases, i.e., $\frac{cf}{N}$.

Finding a percentile rank in grouped data is more complicated since the individual scores in each interval lose their exact value and location in the interval. We circumvent this problem by interpolation and the assumption that the scores in each interval are evenly distributed.

To find the PR of a score X_j, we locate the interval in which it occurs and total the frequencies of the intervals below it (F). Next, we find what fraction of the interval the score X_j consumes by forming the ratio of the distance from the lower real limit "L" to point $(X_i - L)$ over the whole width of the interval (i). Graphically this would be:
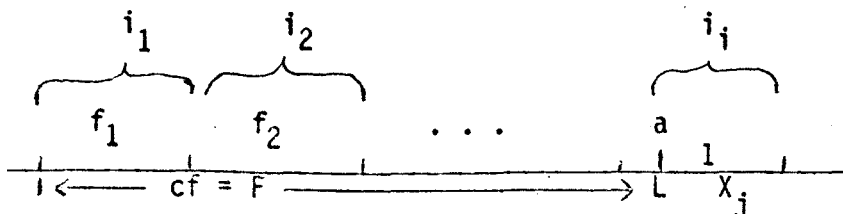
or, in formula form $\dfrac{(X_i - L)}{i}$. Using this ratio we can find what fraction of the number of scores in the interval should be included in our cf by multiplying our ratio by the frequency of the interval. This would be $\left(\dfrac{X_j - L}{i}\right) f$. Adding this to the sum of the scores below it (F), we now have the total number of scores to the point X_i and the PR is:

$$\left[\frac{F + \dfrac{(X - L)f}{i}}{N} \right] (100)$$

This is stated more simply by the formula in Tate:

$$PR(X_i) = \frac{100}{N} \left[F + \frac{(X - L)}{i} f \right]$$

PR for Ordered Data. The above material is applicable to measured data, but we might want to find a PR where an interval scale has little meaning and the scores are ordered or ranked. This is done by forming the ratio of the total number of scores below the rank in consideration over the total number of ranks or scores (N). It should be noted that to find the cf of a rank we begin counting from its real limit. Thus, to find the PR of rank 2 out of 5, we begin counting at 1.5. This would give us a cf of 3.5 and an actual PR of $\dfrac{3.5}{5}$ = 70%.

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$$cf = 2.5$$

N = 5
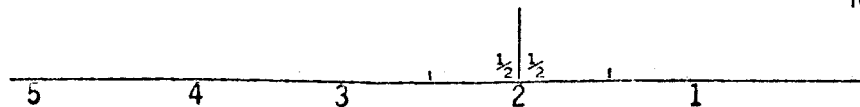
Cumulative Percentage Curve. The cumulative percentage curve is very similar to the cumulative frequency curve, except that the ordinate scale shows percentages instead of frequencies.

Given a point on such a curve, we can read directly across, horizontally, to find its percentile rank (A), or read directly down, vertically, to find its score value (B). Given a score, we can quickly estimate the corresponding percentile rank (C), or given a percentile rank, we can quickly estimate the corresponding score at which it falls (D).
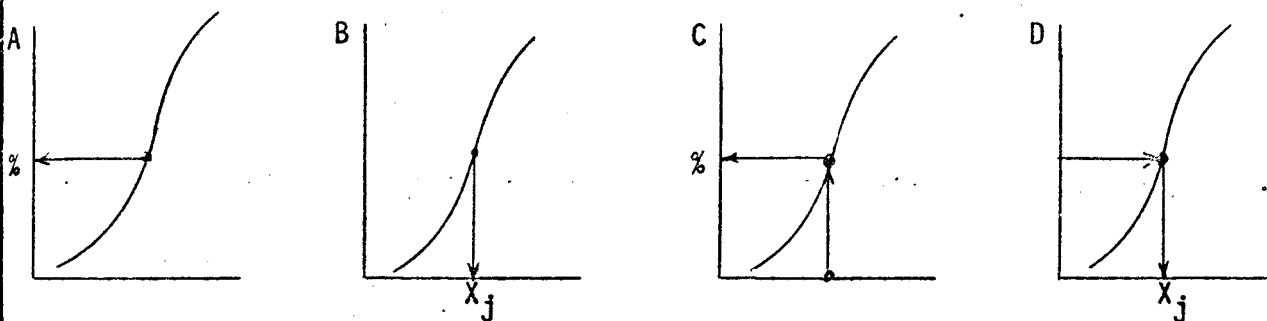
Using the methods of C and D above, we can estimate for a given distribution, the

    a. median
    b. quartile and inter-quartile range
    c. deciles, quintiles and quartiles

Standard Scores. Given a distribution of scores, we can find its mean (M), and standard deviation (s). The explanation of how to find the standard score "z" is clear enough in the textbook, but it might be relevant to emphasize that:

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1. "s" is usually used as a standard unit of measure, much the same as the inch is used in measuring.

2. The "z" score represents the number of these units contained in the distance from the score in question (X) to the mean (M).

3. The z's may be negative or positive depending on whether the score falls to the left or right of the mean.

Advantages:

1. Standard scores are abstract quantities

2. Mean and standard deviation of z are 0 and 1, respectively

3. Simplified various statistical procedures

Additional transformations:

$$Z = 10z + 50$$

$$Z' = 100z + 500$$

Note that Z' differs from Z by a factor of 10, and that Z eliminates the use of decimals and Z' eliminates the use of negative values.

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LESSON 13 - Quiz

1. A $PR(X_i)$ is the ratio of the _____ of the scores to X_i over _____.

2. Given the formula $\dfrac{100}{N}\left[F + \dfrac{(X_i - L)f}{i}\right]$, match the following:

   _____ F   a. the cf to the interval containing X_i

   _____ X   b. the value of score X_i

   _____ L   c. the lower real limit of the interval containing X_i

   _____ X - L   d. the distance from L to X_i in the interval

   _____ i   e. the width of the interval containing score X_i

   _____ f   f. the frequency of the interval containing score X_i

   _____ N   g. the total number of cases in the distribution

3. If 5 scores are ranked 1-5, the PR of rank 3 would be _____.

4. Statistically, $z = \dfrac{X - M}{s}$, $Z = 10z + 50$, and $Z' = 100z + 500$ are examples

   of _____.

5. If it is stated that X_i is $z = 3$, this would imply that X is three

   _____ above the mean of the distribution which contains X_i.

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LESSON 14 - Objectives

The student should:

1. be familiar with the basic properties of the normal curve

2. be able to find percentiles (points) for the normal curve either in z or raw score form

3. be able to find the proportion of scores between two given raw scores or z scores

4. be able to find the percentile rank of a given z score or raw score

LESSON 14 - The Normal Curve

The normal curve is basically a theoretical or limiting case from which applications have been derived to use on "real life" data. Many real distributions may tend to look like the normal curve, but never perfectly match it even though the rules derived from the normal curve are applied to these real life curves.

Basic Facts about the Normal Curve

The normal curve is:

1. often described as bell shaped
2. symmetrical
3. described by a mathematical equation
4. divided into two equal halves at the mean, i.e., 50% above the mean and 50% below the mean
5. has an equal mean, median and mode, i.e., all are at the same score point
6. has a corresponding frequency (ordinate) and score value (abscissa) for every point on the curve

Special Uses: The properties listed above lend the curve to certain special uses. The normal curve can be used to describe real data, i.e., actual frequencies along the vertical axis and score values along the horizontal axis, but a primary advantage of the curve is that we can remove our-

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selves from these restrictive real data and use abstract numbers (devoid of
attributes) to describe the intervals on both. Because the curve is <u>constant
in proportion</u>, certain facts remain true regardless of the scale we use along
either axis:

1. the area under the curve is always 100% of the curve
2. the mean divides the curve into two equal halves, with 50% of the
   cases above the mean and 50% of the cases below the mean
3. if we use z scores to describe the data, the mean of the distri-
   bution becomes 0 and the standard deviation becomes 1, thus, we
   use z scores for the interval scale along the horizontal axis

-1s +1s
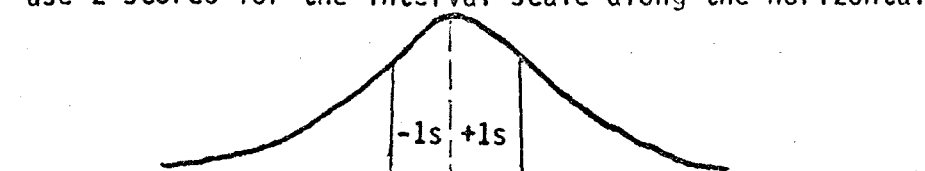
4. for every z score there is always a constant proportion of the
   area between that z and the mean, e.g.:

34.13%

M   1σ
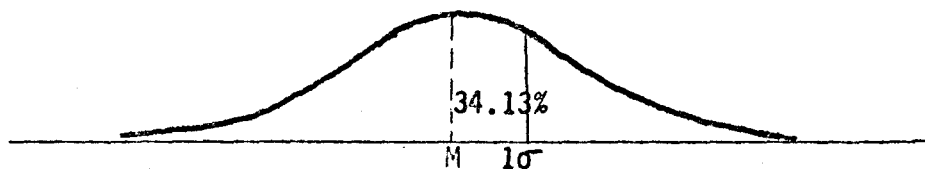
The distance from the mean to 1σ above it will always contain 34.13%
of the number of cases in the distribution.

Finding Percentile Points

It is this last fact which allows us to find at which point on the
horizontal scale a percentile rank falls in either z score or real score form.

<u>Case I</u>: In order to find the z score or raw score that corresponds to
a percentile under 50% ile, it must be remembered that most tables give the
z score and the related proportion. This proportion is the proportion of
scores between the given z score and the mean (z = 0). Thus, to find the
z score that corresponds to, say, 10%, it is necessary to subtract,

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.50 - .10 = .40, and then to find the z score related to .40. The z score is -1.28. See the figure below.
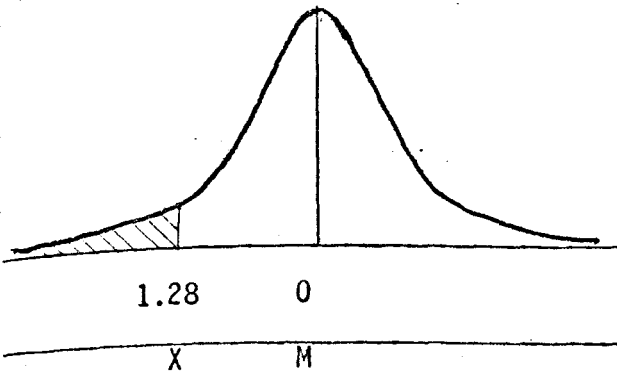
Shaded portion represents 10% of the area.

To find the raw score (X), it is necessary to use the following equation:

X = Sz + M   where M is the mean and s is the standard deviation.

Case II: To find the z score of a percentile greater than 50% ile, we subtract 50% from the percentile and read the corresponding z score from a table. For example, to find the z score of a raw score at the 75th percentile, subtract 50 from 75 which equals 25. Now, the z score corresponding to .25 is +.675. This is demonstrated graphically below.
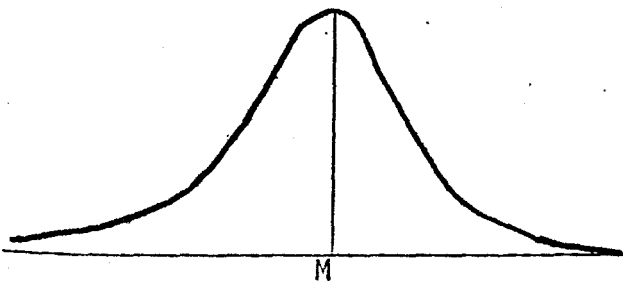
As in Case I, to convert z score to raw score, use the formula--X = Sz + M.

Finding Percentage of Scores Between Two Scores

Similarly, the z score table can be used to find the percentage

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of scores falling between two raw scores or between their corresponding z scores.

Case I:
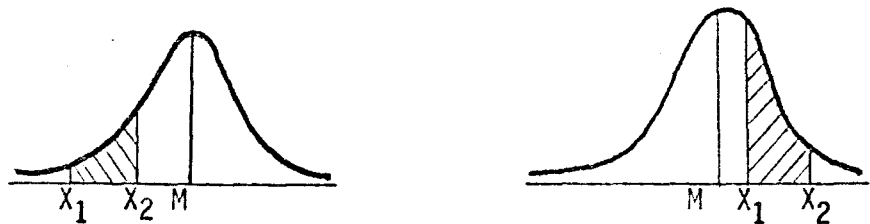
When both scores are above or below the mean, as shown in the above figures, it is necessary to convert to the z scores. This enables one to ascertain the corresponding proportions and, then, by subtracting these proportions, one can find the percentage of scores between the two score points.

Case II:
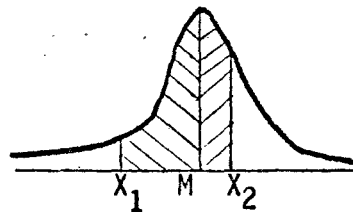
If one X is below the mean and one X is above the mean, again we find the corresponding z's and their percentages. But now we add, and, thus, find our percentage.

For both Case I and Case II we can find the actual number of scores falling between the two given scores merely by multiplying percent by N, the number of cases.

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LESSON 14 - Quiz

1. Many real distributions (approximate, fit exactly) the theoretical normal curve.

2. If we include all the cases from the beginning of the left tail of the normal curve to the mean, we shall have included _____% of the total number of cases.

3. In a normal distribution the proportion of cases between the mean and any score, F_i, will be equal to the _____ under the curve between those points.

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LESSON 15 - Objectives

1.21   Real limits

1.12   Cumulative frequency

1.11   Terminology

1.31   T scores

1.31   Z scores

2.10   T scores and Z scores

3.00   Continuously distributed scores in an interval

LESSON 15 - Normalizing Raw Data - T Scores and Z Scores

In normalizing raw data we take non-normal data and transform it to fit rather closely to the hypothetical normal curve. Generally, we first find the percentile rank of raw score (decimal form), find which z in the table corresponds to that particular proportion, and finally, using the z, place the raw score in its proper place on the hypothetical curve. In effect, we go from A to B as described below, by using cumulative percentage areas under both curves:
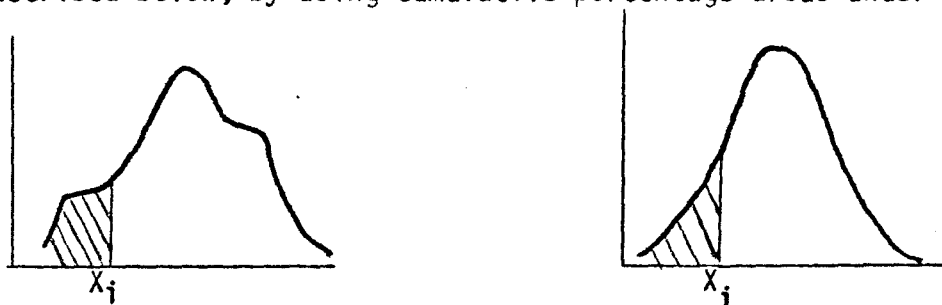
(Note that the shaded areas should represent the same proportion.)

Some further explanation might be useful to describe the steps taken in the Tate example in Table 6.5 on page 120. The raw score column lists which possible scores X_i may assume, while the f column states the frequency of the

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specific scores. The cf is the cumulative frequency of that score, <u>including</u> the total frequency of that interval. The number column is the cumulative frequency of the scores below our X_i, added to ½ the frequency of our interval which contains X_i. Thus, for the raw score of 2, the cf of all scores below it is 8. To find the number value for 2, we add to the 8 only ½ the frequency, which in this case is ½ x 7 = 3.5, for a total of 8 + 3.5 = 11.5. Only ½ of the scores are added because the scores are treated as being equally and continuously distributed throughout the interval which contains 2. Thus, the values for 2 extend from 1.5 to 2.5, and the 7 scores evenly distribute themselves across it. It follows then that at the point 2.0, only 3½ of the scores have been accounted for.

$$cf = 8 \longrightarrow | \longleftarrow 3\tfrac{1}{2} \longrightarrow | \longleftarrow 3\tfrac{1}{2} \longrightarrow | \longleftarrow \longrightarrow$$

```
        1       1.5      2      2.5      3              4
```
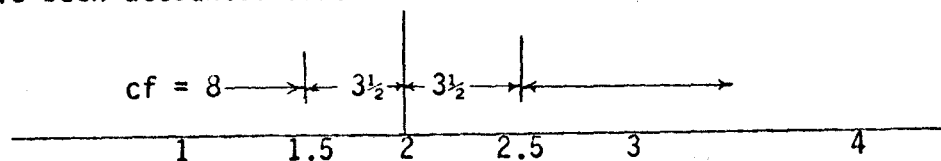
From here on it becomes quite easy. Put the number figure over N, find the corresponding decimal and find the value of z which corresponds to that decimal.

Difference between Z and T Scores

The Z and T scores are very much alike in that $Z = 10z + 50$ and $T = 10Z + 50$. The difference lies in the <u>kind</u> of z used. There are two types of z scores which can be derived from a set of data. The first z is the one derived directly from the data and the formula $\frac{X - M}{s}$. This is the type of z used in the Z transformation. The second type of Z is the one derived from normalized data. This is the one we used with T. Thus, a Z score is derived

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directly from the original data, while the T is derived from the data <u>after</u> they have been normalized.

LESSON 15 - Quiz

Answer the following questions which pertain to the data given below:

x_j	f
4	1
3	3
2	4
1	2

1. The real limits for the score 2 are _____ to _____.

2. The cf to 2.0 is _____.

3. The number of cases in the interval to 2.0 is _____.

4. The decimal to be used to find the corresponding z for 2.0 is _____.

5. T and Z are examples of _____.

6. T scores are derived from (original, normalized) data.

7. T scores and Z scores usually will differ. The T score may equal the Z score in the special case that the original data is _____.

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LESSON 16 - Objectives

1.24   Scatter plot, graphs of positive, negative and perfect correlation

2.10   Standard deviation, coefficient of correlation, number of pairs of
        scores, summation of the products

1.10   Formulae for standard deviation, coefficient of correlation

LESSON 16 - Correlation

Two variables are said to be correlated if a change in one is accompanied by a predictable change in the other. In figure 16.1 the variable plotted on the x axis correlates perfectly with the variable plotted on the y axis.
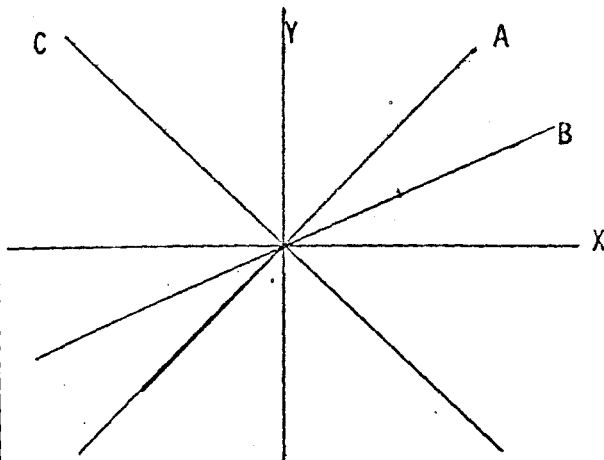
Each of the lines represents a different relationship between the variable X and the variable Y.

Figure 16.1.

- Line A is a graph showing a unit increase in X accompanied by a unit increase in Y

- Line B is a graph indicating a unit increase in Y accompanied by a 2 unit increase in X

- Line C is a graph showing that variable X is negatively correlated with variable Y

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This discussion will be limited to the consideration of linear correlation. It should be known, however, that curvilinear correlation does exist.

A single number that expresses the relationship between two variables is more useful in some circumstances than a graph would be. Such a number exists and is called the "coefficient of correlation". It is symbolized by "r" and "r_{xy}" (if the two variables are labeled x and y).

The Pearson Product Moment, r_{xy}, is expressed by the following formula:

$$r_{xy} = \frac{\sum xy}{N(s_x)(s_y)}$$ (Note that x and y are deviation scores)

xy = Summation of the product of x and y
N = Number of pairs
s_x = Standard deviation of the x distribution
s_y = Standard deviation of the y distribution

However, since $s_x = \sqrt{\dfrac{\sum x^2}{N}}$ and $s_y = \sqrt{\dfrac{\sum y^2}{N}}$,

$$r_{xy} = \frac{\sum xy}{N \sqrt{\dfrac{\sum x^2}{N}} \sqrt{\dfrac{\sum y^2}{N}}} = \frac{\sum xy}{\sqrt{\sum x^2}\sqrt{\sum y^2}} = \frac{\sum xy}{\sqrt{(\sum x^2)(\sum y^2)}}$$

In the above formula the x's only represent deviation scores. Below is the raw score formula for the coefficient of correlation. This can be derived by substituting $(X - \overline{X}) = x$ and $(Y - \overline{Y}) = y$ in the formulae above:

$$r_{xy} = \frac{N \sum XY - (\sum X)(\sum Y)}{\sqrt{[N \sum X^2 - (\sum X)^2]\ [N \sum Y^2 - (\sum Y)^2]}}$$

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The Pearson Product Moment Correlation (r_{xy}) can assume all values between and including -1 and +1. In the behavioral sciences, however, it is unlikely to have variables that have perfect positive or negative correlation. It is a matter of judgment and experience to determine when two variables are correlated well enough to be meaningful or useful.

The values of r_{xy} do not determine a ratio scale. That is, an r_{xy} = .90 is not twice as good as an r_{xy} = .45.

When there is a high correlation between variables, students often conclude that one variable causes the other. This may not always be the case, since two variables may be highly correlated accidentally.

The Pearson Product Moment Correlation can be calculated from grouped data in the following manner: (see next page)

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H E I G H T

	49-54	55-60	61-66	67-72	73-78	fy	dy	fydy	fy(dy)^2	$\sum$dx row cell	dy$\sum$dx row cell
201-250	0	1	2	3	5	11	1	11	11	12	12
151-200	0	3	9	7	1	20	0	0	0	6	0
101-150	2	7	3	1	0	13	-1	-13	13	-10	10
51-100	4	1	0	0	0	5	-2	-10	20	-9	18
1-50	1	0	0	0	0	1	-3	-3	9	-2	6
fx	7	12	14	11	6	50	-5		53		
dx	-2	-1	0	1	2	0					
fxdx	-14	-12	0	11	12					-3	
fx(dx)^2	28	12	0	11	24	75					
$\sum$dy col.	-13	-8	-1	2	5			-15			
dx$\sum$dy col. cell	26	8	0	2	10						46

W E I G H T

Table 16.1.

1. fx and fy   - place total frequencies in the respective rows and columns.

2. dx and dy   - select the column and row with the highest frequency and label it 0. Mark those intervals to the right and up as +1. +2. +3, etc. and those intervals to the left and down as -1, -2, -3, etc.

3. fxdx and fydy   - are simply the products of the first and second row and first and second column.

4. $\sum$fxdx^2 and fydy^2 - first square the dx and dy column, then multiply by fx and fy respectively.

