THE DEVELOPMENT OF A SEMANTIC DIFFERENTIAL TO MEASURE ATTITUDES TOWARD MATHEMATICS

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PREFACE

For some time I have been interested in the attitudes displayed by persons participating in mathematics. The attitudes of the student seemed to be such an important ingredient for success in the learning of mathematics. Also, the related problem of measuring such a seemingly intangible entity was intriguing. This study gave me the opportunity to investigate one process of understanding this multifaceted problem.

The puzzle of how to measure these attitudes, especially accurately enough to note a change, was first to be managed. The interesting semantic differential, developed by Charles E. Osgood, seemed apt for this purpose. The literature concerning the semantic differential is well-documented and touches on many fields of research. There was little use of this tool in the classroom situation, however, especially at the college level. All of these circumstances helped to nurture this study in its final direction.

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CHAPTER I

INTRODUCTION

The Problem

Often the claim is made by an instructor of a college course in mathematics that the attitude toward mathematics held by the students in a certain course has been altered. Students themselves remark that certain courses or particular teachers have an influence on their feelings toward mathematics. Often a college course in mathematics will have improvement of student attitude as one of the main goals. This is especially true in survey courses for liberal arts majors or mathematics courses for prospective elementary teachers. In order to successfully approach this goal much needs to be learned about attitudes. Certainly, pertinent to the problem of understanding attitude is the related problem of measuring attitude. One cannot tell if attitude has been changed if it cannot be successfully measured. The study reported in this dissertation was an effort to establish an instrument with which to measure the attitude toward mathematics held by undergraduate students enrolled in mathematics courses.

Much attention has been given the role played by the student's attitude toward mathematics in a learning situation. The importance of attitudes in relation to mathematics is emphasized in these statements of Johnson:

> In our concern for improving the mathematics curriculum and increasing enrollment in mathematics, have we forgotten a crucial factor, namely attitudes?...It is the attitudes that our students develop which are likely to stimulate or to stop further study of mathematics. It is the attitudes which we build that are highly involved in the learning and retention of our subject. It is the attitudes which we teach that are the most important factors in the activities in which our youth participate--now and later (16, p. 113).

Aiken concurs with the following remarks from his article about research on attitudes toward mathematics:

> It is sometimes forgotten that in addition to learning principles, facts, and methods in school children learn attitudes, values, and appreciation and, it is hoped, develop a desire for further learning. Terms such as attitude, value, and appreciation refer to affective objectives of instruction, objectives that should constitute a part of learning every subject (3, p. 229).

In much of the literature concerning the modern approaches to curriculum there are many statements which indicate that attitudes toward mathematics are considered important. Although the following remarks from the Cambridge Conference report do not specifically state that they are related to the attitude of educated people, they certainly imply this importance:

> The conference felt that mathematics is a subject of great humanistic value: its importance to the educated man is almost as great as its importance to many technical specialists. The strongest argument for the early inclusion of the calculus was one of general education: liberal education requires the contemplation of the works of

> genius, and the calculus is one of the grandest edifices constructed by mankind (8, p. 9).

In another place the report states:

> To foster the proper attitude toward both pure and applied mathematics we recommend that each topic should be approached intuitively, indeed through as many different intuitive considerations as possible (8, p. 11).

Corcoran and Gibb (10, p. 105) assert that attitudes are an important aspect of learning and that they are rarely considered in evaluating a student's achievement in mathematics. The reason for this, in their opinion, is that suitable instruments have not been widely available. They state that the special problems involved in measuring account for this since obtaining unbiased evidence of attitudes presents special problems, and it is more difficult to establish validity for measures of attitudes than for measures of achievement.

Aiken (2, p. 589) concurs that much could be done to improve the quality of research concerning attitudes. Since the usefulness of the results of research is frequently limited by the precision with which outcomes are measured, something needs to be done to improve the accuracy of measures of attitudes. He states that the stimulus-response approach would be appropriate to work with in the measurement of attitudes since this approach would consider the distinction between the cognitive and emotional components of attitudes in the design of attitude instruments.