5. $\sum$dy (col. cell)   - sum of the products of the frequency of the cell, times dy of that row. e.g., For 49-54 column -- 2(-1) + 4(-2) + 1(-3) = -2-8-3 = -13

$\sum dx$ (row cell) — Sum of the products of the frequency of the column times the dx of that column. e.g., For 201-250 row — $0(-2) + 1(-1) + 2(0) + 3(1) + 5(2) = 12$

6. $dx \sum dy$ — row (2) times row (5)

$dy \sum dx$ — column (2) times column (5)

From the preceding table the following statistics can be calculated:

Mean weight $\bar{y} = 175.5 + \left(\dfrac{-15}{50}\right) 50$

Mean height $\bar{x} = 63.5 + \left(\dfrac{-15}{50}\right) 6$

and since

$$r = \frac{n \sum xy - (\sum x)(\sum y)}{\sqrt{\left[n \sum x^2 - (\sum x)^2\right]\left[n \sum y^2 - (\sum y)^2\right]}}$$

or in terms of the above symbols,

$$r = \frac{n(dx \sum dy) - \sum dx(\text{row cell}) \quad \sum dy(\text{col. cell})}{\sqrt{\left[n \sum fx(dx)^2 - (\sum fxdx)^2\right]\left[n \sum fy(dy)^2 - (\sum fydy)^2\right]}}$$

$$r = \frac{50(46) - [-3][-15]}{\sqrt{\left[50(75) - (-3)^2\right]\left[50(53) - (-15)^2\right]}}$$

$$r = \frac{2300 - 45}{[3741][2425]} = \frac{2255}{3011.8} = .74$$

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LESSON 16 - Quiz
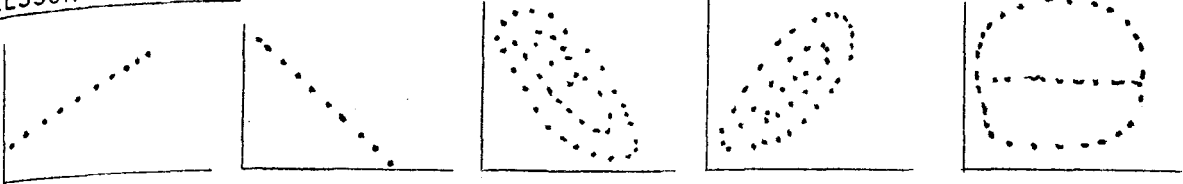
Match the following descriptions to the above graphs:

1. Perfect negative correlation _____

2. Perfect positive correlation _____

3. Zero correlation _____

4. Positive correlation _____

5. Negative correlation _____

Match the following symbols with their meanings: r_{xy}, N, xy, s_x, s_y

6. Standard deviation of x _____

7. Standard deviation of y _____

8. Coefficient of correlation between x and y _____

9. Number of pairs of scores _____

10. State the formula for r_{xy} using the above symbols

_____

11. State the formula for s_x _____

12. State the formula for s_y _____

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13. Complete the following table:

x	y	xy	x^2	y^2
-2	7			
2	-5			
0	1			
-1	4			
1	-2			

14. $\sum xy$ = _____

15. N = _____

16. $\sum x^2$ = _____

17. $\sum y^2$ = _____

18. s_x = _____

19. s_y = _____

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LESSON 17 - Objectives

3.00   Spearman rank difference correlation

6.20   Positive, negative correlation

1.10   Pearson product moment correlation

LESSON 17 - Spearman Rank Difference Correlation

The Spearman rank difference correlation coefficient, r_d, provides us with a method of determining the degree of relationship between two variables when only their ranks or difference in ranks is given. The interpretation of r_d is the same as r_{xy} with one exception. In calculating r_{xy} we are dealing with raw scores or deviation scores, and the assumption of linearity is made. With r_d, however, the relationship may be curvilinear in which case r_d would not underestimate the degree of relationship as would r_{xy}.

The following example may clarify the application of the formula for the Spearman rank difference correlation coefficient (r_d):

By using a table of random numbers, the following table was developed:

Order	Number	Rank (L)*	D	D^2
1	3	1	0	0
2	97	10	-8	64
3	16	3.5	-0.5	0.25
4	12	2	2	4
5	55	6	-1	1
6	16	3.5	2.5	6.25
7	84	9	2	4
8	63	8	0	0
9	33	5	4	16
10	57	7	3	9

Table 17.1.

Rand (L)* = Rank 1 beginning with lowest number

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Column 1 contains the order of the number in the table.

Column 2 contains the random number.

Column 3 contains the ranking according to the magnitude of the number.

Column 4 contains the difference (D) between rank (Column 1 - Column 3).

Column 5 contains the squares of column 4 (D^2).

Before proceeding, what do you think the correlation of variables formed in this way should be? (Zero)

$$r_d = 1 - \frac{6 \sum D^2}{N(N^2 - 1)}$$

$$= 1 - \frac{6(104.5)}{10(100 - 1)}$$

$$= 1 - \frac{627.0}{990}$$

$$= 1 - .633$$

$$= .366$$

Since the variables are randomly related, this correlation should be 0 and would be 0, had we used a larger sample. In the preceding example, we dealt with tied ranks which were solved by adding the ranks, dividing by 2, and assigning each the common rank of 3.5. However, this produces a slight inaccuracy in r_d for which a correction factor exists. Since this correction factor required more computation, it is seldomly used unless the particular study requires that degree of accuracy.

If we assigned the highest rank (1) to the highest score in the above example, the following table would result:

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Order	Number	Rank (H)*	D	D^2
1	3	10	-9	81
2	97	1	1	1
3	16	7.5	4.5	20.25
4	12	9	-5	25
5	55	5	0	0
6	16	7.5	1.5	2.25
7	84	2	5	25
8	63	3	5	25
9	33	6	3	9
10	57	4	3	36

Table 17.2.

Rank (H)* = Rank 1 beginning with highest number

$$r_d = 1 - \frac{6 \sum D^2}{N(N^2 - 1)}$$

$$= 1 - \frac{6(2245)}{10(99)}$$

$$= 1 - \frac{1347.0}{990}$$

$$= 1 - 1.361$$

$$= -.361$$

The discrepancy between -.361 and +.333 is due to the fact that (1) we had tied ranks, and (2) the difference in sign is due to the way we assigned the ranks to the number. In each case, however, we reach the conclusion that as the order increases, the magnitude of the number decreases. Note that the correlation is not very high, and if our sample were large enough these variables would not be correlated at all.

As an exercise in mathematical reasoning, attempt to explain why the discrepancy found above is due to tied ranks.

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LESSON 17 - Quiz

X	Rank X	Y	Rank Y	D	D^2
26		31			
39		54			
53		75			
6		19			
66		61			
85		82			
31		20			
44		40			
79		93			
13		7			

N = _____

$\sum D^2$ = _____

1. State the Spearman rank difference formula r_d: _____.

2. What is r_d in the above table? _____.

3. State the Pearson product moment formula r_{xy}: _____.

Match the following:

4. _____ Side of a square and its perimeter

5. _____ I.Q. and grade point average

6. _____ Temperature on the centigrade and Fahrenheit

7. _____ Intelligence and creativity

8. _____ Mathematics aptitude and grades in statistics

9. _____ Height and weight

a. Perfect positive correlation

b. Perfect negative correlation

c. Positive correlation

d. Negative correlation

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10. Calculate the Pearson product moment correlation r_{xy} on the data in the table on the preceding page. (For homework)

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LESSONS 18 and 19 - Objectives

2.10   Biserial

2.10   Point Biserial

1.10   Tetrachoric
        Phi

LESSONS 18 and 19 - Other Correlation Coefficients

The following discussion is meant to serve as an introduction to correlation coefficients other than the Pearson r_{xy} and the Spearman r_d. The correlation coefficients to be covered will be the biserial r_b; point biserial r_{pb}; tetrachoric r_t; and phi r_ϕ. (A more complete treatment of these topics may be found in texts by Walker, Guilford and Edwards.)

Biserial r_b: The biserial coefficient of correlation is applied to two variables, both of which are really continuous, but one of which is "artificially" dichotomized. It must also be assumed that this variable has a normal distribution. Suppose we were investigating two continuous variables such as weight and I.Q., and decided to dichotomize weight so that the cases above 150 lbs. would be considered heavyweight and the cases below 150 lbs. would be considered lightweight:

Above 150 lbs.			2	5	13	15	13	11	3	3		65	.65	p
Below 150 lbs.	1	3	2	5	11	8	3	2				35	.35	q
Interval (I.Q.)	60-69	70-79	80-89	90-99	100-109	110-119	120-129	130-139	140-149	150-159	160-169			
Total	1	3	4	10	24	23	16	13	3	3		n	$\frac{n}{N}$	

Table 18.1.

$$r_b = \frac{M_p - M_q}{s_t} \cdot \frac{pq}{y}$$ (Assumption is made that scores are concentrated at the mean of the interval.)

M_p = Mean I.Q. score of those above 150 lbs.

M_q = Mean I.Q. score of those below 150 lbs.

p = Proportion of those above 150 lbs.

q = Proportion of those below 150 lbs.

y = Ordinate (y-value) at the point of division between p and q

s_t = Standard deviation of total sample

An alternate formula which may be more convenient is:

$$r_b = \frac{M_p - M_t}{s_t} \cdot \frac{p}{y}$$ (M_t = mean of total scores.)

The biserial r_b is not as reliable as the Pearson r_{xy}, and one should favor the latter, unless the sample is very large, and unless computation time is an important consideration. The standard error for a biserial r is consid-- erably larger than that for a Pearson r derived from the same sample.

Point Biserial r_{pb}: The point biserial coefficient of correlation is very similar to the biserial r_b, except that one of the variables may <u>actually</u> be a dichotomous variable and the other variable may be continuous. The point biserial coefficient may be used in the following example and any other situation that may be parallel to it.

Suppose we wanted to determine if a particular question on a test measured the same trait as the entire test. If the test is given to several

students, one may reasonably expect that if a student scores well on the test he would get the item correct, and if he did poorly on the test he would fail the item. Consider Table 18.2 on the following page.

$$r_{pb} = \frac{(M_p - M_q)\sqrt{pq}}{s_t} \qquad \text{or} \qquad r_{pb} = \frac{(M_p - M_t)}{s_t}\sqrt{\frac{p}{q}}$$

where M_p = Mean of all those passing (1) the item

M_q = Mean of all those failing (0) the item

s_t = Standard deviation of total sample

p = Proportion passing the item

q = Proportion failing the item

Assigning the value of "1" or "0" is a matter of choice, but the interpretation of r_{pb} must take this into account. For example, if sex were dichotomized by assigning "0" to females and "1" to males, a large positive r_{pb} would indicate that males have more of the particular variable in question than females, and a large negative r_{pb} would indicate that females would have more of the variable than males. An r_{pb} close to zero would indicate that neither sex possessed significantly more of the variable than the other.

r_b and r_{pb} are related by the following equation:

$$r_b = (\sqrt{pq}/y)(r_{pb})$$

Tetrachoric r_t: The tetrachoric correlation coefficient is most properly applied when one dichotomizes both of two variables that are continuous and normally distributed.

Individual	Item 1	2	3	4	5	6	7	8	t_i	Individual	Item 1	2	3	4	5	6	7	8	t_i
1	1	0	0	0	0	0	0	0	1	11	1	1	1	1	1	1	0	1	7
2	1	1	1	1	0	0	1	1	6	12	1	1	0	1	1	0	1	0	5
3	1	0	1	0	0	0	0	0	2	13	1	1	1	1	1	1	0	0	6
4	1	1	1	1	1	1	1	0	7	14	0	1	1	1	1	0	0	0	4
5	1	1	1	1	0	0	0	0	4	15	1	1	1	0	0	0	0	0	3
6	1	1	0	0	0	0	0	0	2	16	1	1	1	0	1	0	0	0	4
7	1	0	1	1	1	1	0	0	5	17	1	1	0	1	0	0	0	0	3
8	1	1	1	0	0	0	0	0	3	18	1	1	1	1	1	1	1	1	8
9	1	1	1	0	1	1	1	0	6	19	1	1	1	1	0	1	0	0	5
10	1	0	0	1	1	1	0	0	4	20	1	1	1	1	1	0	0	0	5
										TOTAL	19	16	15	13	11	8	5	3	90

Table 18.2.

Using the data of Table 18.1 and considering 100 as the dividing point, the following table results:

	Below 100 I.Q.	Above 100 I.Q.	Total
Above 150 lbs.	7 (a)	58 (b)	65
Below 150 lbs.	11 (c)	24 (d)	35
Total	18	82	100

Table 18.3.

From this 2x2 table we form the products (a·b) and (c·d). Then we form a fraction with the larger of these two products in the numerator and the smaller in the denominator:

$$k = \frac{ab}{cd} \qquad k = \frac{cd}{ab}$$

Referring to Table 18.1, ab = 406 and cd = 264. Therefore,

$$k = \frac{ab}{cd} = \frac{406}{264} = 1.54$$

Phi $r_\emptyset$: If two variables are both dichotomous, the phi coefficient is used. An example of dichotomous variables are two items on a test, item "i" and item "k". If the item is answered correctly, the student is assigned a "1". If the item is answered incorrectly, the student is assigned a "0".

$$r_\emptyset = \frac{P_{ik} - P_i P_k}{\sqrt{P_i q_i P_k q_k}} = \frac{BC - AD}{\sqrt{(A + B)(C + D)(A + C)(B + D)}}$$

Item k

Item i	0	1	
1	A	B	p_i
0	C	D	q_i

q_k p_k

Table 18.4.

The following materials were prepared because the formative evaluations revealed that the students had not mastered the concepts relating z-scores, areas under the normal curve, and proportion of total scores.

Mean, Standard Deviation and Normal Curve

The area under the normal curve is considered a unity. The attached table gives the proportion of the area between the mean and the numbers of standard deviations (z scores). Since the normal curve is symmetrical, the mean, median and mode fall at the same point, namely, the middle of the distribution. It follows that half of the area falls below the mean and half above the mean. The proportion that is read from the table can be interpreted as the proportion of the total N in a particular discussion.

The normal curve can be completely described by the mean and standard deviation.

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The following "program-like" materials were devised because the weekly formative quiz revealed that the students had not retained some of the concepts that they had previously learned. Listed below are the 96 frames that were introduced in class but were to be completed by the student outside of class.

1. Approximately 34% of the area under the normal curve falls between the mean and a point the is 1 S.D. distant. Therefore, the percentage of the area between the mean and the point 1 S.D. above the mean is _____.

2. The percentage of the area under the normal curve between the mean and a point 1 S.D. above the mean is about 34%. What is the percentage below a point 1 S.D. below the mean? _____.

3. To get this answer we subtract 34% (the area between the mean and a point 1 S.D. below the mean) from _____.

4. The area falling above a point 1 S.D. above the mean is equal to _____.

5. If M = 100 and s = 10, what percent of the area falls between 100 and 110? _____.

6. Suppose in the previous example the sample consisted of 200 cases. What number of cases would fall between 100 and 110? _____.

7. If M = 100 and s = 10, 34% of the area falls between 90 and _____.

8. And 34% falls between 100 and _____.

9. With M = 100 and s = 10, what percent of the area falls below 90? _____.

10. To find this we subtract the percentage of the area between 90 and 100 from 50%. What percent of the area falls between 90 and 100? _____.

11. If M = 10 and s = 1, 16% of the area falls below what point? _____.

12. If M = 25 and s = 5, then 16% of the area falls above _____.

13. Let M = 100 and s = 10, then the area between 90 and 110 is _____.

14. This last problem illustrates a principle: If we wished to find an area under the curve, which falls on both sides of the mean, we must find the area between the lowest point and the mean and add this to the area between the highest point and the _____.

15. If M = 1000 and s = 200, what percent of the area falls below 800? _____.

16. What percent of the area falls above 1200? _____.

17. If M = 100 and s = 10, what percent of the cases falls below 90 and above 110? _____.

18. Approximately 47.5% of the cases falls between the mean and point 2 standard deviations away from the mean. If M = 100 and s = 10, what proportion of the total cases would fall between 100 and 120? _____.

19. What proportion falls between 80 and 120? _____.

20. What proportion of cases falls outside the 80-120 range? _____.

21. M = 50 and s = 2. 95% of the cases under the normal curve fall between _____ and _____.

22. M = 1000 and s = 100. 2.5% of the scores fall above what point? _____.

23. M = 1000 and s = 100. What percent of the scores fall below 900 and above 1200? _____.

24. To get this answer we find the area below _____, the area above _____, and then we _____.

25. M = 80 and s = 3. What percent of the area falls between 77 and 86? ____.

26. To find this last answer we first find the area between 77 and _____.

27. This area is equal to _____.

28. Next we find the area between 86 and _____.

29. This area is equal to _____ %.

30. Therefore, _____ percent of the area falls between 77 and 86.

31. M = 10 and s = 1. What percent of the area falls between 9 and 12? _____.

32. M = 10 and s = 1. What percent of area falls below 8 and above 11? _____.

33. M = 20 and s = 4. What percent of the area falls above 12? _____.

34. M = 100 and s = 10. If 34% of the cases falls between 100 and 110, and if 47.5% of the cases fall between 100 and 120, then what percent of the cases falls between 110 and 120? _____.

35. While we can give rough approximations of the percentage of cases (area) under the normal curve by memory, we must use a z score table to be accurate. A z score is a distance stated in terms of standard deviations.

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For example, if M = 100 and s = 10, 110 would be 1 standard deviation above the mean and z would equal 1.00. If M = 100 and s = 10, then if X = 120, z would equal _____.

36. To find a z score, simply subtract the mean from the (raw) score and divide by s or z = (X - M)/s. If M = 1000, s = 50, and X = 1100, then S expressed in z score units would equal _____.

37. Be careful to note that since the mean is subtracted from the score, that a z score representing a score above the mean is positive, while a z score representing a score below the mean is _____.

38. If M = 100, s = 15, and X = 85, then z = _____.

39. The sign of the z score is _____ because X is _____ the mean.

40. If M = 50, s = 2 and X = 53, then z = _____.

41. The process can be reversed. That is, we can find a score if the z score is given. Since z = (X - M)/s, then X = z s + M. If M = 100, s = 15, and z = 1.00, then X = _____.

42. X = z s + M. If M = 100, s = 15, and z = -.67, then X = _____.

43. M = 80, s = 3, and z = 0.0, then X = _____.

44. We know that approximately 34% of the cases fall between the mean and a point 1 standard deviation from the mean. Thus, the proportion of cases under the normal curve between the mean and z = 1.00 is equal to _____.

45. The area above z = 1.00 is equal to _____.

46. The area below z = -1.00 equals _____.

47. The proportion of cases above z = -1.00 equals _____.

48. The area between z = -1.00 and z = 1.00 is equal to _____.

49. The area between a point 2 standard deviations below the mean and a point 2 standard deviations above the mean is equal to 95%. Hence, the area between z = -2.00 and z = 2.00 is equal to _____.

50. The area between z - -2.00 and z = 1.00 is equal to _____.

51. If 34% of the cases fall between z = 0.0 and z = 1.0, and if 47.5% falls between z = 0.0 and z = 2.00, then _____ % fall between z = 1.00 and z = 2.00.

52. Since the curve is symmetrical, the area between $z = -2.00$ and $z = -1.00$ is equal to _____.

53. Referring to the attached table, the numbers in the body of the table are areas (can be interpreted as the proportion of the total number of cases) under the normal curve between the mean and _____.

54. In the table if you wish to find the area between the mean and $z = 2.22$, you go down the z-column to $z = 2.2$ and go across the row to the _____ column.

55. According to the table what proportions of the cases fall between the mean and $z = 1.55$? _____

56. If the sample had 10,000 cases how many would fall between $z = 0$ and $z = 1.55$? _____

57. The mean can be expressed as a z score which is _____.

58. If $z_1 = 0.00$ and $z_2 = .50$, what proportion of the total number of cases falls between z_1 and z_2? _____

59. If $z_1 = 0.00$ and $z_2 = 1.50$, what proportion of cases is between z_1 and z_2? _____

60. If the proportion between $z = 0.0$ and $z = 1.50$ is equal to _____, and if the area between $z = 0.0$ and $z = .50$ is equal to _____, then the proportion between $z = .50$ and $z = 1.50$ is _____:

61. $z_1 = 1.00$; $z_2 = 2.00$; What proportion falls between z_1 and z_2? _____

62. The reason for this answer is that .3413 falls between the mean ($z = 0.00$) and $z = 1.00$, and .4772 falls between $z = 0.00$ and $z = 2.00$. To find the proportion between $z = 1.00$ and $z = 2.00$, you _____ the smaller from the larger.

63. The proportion between $z = -.50$ and $z = 0.00$ is equal to _____.

64. The proportion between $z = 0.0$ and $z = .75$ would be equal to _____.

65. If the proportion $z = -.50$ and $z = .00$ is equal to _____, and the proportion between $z = .00$ and $z = .75$ is equal to _____, then the proportion between $z = -.50$ and $z = .75$ is equal to _____.

66. If we wish to find proportions between two z scores on opposite sides of the mean, we _____ the proportion between each of the z scores and the mean.

67. But if both z scores are on the same side of the mean, and we wish to find the proportion between the two, then we _____ the smaller from the larger.

68. Suppose M = 100 and s = 10. We wish to find the proportion between 100 and 120. Since the proportion is dependent on M and s, the scores must be converted to z scores; z_1 = _____ and z_2 = _____.

69. We wish to find the proportion between 9 and 12. M = 10, and s = 2. What proportion falls between 9 and 10? _____

70. What proportion between 10 and 12 is there? _____

71. Now the proportion between 9 and 12 is the _____ of the proportion between 9 and 10 _____ the proportion between 10 and 12.

72. If we wished to go from a raw score to a z score, we would use the formula: z = (X - M)/s. But if we wished to go from a z score to a raw score, we would use what formula? X = _____.

73. If M = 50, s = 4 and z = 1.50, then X = _____.

74. The tabled z score that most nearly contains 25% between itself and the mean is z = _____.

75. $Q_1 \implies z$ = _____.

76. $Q_3 \implies z$ = _____.

77. Suppose we wanted to find the score which, between itself and the mean, a certain proportion falls. To do this we would first translate the proportion into a _____.

78. Then we would translate the z score into a _____ score.

79. M = 100 and s = 10. We wish to find the point that includes 20% of the cases under the normal curve between itself and the mean. The z most nearly corresponding to 20% is _____.

80. A z score of _____ corresponds to a raw score of _____.

81. Thus 20% of the cases falls between 100 and _____ when M = 100 and S = 10.

82. M = 40 and s = 4. We wish to find the point above which 20% of the cases fall. To do this we must go from a z score to a raw score. To find the top 20% we must find the z score from the table corresponding to _____%.

83. Our table is constructed so as to give proportions (percentages) between the mean and some point. If the percentage in which we are interested falls beyond some point, then we must subtract the percent from _____.

84. The result of this is the percentage which falls between the mean and the point in which we are interested. The z score corresponding to the lowest score of the 20% is found by subtracting 20% from 50% and getting 30%. The z score corresponding to 30% is _____.

85. The raw score corresponding to a z score of .84 is equal to _____.

86. Hence 20% of the scores fall above _____. We wish to find the point below which 30% of the scores fall. The z score corresponding to this point is _____.

87. And with M = 40, s = 4, z = (above)_____, then X = _____.

88. Suppose a class was given a test in which M = 60 and s = 5. 20% of the class was given a grade of "A". To find the lowest "A" scores we must find the proportion between the mean and the lowest "A". This proportion is _____.

89. The z score corresponding to 30% is _____.

90. With M = 60 and s = 5, the raw score corresponding to a z score of .84 is equal to _____.

91. Hence every scoring above _____ would receive a grade of "A".

92. With reference to the same test (M = 60, s = 5), 20% of the class received a "B". We know 64 was the highest "B" and we wish to find the lowest "B". What proportion falls between the mean and the lowest "B"? _____

93. This is because the "A" that comprised 20% of the area fell above the lowest "B" as well as the _____% of the students who received a grade of "B".

94. We wish to find the point which between itself and the mean 10% of the scores fall. 10% of the area corresponds to a z of _____.

95. If M = 60, s = 5, and z = .25, then X = _____.

96. Therefore, students who received scores between _____ and 64, received a grade of B.

Similarly, C grades can be computed, but keep in mind the lowest C should give a negative z score.

AREAS under the STANDARD NORMAL CURVE from 0 to z

z	0	1	2	3	4	5	6	7	8	9
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.0359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0754
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2258	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
0.7	.2580	.2612	.2642	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2996	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990
3.1	.4990	.4991	.4991	.4991	.4992	.4992	.4992	.4992	.4993	.4993
3.2	.4993	.4993	.4994	.4994	.4994	.4994	.4994	.4995	.4995	.4995
3.3	.4995	.4995	.4995	.4996	.4996	.4996	.4996	.4996	.4996	.4997
3.4	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4998
3.5	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998
3.6	.4998	.4998	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999
3.7	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999
3.8	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999
3.9	.5000	.5000	.5000	.5000	.5000	.5000	.5000	.5000	.5000	.5000

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raw score	f	cf	f to cumulative midpoint	cumulative proportion to midpoint	Value of z in normal curve corresponding to proportion
20	20	99			
19	18	79			
18	14	61			
17	14	47			
16	12	33	27		
15	10	21	16		
14	6	11	8	.0808	
13	4	5	3	.0303	-1.88
12	1	1	½	.0051	-2.58
1	2	3	4	5	6

1. To form the numbers in column 4 simply add ½f of that row to the cf up to the lower limit of that row.

2. To form the numbers in column 5 divide the numbers in column 4 by the total N (in this case 99).

3. To form the numbers in column 6 one must refer to the body of the z table, remembering that .0051 is very close to the left or lower end of the normal curve and the corresponding z score will be negative. It must be kept in mind that the proportion found in the z table is between the mean and the point, whereas the proportion .0051 starts at the lower end, therefore, to get the proper z score, we must subtract, .5000 - .0051 = .4949, and read .4949 which corresponds to a z score of -2.58.

z=-2.58   M
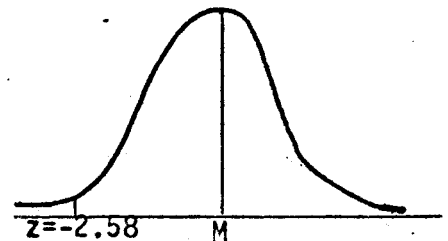
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<u>LESSONS 18 and 19 - Quiz</u>

a. r_t

b. r_b

c. r_{pb}

d. r_ϕ

1. _____ Phi coefficient of correlation

2. _____ Used when given two normally distributed continuous variables, one of which is artificially dichotomized

3. _____ Biserial coefficient of correlation

4. _____ $\dfrac{\sqrt{pq}}{y} \cdot r_{pb}$

5. _____ Tetrachoric coefficient of correlation

6. _____ Used when both variables are dichotomous

7. _____ $\dfrac{BC - AD}{\sqrt{(A+B)(C+D)(A+C)(B+D)}}$

8. _____ Point biserial coefficient of correlation

9. _____ Used when one variable is dichotomous and the other is continuous

10. _____ $k = \dfrac{ab}{cd}$ or $k = \dfrac{cd}{ab}$

11. _____ Used when two continuous normally distributed variables are artifically dichotomized

August 1, 1969

<u>LESSON 20 - Objectives</u>

1.11   Linear Regression

2.20   Equation of a straight line

1.10   Coefficient of linear regression

1.10   Equation for lines of regression

6.20   Regression line and standard error of estimate

<u>LESSON 20 - Linear Regression</u>

When working with a scatter diagram, if the points tend to approach a particular line (either curved or straight), they tend to regress toward that line. We can describe the relationship between two variables by describing the pattern (or line) in the scatter diagram. The mathematical description of the pattern is the regression equation. When the pattern tends toward a straight line, the regression is linear. Here, we will be concerned with linear regression chiefly. The mathematical equation of the straight line is, therefore, of prime importance. Through this equation we can express the relationship between two variables.

<u>The Regression Equation</u>: The main use of the regression equation is to predict the most likely measurement in one variable from the known measurement in another variable. The dependent variable "Y" is referred to as the <u>criterion</u> <u>variable</u>; and the independent variable "X" is referred to as the <u>predictor</u> <u>variable</u>.

From elementary algebra we know that the general form of the equation for a straight line is $Y = bX + a$, where b is the slope of the line and a is the Y intercept.

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If a and b are given, this equation defines one and only one straight line. Examine the following scatter diagram:
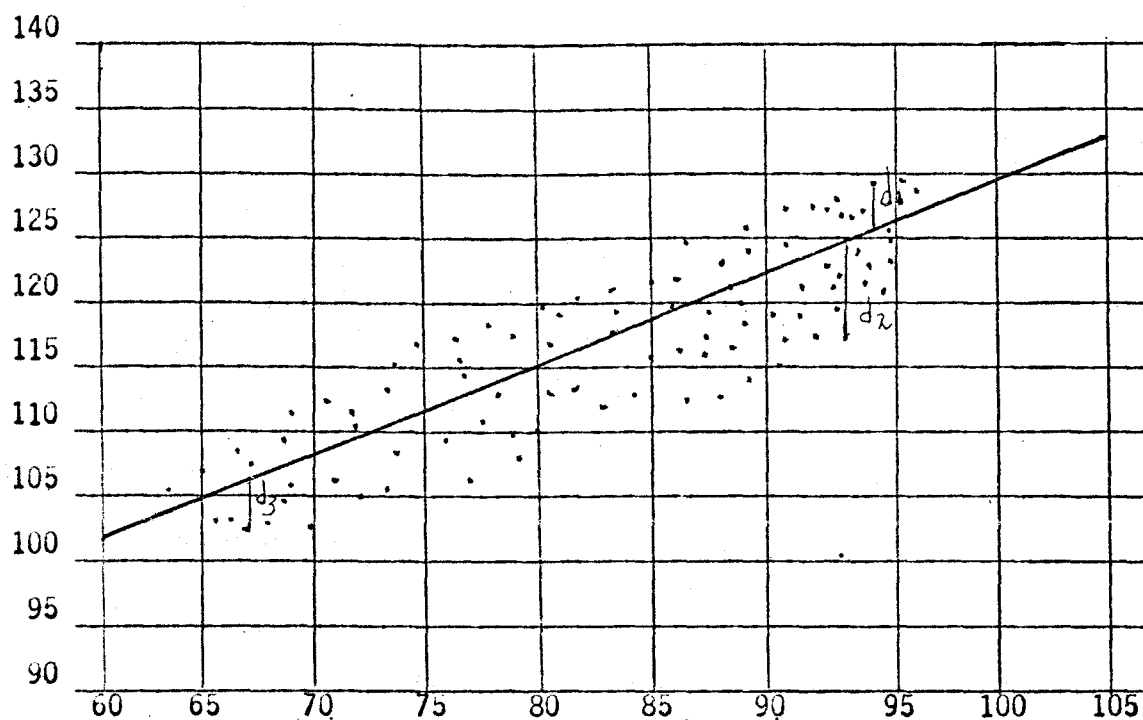
Figure 20.1.

By inspection we could draw a line as close as possible to where the majority of dots cluster; however, this is not an exact measurement, since different people may construct various lines. We need a more exact way of finding the line of "best fit". The standard mathematical method in statistics for finding the linear regression line is that of least squares. Through this method we find the equation of the line, such that the sum of the squares of the vertical distances (d) of the points from the regression line is a minimum. (Refer to diagram.) The general formula in deviation score form for the line

of regression of Y on X is:

$$Y' = r_{xy}\left(\frac{s_y}{s_x}\right)X + \overline{Y}$$

where $r_{xy}\left(\dfrac{s_y}{s_x}\right)$ is the coefficient of regression of Y on X and is referred to

as b_{yx}. In raw score form the equation for the line of regression of Y on X

would be:

$$Y' = r_{xy}\left(\frac{s_y}{s_x}\right)(X - \overline{X}) + \overline{Y}$$

The equation for the line of regression of X on Y is:

$$X' = r_{xy}\left(\frac{s_x}{s_y}\right)(Y - \overline{Y}) + \overline{X}$$

In order to write the regression equation, we first need the means, the standard deviations, and the correlation coefficient.

In order to clarify this, let us examine the equation for the straight line: Y = bX + a. Disregarding the "a" temporarily, we have Y = bX. From this we can see that "b" is a ratio -- it tells us how many units Y increases for every increase of one unit in X. For example, if "b" = 2, then every unit of increase in X is accompanied by a two unit increase in Y. The "b" coefficient gives us the slope of the regression line which depends upon the coefficient of correlation and the two standard deviations.

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For the equation of the line of regression, "b" becomes

$b_{yx} = r_{xy}\left(\dfrac{s_y}{s_x}\right)$, and it is called the coefficient for linear regression of Y

on X. The b_{yx}, with the subscripts in that order, implies that we are pre-

dicting Y from X.

Going back to the original equation for a straight line; $Y = bX + a$,

let us now examine the second part of the right hand term. The "a" is merely

a constant that must always be added in order to insure that the mean of the

predictions will equal the mean of the obtained values. The a determines the

level of the line as the b determines the slope.

Therefore, the two equations for linear regression are:

1. $Y' = r_{xy}\left(\dfrac{s_y}{s_x}\right)(X - \overline{X}) + \overline{Y}$ (Line of regression of Y on X)

2. $X' = r_{xy}\left(\dfrac{s_x}{s_y}\right)(Y - \overline{Y}) + \overline{X}$ (Line of regression of X on Y)

where r_{xy} is the correlation coefficient

s_x and s_y are the respective standard deviations

$\overline{X}$ and $\overline{Y}$ are the respective means

X and Y are the variables

The coefficient for linear regression of (1) is:-

$.b_{yx} = r_{xy}\left(\dfrac{s_y}{s_x}\right)$ (Y on X)

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The coefficient for linear regression of (2) is:

$$b_{xy} = r_{xy}\left(\frac{s_x}{s_y}\right) \quad (X \text{ on } Y)$$

To illustrate these formulae, consider a set of data in which $\overline{X} = 78.15$; $\overline{Y} = 115.28$; $s_x = 7.60$; $sy = 7.85$; and $r_{xy} = .61$. Using formula (1) we find that:

$$
\begin{aligned}
y' &= .61 \ (7.85/7.60) \ (X - 78.15) + 115.28 \\
&= .61 \ (1.03) \ (X - 78.15) + 115.28 \\
&= .630X - 49.23 + 115.28 \\
&= .630X + 66.05
\end{aligned}
$$

$$
\begin{aligned}
X' &= .61 \ (7.60/7.85) \ (Y - 115.28) + 78.15 \\
&= .591Y + 10.02
\end{aligned}
$$

$b_{yx} = .630$ (equation 1.)

$b_{xy} = .591$ (equation 2.)

Interpreting these equations, we may say that Y' increases .630 unit for every unit increase in X; and that X' increases .591 unit for every unit increase in Y. It should be remembered that Y' and X' are theoretical equations for the lines of regression; that is, if the two points were perfectly correlated, all the points would fall on these lines. In practice, however, we do not often see the points behave in this manner.

The Standard Error of Estimate: In describing the relationship between two variables, it is not enough to simply state the regression equation. We must also show how the points scatter around the regression line -- the standard error of estimate. Just as we needed both a measure of central tendency and a measure of variability when describing a distribution, so too we need a

regression and a standard error of estimate. Through the formula for the standard error of estimate, we have an exact measure of the scatter of the points from the regression line. The formula for the standard error of estimate is:

$$s_{y \cdot x} = s_y \sqrt{1 - (r_{xy})^2}$$

where $s_{y \cdot x}$ is the standard error of estimate

s_y is the standard deviation of the Y variable

r_{xy} is the correlation coefficient

In the previous example, $s_y = 7.85$, $s_x = 7.60$, and $r_{xy} = .61$. Applying the formula for standard error of estimate, the following results:

1. $s_{y \cdot x} = 7.85 \sqrt{1 - (.61)^2}$

$= 7.85 \sqrt{1 - .3721}$

$= 6.22$

2. $s_{x \cdot y} = 7.60 \sqrt{1 - .3721}$

$= 6.02$

1. The statistic $s_{y \cdot x}$ (standard error of estimate of Y on X) tells us that about 68% of the scores will be distributed about the regression line Y', within the limits of 6.22 units above the line and 6.22 units below the line.

2. The statistic $s_{x \cdot y}$ (standard error of estimate of X on Y) tells us that about 68% of the scores will be distributed about the regression line X' within the limits of 6.02 units above the line and 6.02 units below the line.

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In order to make these statements about the standard error of estimate, we must make three basic assumptions about the data:

1. Assume that the relationship between the two variables is linear; that is, that there is a linear regression; and

2. Assume homoscedasticity of the data; that is, the scatter for the relationship between the two variables will be the same for the total population in the past, present, and the future; and

3. Assume that the observed criterion scores will be distributed normally in each column.

LESSON 20 - Quiz

True or False:

1. _____ When the pattern of the points in a scatter diagram tend to form a straight line, the regression is termed linear.

2. _____ In the general equation for a straight line, $Y = bX + a$, the "b" tells how many units Y increases for every increase of one unit in X.

3. _____ The coefficient for linear regression of Y on X is: $b_{xy} = r_{xy}\left(\dfrac{s_x}{s_y}\right)$.

4. _____ The general equation for the line of regression of X on Y is:

$$X' = r_{xy}\left(\frac{s_x}{s_y}\right)(Y - \overline{Y}) + \overline{X}.$$

5. For a given set of data the following statistics were computed: $\overline{X} = 14.19$; $\overline{Y} = 21.65$; $s_x = 5.71$; $s_y = 6.73$; and $r_{xy} = .657$. Find the regression equation of the variable Y on the variable X.

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LESSON 21 - Objectives

1. The student should know that contingency data consists of two variables.

2. The student should be familiar with the format of the contingency table, including knowledge of how to find the number of cells it contains.

3. The student should be familiar with the formula for chi square.

4. The student should know the various properties of the chi square distribution.

5. The student should know how to use chi square formula.

LESSON 21 - Testing Hypotheses about Attributes

Chi square can be used to measure the <u>probability</u> of obtaining a discrepancy between an observed frequency of an event and the hypothetical frequency expected -- in other words, the discrepancy between the results we actually get and what we thought we might get.

For example, when 60% of the students in a school are girls, we would expect 60% of all "A" math grades to be given to girls (i.e., all variables being equal). If we found that only 10% of all "A" grades are being given to girls, we could use chi square to test the probability of such an event, and if the probability is low enough (or high enough depending on how we want to look at it), we could suspect that the boys are not the same as the girls with regard to those variables instrumental in learning math.

A possible use of chi square is in contingency data, which Tate defines as observations made on two qualitative variables or one qualitative and one quantitative variable. An example of such data might be the sex of all students in a grade school and their scores on a math test. When we have only

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the two variables, we can make a two dimensional picture of our information in the form of a table, such as the one below:

	91-100	81-90	71-80	61-70	Total
Boys	8	4	3	5	20
Girls	2	6	7	5	20
Total	10	10	10	10	

Table 21.1.

It should be noted that in such a table:

1. Only two attributes (variables) are involved, but each variable might have several divisions or classes;

2. In the previous example, there are 2 x 4 = 8 cells in which we can enter data;

3. In general, if one variable has n subdivisions and the second variable has k divisions, the total number of cells will be n x k;

4. Around the lower and right edge of the table, we can form marginal sums across each row and down each column;

5. If we add the marginal row totals and compare the grand sum to the grand sum of the marginal column totals, these two grand sums should be equal, e.g., in our previous example notice how the margin row and column totals respectively total 40;

6. The distribution (i.e., set of values) we use for chi square depends upon the number of categories being tested and not the total N nor the number of cases in each category;

7. Chi square tables consist of a set of chi square distributions, one for each N classes.

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Contingency Coefficient (Independence of Attributes)

The form for the contingency coefficient "C" is:

$$C = \sqrt{\frac{x^2}{N + x^2}}$$

This formula can be used to determine the relationship between two variables in a contingency table. Note that:

1. C will always be between 0 and 1;

2. The type of sign (+ or -) relation must be determined by inspection, since this formula always yields a positive value.

LESSON 21 - Quiz

1. The symbol x^2 represents the statistic known as _____.

2. In the formula for chi square, $x^2 = \frac{\sum(f_o - f_e)^2}{f_e}$, f_o represents the _____ frequency, while f_e represents the _____ frequency in any particular class.

3. Contingency data contains _____ attributes or variables.

4. Contingency data may be expressed more clearly (pictorally) in a _____ table.

5. The "C" coefficient may be used to measure the _____ between the two attributes in a contingency table.

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LESSON 22 - Objectives

The student should:

1. be familiar with the meaning of the null hypothesis.

2. be familiar with the general meaning of the alternative hypothesis.

The student should know that:

3. the null hypothesis is the simplest of hypotheses and very often used in science.

4. χ^2 is used in connection with the median test.

5. samples of subjectives can be divided into levels.

6. interaction (or effects) can take place at one level but not throughout the whole experiment.

LESSON 22 - Alternative Hypothesis, Median Test and Interpretation of
Interactions

The alternative hypothesis implies the question "Alternative to what?" The "what" here is the null hypothesis often symbolized as H_0. The null hypothesis is very simple and used frequently in the early stages of investigation. The null hypothesis is stated in a negative manner, e.g., if I am studying the effect of two reading methods on equivalent groups, I would hypothesize that there will be no difference in the effects of the two methods on the groups. If the evidence shows that I can accept the null hypothesis, then I may assume that the two methods are the same; but if I get results which allow me to reject the null hypothesis, then I may begin seeking alternative hypotheses.

Tate states that with every null hypothesis, there is implicitly suggested an alternative hypothesis. This is true; however, it should be

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noted that there may be numerous alternative (or positive) hypotheses to be considered. Also, it is important to realize that when we reject the null hypothesis, it is <u>not</u> good experimental procedure to assume or accept the truth of an alternative hypothesis on the basis of that same experiment. Ideally, we should form our alternative hypothesis and design a different experiment to test it.

Median Test and Interpretation of Interactions:

Just a few notes here would be relevant to this course. The median test is a type of statistical test which can be used in experimental investigations. Chi square is the statistic used in such a test.

Finally, when testing subjects, we do not <u>always</u> have to divide our S's into random groups. Instead, we might form subgroups with different levels. Example: In a test of an arithmetic procedure on boys and girls respectively, we could just have two groups, boys and girls. But we might want to be more detailed and divide the group of boys into three groups: (1) above average, (2) average, and (3) below average.

We can do the same with the girls. Then, when we test the effect of method on the sexes and their respective levels, certain statistical methods detect differences which exist at a certain level, but would not be evident in an overall effect. Example: The reading methods mentioned before might differentially effect only the above average groups. This difference in effect is called interaction (at one level but not another).

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LESSON 22 - Quiz

1. H_0 is the symbol representing the _____ hypothesis.

2. Once the null hypothesis is _____ then we should begin to test
   $\overline{\text{accepted, rejected}}$
   alternative hypotheses.

3. If we want to use the median test, we should use the statistic _____
   _____.

4. If we find that a method effects two groups at one level but not at the
   others, _____ is said to have taken place at that level.

NAME: _____

FORM A 1967   TEST OF MATHEMATICAL ESSENTIALS FOR
                                    STATISTICS

For each of the items of the test, choose the response you think is correct and PRINT A CAPITAL LETTER that corresponds to it in the space at the left.

Order of Arithmetic Operations

_____ 1. $(48 - 6 + 2) + (72 - 2 + 4) =$
          A. 50   B. 22   C. 46   D. 18

_____ 2. $1/8(32 + 16) + 1/7(28 + 14) =$
          A. 26   B. 38   C. 12   D. 24

_____ 3. $3 \left[\dfrac{8 + 3}{3} - 2(3 + 2) \right] =$
          A. 3   B. 5   C. -19   D. -21

_____ 4. $36 + 64 - (6 + 8) +$
          A. 16   B. 12   C. 0   D. -4

Operations with Fractions

_____ 5. $10(4/5) + 5(2/10) =$
          A. 9   B. 8 1/5   C. 1 4/5   D. 1

_____ 6. $1 + k/n =$
          A. $\dfrac{n + k}{n}$ B. $\dfrac{1 + n}{k}$ C. $\dfrac{1 + k}{n}$ D. None of these

_____ 7. Which of the following is not equivalent to $7 - 8/3 - 1/6$?
          A. $7 - \dfrac{8 + \frac{1}{2}}{3}$ B. $\dfrac{21 - 8}{3} - 1/6$ C. $\dfrac{42 - 1}{6} - 8/3$
          D. All are equivalent

Placing Decimal Points

_____ 8. $48 - .06 =$
          A. 800   B. 80   C. 8   D. 0.8

_____ 9. $(3.14)(.002) =$
          A. 6.28   B. 628   C. .00628   D. 0.628

_____ 10. Change 0.0017 to percent.
          A. 17%   B. 1.7%   C. 0.17%   C. 0.017%

_____ 11. $\dfrac{125.75}{7.5}$ =

    A. 16.77   B. 1.677   C. 167.7   D. 0.1677

_____ 12. $\dfrac{.023}{25}$ =

    A. .000092   B. .00092   C. .0092   D. .092

_____ 13. .0012 x 1,586,247.5 =

    A. 1903.497   B. 19034.97   C. 190.34970   D. 190349.7

_____ 14. $\dfrac{12,665.755}{5,275.25}$ =

    A. .24010   B. 2.4010   C. 24.010   D. 240.10

_____ 15. $\sqrt{1125}$ =

    A. .3354   B. 3.354   C. 33.54   D. 335.4

_____ 16. $\sqrt{112.5}$ =

    A. .01061   B. .1061   C. 1.061   D. 10.61

_____ 17. $\sqrt{55.40}$ =

    A. 7.4431   B. 74.41   C. .74431   D. .07431

_____ 18. $\sqrt{5.54}$ =

    A. .02354   B. .2354   C. 2.354   D. 23.54

Significant Digits

Round off the number 9.35476 to the indicated number of decimal places.