The need of an instrument with which to measure the attitudes of college students enrolled in mathematics classes seems especially acute. These classes may provide the last chance in the educational experience for such attitudes to be changed, if, indeed, they can be changed. Also, an instrument of some depth should be found if it is to measure a change. This change could be small and, thus, the measure should not be very gross. Hence, it seems appropriate to attempt the development of an instrument with which to measure attitudes toward mathematics.

The development of a reliable and valid instrument for measuring attitudes toward mathematics was the purpose of this study. The form of the instrument is the semantic differential, which will be discussed in detail in a later section. The instrument was established during the summer of 1973. It was administered to students enrolled in mathematics courses at North Texas State University and Texas Woman's University during the summer session of 1973, and then during the fall and spring terms of the 1973-74 school year to students of these two universities in Denton, Texas. This is, then, the report of the justification of this instrument hereafter called the Mathematics Attitude Semantic Differential and referred to as MASD.

Review of Literature

What is an Attitude?

The problem of dealing with attitudes is quite evident in the literature about teaching. Corcoran and Gibb (10, p. 105) assert that the idea that an attitude involves both cognitive and noncognitive aspects--that is, both beliefs and feelings about the object of the attitude--is basic to the study of attitudes toward mathematics. They state that a student's attitude toward mathematics is a composite of intellectual appreciation of the subject and emotional reactions to it. Involved in an evaluation of attitude is an awareness of two important dimensions: direction (Does the student generally like or dislike the subject?) and intensity (How strongly does the student feel about this attitude?). They mention other aspects of individual attitudes that are sometimes studied. These are consistency (the extent to which an attitude toward one aspect of the subject agrees with an attitude toward another), salience (the importance the individual attaches to the attitude), and public vs. private quality (the extent to which the individual is willing to reveal his feelings).

Despite a plethora of definitions of "attitude" in contemporary social science, some consensus and agreement is evident, particularly with respect to the major properties that attitudes are assumed to possess. Most authorities agree that attitudes are learned and implicit--they are inferred states that are presumably acquired in much the same manner that other such internal learned activity is acquired. Further, they are predispositions to respond, but are distinguished from other such states of readiness in that they predispose toward an evaluative response. Thus, attitudes are referred to as "tendencies of approach or of avoidance," or as "favorable or unfavorable" (22, p. 189). Kerlinger (18, p. 483) reinforces this idea when he states that attitudes are really an integral part of personality. An attitude is a predisposition to think, feel, perceive, and behave toward a cognitive object. One has an attitude toward something "out there."

George Stern (30, p. 404), in his chapter "Measuring Noncognitive Variables in Research on Teaching," mentions several studies that used attitudes as a central variable. These studies regarded an attitude as an internalized counterpart of an external object, representing the individual's subjective tendencies to act toward that object. He states that subsequent definitions have agreed on four fundamental points:

1. Attitudes are socially formed. They are based on cultural experience and training and are revealed in cultural products.
2. Attitudes are orientations toward others and toward objects. They incorporate the meaning of a physical event as an object of potential or actual activity.
3. Attitudes are selective. They provide a basis for discriminating between alternative courses of action and introduce consistency

of response in social situations of an otherwise diverse nature.

4. Attitudes reflect a disposition to an activity, not a verbalization. They are organizations of incipient activities, of actions not necessarily completed, and represent therefore the underlying dispositional or motivational urge (80, p. 404).

Considering these remarks and the many facets of attitudes, the following definition will be used for attitude throughout this study: "An emotionalized tendency, organized through experience, to react positively or negatively toward a psychological object" (24, p. 362).

How Might an Attitude be Measured?

Romberg (26, p. 474) asserts that attitude studies have not been fruitful and offers some reasons for this position. One such weakness is the use by most investigators of a single, global measure of attitudes toward mathematics. Romberg objects to this as being an unrealistic approach since there is probably a set of predispositions or feelings that vary from computation to problem solving to other aspects of mathematics.