_____ 19. To four places   A. 9.3547   B. 9.3548

_____ 20. To three places A. 9.354   B. 9.355

_____ 21. To two places   A. 9.35   B. 9.36

_____ 22. To one place   A. 9.3   B. 9.4

_____ 23. To no places   A. 9   B. 10

Factoring and Expansion

_____ 24. $(x - y)^2$ =

    A. $x^2 - y^2$ B. $x^2 - 2xy - y^2$ C. $x^2 - 2xy + y^2$

    D. None of these

_____ 25. $(y - b)^2 =$
A. $y^2 - b^2$ B. $y^2 - 2yb - b^2$ C. $y^2 - 2yb + b^2$
D. None of these

_____ 26. $(n - 1)^2 =$
A. $n^2 - 1$ B. $n^2 - 2n + 1$ C. $n^2 + 2n - 1$
D. None of these

_____ 27. $(p + q)^3 =$
A. $p^3 + q^3$ B. $p^3 + 3(p^2q + pq^2) + q^3$
C. $(p + q)(p^2 + pq + q^2)$ D. None of these

_____ 28. $(x^2 + 2xy + y^2) =$
A. $(x - y)^2$ B. $(x + y)^2$ C. $(x + y)(x - Y)$
D. None of these

_____ 29. $xy - dx - cy + cd =$
A. $(x - c)(y - d)$ B. $(x + y)(c - d)$
C. $(x + y)^2$ D. None of these

Operations with Linear Equations

_____ 30. If $T = 50 + 10Z$ and $Z = -\frac{1}{2}$, then T is equal to
A. 30   B. 55   C. 45

If $Y = c + dx$, what is Y when

_____ 31. c is 20, d is $\frac{1}{2}$, X is 40?
A. 30   B. 40   C. 50   D. 60

_____ 32. c is 15, d is -1/5, X is 50?
A. 13   B. 5   C. 25   D. None of these

_____ 33. c is 10, d is -1/3, X is 60?
A. 30   B. -10   C. 10   D. None of these

If $K + L = U$,

_____ 34. What is U when K is 11, L is 9?
A. 19   B. 1   C. 20   D. 2

_____ 35. What is K when U is 16, L is 9?
A. 25   B. 7   C. 9   D. 8

_____ 36. What is L when K is 3, U is 3?
A. 6   B. 3   C. 1   D. 0

If $Z = \dfrac{10(X - M)}{S} + 50$, what is Z when

_____ 37. X is 24, M is 96, S is 18?

       A. 90   B. 10   C. -10   D. 0

_____ 38. X is 73, M is 49, S is 12?

       A. 70   B. 30   C. 0   D. None of these

FORM B 1968   TEST OF MATHEMATICAL ESSENTIALS FOR STATISTICS

NAME: _____

DATE: _____

DIRECTIONS: For the following items, choose the response you think is correct and PRINT THE LETTER that corresponds to it in the space at the left.

_____ 1. (3.14) x (.002) =
A. 6.28   B. 628   C. .00628   D. 0.628

_____ 2. Change 0.0017 to per cent
A. 17%   B. 1.7%   C. 0.17%   D. 0.017%

_____ 3. $\frac{125.75}{7.5}$ =
A. 16.77   B. 1.677   C. 167.7   D. 0.1677

_____ 4. $\frac{12,665.755}{5,275.25}$ =
A. .24010   B. 2.4010   C. 24.010   D. 240.10

_____ 5. $\sqrt{1125}$ =
A. .3354   B. 3.3354   C. 33.54   D. 335.4

_____ 6. $\sqrt{55.40}$ =
A. 7.443   B. 74.4431   C. .74431   D. .074431

_____ 7. What is 15% of 60?
A. 4   B. 9   C. 15   D. 20

_____ 8. 70 is 35% of what number?
A. 9.80   B. 2.00   C. 200   D. 20.00

DIRECTIONS: For the following items substitute the indicated values into the given equations. Show all your work in the space provided at the right. And put your answers in the indicated boxes. Label the problems on the work sheet.

9. Find the value of M:

$M = A + \left(\frac{fd^2}{N}\right) i$ where: A = 5
f = 3
d = 4
N = 12
i = 2

M = [   ]

WORK SHEET

10. Find the value of M:

$$M = L + \left(\frac{N/2 - F}{f} \right) i \quad \text{where:} \quad \begin{array}{l} L = 15 \\ N = 20 \\ F = 3 \\ f = 2 \\ i = 3 \end{array}$$

M =

WORK SHEET

11. Find the value of Y:

$$Y = \frac{ab + cd}{a + c} \quad \text{where} \quad \begin{array}{l} a = 4 \\ b = 10 \\ c = 3 \\ d = 5 \end{array}$$

Y =

12. Find the value of Z:

$$Z = \frac{X - M}{S} \quad \text{where} \quad \begin{array}{l} X = 6 \\ M = 18 \\ S = 4 \end{array}$$

Z =

13. Find the value of T:

$$T = 10z + 50 \quad \text{where} \quad z = -2.5$$

T =

14. Find the value of R:

$$R = (xy)^2 - x^2 y^2 \quad \text{where} \quad \begin{array}{l} x = -4 \\ y = \tfrac{1}{2} \end{array}$$

R =

15. Find the value of P:

$$P = \frac{100}{N} \left[F + \frac{(X - L)f}{i} \right]$$ where
N = 50
F = 3
X = 7
L = 2
f = 3
i = 5

P =

16. Find the value of Y:

Y = dx - c   where
d = 6
x = -1/3
c = -10

Y =

WORK SHEET

17. Plot the following sets of points.

X	Y
0	0
1	3
-2	4
1	-2
-3	-2

18. Graph the following equation:

$y = \frac{1}{2}x - 3$

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NAME: _____

DATE: _____

OPINIONNAIRE

PART I

DIRECTIONS: Please write your name in the upper right hand corner. Each of
               the statements on this opinionnaire expresses a feeling which a
particular person has toward mathematics. You are to express, on a five-point
scale, the extent of agreement between the feeling expressed in each statement
and your own personal feeling. The five points are: Strongly Disagree (SD),
Disagree (D), Undecided (U), Agree (A), Strongly Agree (SA). You are to
encircle the letter (s) which best indicates how closely you agree or disagree
with the feeling expressed in each statement AS IT CONCERNS YOU.

THE CHOICES YOU MAKE WILL IN NO WAY AFFECT THE GRADES YOU RECEIVE IN THIS

     COURSE.

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
1. I am always under a terrible strain in math class.	5-SD	4-D	3-U	2-A	1-SA
2. I do not like mathematics, and it scares me to have to take it.	5-SD	4-D	3-U	2-A	1-SA
3. Mathematics is very interesting to me, and I enjoy math courses.	1-SD	2-D	3-U	4-A	5-SA
4. Mathematics is fascinating and fun.	1-SD	2-D	3-U	4-A	5-SA
5. Mathematics makes me feel secure, and at the same time it is stimulating.	1-SD	2-D	3-U	4-A	5-SA
6. My mind goes blank, and I am unable to think clearly when working math.	5-SD	4-D	3-U	2-A	1-SA
7. I feel a sense of insecurity when attempting mathematics.	5-SD	4-D	3-U	2-A	1-SA
8. Mathematics makes me feel uncomfortable, restless, irritable, and impatient.	5-SD	4-D	3-U	2-A	1-SA
9. The feeling I have towards mathematics is a good feeling.	1-SD	2-D	3-U	4-A	5-SA
10. Mathematics makes me feel as though I'm lost in a jungle of numbers and can't find my way out.	5-SD	4-D	3-U	2-A	1-SA
11. Mathematics is something which I enjoy a great deal.	1-SD	2-D	3-U	4-A	5-SA
12. When I hear the work math, I have a feeling of dislike.	5-SD	4-D	3-U	2-A	1-SA
13. I approach math with a feeling of hesitation, resulting from a fear of not being able to do math.	5-SD	4-D	3-U	2-A	1-SA

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
14. I really like mathematics.	1-SD	2-D	3-U	4-A	5-SA
15. Mathematics is a course in school which I have always enjoyed studying.	1-SD	2-D	3-U	4-A	5-SA
16. It makes me nervous to even think about having to do a math problem.	5-SD	4-D	3-U	2-A	1-SA
17. I have never liked math, and it is my most dreaded subject.	5-SD	4-D	3-U	2-A	1-SA
18. I am happier in math class than in any other class.	1-SD	2-D	3-U	4-A	5-SA
19. I feel at ease in math class, and I like it very much.	1-SD	2-D	3-U	4-A	5-SA
20. I feel a definite positive reaction to mathematics; it's enjoyable.	1-SD	2-D	3-U	4-A	5-SA

Date _____   Name _____

Instructor _____   Course _____

STATISTICS OPINIONNAIRE

INSTRUCTIONS: Below is a list of statements which will enable you to evaluate the course. If you agree with a statement (feel that it is a TRUE statement) mark in the "agree" column. If you disagree, mark in the other column provided.

THIS IS NOT AN INTELLIGENCE TEST. THE CHOICES YOU MAKE WILL IN NO WAY AFFECT YOUR GRADE.

	AGREE	DISAGREE
1. This course should be considered one of the most valuable courses offered here.	____	____
2. This course encourages the development of ideals.	____	____
3. My likes for this course outweigh my dislikes.	____	____
4. The material covered in this course is uninteresting.	____	____
5. The time I spend studying for this course is completely wasted.	____	____
6. Only about 10% of the students enjoy this course.	____	____
7. This course increases my qualifications to associate with educated people.	____	____
8. This course helps the student to feel that he belongs in college.	____	____
9. This course is of some value in promoting university life.	____	____
10. The value of this course is overestimated by most people.	____	____
11. This course is an important part of the educational system at this university.	____	____
12. No university should offer a course of this type.	____	____
13. A passing grade on the final examination should be the only requirement for this course.	____	____

		AGREE	DISAGREE
14.	Usually I enjoy studying the lesson assignments for this course.	_____	_____
15.	There is a definite need for this course on this campus.	_____	_____
16.	This course limits individualistic thinking to an unwholesome degree.	_____	_____
17.	This course has its defects but is still worthwhile.	_____	_____
18.	The students do not remember the information they obtain from this course.	_____	_____
19.	I estimate that 90% of the students enjoy this course.	_____	_____
20.	This course helps prepare the students to face the problems of everyday life.	_____	_____
21.	I shall be able to use the information obtained from this course at various times during my college career.	_____	_____
22.	This course is based upon sound educational principles.	_____	_____
23.	The number of unexcused absences should be increased in this course.	_____	_____
24.	Sometimes this course makes me doubt the value of a college education.	_____	_____
25.	This course is not worth the time and effort it requires.	_____	_____
26.	This course is essential to adequate cultural development.	_____	_____
27.	Through this course I am better acquainted with the problems of acquiring an education.	_____	_____
28.	The students who do not enjoy this course slightly outnumber the ones who do enjoy it.	_____	_____
29.	I believe that a course of this type is needed by all college students.	_____	_____
30.	Sometimes the class is interesting but more often it is uninteresting.	_____	_____
31.	This course helps in promoting proper conduct among college students.	_____	_____

		AGREE	DISAGREE
32.	I feel that all new students should be required to take this course.		
33.	A person who teaches this course should feel that he is performing a valuable service.		
34.	Even though I fail to appreciate it, this course may be an important part of my education.		
35.	This course has no intergrating influence upon the values and ideals of the students.		
36.	After graduation from college, the information obtained from this course will be valuable.		
37.	After studying this course, I shall be able to enjoy life more fully.		
38.	This course gives ample opportunity for self-expression.		
39.	I have no antagonistic feeling toward this course.		
40.	The basic principles of this course are outmoded.		
41.	The amount of valuable information derived from this course is very large.		
42.	No time should be devoted to this subject outside class.		
43.	This course requires time which I could use more beneficially.		
44.	The material covered by this course makes full use of my capabilities.		
45.	I am inspired by this course to make full use of my capabilities.		

OBJECTIVES FOR MIDTERM EXAMINATION

1.11   Predictor variable
        Independent variable
        Dependent variable
        Criterion variable
        Continuous variable
        Nominative scale
        Ordinal scale
        Interval scale
        Ratio scale

1.11   Semi-interquartile range

1.24   Variability

2.10   Raw score
        Sum of squares
        Standard deviation
        Total number of scores
        Population standard deviation
        Variance
        Mean
        Median

2.20   Inferential statistics

2.30   Central tendency

3.00   Range
        Size of interval
        Mode
        Median
        Mean
        Quartile deviation
        Standard deviation

4.20   Quartiles and percentiles

4.20   Mean
        Median
        Mode

6.20   Characteristics of distributions
            Skewed to right (positive)
            Skewed to left (negative)
            Leptokurtic (peaked)
            Mesokurtic (normal)
            Platykurtic (flat)

Characteristics of central tendency
    Mode
    Median
    Mean

Educ. 380
1st SS '69
Dr. Mayo

MIDTERM
EXAMINATION

NAME _____

Score Distribution

Class Interval	f	d	fd	fd^2	cf
33-35	1	5	5	25	80
30-32	4	4	16	64	79
27-29	6	3	18	54	75
24-26	8	2	12	32	69
21-23	12	1	12	12	61
18-20	15	0	0	0	49
15-17	13	-1	-13	13	34
12-14	8	-2	-16	32	21
9-11	7	-3	-21	63	13
6-8	4	-4	-16	64	6
3-5	2	-5	-10	50	2
	80		-9	409	

1. Use the score distribution above and find the following:

    a. range _____ (1 pt.)

    b. size of interval _____ (1 pt.)

    c. mode _____ (1 pt.)

    d. mdn _____ (6 pts.)

    e. mean _____ (4 pts.)

    f. Quartile deviation _____ (11 pts.)

    g. Standard deviation _____ (4 pts.)

    USE THE PROVIDED WORKSHEET FOR YOUR CALCULATIONS.
    LABEL YOUR PROBLEMS.
    PUT YOUR FINAL ANSWERS IN THE BLANKS ABOVE.

MIDTERM EXAMINATION

Part II

Educ. 380
1st SS '69
Dr. Mayo

NAME _____

1. The primary purpose of inferential statistics is to permit the user to

    a. enlarge upon the picture which descriptive statistics provides.
    b. draw conclusions about a population from somewhat incomplete evidence.
    c. compare the performance of two different groups.
    d. guarantee probable certainty.

In the blank before each of the numbered items, write the letter which refers to the appropriate variable for the case in point.

      A. Predictor variable
      B. Independent variable
      C. Dependent variable
      D. Criterion variable
      E. Continuous variable

_____ 2. The variable which an experimenter manipulates

_____ 3. A set of scores used as a standard

_____ 4. A variable used to foretell a possible outcome

_____ 5. Data that result from an experiment

_____ 6. A variable that can assume any one of an infinite number of fractional or whole number values along a given scale

In the blank before each of the numbered items, write the letter which refers to the simplest appropriate scale for the case in point.

      A. Nominative
      B. Ordinal
      C. Interval
      D. Ratio

_____ 7. A scale used for ranking

_____ 8. A scale used to determine that X has twice the value of Y

_____ 9. A scale used to show that A is given number of points above B in achievement

_____ 10. A scale used to name objects

11. Which of the following best describes a characteristic of any measure of central tendency?

   a. range
   b. interval
   c. point
   d. distance

In the blank before each of the numbered items, write the letter which refers primarily to the appropriate group designation.

          A. Heterogeneous group
          B. Homogeneous group
          C. Neither a heterogeneous nor a homogeneous group
          D. Both a heterogeneous and a homogeneous group

_____ 12. Large semi-interquartile range

_____ 13. Small standard deviation

_____ 14. Distribution markedly skewed to the left

_____ 15. Distribution markedly skewed to the right

_____ 16. Distribution that is normal

_____ 17. Distribution that is leptokurtic

In the blank before each of the numbered items, write the letter which refers to the measure of central tendency described.

          A. Mode
          B. Median
          C. Mean

_____ 18. Determined by the number of cases in an interval

_____ 19. Point below which 50% of the cases fall

_____ 20. "Average" least affected by extreme scores

_____ 21. "Average" most affected by a few extreme scores

_____ 22. "Average" defined as $\frac{\sum X}{N}$

_____ 23. "Average" used in most cases

24. Which of the following equalities is true?

a. $Q - Q_1 = P_{75} - P_{25}$

b. $Q_2 - Q_1 = P_{75} - P_{25}$

c. $Q_3 - Q_2 = P_{75} - P_{25}$

d. $Q_3 - Q_1 = P_{75} - P_{25}$

25. The semi-interquartile range is expressed by

a. $\frac{Q_3 - Q_1}{2}$

b. $\frac{Q_2 - Q_1}{2}$

c. $\frac{Q_3 + Q_1}{2}$

d. $\frac{Q_2 + Q_1}{2}$

In the blank before each of the numbered items, write the letter that refers to the symbol which represents that item.

_____ 26. Raw score

_____ 27. Sum of squares

_____ 28. Standard deviation

_____ 29. Total number of scores

_____ 30. Population standard deviation

_____ 31. Variance

A. $\sqrt{\frac{\sum x^2}{N}}$

B. n

C. N

D. X

E. x

_____ 32. Mean

_____ 33. Median

F. $\sum x^2$

G. 50% ile

H. σ

I. M

J. s^2

34. The <u>simplest</u> way of describing the variability of values in a series is to state the

a. standard deviation
b. range
c. quartile deviation
d. percentile rank

35. The <u>least</u> descriptive measure of variability is

a. quartile deviation
b. percentile rank
c. range
d. standard deviation

In the blank before each numbered item, write the letter that refers to the situation that would exist for each case in point.

A. Mean is equal to the median
B. Mean is greater than the median
C. Mean is less than the median

_____ 36. Normal distribution

_____ 37. Distribution skewed to the left

_____ 38. Mesokurtic distribution

_____ 39. Distribution skewed to the right

_____ 40. Symmetrical distribution

In the blank before each numbered item, write the letter of the item that does not belong in the group it has been associated with.

_____ 41. a. mean   b. standard deviation   c. mode   d. median

_____ 42. a. range   b. mean   c. standard deviation
          d. semi-interquartile range

_____ 43. a. sum of squares   b. standard deviation   c. range
          d. d. variance

_____ 44. a. leptokurtosis   b. normality   c. mesokurtosis
          d. skewness

_____ 45. a. σ b. s   c. s^2 d. $\sqrt{\dfrac{\sum x^2}{N}}$

MIDTERM
EXAMINATION II

Educ. 380
1st SS '69
Dr. Mayo

NAME _____

Score Distribution

Class Interval	f	d	fd	fd^2	cf
69-71	3	4	12	48	60
66-68	8	3	24	72	57
63-65	10	2	20	40	49
60-62	12	1	12	12	39
57-59	9	0	0	0	27
54-56	7	-1	-7	7	18
51-53	6	-2	-12	24	11
48-50	4	-3	-12	36	5
45-47	1	-4	-4	16	1
	60		33	265	

1. Use the score distribution above and find the following:

   a. range _____ (1 pt.)   e. mean _____ (4 pts.)

   b. size of
      interval _____ (1 pt.)   f. Quartile deviation _____
                                           (11 pts.)

   c. mode _____ (1 pt.)   g. Standard deviation _____
                                           (4 pts.)
   d. mdn _____ (6 pts.)

   USE THE PROVIDED WORKSHEET FOR YOUR CALCULATIONS.
   LABEL YOUR PROBLEMS.
   PUT YOUR FINAL ANSWERS IN THE BLANKS ABOVE.

MIDTERM EXAMINATION

Second Version

Part II

Educ. 380
1st SS '69
Dr. Mayo

NAME _____

1. Among the uses for statistics is/are the ability to

   a. reduce data to shorter form.
   b. enable one to draw conclusions from less than complete evidence.
   c. Neither a nor b
   d. Both a and b

In the blank before each of the numbered items, write the letter that designates the **simplest** scale appropriate for the variable stated.

A. Nominative scale
B. Ordinal scale
C. Interval scale
D. Ratio scale

_____ 2. I.Q.

_____ 3. Achievement tests

_____ 4. Rank order for scores on a test

_____ 5. Social Security numbers

_____ 6. Inches

In the blank before each of the numbered items, write the letter that necessarily designates the most descriptive variable in the case in point.

A. Continuous variable
B. Discrete variable
C. Dependent variable
D. Independent variable
E. Criterion variable

_____ 7. The number of children in a family

_____ 8. Any norm group

_____ 9. I.Q. scores

_____ 10. Two teaching methods in an experiment on effectiveness of teaching methods

_____ 11. Children's attitudes toward an experimental textbook
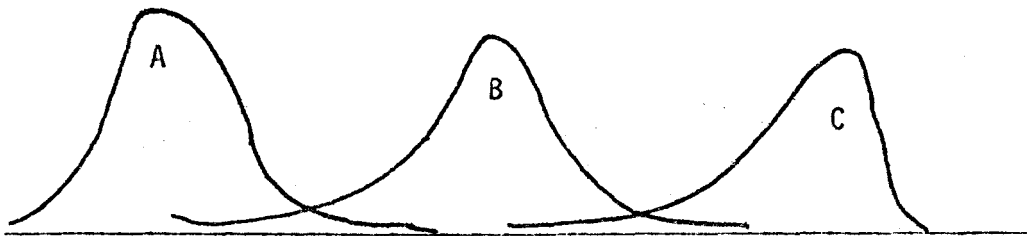
In the blank before each numbered item write the letter designating the curve to which the statement applies. Use the three curves above to answer items 12 through 20.

_____ 12. Has mean greater than its median

_____ 13. Has mean equal to its median

_____ 14. Is negatively skewed

_____ 15. Has the least number of cases in its mode

_____ 16. Has the largest mode

_____ 17. Is most nearly normal

_____ 18. Is not skewed

_____ 19. Has a mode greater than its mean

_____ 20. Has a median greater than its mean

In the blank before eacn numbered item, write the letter tnat designates the element that does not belong with the group it has been associated with.

_____ 21. a. platykurtic   b. leptokurtic   c. mesokurtic   d. normal

_____ 22. a. median   b. variance   c. mode   d. mean

_____ 23. a. $\sqrt{\dfrac{\sum(X-M)^2}{N}}$ b. s   c. $\sqrt{\dfrac{\sum x^2}{N}}$ d. s^2

_____ 24. a. median   b. $\dfrac{\sum X}{N}$ c. P_{50} d. 50% ile

_____ 25. a. $Q_3 - Q_1$ b. i   c. s^2 d. $\sqrt{\dfrac{\sum x^2}{N}}$

26. A teacher constructed and gave an examination in arithmetic to her fourth-grade class and discovered that tne distribution of scores formed a positively skewed curve. She correctly concluded that the test was

a. Too easy for the class
b. Too hard for tne class
c. Neither too easy nor too hard for the class
d. Very discriminating

In the blank before each of tne numbered items, write the letter that refers to the measure of variability most appropriate to the case in point.

    A. Range
    B. Quartile deviation
    C. Standard deviation
    D. Variance

_____ 27. The measure of variability least affected by extreme scores

_____ 28. The measure of variability easiest to compute

_____ 29. $\dfrac{\sum x^2}{N}$

_____ 30. The measure of variability usually used when the mean is the appropriate measure of central tendency

_____ 31. Measure of variability most affected by extreme scores

32. Which of the following equalities is true?

    a. $Q = .675\sigma$
    b. $Q = .845\sigma$
    c. $Q = 1.253\sigma$
    d. $Q = 1.183\sigma$

In the blank before each of the numbered items write the letter that refers to the symbol which represents that item.