Aiken (2, p. 589) agrees when he states that the concept of a general attitude toward mathematics should be supplemented with that of attitudes toward specific aspects of mathematics, such as routine drill and problem solving. Such instruments should be of greater diagnostic usefulness than the current scales of general attitudes toward mathematics with their single over-all score. Aiken further states that:

> Investigations concerned with the developing and influencing of attitude toward mathematics have dealt almost exclusively with enjoyment of the subject or anxiety in its presence...Although various psychometric procedures have been applied in constructing the measures of attitude employed in such investigations, the attitude dimension assessed by these instruments usually involves only one of the affective goals of mathematics instruction (4, p. 67).

Corcoran and Gibb (10, p. 105) also discuss the content of an attitude instrument. They state that most studies in this field have been concerned with the direction and intensity of attitudes regarding mathematics in general. They do cite some examples of attitude study that include attitudes toward specific mathematics courses and such specific aspects of mathematics as computation, problem solving, and figure construction. There are other aspects, however, that need study in their opinion. They suggest that attitudes about mathematics teachers, about the way mathematics is taught, and about the setting in which it is taught should be investigated. Still other areas of exploration that they think merit study are the student's reaction to the difficulty of mathematics (the extent to which he regards it as a challenge or a hard subject), his interest (whether he is very curious about mathematics or finds it dull and boring), and the kind of value he uses to justify its study (whether he thinks mathematics should be studied because it is practical or thinks it is worth studying because it is intrinsically interesting).

Theoretical Background

The Semantic Differential

The semantic differential was chosen as the vehicle to use to develop an instrument for several reasons. Much research effort has been directed to refining this instrument as a method of measuring many different things, particularly measuring attitudes. It seems to hold potential as a measuring instrument and little use of it has been made as an attitudinal measure with regard to mathematics. The semantic differential was first used by Charles E. Osgood, George J. Suci, and Percy H. Tannenbaum. Their book, The Measurement of Meaning, is a report of their use and refinement of this tool in extensive empirical research at the University of Illinois during the fifties. The semantic differential is composed of two basic parts: first, concepts expressed as words or phrases that suggest different aspects of the field to be measured and, second, scales expressed as bipolar pairs of words against which the subject is to rate the concept suggested. These important aspects of the instrument will be discussed in detail in the following paragraphs.

Tannenbaum (31, p. 418) states that perhaps the simplest and most typical communication message is one in which an identifiable source makes a favorable or unfavorable assertion about a particular object or concept. In most cases, a person exposed to such a message brings into the communication situation his original attitudes toward both the source and the concept. Tannenbaum supports the use of the semantic differential as a novel technique to secure this type of communication message as a measure of attitude.

Osgood (22, p. 20) describes the semantic differential as essentially a combination of controlled association and scaling procedures. The subject is provided with a concept to be differentiated and a set of bipolar adjective scales against which to do it. His only task is to indicate, for each item (pairing of a concept with a scale), the direction of his association and its intensity on a seven-step scale. The crux of the method lies in selecting the sample of descriptive polar terms. Osgood feels that, ideally, the sample should be as representative as possible of all the ways in which meaningful judgments can vary, and yet be small enough in size to be efficient in practice.

Kerlinger (18, p. 578) admits that while psychologists have seized upon the semantic differential with enthusiasm, educators have shown much less ardor. Educational studies in which the semantic differential has been used are rare. Is the semantic space in which teacher is embedded one that will promote learning? Or will it impede learning? These are questions which Kerlinger believes can be answered, in part at least, with the aid of the semantic differential.

Kerlinger refers to this instrument as a useful and sensitive tool to help in the exploration of an extremely important area of psychological and educational concern: connotative meaning. Brinton (6, p. 293) and Cronbach (11, p. 565) concur that the semantic differential is a proper tool for use in measuring attitudes.