_____ 33. Standard deviation   A. Q

_____ 34. Total number of scores   B. X

_____ 35. Raw score   C. x

_____ 36. Semi-interquartile range   D. σ

_____ 37. Interval   E. N

_____ 38. Population standard deviation   F. n

_____ 39. Deviation score   G. S

_____ 40. Median   H. i

_____ 41. First quartile   I. $\sqrt{\dfrac{\sum x^2}{N}}$

     J. M

     K. 50% ile

     L. 25% ile

In the blank before each of the numbered items write the letter that designates the graph appropriate to the characteristic or case in point.

     A. Histogram
     B. Frequency polygon
     C. Neither a histogram nor a frequency polygon
     D. Both a histogram and a frequency polygon

_____ 42. Depicts the frequencies as well as the scores

_____ 43. Uses midpoints of class intervals for graphing

_____ 44. Shows skewness

_____ 45. Shows smoothed distribution

_____ 46. Shows cumulative frequency

_____ 47. Shows kurtosis

Education/Psychology 380
First Summer Session   Quiz #1
                              OBJECTIVES

1. The student should be able to comprehend the concept of variable, taking
   into consideration both dependent and independent variables.

2. The student should be able to comprehend the concept of statistical
   attribute.

3. The students should have a knowledge of the concept of property.

4. The students should have an understanding of the concept of randomization.

5. The student should be able to understand the difference between descriptive
   and inferential statistics.

6. The students should understand the meanings of the term "statistics".

7. The student should have a knowledge of the concept of frequency.

8. The student should have a concept of scales in statistics.

9. The student should comprehend the differences between the various types of
   scales (i.e., Nominative, Ordinal, Internal, and Ratio).

                              Quiz #1

1. Unlike the concept of attribute or property, the concept of variable
   implies

   a. order
   b. a zero point
   c. number
   d. range

2. A researcher wanted to know whether white rats gained more weight when fed
   Diet X than when fed Diet Y. In this experiment, the dependent variable
   was

   a. Diet X
   b. Diet Y
   c. Both Diet X and Diet Y
   d. Neither Diet X nor Diet Y

3. Which of the following is a random sample of adults in a given community?

   a. A population determined by choosing every fifth person listed in that community's telephone book.
   b. A population determined by selecting all the adults listed in a randomly-selected, local church directory.
   c. A population determined by selecting every third adult passing a randomly-selected intersection on a randomly-selected day between noon and 5:00 P.M.
   d. None of these

4. Inferential statistics finds its best use in the case where the researcher wants to

   a. describe his data.
   b. categorize his data.
   c. predict future occurrences.
   d. determine the significance of some result.

5. In the statement "... you compute statistics from statistics by statistics", the second word "statistics" means

   a. A discipline
   b. A method
   c. A field
   d. None of these

6. When used as a term in statistics, the work "frequency" is associated with

   a. Type of scale
   b. Number of events
   c. Kind of variable
   d. Specific statistic

7. A teacher wanted to compare the arithmetic achievement of her fourth-grade class to the arithmetic achievement of another fourth-grade class. Therefore, she needed as a standard which of the following types of scales?

   a. Nominative
   b. Ordinal
   c. Interval
   d. Ratio

In the blank, beside each item, print the letter to indicate what the item correctly refers to:

        A.   Nominative Scale
        B.   Ordinal Scale
        C.   Interval Scale
        D.   Ratio Scale

_____ 8. Numbering of football players

_____ 9. Use of arithmetical operations of addition, subtraction, multiplication, and division

_____ 10. Temperature scales

_____ 11. To determine dispersion, or spread of scores

_____ 12. Building B has twice as many rooms as Building C

_____ 13. Leather X wears better than Leather Y

Education/Psychology 380
First Summer Session   Quiz #2

                              OBJECTIVES

1.10   Skewness and Kurtosis

2.20   Skewness and Kurtosis

3.00   Histogram and Frequency Polygon

6.20   Range, Real and Indicated Limits, Midpoint

                              Quiz #2

1. Identify the names of the distributions shown in the figures.

    A. _____

    B. _____

    C. _____

    D. _____
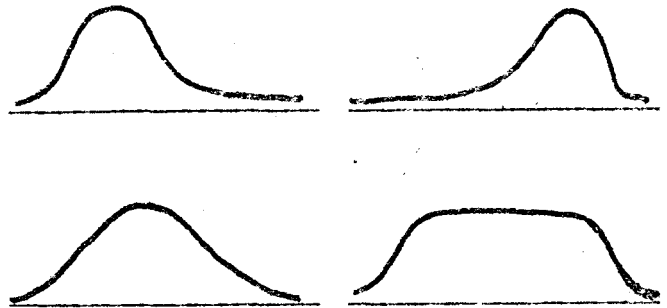
2. Use the four figures above and write their capital letter next to the
    following statements which are true with respect to that figure.

    a. mean is greater than the median: _____
    b. mean is smaller than the median: _____
    c. mean is equal to the median: _____

THE REST OF THE PROBLEMS REFER TO THE DISTRIBUTION GIVEN BELOW:

Class Interval	f	cf
90-99	2	26
80-89	3	24
→ 70-79	5	21
60-69	8	16
50-59	4	8
40-49	3	4
30-39	1	1

3. What is the RANGE of the distribution? _____

QUESTIONS 4, 5, and 6 REFER TO THE CLASS INTERVAL MARKED BY AN ARROW (⟶).

4. Name the indicated (or expressed) class limits of that interval: _____

5. Name t's MIDPOINT of that interval: _____

6. Name the REAL CLASS LIMITS of that interval: _____

7. Draw a HISTOGRAM and superimpose the FREQUENCY POLYGON for the distribution given on the first page. BE SURE YOU WRITE IN THE SCALING UNITS.

Education/Psychology 380
First Summer Session

Quiz #3

OBJECTIVES

2.20   Characteristics of the mean, mode and median in frequency polygons

3.00   Application of the measures of central tendency

1.11   Measures of central tendency, measures of variability, frequency and
        skewness

Quiz #3

1. Which of the following is <u>not</u> true concerning the three smoothed frequency
    polygons sketched below?
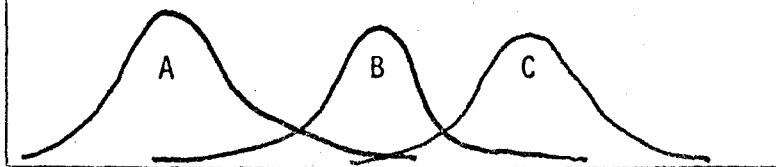
    a. The mean of curve B is smaller than the mode of curve C.
    b. The median of curve C is larger than the mean of curve A.
    c. The mode of curve B is larger than the mean of curve C.
    d. Not enough information is given to compare the three curves.

2. Which of the following is true concerning the three smoothed polygons
    sketched below?
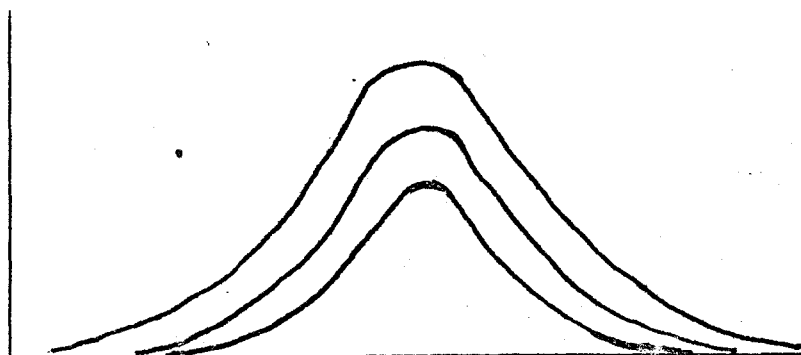
    a. The modes of all three curves are equal.
    b. The means of all three curves are equal.
    c. The medians of all three curves are equal.
    d. All the above are true.

USE THE TABLE GIVEN BELOW FOR PROBLEMS 3, 4, 5, and 6.

Class Interval	f	d	fd	cf
90-99	2			
80-89	3			
70-79	5			
60-69	8			
50-59	4			
40-49	3			
30-39	1			

3. What is the MODE of this score distribution? _____

4. Find the MEDIAN of this score distribution. Use the space provided below. BOX YOUR ANSWER.

5. Find the MEAN of this score distribution. Use the space provided below. BOX YOUR ANSWER.

6. Is the score distribution positively or negatively skewed? _____

In the blank before each numbered item, write the letter which corresponds to the best measure of central tendency to use for the purpose specified or to the fact that no measure of central tendency is applicable.

      A. Mode
      B. Median
      C. Arithmetic mean
      D. None of these

_____ 7. To determine the dress size that should be most in demand for a new style

_____ 8. To determine the 25th percentile on a standardized test.

_____ 9. To determine the "average" annual income in a community of 20,000 whose population, except for 3 millionaires, have annual incomes that range from $40,000 to $55,000.

_____ 10. To determine the annual per capita expenditure on dental care in Canada.

_____ 11. To determine the "average" score made by a figure skater whose performance is judged by three different experts.

In the blank before each numbered item, write the letter of the item that does **not** belong in the group it has been associated with.

_____ 12. a. mode   b. frequency   c. median
          d. mean

_____ 13. a. 50th percentile   b. central tendency   c. mode
          d. variability

_____ 14. a. positive skewness   b. negative skewness   c. normality
          d. asymmetry

_____ 15. a. real limits   b. frequency   c. midpoint
          d. interval

In the blank before each numbered item write the letter which designates the symbol that represents that item.

_____ 16. frequency   A. X̄

_____ 17. sum of   B. x

_____ 18. mean   C. n

_____ 19. total scores   D. N

_____ 20. raw score   E. M

_____ 21. interval   F. z

                                        G. i

                                        H. f

Education/Psychology 380
First Summer Session

OBJECTIVES

Quiz #4

1.20   Measures of Central Tendency;   Measures of Variability

1.25   Measures of Variability

2.20   Distribution of a set of data

3.00   Percentile Rank and Percentage

6.20   Percentile Rank and z scores

Quiz #4

Class Interval	f	cf
115-119	5	200
110-114	14	195
105-109	18	181
100-104	21	163
95-99	26	142
90-94	46	116
85-89	34	70
80-84	14	36
75-79	16	22
70-74	6	6

1. Using the score distribution listed above find the PERCENTILE RANK of 100.

$$PR(X) = \frac{100}{N} \left[F + \frac{(X - L)\ f}{i} \right]$$

SMOOTHED

CUMULATIVE

PERCENTAGE

CURVE
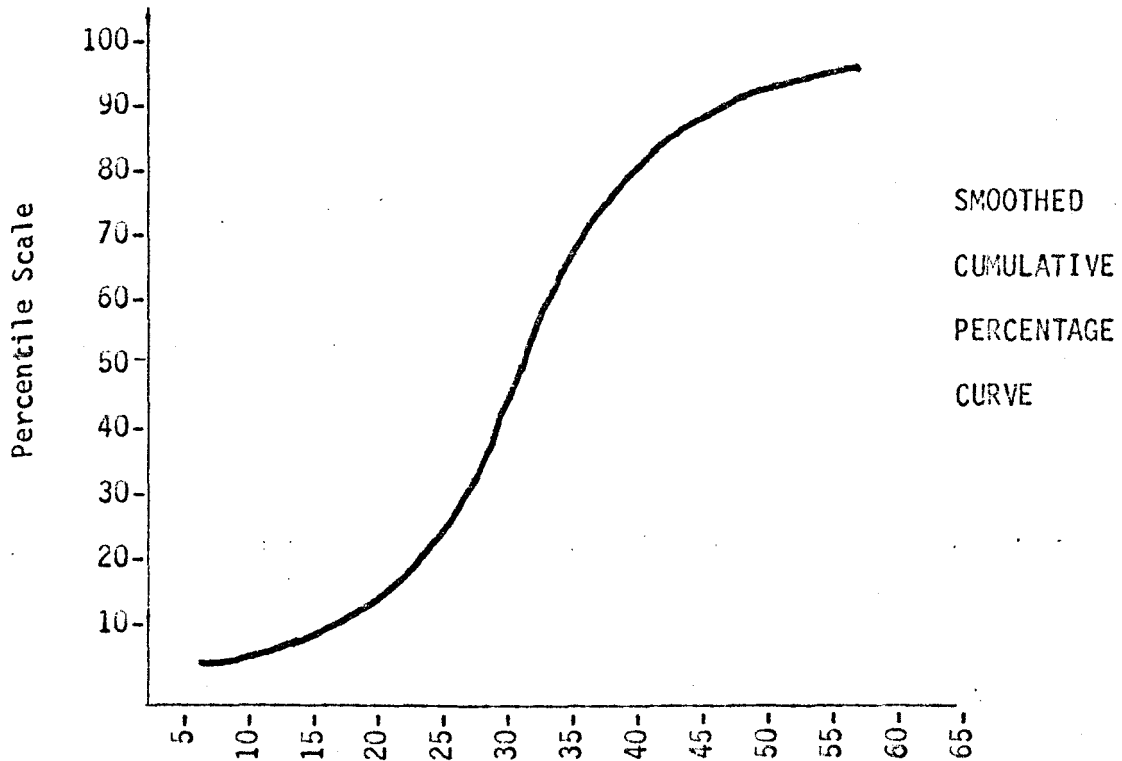
2. Estimate the PERCENTILE RANK of the score 30. _____

3. Estimate the score which has a percentile rank of 70. _____

4. Estimate the percentage of cases between the scores fifteen (15) and forty (40). _____

5. A set of raw scores had a mean of 64, a median of 53, and a mode of 50. On the basis of this information, one could conclude that

   a. Fifty percent of the students made scores above 64.
   b. The distribution of scores was normal.
   c. Both A and B are true.
   d. Neither A nor B is true.

DISTRIBUTION OF SCORES ON A 50-ITEM VOCABULARY

TEST FOR 150 GRADUATE STUDENTS

Class Interval	f	$\sum f(x')^2$	Cumulative Frequency
48-50	44	1584	150
45-47	26	650	106
42-44	18	288	80
39-41	12	108	62
36-38	9	36	50
33-35	9	9	41
30-32	7	0	32
27-29	6	6	25
24-26	3	12	19
21-23	2	18	16
18-20	2	32	14
15-17	2	50	12
12-14	3	108	10
9-11	4	196	7
6-8	3	192	3
Sum:	150	3289	

USE THE ABOVE TABLE TO ANSWER QUESTIONS 6 - 11.

6. The most appropriate average to report for the given distribution would be the

   a. Mode
   b. Mean
   c. Median

7. The most appropriate measurement of variability to report for a distribution like this would be the

   a. Range
   b. Standard deviation
   c. Semi-interquartile range
   d. Mode minus the median

8. In the given distribution what percentage of the students would have scores between Q_1 and Q_3?

   a. 25%
   b. 50%
   c. 68%
   d. It is impossible to determine this without additional information.

9. From the given distribution what can you say about the appropriateness of this test for this group?

   a. The test is too difficult for the group.
   b. The test is too easy for this group.
   c. The test is just about at the right level of difficulty for the group.
   d. It is impossible to determine this without additional information.

10. The column headed $\sum f(x')^2$ would be used in computing the

   a. Semi-interquartile range.
   b. Mean.
   c. Median.
   d. Standard deviation.

11. What is the approximate percentile rank of a score of 30?

   a. 10
   b. 16
   c. 35
   d. 40

FOR QUESTIONS 12-14, ASSUME NORMAL DISTRIBUTION.

12. Given a mean of 10 and a standard deviation of 5, what is the z score for a raw score of 15?

   a. +1
   b. -1
   c. +2
   d. -2

13. An arithmetic test yielded a mean of 60 and a standard deviation of 10. What was the percentile rank of a person whose raw score was 50?

   a. 84
   b. 50
   c. 16
   d. 70

14. What was tne Z score of the raw score of 50 in the above question?

    a. 70
    b. 60
    c. 50
    d. 40

Education/Psychology 380
First Summer Session
Quiz #5

OBJECTIVES

2.10   Raw scores to z scores
        z scores to Z scores
        z scores to raw scores
        Raw scores to T scores

1.25   Proportion between two raw scores
        Proportion above a score

1.12   Median in a normal distribution

1.25   Percentile of a distribution

1.25   Percentile rank of a raw score

Quiz #5

Directions: Perform all your calculations on the provided worksheet.   Label
              all your problems.   Put only your final answers on this paper.

1.   A normal distribution of 300 scores has a mean of 24 and a standard
     deviation of 4.

     a. Find the z score of 14.   a. _____

     b. Find the Z score of 14.   b. _____

     c. Find the raw score which has a z score of 0.   c. _____

     d. How many scores lie between 20 and 30?   d. _____

     e. Find the median of this distribution.   e. _____

     f. Find the 75th percentile of this distribution.   f. _____

     g. How many scores lie above 32?   g. _____

     h. Find the percentile rank of 20.   h. _____

Raw score	f	cf	f to cumulative midpoint	cumulative proportion to midpoint	Value of z in normal curve corresponding to proportion
20	20	99	89	.8990	
19	18	79	70	.7071	
18	14	61	53	.5353	
17	14	47	40	.4040	
16	12	33	27	.2727	
15	10	21	16	.1616	
14	6	11	8	.0808	
13	4	5	3	.0303	
12	1	1	$\frac{1}{2}$	.0051	

2. Using the table listed above, find the T-score of

   a. 13   a. _____

   b. 19   b. _____

Education/Psychology 380
First Summer Session   Quiz #6

                              OBJECTIVES

3.00   Spearman rank order correlation

3.00   Point biserial coefficient correlation

                                Quiz #6

A test was administered to a group of ten students. Their order of finishing
this test, their sex (0 = male, 1 = female), and their test score are listed
in the table below.

Order of Finishing Sex   Test Score

        1   0   15
        2   1   11
        3   0   10
        4   1   18
        5   1   17
        6   0   12
        7   1   19
        8   0   13
        9   0   13
       10   1   16

a.   Find the correlation between the order of finishing and the test scores.

b.   Find the relationship between sex and test scores.

Review for Final Examination

1. Give several examples of the different types of scales; ratio, interval, nominative and ordinal.

2. Given the range of a set of scores, describe how to determine the size and number of intervals.

3. Describe, compare and contrast the following measures of central tendency: mean, median and mode.

4. Describe the steps involved in determining a mean from grouped data; also give reasons for each step.

5. What is always true about the sum of the deviation scores.

6. What effect does adding or subtracting a constant have on the mean and S.D.

7. What effect does multiplying or dividing have on the mean and S.D.

8. Explain how the normal curve can be used to assign grades.

9. What is the minimum number of factors required to reconstruct a normal distribution.

10. Describe, compare, and contrast the following measures of variability: semi-interquartile range, range, and standard deviation.

11. Compare and contrast indices of central tendency and variability.

12. Relate the percentage of scores falling below -3, -2, -1, 0, +1, +2, and +3 standard deviations.

13. Define percentile.

14. Draw a normal curve and divide the score scale in deciles. How does the decile interval on the score scale compare with the z score interval.

15. What does the sign of the standard deviation tell about the group from which the S.D. was computed.

16. Draw a normal curve and show relationship between Q, Q_1, Q_2, and Q_3; and the mean and standard deviation.

17. Determine what percentages of scores fall between various combinations of Q_1, Q_2, Q_3, and the mean (give the standard deviation).

18. Given Q_1, Q_2, Q_3, M and S.D., determine whether the curve has symmetry and/or kurtosis.

19. State the differences between T and Z.

20. Given M and s, transform a raw score to a T score.

21. Given M and s, convert a raw score to a z score.

22. What are some applications of standard scores.

23. What can be readily determined from the cumulative percentage curve.

24. Statistic used to determine the reliability of a test.

25. Analysis used for prediction.

26. What does high correlation between two tests indicate about the traits being measured.

27. What statistic can be applied to express the relationship between ranked data.

28. What is the effect of the size of the coefficient of correlation on regression equations used for prediction.

29. Given a set of X variables and the corresponding Y variables, approximate the coefficient of correlation.

30. Name all the variables used in regression analysis.

31. Construct a scattergram.

32. Give examples of the following: perfect positive correlation, positive correlation, zero correlation, negative correlation, and perfect negative correlation.

33. What is related to the following symbols: ρ, r, s, σ, $\sum x^2$, $\sum xy$, $\dfrac{\sum x^3}{N}$, $\dfrac{\sum x^4}{N}$, Q_1, Q, Q_3, Mdn, Mo, T and Z.

34. Define:

Mean	Skewness
Median	50th %ile
$Q_2 - Q_1$	Midscore

$Q_3 - Q_2$
Normal
Leptokurtic
Symmetrical
Bell-shaped
Variability
S.D.
Range

Frequency polygon
Central tendency
Frequency distribution
Histogram
Continuum
Discrete
Continuous

35. What is involved in a median test.

36. What statistic can be used to determine if two samples are drawn from the same population.

37. In statistics, to what is the theory of least squares related.

38. Be able to transform the following equation to raw score formula

$$S = \sqrt{\frac{\sum x^2}{N}} = \underline{\hspace{6cm}}.$$

39. Determine whether a coefficient of correlation of $r = .90$ can be compared to a coefficient of correlation of $r = .30$.

40. State the underlying assumptions one must make to use the coefficient of correlation.

41. For prediction, is the <u>sign</u> of r or its <u>magnitude</u> more important.

42. Be able to determine which of the following four coefficients of correlation applies to what type of variables (truly dichotomous, artificially dichotomous, etc.): $r_\emptyset$, r_{pb}, r_b, r_t.