McCallon and Brown assert that to the extent that principles governing the change of attitudes can be known, they may be used to manipulate an individual's reactions to relevant objects. They feel that this accounts, at least in part, for the fact that the study of attitudes has occupied a central place in education, psychology, psychotherapy, and social psychology during the past 50 years. They assert that semantic differential scales of the type developed by Osgood have proven useful to researchers in quantifying highly subjective data. They further note that:

> It was hypothesized that the more easily constructed semantic differential could be used to measure attitude toward mathematics as effectively as the...more involved and difficult Likert technique (19, p. 69).

Unlike the construction of Likert technique instruments, elaborate item analysis procedures and repeated revisions of the semantic differential instrument are not necessary. In the opinion of McCallon and Brown, this constitutes a major advantage of the semantic differential technique (19, p. 70)

Osgood (22, p. 21) asserts that meaning is one of the most significant pivotal variables in human behavior, and even a crude and very provisional measure of it, such as the semantic differential now is, readily finds uses.

These remarks by Osgood from his preface to Semantic Differential Technique are enlightening:

> I must confess that sometimes I feel like the Geppetto of a wayward Pinocchio who has wondered off into the Big City, and Lord knows what mischief he is getting into. Some people think Pinocchio is a specific standardized test: he is not, of course, being subject to concept/scale interaction. Some think he is a measure-in-general: he is not, of course, reflecting primarily affective meaning by virtue of the metaphorical usage of his scales (22, p. ix).

There seems to be much evidence that this is a valid and interesting technique with which to work.

Overview of the Semantic Differential

Osgood (22, p. 82) discusses two forms for the semantic differential. Form I has the concept on each line followed by the bipolar pair. Form II has the concept at the top of the page and the scales gathered on the page. Osgood states that there is no evidence of differences between the use of these two graphic forms. Thus, because of the ease of construction and administering, Form II will be used in this study.

Brinton (6, p. 291) reports the use of an interesting device placed at the end of the semantic differential in a study he conducted on capital punishment. The subject was asked to rate his over-all feeling about capital punishment. This was to be with "Strongly in favor of it" and "Strongly against it" as the two extreme comments of a scale with seven intervals. The purpose of this single scale was to establish an attitudinal rating for the subjects so that they could be divided into pro- and anti-capital punishment groups. The single scale, rating overall feeling, seemed to be an extremely simple method of dividing the subjects into two groups. Subjects checking the first, second, or third intervals on the scale were placed in a pro-capital punishment group. Subjects checking the fifth, sixth, or seventh intervals were placed in an anti-capital punishment group. Those scoring in the fourth interval were regarded as being in a neutral position. This device seems to be meaningful for this study. Such a scale has been included at the end of the instrument and was used to support the validity of the instrument. It was helpful to see if the instrument "sees" the subject as the subject "sees" himself.

Concepts and Scales

Osgood (22, p. 77) uses the term "concept" in a very general sense to refer to the "stimulus" to which the subject's checking operation is a terminal "response." Although single "words" often serve, Osgood suggests that a unitary semantic concept may require a noun phrase, such as: "My Ideal Self." It is the nature of the problem under study that chiefly defines the class and form of the concept to be selected. Sometimes the investigator may actually make a sampling analysis, but more often, in Osgood's experience, he simply uses "good judgment" with respect to his problem. In exercising such judgment, the investigator will usually try to select concepts for the meanings of which he can expect considerable individual differences, since this is likely to augment the amount of information gained from a limited number of concepts. Also, he must try to select concepts having a single, unitary meaning for the individual, since otherwise the subject may vacillate in what is being judged. Osgood's last suggestion is that the investigator use concepts that can be expected to be familiar to all of his subjects, since unfamiliar concepts for some subjects will produce a regression toward the middle of the scales.