43. How is the standard error of the estimate used in conjunction with the regression line.

REVIEW FOR FINAL EXAMINATION

Be Able To Apply And Know All The Variables Involved In The Following Formulae:

1. $M = AO + \left(\dfrac{\sum fd}{N}\right) i$

2. $M_{dn} = L + \left(\dfrac{\frac{N}{2} - F}{f}\right) i$

3. $s = i \sqrt{\dfrac{\sum fd^2}{N} - \left(\dfrac{\sum fd}{N}\right)^2}$

4. $P_p = L + \left(\dfrac{PN - F}{f}\right) i$

5. $PR(X) = \dfrac{100}{N} \left[\overline{F + \dfrac{(X - L)f}{6}}\right]$

6. $S_{y \cdot x} = S_y \sqrt{1 - (r_{xy})^2}$

7. $r_d = 1 - \dfrac{6 \sum D^2}{N(N^2 - 1)}$

8. $r_{pb} = \dfrac{(\overline{y}_1 - \overline{y}_0) \sqrt{pq}}{S_y}$

9. $\chi^2 = \sum \dfrac{(f_0 - f_e)^2}{f_e}$

10. $\chi^2 = \dfrac{N(ad - bc)^2}{(a + b)(c + d)(a + c)(b + d)}$

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FINAL EXAMINATION

NAME _____

Table A

Scores	f	d	fd	fd^2	cf
46-50	3	4	12	48	60
41-45	5	3	15	45	57
36-40	8	2	16	32	52
31-35	12	1	12	12	44
26-30	14	0	0	0	32
21-25	8	-1	-8	8	18
16-20	5	-2	-10	20	10
11-15	3	-3	-9	27	5
6-10	2	-4	-8	32	2
	60		20	224	

Table B

Percentage Scale

100-
90-
80-
70-
60-
50-
40-
30-
20-
10-

8 . 16   24   32   40   48   56   64

Scale of Scores
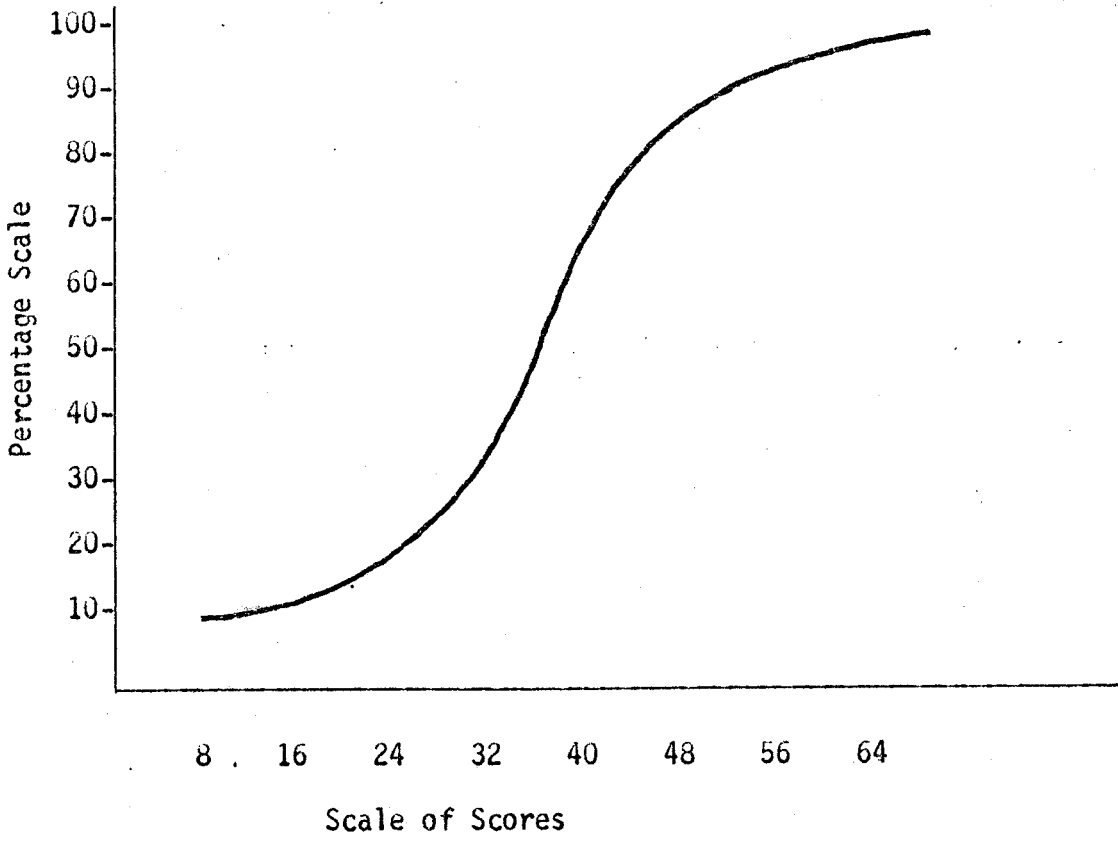
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FINAL EXAM

Part 1   NAME _____

Directions: Use the data listed in Table A for questions 1 - 6. Perform all
your calculations on the back pages of Part II of the exam. Write
your FINAL ANSWER into the blanks of this sheet.

1. Find the mean of this distribution.   1. _____

2. Find the median of this distribution.   2. _____

3. Find the mode of this distribution.   3. _____

4. Find the 75th Percentile.   4. _____

5. Find the standard deviation.   5. _____

6. Find the Percentile Rank of 29.   6. _____

FORMULAS FOR PART I

1. $M = AO + \left(\dfrac{\sum fd}{N}\right) i$

2. $Mdn = L + \left(\dfrac{\frac{N}{2} - F}{f}\right) i$

3. $S = i \sqrt{\dfrac{\sum fd^2}{N} - \left(\dfrac{\sum fd}{N}\right)^2}$

4. $P_p = L + \left(\dfrac{PN - F}{f}\right) i$

5. $PR(X) = \dfrac{100}{N} \left[F + \dfrac{(X - L)f}{i}\right]$

6. $S_{y \cdot x} = S_y \sqrt{1 - (r_{xy})^2}$

7. $r_d = 1 - \dfrac{6 \sum D^2}{N(N^2 - 1)}$

8. $r_{pb} = \dfrac{(\bar{y}_1 - \bar{y}_0) \sqrt{pq}}{S_y}$

9. $\chi^2 = \sum \dfrac{(f_0 - f_e)^2}{f_e}$

10. $\chi^2 = \dfrac{N(ad - bc)^2}{(a + b)(c + d)(a + c)(b + d)}$

Directions: Use Table B for questions 7 and 8.

7. Estimate the percentile rank of 16.   7. _____

8. Estimate the 80th percentile of this distribution. 8. _____

Directions: For questions 9 - 11 use the following information:

A certain score frequency distribution has a mean of 36 and a standard deviation of 6.

9. Find the z score of 26.   9. _____

10. Find the raw score which has a z score of -1.8.   10. _____

11. Find the Z score of 30.   11. _____

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FINAL EXAMINATION

NAME _____

Part II

1. When tabulating data in a frequency distribution, it is approved practice to group data in about

   a. 7 classes
   b. 10 classes
   c. 15 classes
   d. 25 classes

In the blank before the numbered item write the letter that designates the simplest scale appropriate to the case.

A. Nominative
B. Ordinal
C. Interval
D. Ratio

_____ 2. Grade on a spelling test

_____ 3. Telephone numbers

_____ 4. Weight of meat

_____ 5. A .300 batting average

_____ 6. Last place in race

7. What is the raw score of a person who is at the 16% ile of a normal distribution of scores, that has a mean of 30 and a standard deviation of 10?

   a. 40
   b. 20
   c. 10
   d. 0

In the blank before the numbered item, write the letter that designates the appropriate measure most closely related

A. Mode
B. Median
C. Mean
D. Range
E. Quartile deviation
F. Standard deviation
G. Inter-quartile range

_____ 8. Average affected most by extreme scores

_____ 9. Measure of variability least affected by extreme scores

_____ 10. Point on scale at which greatest number of cases are found

_____ 11. Interval in which middle 50% of the cases occur

_____ 12. Average least affected by extreme scores

_____ 13. Least informative measure of variability

_____ 14. Most appropriate measure of variability when the median is the most appropriate measure of central tendency

_____ 15. Point below which half the cases lie

_____ 16. Average which has the smallest value in a negatively skewed distribution

_____ 17. Average which is a function of all the raw scores

_____ 18. Average which is most appropriate to use when the standard deviation is the most appropriate measure of variability

_____ 19. Best measure of variability to use for a normal distribution

_____ 20. Measure of variability most affected by extreme scores

_____ 21. Point on a scale associated with Q_2

In the blank before each numbered item, write the letter which designates the term that completes the analogy.

_____ 22. Mean is to standard deviation as median is to
a. range   b. decile   c. quartile   d. variance

_____ 23. Sum of squares is to standard deviation as least squares is to
   a. correlation coefficient   b. deviation scores
   c. variance   d. regression coefficient

_____ 24. Experimental manipulation is to independent variable as experimental results are to
   a. criterion variable   b. dependent variable
   c. predictor variable   d. discrete variable

_____ 25. Ratio scale is to 3/4 as nominative scale is to
   a. $4/2 = 1.5$ b. $a + b = c$ c. 6   d. $2 = 4$

_____ 26. $\sqrt{\dfrac{\Sigma(X - \bar{X})^2}{N}}$ is to $\sqrt{\dfrac{\Sigma x^2}{N}}$ as $\dfrac{\Sigma xy}{N s_x s_y}$ is to

   a. $\dfrac{\Sigma xy}{\Sigma x^2} x$

   b. $r_{xy}\left(\dfrac{s_y}{s_x}\right)(X - \bar{X}) + \bar{Y}$

   c. $\dfrac{\Sigma xy}{\sqrt{(\Sigma x^2)(\Sigma y^2)}}$

   d. $\dfrac{\Sigma x^2}{N}$

_____ 27. P_{50} is to median as P_{25} is to
   a. mean   b. Q_1 c. mode   d. Q

_____ 28. $Q_3 - Q_1$ is to 50% as, for normal distributions, mean $+1$ is to
   a. 50%   b. 84%   c. 68%   d. 34%

_____ 29. Median is to point as standard deviation is to
   a. score   b. distance   c. area   d. square

_____ 30. Mean is to mode as standard deviation is to
   a. range   b. variance   c. quartile deviation   d. σ

_____ 31. Descriptive statistics is to summarization as inferential statistics is to
   a. conclusion   b. certainty   c. assumption   d. absoluteness

32. For one pair of variables a researcher obtained a correlation coefficient of $+.30$, and for a second pair of variables he obtained a correlation coefficient of $+.60$. He correctly concluded that the correlation coefficient of the first pair had

   a. one-half the relationship of the second pair
   b. one-fourth the relationship of the second pair
   c. the same degree of relationship as the second pair
   d. a degree of relationship which couldn't be compared to the second pair

33. A personality test with four different scales was correlated in a job situation with results as shown below. Which scale would be most accurate in predicting job success?

   a. Ascendancy $r = +.35$
   b. Introversion $r = -.20$
   c. Neurotic tendency $r = -.50$
   d. Self-sufficiency $r = +.40$

34. Before one can use correlation r as a fair measure of relationship between two variables, he must be able to assume

   a. Linearity
   b. Normality
   c. Both a and b
   d. Neither a nor b

In the blank before the numbered item, write the letter that refers to the symbol that designates the item

_____ 35. mean   A. r

_____ 36. variance   B. Mdn.

_____ 37. Pearson product-moment   C. $\overline{X}$

_____ 38. regression equation   D. S

_____ 39. Q_2 E. $\dfrac{\Sigma (X - M)^2}{N}$

_____ 40. deviation score

_____ 41. Y-intercept   F. $y = bx + a$

_____ 42. area transformation score   G. $\sqrt{\dfrac{\Sigma x^2}{N}}$

_____ 43. Chi square   H. x

_____ 44. Q_3 I. a

                                          J. $\Sigma \left[\dfrac{(f_o - f_e)^2}{N} \right]$

                                          K. T

                                          L. C   M. 75% ile

In the blank before the numbered item, write the letter that refers to the element that does <u>not</u> belong to the group with which it is associated.

_____ 45. a. x^2 b. s^2 c. Q d. s

_____ 46. a. mesokurtic   b. normal   c. platykurtic   d. leptokurtic

_____ 47. a. 50%   b. Q c. 68%   d. P_{25}

_____ 48. a. standard error of estimate   b. quartile deviation
             c. standard deviation of residuals   d. scatter

49. A researcher compared intelligence and reading achievement between two different groups of students. From his results he concluded that there was a difference in the "range of talent" between these groups and this meant that

     a. the two groups were comparable in terms of variability with respect to the variables measured.
     b. the two groups were not comparable in terms of variability with respect to the variables measured.
     c. one group was lacking in talented members.
     d. both groups were lacking in talented members.

50. A researcher wanted to determine if there was a relationship between sex and whether a person voted in the last election. He should have chosen which of the following correlation techniques to find the answer?

     a. Pearson product-moment
     b. four-fold correlation
     c. Spearman rank difference correlation
     d. point biserial correlation

51. Of all of the various correlation techniques available, which is the one used most often?

     a. Pearson product-moment
     b. four-fold correlation
     c. Spearman rank difference correlation
     d. point biserial correlation

52. Which of the following correlation techniques assumes that the dichotomous variable is normally distributed?

    a. multiple correlation
    b. biserial correlation
    c. point biserial correlation
    d. Spearman rank difference correlation

53. The standard error of estimate (standard error of Y independent of X) is the standard deviation of

    a. points
    b. scores
    c. residuals
    d. marks

54. A standard error of estimate is necessary because the regression line is merely a kind of

    a. standard deviation
    b. range
    c. mean
    d. mode

55. A test was given to a group of 100 students, half of which were coeds and the other half of which were males. To find the degree of association between test scores and "being coed", one would use

    a. point biserial correlation
    b. Pearson product-moment
    c. Spearman rank difference correlation
    d. four-fold correlation

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FINAL EXAMINATION

Matching Exercises

Directions: In the following items, choose the procedure (or step) at right
             which would yield the best answer to the problem at left. Then
mark the letter on the IBM answer sheet corresponding to your choice. Proce-
dures may be used more than once in different items, but only one procedure is
required for each item. (Items 1 - 9)

Kind of Problem	Procedure (or step)
1. Reliability of a test.	A. Cumulative percentage curve
2. To predict the academic average of a student tested before entering school	B. Pearson product-moment correlation
3. To determine if two tests are measuring the same ability	C. Regression analysis
	D. Spearman rank-differ-ence correlation
	E. Standard scores

---

4. To compute percentile ranks	A. Cumulative percentage curve
5. To study agreement between two "judges" who have arranged a set of candidates in order of their judged ability	B. Chi square
6. To carry out the median test	C. Pearson product-moment correlation
	D. Spearman rank-differ-ence correlation
	E. Semi-interquartile range

7. To test whether two skewed frequency distributions can be considered as samples from the same population.

8. To study pictorially the linearity of relationship between two variables

9. To make two variables expressed in raw-score form comparable as far as standing in the group

A. Chi square

B. Regression analysis

C. Standard error of estimate

D. Standard scores

E. Scatter diagram

Directions: Classify each of the dimensions in the left-hand column according to which scale type it represents and place the letter corresponding to the scale type on the IBM answer sheet.

Dimension Measured

Basic Type of Scale

10. Degree Fahrenheit

11. Inches

12. I.Q. Scores

13. Teacher-made test scores

14. Percentile ranks

15. Automobile license plate numbers

A. Ratio Scale

B. Interval Scale

C. Nominative Scale

D. Ordinal Scale

Directions: In each of the items below choose from the right hand column the letter corresponding to the term which best matches the item in the left hand column.

Situation

Measures of Central Tendency

16. When the most often recurring score is sought.

17. When there are extreme measures which would affect the average disproportionately.

18. When each score of measure should have equal weight in determining the measure of central tendency.

A. Arithmetic mean

B. Median

C. Mode

19. You desire the score which is most useful
    for a quick inspection of central tendency.

20. The least dependable and least useful
    measure of central tendency.

21. When you wish to convert raw scores to
    z scores.

Situation	Measures of Variability
22. When the degree of concentration around the median is sought.	A. Q
23. When it is desired to minimize the effect of extreme deviations.	B. Range
	C. Standard deviation
24. When it is desired that extreme deviations have a proportionately greater influence upon the measure of variability.	
25. When it is desired to compute z scores.	
26. When a quick, approximate measure of variability is needed.	

Matching Exercises

Directions: For each of the symbols at the left, choose the term at the right
             which corresponds most closely and mark your answer on the IBM
answer sheet. (Items 27 - 33)

Symbol	Term
27. p	A. assymmetry
28. r	
29. S	B. platykurtosis
30. Σx^2	
31. ΣXY	C. rank-difference correlation
32. $\Sigma x^3/N$	
33. $\Sigma x^4/N$	D. "sum of cross-products"
	E. "sum of squares"

Of the correlation coefficients given below and designated A through E, choose the one which is most appropriate for the given situation.

Correlation Coefficients

A. -1.00
B. + .05
C. + .50
D. +1.00
E. +2.00

34. Correlation of two perfectly correlated variables which vary inversely.

35. Correlation of height and weight.

36. Correlation of two perfectly correlated variables where there was an error in calculation of the coefficient.

Multiple Choice

Directions: Mark the letter corresponding to the best response on your IBM answer sheet.

37. You have scores on an achievement test of 30 children. The scores range from 45 to 88. You wish to make a frequency distribution, so that you can compute the median and various percentiles. The most satisfactory way to group the scores would be to begin with the lowest class interval as

a. 44-45
b. 45-47
c. 44-47
d. 40-49

38. Which of the following measures is most affected by extreme scores?

a. mean
b. median
c. quartile deviation
d. mode

39. The 40th percentile indicates what point in a distribution?

a. The point above which 40% of the cases lie.
b. The point below which 40% of the cases lie.
c. The point below which 60% of the cases lie.
d. The point above which 60% of the cases lie.
e. The point at which 40% of the cases lie.

40. The interpercentile distance measured in raw scores in a normal distribution is greatest at

   a. the right hand end
   b. the middle
   c. the left hand end
   d. both ends

41. Three consecutive steps in computing the mean are shown below. A major error has been introduced into which step?

   a. $\dfrac{-38-}{81-} = .47$
   b. $2(-.47) = -.94$
   c. $42.5 + .94 = 43.44$

42. The following scores were obtained by two 10th grade classes on the same history test:

Class	N	$\overline{X}$	S.D.
X	40	70	10
Y	50	65	25

   How should these results be interpreted?

   a. Class X is significantly better in history than Class Y.
   b. The student making the highest score on the test is in Class X.
   c. The teacher of Class X has done a better job of teaching history than the teacher of Class Y.
   d. Class X is more homogeneous than Class Y with respect to achievement in history.
   e. The distribution of scores on the history test is probably skewed in Class Y.

The following data were reported for a class which had taken a standardized reading test. (Items 43 - 45)

Mean	38.5	Q_3	42.1
Std. Dev.	5.3	Median	38.3
		Q_1	34.4

43. From the data on the preceding page, between what two score values will you expect the middle two thirds of the group to fall?

   a. Between 34.4 and 42.1
   b. Between 33.2 and 43.8
   c. Between 38.5 and 5.3
   d. Between 38.5 and 38.3

44. What interpretation can we give to an individual's score of 43 from the above data?

   a. It is a score surpassed by about 75% of the group.
   b. It falls near the upper quartile.
   c. It represents better achievement than could be expected for that individual.
   d. No interpretation is possible from the inofrmation given.

45. What statement can we make about the shape of the distribution of scores on this test?

   a. It appears to be approximately symmetrical.
   b. It appears to have marked positive skewness.
   c. It appears to have very little kurtosis.
   d. No statement is possible from the information given.

---

46. On a given test the M was 75 and the S.D. was 3. What T score would be assigned to a raw score of 75?

   a. 25
   b. 50
   c. 75
   d. 100

47. What z score would be assigned to a raw score of 81 on the test described above?

   a. -1
   b. -2
   c. +1
   d. +2

48. The mean age in months for two groups of nursery school children was reported as 25.5. The standard deviation for group 1 was 3.4 and for group 2, 4.9. From this we conclude that

a. group 1 is more variable than group 2.
b. the age range of group 2 is greater than the age range in group 1.
c. the median age for group 2 is higher than for group 1.
d. the measure of central tendency for group 2 is larger than for group 1.

49. Which of the values of correlation coefficients below would you expect to best describe the relationship between the two measures in the data shown at the right?

a. -1.00   X   2 3 4 5 6
b.   0.00
c. +0.50   _____
d. +1.00   Y   4 3 2 1 0

50. In a particular experiment the correlation of two samples of measurements on variables X and Y respectively was found to be .95. Which of the following statements makes the best interpretation of the obtained relationship?

a. It is certain that changes in both X and Y are related to a third variable.
b. A decrease in X causes a decrease in Y.
c. High scores on X are accompanied by high scores on Y.

51. Which of the following coefficients of correlation would give the poorest basis for prediction?

a. 1.00
b.   .00
c. -.50
d. -1.00

52. Which of the following techniques is not intended to assist us in making predictions?

a. Correlation
b. Regression
c. Standard error of estimate
d. Median
e. Chi square

53. A percentile score of 70 means that a person

a. is equalled or exceeded by 70% of the persons tested.
b. has an I.Q. equal to 70% of the persons tested.
c. answered 70% of the questions.

d. is equalled or exceeded by 30% of the examinees.

e. None of the above.

54. A normal distribution has a mean of -50 and a S.D. of 50. What percent of the examinees received negative (minus) scores?

a. 16
b. 25
c. 34
d. 68
e. 84

55. In general, a distribution can best be reconstructed by knowing

a. the mean and the range.
b. the median and the S.D.
c. the mode and Q.
d. the mean and the S.D.
e. the median and Q.

56. Which of the following third grade teachers had the smallest range of individual differences in I.Q.?

a. Miss Peterson; her class had a mean I.Q. of 106 and a S.D. of 11.
b. Mrs. Jones; her group had a range of I.Q.'s from 93 to 119.
c. Mr. Henderson; Mdn. I.Q. of 100 and interquartile range from 85 to 115
d. Mr. Bishop; mean I.Q. of 110 and S.D. of 15.

57. If the top interval of a set of class intervals has an indeterminate upper limit (e.g. "40 and above"), we could compute

a. the mean only
b. the median only
c. both mean and median
d. mean nor median

58. In the formula for calculating the mean from grouped data, one term involves multiplying by i (the width of a class interval). The reason for multiplication by i is to

a. correct for an error in calculation.
b. convert from raw scores back to coded scores.
c. convert from coded scores back to raw scores.

59. In comparing and contrasting the nature of indexes of central tendency and variability, one should understand that

 a. both can be interpreted as either points or distances.
 b. indexes of central tendency should be interpreted as distances, while indexes of variability should be interpreted as points.
 c. indexes of variability should be interpreted as distances, while indexes of central tendency should be interpreted as points.

60. The two types of standard scores designated Z and T scores may be compared or contrasted as follows:

 a. They are synonymous and therefore interchangeable.
 b. They have different means and standard deviations.
 c. Z scores come about through an area transformation, while T scores come about through a linear transformation.
 d. They bear a relationship other than any of the above.

61. When the normal curve is used as a basis for assigning letter grades to a set of scores and when normality is assumed, common practice recommends that the middle group (the C's) be

 a. in the range ±1 S.D. on either side of the mean and include 68% of the cases.
 b. in the range ±½ S.D. on either side of the mean and include 38% of the cases.
 c. defined as something other than A or B.

62. The numerical value of the sum of deviations of a set of raw scores from their mean is

 a. always equal to zero.
 b. a positive number.
 c. the basis for computing the average deviation.

63. If a constant numerical value is subtracted from each score in a group,

 a. the value of the mean is unaffected.
 b. the value of the standard deviation is unaffected.
 c. both mean and standard deviation are affected.
 d. we have more difficulty in calculations.

64. If a constant numerical value is multiplied by each score in a group,

 a. the values of both mean and standard deviation are affected.
 b. only the mean is affected.
 c. only the standard deviation is affected.

Conceptual Multiple-Choice: Pick the term which least belongs with the others in meaning.

65.   a.   continuum   b.   discrete   c.   time   d.   continuous

66.   a.   seconds   b.   I.Q.   c.   pounds   d.   inches

67.   a.   histogram   b.   frequency distribution   c.   central tendency
      d.   frequency polygon

68.   a.   mean   b.   50th %ile   c.   median   d.   midscore

69.   skewness   b.   range   c.   S.D.   d.   variability

70.   a.   normal   b.   symmetrical   c.   bell-shaped
      d.   Gaussian

71.   a. $M \neq Mdn$ b. $Q_2 - Q_1 = Q_3 - Q_2$ c.   normal
      d.   leptokurtic

1967
STUDY INVENTORY

Name _____ Teacher _____

Date _____ Course _____

1. For this course, how much time did you spend per week in out-of-class
   studying <u>after</u> the midterm?

   Less than
   3 hours   3-6 hours   6-12 hours

   12-18 hours   18-24 hours   More than 24 hours

2. Write the amount of time you spent studying

   a. By yourself   _____

   b. With classmates   _____

   c. With a tutor   _____

   d. Other: _____   _____

1968
STUDY INVENTORY

Name _____   Teacher _____

Date _____   Course Name _____

1. In this course, how much time have you spent in out-of-class studying during the last week? Circle the appropriate response below.

Less than
1 hour   1-2 hours   2-4 hours   6-8 hours   More than
                                                                   8 hours

2. Write the amount of time you spent studying

    a. By yourself   _____
    b. With classmates _____
    c. With an adult   _____
    d. Other: _____   _____

3. At the conclusion of the last chapter you studied, you took a formative evaluation test. Below are some statements about that test. Put a check beside those statements which indicate the value of the formative evaluation test for you.

    a. The test made me study to prepare for it.   _____
    b. The test showed me things I still had to learn.   _____
    c. The test reassured me of my learning progress.   _____
    d. The test helped me identify the important ideas to be
        learned in the chapter.   _____
    e. Other: _____   _____

4. The formative evaluation test you took at the end of the last chapter you studied suggested some ways you could learn those items you got wrong. Below is a list of these suggested alternative learning resources. Check those you used to correct your errors, and circle whether these were or were not helpful.

    a. Reread textbook   _____   Helpful   Not helpful
    b. Study other textbooks _____   Helpful   Not helpful
    c. Study with classmates _____   Helpful   Not helpful
    d. Use workbooks   _____   Helpful   Not helpful
    e. Tutor   _____   Helpful   Not helpful
    f. Other: _____   _____   Helpful   Not helpful

1969
STUDY INVENTORY

Name _____   Teacher _____

Date _____   Course _____

1. For this course, how much time did you spend per week in out-of-class studying before the first midterm?

   Less than 3 hours   3-6 hours   6-12 hours   12-18 hours

   18-24 hours   More than 24 hours

2. Write the amount of time you spent studying

   a. By yourself
   b. With a classmate(s)   _____
   c. With a tutor   _____
   d. Other: _____   _____
                                  _____

3. From time to time you have taken quizzes. Below are some statements about quizzes in general (all you have taken in this course). Put a check beside those statements which indicate the value of the quizzes for you.

   a. The quizzes made me study to prepare for them.
   b. The quizzes showed me things I still had to learn.
   c. The quizzes reassured me of my learning progress.
   d. The quizzes helped me identify the important ideas to be learned.
   e. Other: _____

4. Several alternative resources have been suggested to you to help you in this course. Below is a list of these suggested resources. Check those you used to correct your errors, and circle whether these were or were not helpful.

   a. Reread textbook   _____   Helpful   Not helpful
   b. Study other textbooks   _____   Helpful   Not helpful
   c. Study with classmates   _____   Helpful   Not helpful
   d. Use workbook   _____   Helpful   Not helpful
   e. Tutor   _____   Helpful   Not helpful
   f. Other: _____   _____   Helpful   Not helpful

Quiz #1   SS '67
                                           Educ. 380
                                           Dr. Mayo

I. Multiple Choice: Print the capital letter of the best answer in the blank
                      in front of the number.

_____ 1. The simplest way to organize test scores statistically is to arrange
             the scores

             a. in alphabetical order.
             b. in a frequency distribution.
             c. in numerical order.
             d. in order of age of student.

_____ 2. In grouping, we divide the score range roughly into how many groups?

             a. 10
             b. 15
             c. 18
             d. 24

_____ 3. In determining the range of scores, we

             a. use the middle score.
             b. divide the number of scores in half.
             c. subtract the middle score from the highest score.
             d. subtract the lowest score from the highest score.

_____ 4. A graphical device showing the distribution of scores is a

             a. cube graph
             b. histogram
             c. line graph
             d. frequency table

_____ 5. What would be your first step in making an ordinary grouped frequency
             distribution?

             a. select the class interval
             b. determine the range
             c. determine the limits of the classes
             d. make the tabulation

____ 6. In statistics, a score of 25 should be thought of as meaning

    a. more than 24, but not more than 25.
    b. from 25 to just not quite 25.
    c. from 24.5 to 25.5.
    d. exactly 25.

____ 7. In deciding upon a class interval, we should proceed by first

    a. choosing some interval arbitrarily before looking at the data.
    b. dividing the number of cases by the number of intervals desired.
    c. dividing the range by the number of intervals desired.
    d. doing something other than one of the above.

____ 8. Which of the following statements is true of score limit and real limits?

    a. Real limits are better than score limits.
    b. Real limits are more often used in practice in setting up a frequency distribution.
    c. Score limits are whole numbers for educational test scores.
    d. Score limits are used for arbitrary origins in computing the mean from grouped data.

____ 9. The arbitrary origin in the given distribution is

    a. 30-32
    b. 29.5
    c. 31.0
    d. 29.5-32.5

(See distribution on next page.)

Class Interval	f	x'
48-50	44	6
45-47	26	5
42-44	18	4
39-41	12	3
36-38	9	2
33-35	9	1
30-32	7	0
27-29	6	-1
24-26	3	-2
21-23	2	-3
18-20	2	-4
15-17	2	-5
12-14	3	-6
9-11	4	-7
6-8	3	-8

_____ 10. The width of the class interval in the given distribution is equal to

    a. 1
    b. 2
    c. 3
    d. 4

II. Short Answers

1. Complete the following, assuming ordinary data such as heights, weights, etc.

High	Low	Range	Width of Class Interval	Score	Limit	Real Limits (For lowest C_2)
170	61					
195	46					
68	2					
978	368					
26	10					

2. Complete the following (Data represent ages to previous birthday.)

High	Low	Range	Width of Class Interval	Mid-Point	Lower Limit	Real Limits
73	2					
52	36					

High	Low	Range	Width of Class Interval	Mid-Point	Lower Limit	Real Limits
123	7					
175	12					
47	13					

3. Round the following to three significant digits:

67583 _____   377500 _____

28760 _____   .0006785 _____

29850 _____

4. Give the number of significant digits in the following:

_____ .3876021   _____ 87.0002

_____ 33.7625   _____ 0.02176

_____ .0071250

Education/Psychology 380   First Summer Session

Quiz #2   NAME _____

I. Multiple Choice: Print the capital letter of the best answer in the blank
                    in front of the number.

_____ 1. A measure derived by adding all the test scores and dividing by the
          number of scores is the

          a. mode
          b. median
          c. mean
          d. standard deviation

_____ 2. A measure which separates the distribution of scores into two groups
          with equal numbers of cases is known as the

          a. mode
          b. median
          c. mean
          d. standard deviation

_____ 3. In the set of scores, 27, 50, 13, 5, 46, 34, 63, the median is equal
          to

          a. 29
          b. 34
          c. 36.5
          d. 35.4

_____ 4. Which of the following assumptions is not made in computing the
          median from grouped data?

          a. The variable is continuous.
          b. The variable is ordered.
          c. The variable is normally distributed.
          d. Values of the variable are uniformly distributed throughout the
             class intervals.

_____ 5. What is the mean of the given distribution?

          a. 5.00
          b. 6.00
          c. 7.00
          d. None of these

X	f
8	1
7	2
6	4
5	2
4	1

_____ 6. Percentile ranks are computed through statistical treatment similar to that employed to calculate the

    a. standard deviation
    b. arithmetic mean
    c. median
    d. mode

_____ 7. In a normal distribution, the range of scores from minus 1 standard deviation to plus 1 standard deviation on either side of the mean includes approximately what percent of cases?

    a. 34%
    b. 50%
    c. 68%
    d. 87%

_____ 8. In a normal distribution the raw scores are such that Q_3 is 84 and Q_1 is 60. What is the median of the distribution?

    a. 24
    b. 12
    c. 72
    d. Cannot be determined without more data.

_____ 9. The most frequently occurring score is called the

    a. mode
    b. median
    c. mean
    d. standard deviation

_____ 10. A single summarizing number used to describe a whole distribution of test scores could be

    a. the mean.
    b. the median.
    c. the mode.
    d. all of these (that is, a, b, and c)

II. Short Answer:

11. Round the following to three figures:

    _____ a. 169.09   _____ c. 21,450

    _____ b. 9.995

12. Write the number of significant figures in the left of the number for each of the following:

_____ a. .0001   _____ c. 900.0

_____ b. 169,001

III. Matching:

Percentile rank is the percentage corresponding to a centile. Choose the percentile rank from the list at right which corresponds to each of the items at the left below. Percentile ranks may be used more than once. Print the corresponding letters in spaces at left.

Items   Percentile Ranks

_____ 13. First quartile   A. 0

_____ 14. Second quartile   B. 10

_____ 15. Third quartile   C. 16

_____ 16. Q_1 D. 25

_____ 17. Q_2 E. 50

_____ 18. Q_3 F. 75

_____ 19. Median   G. 90

_____ 20. $z = -1$ H. 98

_____ 21. $z = +2$

_____ 22. Point above which 10% of the cases lie

Given the relations between mean, median and mode at the left, match the conclusion about the shape of the resulting distribution from right.

Relations of Averages   Shape of Distribution

_____ 23. Mean < Median < Mode   A. Skewed to the left

_____ 24. Mean = Median = Mode   B. Skewed to the right

_____ 25. Mean > Median > Mode   C. Symmetrical

IV. Calculations:

Calculate the M, Mdn, and grouped Mode for the following distribution.
All relevant work must be shown.

Score	f
110-112	2
107-109	2
104-106	2
101-103	4
98-100	5
95-97	9
92-94	6
89-91	3
86-88	4
83-85	2
80-82	1

Education/Psychology 380

First Summer Session '67

NAME _____

Quiz #3

Part I: Multiple Choice

Items 1 - 10 are based upon the data and analyses shown below. For each item, select the correct answer.

Class Interval	f	x'	fx'	fx'^2	Cumulative Frequency
48-50	44	6	264	1584	150
45-47	26	5	130	650	106
42-44	18	4	72	288	80
39-41	12	3	36	108	62
36-38	9	2	18	36	50
33-35	9	1	9	9	41
30-32	7	0	0	0	32
27-29	6	-1	-6	6	25
24-26	3	-2	-6	12	19
21-23	2	-3	-6	18	16
18-20	2	-4	-8	32	14
15-17	2	-5	-10	50	12
12-14	3	-6	-18	108	10
9-11	4	-7	-28	196	7
6-8	3	-8	-24	192	3

N=150 $\Sigma fx'$=423 $\Sigma fx'^2$=2389

_____ 1. The size of the class interval in the given distribution is

a. 2
b. 2.5
c. 3
d. 4

_____ 2. The arbitrary origin in the given distribution is

a. 29.5-32.5
b. 29.5
c. 31.0
d. 30-32

_____ 3. The crude mode as shown in the given distribution is

    a. 31.0
    b. 44.0
    c. 47.5
    d. 49.0

_____ 4. The most appropriate average to report for the given distribution would be the

    a. mode
    b. median
    c. mean
    d. midscore

_____ 5. The most appropriate measurement of variability to report for a distribution like this would be the

    a. range
    b. S
    c. A.D.
    d. Q

_____ 6. What is the approximate percentile rank of a score of 30?

    a. 10
    b. 16
    c. 35
    d. 40

_____ 7. Into which type of curve would this distribution be best classified?

    a. normal
    b. symmetrical
    c. positively skewed
    d. negatively skewed

_____ 8. The column headed $\Sigma fx'^2$ would be used in computing

    a. Q
    b. the mean
    c. the median
    d. S

_____ 9. In the given distribution, what percentage of the students would score between Q_1 and Q_3?

a. 25%
b. 50%
c. 68%
d. 75%

10. P_{60} would fall in the interval

a. 36-38
b. 39-41
c. 42-44
d. 45-47

---

11. From a statistical standpoint, the best all-around measure of variability is the

a. semi-interquartile range
b. standard deviation
c. percentile rank
d. range

12. In a symmetrical distribution, the limits of the mean ± two standard deviations include approximately what percent of the cases?

a. 50
b. 68
c. 95
d. 99

13. The limits of mean ±Q will include what percent of the cases?

a. 50
b. 68
c. 95
d. 99

14. If a pupil ranks 6th in a class of 30, his percentile rank is

a. 20.
b. 40.
c. 60.
d. 80.

____ 15. A percentile rank of 16 is approximately equivalent to a score that is how many standard deviations below the mean?

   a. one-half
   b. one
   c. one and one-half
   d. two

____ 16. On a test with a mean score of 100 and a standard deviation of 10, how many standard deviations from the mean is a score of 115?

   a. 1.15
   b. 1.5
   c. 15.0
   d. 11.5

____ 17. A student scores 45 on a vocabulary test. The mean for the class is 39 and the standard deviation is 8. His z score is

   a. -.75
   b. +.75
   c. -1.33
   d. +1.33

____ 18. What z score would be assigned to a pupil who had a raw score of 65, where the mean was 80 and the standard deviation was 5?

   a. -5.0
   b. -3.0
   c. -2.0
   d. -1.5

____ 19. An arithmetic test has been administered to 25,000 children in fifth grades throughout the country. The distribution of scores for all pupils was normal. If a pupil got a score one standard deviation below the mean, his percentile rank would be approximately

   a. 10
   b. 16
   c. 25
   d. 34

_____ 20. Mary made a score of 62 on a science test in a class where the mean of the scores was 50 and the standard deviation was 10. Joe made a score of 97 on a spelling test where the mean of the scores in the class was 100 and standard deviation was 20. Which of the following statements is true?

    a. Mary and Joe earned equal percentile ranks in their respective classes.
    b. Mary's percentile rank was higher than Joe's.
    c. Joe's percentile rank was higher than that of Mary.
    d. Insufficient information is given for comparing the percentile ranks of the two pupils for relative standing.

Part II: Matching

		Percentiles
21. _____ Q_2		
22. _____ Second decile		A. 2
		B. 4
23. _____ Point above which 20% of the cases lie.		C. 10
		D. 20
24. _____ $z = -2.0$		E. 21
		F. 23
25. _____ $z = +0.5$		G. 25
		H. 50
		I. 69
		J. 80
		K. 90

Part III: Computation

Find the mean, median, crude mode, and standard deviation. Show all work on the test itself. Report all answers to two decimal places.

Score	f	x'
160-169	5	4
150-159	7	3
140-149	10	2
130-139	15	1
120-129	20	0
110-119	10	-1
100-109	8	-2
90-99	7	-3
80-89	2	-4

PROBLEM SHEETS

I. Using the top intervals of TABLE 2.2, p. 27, TABLE 2.3, p. 37, TABLE 3.2, p. 49, and TABLE 4.2, p. 67, in your text (TATE), name the following for each table:

a. size of the class interval
b. real class limits
c. midpoint
d. consecutive scores included in the interval

II. Problem 7, page 40, of the text (TATE).

III. Find the MODE for each of the score distributions of the TABLES listed in problem I.

IV. The figure below shows the smoothed polygons of three hypothetical score distributions, superimposed on the same axes (i.e., drawn to the same scale). Which distribution, A, B, or C, has the largest MODE? The smallest? Explain.

Scale of Scores
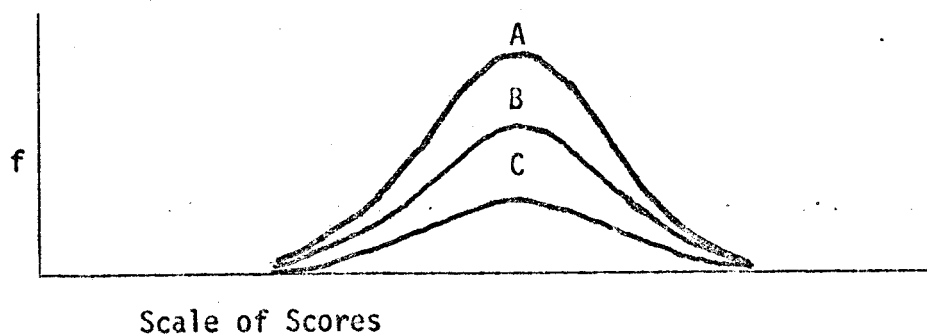
V. Sketch smoothed frequency polygons for the following types of distributions, and indicate the relative position of the MEDIAN and the MEAN:

a. positively skewed
b. symmetrical
c. negatively skewed
d. bimodal symmetrical

VI. Find the MEDIAN for the set of numbers listed below:

46	37	62	59	40
49	51	51	62	68
42	54	52	58	54
53	56	37	48	40
52	85	41	49	46

VII. Find the MEDIAN of the MAT score distribution of problem 7, page 40, in the text (TATE).

VIII. Find the MEDIAN of the score distribution listed in TABLE 4.2, page 67, in the text (TATE).

IX. Find the MEAN of the set of numbers listed in problem VI.

X. Find the MEAN of the MAT score distribution of problem 7, page 40, in the text (TATE).

XI. Find the MEAN of the score distribution listed in TABLE 4.2, page 67, in the text (TATE).

XII. Comparing the three MEDIANS and MEANS calculated in problems VI - XI, what can you say about the three score distributions?

XIII. Find the RANGE of the set of numbers listed in problem VI.

XIV. Find the RANGE of the score distribution listed in TABLE 3.2, page 49, in the text (TATE).

XV. Find the QUARTILE DEVIATION of the score distribution listed in TABLE 2.3, page 33, in the text (TATE).

XVI. Find the DECILE DEVIATION of the MAT score distribution of problem 7, page 40, in the text (TATE).

XVII. Find the STANDARD DEVIATION and VARIANCE of the set of numbers listed in problem VI.

XVIII. Find the VARIANCE and STANDARD DEVIATION of the MAT score distribution listed in problem 7, page 40, in the text (TATE).

XIX. Find the VARIANCE and STANDARD DEVIATION of the score distribution listed in TABLE 4.2, page 67, in the text (TATE).

XX. Using the results of problems XVIII and XIX estimate the percentages of scores in the intervals

    a. M + s and M - s
    b. M + 2s and M - 2s
    c. M + 3s and M - 3s

XXI. Problem 14, page 89, in the text (TATE).

XXII. Problem 20, page 89, in the text (TATE).

XXIII. Find the PERCENTILE RANK of 22 and 50 of the score distribution listed in TABLE 4.2, page 67, in the text (TATE).

XXIV. Draw a CUMULATIVE PERCENTAGE CURVE for the score distribution listed in TABLE 2.3, page 33, in the text (TATE). From this construction estimate the 25th and 75th percentile. How do these compare to the results of problem XV? Estimate the PERCENTILE RANK of the I.Q. scores of 70 and 118.

XXV. Using the results of problems X and XIX, and TABLE 4.2, page 67, in the text (TATE), convert the following scores into z scores and Z scores: 19, 36, and 50
Using TABLE 4.2, estimate the percentage of scores between $z = -1$ and $z = +1$. How does this result compare to problem XXa?

XXVI. A hypothetical normal distribution of 200 scores has a mean of 75 and a standard deviation of 15.

    a. How many scores lie between 30 and 60?
    b. How many scores lie below 90?
    c. What interval on the scale of scores includes the middle 100 scores?
    d. Which score will be exceeded by approximately 10% of the total number of scores? 90%?
    e. If a score were selected at random from the 200, what are the chances that it will fall in the interval 45 - 102.5? That it will fall below 60? That it will fall above 90?

XXVII. Problem 10, page 124-5, in the text (TATE).

XXVIII.

X-Score	Y-Score	X-Score	Y-Score	X-Score	Y-Score
7	7	12	4	15	3
4	12	9	5	11	8
12	6	7	8	2	12
14	5	10	8	8	7
13	5	14	3	9	9
4	11	9	7	13	6
8	9	6	9	12	7
10	6	11	7	4	9
11	4	7	10	6	8
5	11	8	6	3	10

Listed in the table above are the scores of 30 individuals measuring traits X and Y.

a. Plot a SCATTER DIAGRAM for the 30 pairs of scores.
b. Find the PEARSON PRODUCT-MOMENT COEFFICIENT OF CORRELATION, r_{xy}, for the above data.
c. Find the COEFFICIENT OF REGRESSION OF Y ON X.
d. Graph the LINE OF REGRESSION OF Y ON X on the scatter diagram of (a).
e. Find the STANDARD ERROR OF ESTIMATE, $S_{y \cdot x}$.

XXIX. A test was administered to ten students. Their order of finishing this test, whether or not they were science majors (0 = no, 1 = yes), and their test scores are listed in the table below:

ORDER OF FINISHING	SCIENCE MAJOR	TEST SCORE
1	0	38
2	0	40
3	1	33
4	0	35
5	1	33
6	1	26
7	0	31
8	0	29
9	0	21
10	1	37

a. Find the correlation between the order of finishing and the test scores.
b. Find the relationship between being or not being a science major and the test scores.

XXX.   A math aptitude test is administered to a group of men and women. Using the table below find the degree of relationship between sex and math aptitude.

	PASSED TEST	FAILED TEST
MEN	50	20
WOMEN.	35	35

XXXI. Using the table given in problem XXX., test the hypothesis that there is no difference between sexes with respect to math aptitude.

Appendix B

TABLE OF CORRELATION COEFFICIENTS

Page 322 contains a matrix of correlation coefficients. The first row and first column are identification numbers. These numbers correspond to the variables listed below. The correlation coefficients (r's) $\geq$ .42 indicate a significant relationship at the .05 level and the (r's) $\geq$ .55 indicate a significant relationship at the .01 level. An interpretation of this matrix is presented on page 77.

1. Age

2. Score on mathematics pretest

3. Nelson-Denny vocabulary score

4. Nelson-Denny total scores

5. Nelson-Denny reading comprehension scores

6. Pre-course mathematics attitude scores

7. Post-course mathematics attitude scores

8. Pre-course attitude score

9. Post-course attitude score

10. Midterm computation first version

11. Midterm total first version

12. Midterm multiple choice first version

13. Rank of working time on the first midterm

14. Midterm computation second version

15. Midterm multiple choice second version

16. Midterm total second version

17. Rank of working time on the second version

18. Computation final 1967 version

19. Multiple choice final 1967 version

20. Rank of working time on 1967 version of final

21. Sum of quizzes I, II, and III 1967 version

22. Final total score on 1967 version

23. Total score on the 1968 version of the final examination

24. Sum of the total scores on the 1967 and 1968 final examination

25. Total amount of tutoring time spent with student discussing
    subject matter (cognitive)

26. Total amount of time spent with tutors discussing anything
    but subject matter (affective)

27. Total time spent with tutors in cognitive and affective areas

28. Percentage of daily quizzes (total points/total possible) 100.

29. Percentage of weekly quizzes (total points/total possible) 100.

30. Score on weekly quiz I

31. Sum of weekly quizzes I and II

32. Sum of weekly quizzes I and II and III

33. Sum of weekly quizzes I + II + III + IV

34. Sum of weekly quizzes I + II + III + IV + V

35. Sum of weekly quizzes I + II + III + IV + V + VI

36. Weekly quiz II

37. Weekly quiz III

38. Weekly quiz IV

39. Weekly quiz V

40. Weekly quiz VI

41. Sex

42. Grade point average

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
1	-10	-08	-35	-22	20	24	01	19	10	19	18	27	-02	-01	-03	34	21	28	-23	-06	05	-04	03	13	06	12	-02	23	33	29	34	32	34	26	25	17	02	25	-06	49	03
2		27	33	33	35	24	17	-25	44	19	47	-40	52	32	45	-60	43	-55	-26	43	53	55	56	-48	02	-35	72	56	22	00	08	39	51	43	-25	20	54	44	41	14	13
3			76	95	-26	-14	-19	-57	11	-13	00	-27	42	-17	01	-20	59	-10	-15	-26	35	31	37	-43	23	-21	26	-07	01	-03	-01	17	07	11	02	-07	37	-02	-28	23	-16
4				93	-22	-22	12	-46	34	-25	08	-38	34	-13	-05	-28	60	02	-04	-09	29	32	36	-30	17	-15	22	-06	07	-15	-11	13	03	19	-26	-02	46	-06	-18	07	-22
5					-26	-19	-05	-55	23	-20	04	-34	41	-16	-02	-25	63	-05	-11	-19	35	34	39	-39	21	-20	26	-08	04	-09	-06	16	06	15	-12	-05	44	-04	-25	17	-20
6						92	40	50	25	38	45	-07	16	50	49	-10	07	-03	-17	30	21	-02	12	-24	-23	-29	48	48	34	26	27	31	37	35	01	23	11	31	25	28	14
7							26	38	25	16	31	04	11	39	42	00	13	04	-07	21	15	-02	06	-23	-10	-22	31	38	29	27	28	23	32	28	09	18	-04	29	13	19	04
8								33	32	14	33	-07	-16	37	17	-16	20	07	01	29	28	29	34	27	-33	05	44	35	38	23	33	35	21	35	-03	33	08	04	34	08	14
9									11	41	36	02	02	50	40	03	-30	06	-07	04	-23	-25	-23	06	-46	-17	04	10	40	29	25	08	00	14	03	12	-29	-06	24	28	14
10										02	75	-19	37	44	44	-43	70	-20	-20	62	49	64	62	-13	-01	-10	62	44	46	24	29	44	38	49	-16	26	36	22	48	14	-07
11											67	-15	26	42	42	-22	00	-21	-44	17	37	09	28	-21	-32	-31	36	18	15	19	18	31	06	06	14	12	25	-15	29	53	23
12												-25	45	62	62	-47	51	-30	-44	59	61	54	65	-25	-22	-29	71	46	47	35	35	55	35	42	00	24	44	09	54	43	10
13													-33	-14	-18	77	-08	40	37	00	-24	-08	-21	44	27	46	-38	-11	02	-03	01	-22	-16	-27	-07	04	-41	-07	00	-18	-01
14														49	70	-49	43	-43	-36	00	20	40	35	-68	03	-49	52	36	05	-16	-14	20	35	41	-28	-02	60	35	34	33	-17
15															24	-31	20	-35	-32	42	41	40	47	-12	-22	-19	57	55	19	18	21	33	36	45	02	25	23	27	66	19	-01
16																-40	29	-46	-40	33	41	46	48	-40	-18	-38	62	52	14	06	10	29	37	43	-10	20	35	32	61	27	-10
17																	-32	74	51	-24	-31	-32	-35	53	46	62	-65	-17	00	-01	04	-20	-13	-17	-23	10	-43	-03	-31	-01	03
18																		-20	-37	20	64	65	70	-35	02	-25	49	18	24	01	01	29	25	27	16	00	59	14	03	20	-22
19																			44	-22	-27	-30	-28	51	42	56	-51	-05	21	22	30	13	05	15	-13	19	-27	-02	-29	11	-15
20																				-05	-41	-18	-34	56	57	69	-38	-11	04	-05	-04	-32	-20	-15	11	05	-54	-05	03	-35	25
21																					59	49	55	15	04	13	59	55	29	36	40	46	31	27	02	38	18	10	75	-07	23
22																						73	94	-20	04	-13	68	44	18	17	23	50	37	33	-24	25	58	15	30	30	05
23																							90	-14	19	-02	65	50	20	-01	11	39	41	45	-08	27	56	30	51	13	07
24																								-17	11	-08	73	53	23	13	21	53	45	47	36	27	66	26	44	27	01
25																									33	90	-35	-04	11	31	28	-05	-12	06	-06	07	-56	-14	12	36	19
26																										71	-15	15	-04	-07	-04	-07	13	14	24	01	-06	25	07	-15	-02
27																											-33	04	06	20	19	-07	-03	02	03	06	-45	01	12	-14	12
28																												66	33	27	38	59	51	53	06	35	47	30	62	28	11
29																													38	31	51	72	92	86	06	55	45	79	63	36	00
30																														76	72	67	45	56	18	29	03	15	24	32	61
31																															86	69	34	40	76	15	-18	-02	24	12	35
32																																84	53	58	59	62	-13	14	32	38	23
33																																	77	80	39	58	41	37	40	55	11
34																																		92	10	47	51	87	33	43	-05
35																																			08	52	47	74	41	44	-05
36																																				-08	-29	-15	01	-09	07
37																																					02	25	40	54	04
38																																						41	17	34	-20
39																																							18	21	-17
40																																								02	23
41																																									-08

$r \geq .42$ significant at the .05 level.

$r \geq .55$ significant at the .01 level.

For a description of variables used in this matrix see page 319 to 321.

Appendix C

DATA FROM THE

1967, 1968 and 1969

STATISTICS CLASSES

The following page contains the data compiled from 1967, 1968 and 1969 statistics classes. The list below contains the variable identification numbers, the corresponding description of the instruments used and the type of score.

1. Mathematics pretest   proportion correct

2. Nelson Denny vocabulary scores   raw score

3. Nelson Denny comprehension scores raw score

4. Nelson Denny total scores   raw score

5. Pre-mathematics opinionnaire   proportion correct

6. Post-mathematics opinionnaire   proportion correct

7. Pre-statistics opinionnaire   proportion correct

8. Post-statistics opinionnaire   proportion correct

9. 1967 final examination   proportion correct

10. 1968 final examination   proportion correct

11. 1968 midterm   proportion correct

12. Combined proportion on the
    (3) quizzes

Data From 1967 Statistics Class

Variable Numbers

Student Number	1	2	3	4	5	6	7	8	9	10	11	12
1	.677								.479			2.430
2	.557								.521			1.683
3	.677								.718			2.310
4	.677								.775			2.550
5	.677								.535			1.958
6	.717								.690			2.328
7	1.000								.789			2.645
8	.877								.746			2.810
9	.757								.690			2.240
10	.597								.845			2.455
11	.677								.676			2.500
12	1.000								.789			2.683
13	.877								.802			2.353
14	.357								.775			2.392
15	.757								.732			2.238
16	.717								.648			2.395
17	.917								.873			2.623
18	.877								.718			2.273
19	.757								.803			2.270
20	.557								.606			1.651
21	.717								.746			2.293
22	.637								.577			1.995
23	.877								.859			2.400
24	.677								.606			2.183
25	.837								.930			2.265
26	.917								.789			2.353
27	.677								.845			2.625
28	.797								.493			1.563
29	.557								.746			2.335
30	.877								.690			2.245

Data From 1968 Statistics Class

Student Number	1	2	3	4	5	6	7	8	9	10	11	12
31	.889	64	64	128	.670	.870	.515	.490	.916	.892	.932	
32	.611	74	64	138	.320	.420	.442	.343	.732	.855	.877	
33	.722	62	64	126	.630	.610	.530	.501	.718	.735	.767	
34	.778	44	52	96	.430	.310	.440	.436	.676	.723	.658	
35	1.000	44	54	98	.600	.670	.484	.556	.648	.759	.945	
36	1.000	48	54	102	.780	.660	.526	.497	.747	.892	.932	
37	.289	50	64	114	.450	.710	.675	.813	.662	.843	.822	
38	.811	54	66	120	.760	.750	.594	.839	.845	.904	.945	
39	.444	72	58	130	.490	.700	.586	.502	.775	.867	890	
40	1.000	77	60	137	.800	.800	.433	.534	.817	.892	.767	
41	.778	59	58	117	.470	.570	.440	.519	.676	.880	.795	
42	.500	62	54	123	.890	.840	.451	.862	.662	.711	918	
43	.333	57	62	119	.740	.780	.466	.562	.760	.807	863	
44	.944	54	58	112	.780	.850	.710	.578	.732	.904	.918	
45	.833	49	58	107	.840	.950	.666	.792	.620	.855	890	
46	.389	65	58	123	.820	.830	.530	.526	.676	.783	.890	
47	.944	42	52	94	.760	.870	.519	.999	.803	.764	.959	

Data From 1969 Statistics Class

Student Number	1	2	3	4	5	6	7	8	9	10	11	12
48	.389	11	16	27	.770	.740	.478	.794	.521	.740	.831	2.410
49	.666	28	28	56	.960	.890	.783	.736	.930	.940	.999	2.800
50	.722	46	32	78	.740	.850	.348	.340	.789	.860	.845	2.450
51	.666	75	60	135	.520	.550	.504	.345	.718	.880	.859	1.530
52	.778	60	68	128	.640	.570	.727	.340	.817	.824	.859	2.390
53	.889	61	58	119	.740	.740	.629	.457	.831	.916	.972	2.760
54	.611	55	40	95	.490	.470	.252	.272	.789	.853	873	2.470
55	.833	57	48	105	.800	.840	.707	.224	.916	.957	887	2.760
56	.666	58	60	118	.670	.640	.332	.353	.906	.897	.916	2.660
57	.889	45	52	97	.910	.810	.688	.717	.859	.940	.958	2.620
58	.944	56	54	110	.800	.750	.752	.539	.845	.940	.972	2.690
59	.722	46	52	98	.790	.780	.618	.495	.873	.969	.986	2.670
60	.500	76	56	132	.880	.950	.533	.623	.847	.831	.916	2.220
61	.500	54	52	106	.350	.460	.217	.519	.704	.897	.916	2.420
62	1.000	58	52	110	.880	.860	.611	.596	.916	.952	.972	2.850
63	.444	60	56	116	.730	.850	.557	.414	.662	.880	.845	2.340
64	1.000	63	54	117	.840	.800	.511	.410	.831	.903	.986	2.930
65	.944	75	62	137	.510	.610	.306	.210	.916	.999	.886	2.680
66	.889	42	48	90	.870	.860	.398	.373	.760	.807	.916	2.470
67	.333	44	50	94	.430	.470	.819	.420	.847	.909	.901	2.750
68	1.000	48	64	112	.450	.430	.781	.385	.774	.952	.887	2.710
69	1.000	56	42	98	.650	.660	.590	.434	.930	.999	.944	2.730

Appendix D

COURSE OBJECTIVES 1968

Scales

To know that automobile licenses are designations on an ordinal scale

To know that percentile ranks are units on an ordinal scale

To know that teacher-made test scores are units on an interval or ordinal scale

To know that I.Q. scores are units on an interval or an ordinal scale

To know that inches are units on a ratio scale

To know that degrees Fahrenheit are units on an interval scale

To know that pounds are units on a ratio scale

To know that seconds are measures on a ratio scale

Class interval

To determine appropriate size and number of class intervals given a problem situation

To comprehend that we can compute the median and not the mean if the top interval of a set of class intervals has an indeterminate upper limit

Graphical presentations of statistical data

To comprehend the relationships among the histogram, frequency distribution, and frequency polygon

To apply the knowledge of how to set up class intervals for a frequency distribution

To comprehend the nature and uses of the histogram and frequency polygon

Ranking

To comprehend the techniques of ranking a set of scores

Central tendency

To know that either the median or mode is the measure of central tendency used when you desire the score which is most useful for a quick inspection of central tendency

To know that the mode, mean, and median coincide for a symmetrical distribution

To apply the knowledge of how to compute the mode, median, and mean for simple sets of data

To comprehend the nature and uses of the mode, median, and mean

To know the advantages and disadvantages of the mode, median, and mean

Median

To know that the median is the measure of central tendency that is used when there are extreme measures which would affect the average disproportionately

Mode

To know that the mode is the least dependable and least useful measure of central tendency

To apply the knowledge that the mode is the measure of central tendency that is used when the most often recurring score is sought

Mean

To know that the arithmetic mean is the measure of central tendency used when each score should have equal weight

To know the steps used in computing the mean

To know that the mean is most affected by extreme scores

To know that the arithmetic mean is the measure of central tendency to use when you wish to convert raw scores to z scores

To know that for calculating the mean from grouped data, it is necessary to multiply by the term i (the width of a class interval) to convert from coded scores back to raw scores

Measures of variability

To comprehend the meaning of the term "variability" and its connection with such terms as "scatter", "dispersion", "deviation", "homogeneity", and "heterogeneity"

To comprehend that, in comparing and contrasting the nature of indexes of central tendency and variability, indexes of variability should be interpreted as distances, while indexes of central tendency should be interpreted as points

To know that the numerical value of the sum of deviations of a set of raw scores from their mean is always equal to zero

To comprehend the relationship between range, standard deviation, and variability

Range

To know that the range is the measure of variability to use when a quick, approximate measure of variability is needed

Percentiles

To know that a given percentile score indicates the point below which the same percentage of cases lie

Semi-interquartile range

To apply the knowledge that Q_3 is the lower limit of the upper quartile

To know that Q is the measure of variability to use when it is desired to minimize the effect of extreme deviations

To know that Q is the measure of variability to use when the degree of concentration around the median is sought

To comprehend the steps in computing the semi-interquartile range for simple sets of data

To comprehend the nature and uses of the semi-interquartile range

Standard deviation

To apply the knowledge that the standard deviation can be used to determine the relative homogeneity of a group

To know that standard deviation is the measure of variability to use when it is desired that extreme deviations have a proportionately greater influence upon the measure of variability

To know that standard deviation is the measure of variability to use when it is desired to compute z scores

To apply the knowledge that the standard deviation can be used to determine the percentage of scores that will fall in any given area under the normal curve

To comprehend the nature and uses of the standard deviation

Standard error of measurement

To comprehend the basic concept of the standard error of measurement

Symmetry

To apply the knowledge that the symmetry of a distribution can be determined by means of the mean, standard deviation, Q_3, median, and Q_1

To know the meaning of the terms used to designate certain common non-normal distributions such as "positively skewed", "negatively skewed", and "bimodal" distributions

To comprehend the relationship of $Q_2 - Q_1 = Q_3 - Q_2$, normal, and leptokurtic-- all being symmetrical

Percentile ranks

To know that one can compute percentile ranks from a cumulative percentage curve

To know the approximate percentile ranks associated with standard scores along the horizontal baseline of the normal curve

Standard scores

To comprehend the fact that a raw score has no meaning alone and needs some context in which it can be interpreted

To comprehend how to interpret raw scores from a given set of norms

To know that if a constant numerical value is multiplied by each score in a group, the values of both the mean and the standard deviations are affected

To know that if a constant numerical value is subtracted from each score in a group, the value of the standard deviation is unaffected

To comprehend that standard scores can make two variables expressed in raw score form comparable as far as standing in the group

To apply the knowledge of how to compute a z score from a raw score

To know how to convert from one type of standard score to another

To know some common applications of standard scores

To know the means and standard deviations of common standard score scales such as the z, T, stanine, deviation I.Q., and CEEB scales

To know how to convert a given raw score into a z score from a mean and standard deviation of a set of scores

To comprehend how to compare and contrast two types of standard scores--Z and T scores

Normal curve

To know that the interpercentile distance measured in raw scores in a normal distribution is greatest at both ends

To know the percentage of the total number of cases included between + or - 1, 2, or 3 standard deviations from the mean in a normal distribution

To know that any normal distribution can be completely described in terms of its mean and standard deviation

To know this practical limitation to using the normal curve: that for large heterogeneous groups it "fits" most test data rather well and that it aids in the interpretation of test scores, but does not necessarily apply to small selected groups

To know that the normal curve is an ideal distribution, an abstract model approached but never achieved fully in practice

To know that when the normal curve is used as a basis for assigning letter grades to a set of scores and normality is assured, common practice recommended states that the middle group (the C's) be in the range $\pm\frac{1}{2}$ S.D. on either side of the mean and includes 34% of the cases

To know that the 50th percentile and the median are the same thing

To know that the normal, bell-shaped, and Gaussian are synonymous terms

Scatter diagram

To apply the knowledge of how to make simple interpretations from a scatter diagram

To comprehend that a scatter diagram can be used to study pictorially the linearity of relationship between two variables

Pearson product-moment

To comprehend how to determine the values of correlation coefficients which would be expected to describe the relationship between two measures when data for both variables are given

To know how to make an interpretation of an obtained relationship between two variable when a correlation coefficient is given

To know that a .00 coefficient of correlation would give the poorest basis for prediction

To know that ±2.00 (or anything beyond 1.00) cannot be a value for a correlation coefficient

To know that +.50 is the correlation coefficient between height and weight

To know that -1.00 is the correlation of two perfectly correlated variables which vary inversely

To comprehend the meaning of a given correlation coefficient in terms of whether it is "high", "low", or "moderate"

To know that correlation coefficients alone do not indicate any kind of percentage

To know what size correlation to expect between two given variables in terms of logical reasoning, e.g., in terms of a common factor

To know that correlation coefficients do not imply causality between two measures

To know the definition of the concept of correlation, including such terms as "positive correlation", "negative correlation", "no relationship", and "perfect relationship"

To know the significance of the numerical magnitude and the sign of the Pearson product-moment correlation coefficient

Spearman rank-difference

To comprehend that the Spearman rank-difference correlation can be used to study agreement between two "judges" who have arranged a set of candidates in order of their judged ability

Chi square

To know that chi square technique can be used to carry out the median test

To comprehend that the chi square technique can be used to test whether two skewed frequency distributions can be considered as samples from the same population

Median test

To know that correlation, regression, standard error of estimate, and chi square are intended to assist in making predictions, while the median test is not

Symbols

To know that ρ is the symbol for rank-difference correlation

To know that Σx^2 is the symbol for "sum of squares"

To know that Σxy is the symbol for "sum of cross-products"

To know that $\Sigma x^3/N$ is the symbol for assymmetry

To know that $\Sigma x^4/N$ is the symbol for platykurtosis

Variables

To comprehend the difference between discrete and continuous variables

APPENDIX E

ED. 380   SESSION: _____

STATISTICAL METHODS

PERSONAL DATA SHEET

NAME: _____   AGE: _____   SEX: _____

ADDRESS: _____   TELEPHONE: _____

ACADEMIC STATUS: (e.g., Junior, Senior, Graduate, Special Student, etc.)

MAJOR AND MINOR FIELDS: (If undecided, so indicate; if graduate student,
                           indicate both graduate and undergraduate majors and
                           minors.)

DEGREE WORKING TOWARD: (If not working for a degree, so indicate.)

LIST PREVIOUS COURSES IN THE FOLLOWING FIELDS: (If you completed more than
three courses in any of the fields, merely state the approximate number of
courses or semester hours.)

                    UNDERGRADUATE   GRADUATE

1. EDUCATION: _____

2. PSYCHOLOGY: _____

3. MATHEMATICS: _____

4. SCIENCE: _____

KIND OF WORK PREPARING FOR:

PRESENT POSITION:

REASON FOR TAKING COURSE:

APPENDIX F

DISTRIBUTION OF GRADES

	A		B		C		D		F		Total	
	Actual	%	Actual	%	Actual	%	Actual	%	Actual	%	Actual	%
1967 Traditional Learning	3	10.0	17	56.7	9	30.0	1	3.3	0	0.0	30	100
1968 Mastery Learning	11	65.0	4	23.5	2	11.5	0	0.0	0	0.0	17	100
1969 Capsulized Mastery Learning	21	94.5	1	05.5	0	0.0	0	0.0	0	0.0	22	100

——— 1967 Traditional Learning

—·—· 1968 Mastery Learning

···· 1969 Capsulized Mastery Learning
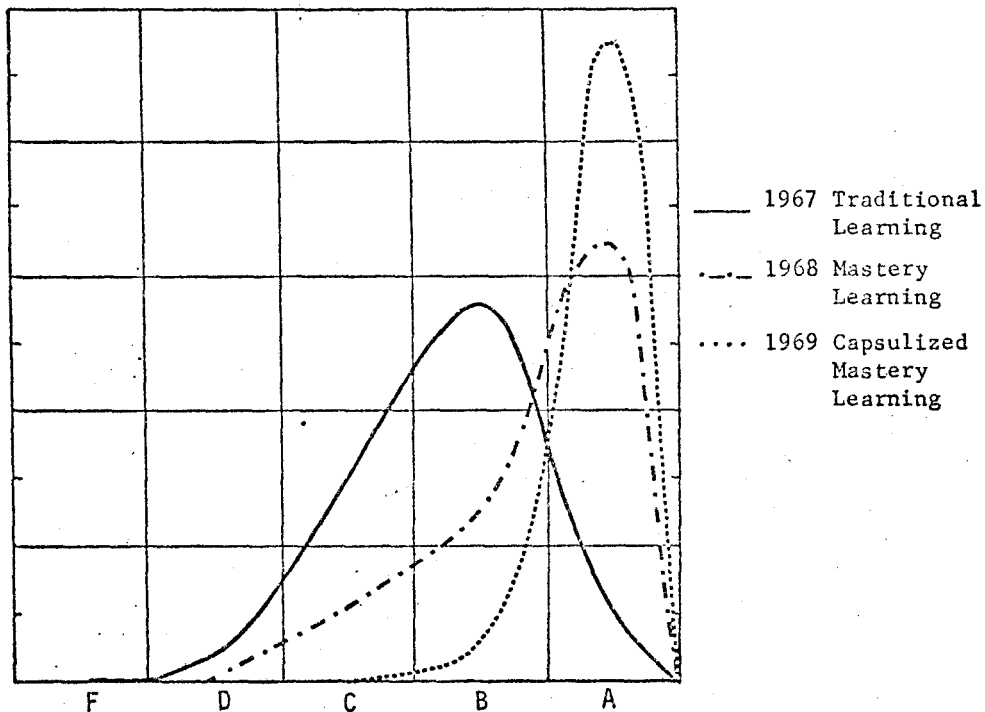
APPROVAL SHEET

The dissertation submitted by Rocco S. Caponigri has been read and approved by Dr. Raynard Dooley, Dr. Anne Juhasz and Dr. Samuel T. Mayo, members of the department of Foundations, School of Education.

The final copies have been examined by the director of the dissertation, Dr. Samuel T. Mayo, his signature which appears below verifies the fact that any necessary changes have been incorporated and that the dissertation is now given final approval with reference to content and form.

The dissertation is therefore accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

5/18/72
Date

Samuel T Mayo
Signature of Advisor