The other part of the instrument is the scales, which Nunnally (20, p. 43) described as a seven-point rating continuum used for each pair of bipolar adjectives. Scales may be chosen to incorporate the factors which have been found in previous studies. Osgood (22, p. 78) describes three factors: (1) evaluation, defined by scales like good-bad, valuable-worthless, and kind-cruel; (2) potency, defined by scales like strong-weak, large-small, and rugged-delicate; (3) activity, defined by scales like active-passive, fast-slow, and sharp-dull. He states that the relative weights of these factors have been fairly consistent; evaluation accounting for approximately double the weight of any subsequent factors. But since a large portion of the total variance remains unaccounted for, he assumes that there must be other factors operating. Since their individual contributions to the total variance are small, he assumes their number must be large, that is, a large number of relatively specific semantic factors. Nunnally (20, p. 43) has found a fourth factor, understandability, which occurs prominently in his studies of mental-health concepts. It is defined by scales like understandable-mysterious, familiar-strange, simple-complicated, and predictable-unpredictable. It seems that this factor is applicable to a study of attitudes toward mathematics.

Osgood (22, p. 78) states that the process of choosing scales is necessarily more structured than that of choosing concepts. The first criterion for selecting scales is their factorial composition. He suggests selecting about three scales to represent each factor, these being maximally loaded on that factor and minimally on others. Another criterion in scale selection is relevance to the concepts being judged. Still another is their semantic stability for the concepts and subjects in a particular study. He suggests further that the use of scales of unknown factorial composition might be highly relevant to a particular problem. Kerlinger (18, p. 569) concurs and further states that Osgood's original fifty scales (22, p. 67) by no means exhaust adjective possibilities.

He comments that one might wish to use polarities like progressive-traditional and permissive-restrictive in a study of educational attitudes.

The pairs of adjectives are separated by seven spaces. Osgood (22, p. 328) states that the use of seven-step scales having a bipolar or verbal opposites form and defined by certain adjectives has been fairly constant in his work with the semantic differential. He related the following adjectives to the scaled position between the bipolar pair X and Y: (1) extremely X, (2) quite X, (3) slightly X, (4) neither X nor Y; equally X and Y, (5) slightly Y, (6) quite Y, (7) extremely Y. Osgood is convinced that this seven-step scale, defined by the linguistic quantifiers "extremely," "quite," and "slightly," in both directions from a neutral "meaningless" origin, do yield nearly equal psychological units in the process of judgment. He suggests that scales could be made up with polar terms defined by nouns (good vs. evil, strength vs. weakness, etc.) or verbs (loving vs. hating, going vs. stopping, etc.). However, the choice was more conventional in this beginning setting.

Brinton (6, p. 291) reports that using the evaluative factor loadings, as reported by Osgood, which represent an average over many concepts may not be the best criterion for selecting adjectives for use on one specific concept. The meaning and evaluative strengths of adjectives can change from one concept to another. In other cases, loss of evaluative strength might be caused by ambiguity when applied to a given concept or by irrelevance to the concept. There are many reservations about the consistency of correlating factor loadings. This is done by generating data in a particular setting. Since the setting of the study reported here is relatively virgin, the relationship of factors is one of the goals of this study.

Kerlinger (18, p. 571) agrees that the selecting of bipolar pairs is an interesting and important part of the construction of the instrument. He suggests the use of unknown quantities. One cannot always be sure of relevance. Meanings are rich and complex, and an apparently irrelevant adjective pair may turn out to be relevant.

All of these comments were considered when the concepts and scales were selected for the instrument used in this study. There was an effort to construct an instrument that was not too global, one that could measure more than one of the many facets of attitudes. Also, an instrument of some length was considered so that there would be the possibility of measuring a small change of attitude.

The concepts were selected to sample three areas related to a college student's exposure to mathematics. Each area was then represented by specific concepts as follows:

1. Educational Experiences with Mathematics
    My Favorite Elementary Mathematics Teacher Was:
    My Favorite High School Mathematics Teacher Was:
    Most Elementary Mathematics Classrooms Are:
    Most High School Mathematics Classrooms Are:

2. Mathematics Skills and Courses
   Computational Skills
   Word Problems
   Modern Math
   Geometry
   Algebra
   Arithmetic
   Calculus

3. Mathematics in the World
   Mathematicians are:
   Historically, Mathematics Is:
   In a Practical Sense, Mathematics Is:

These fourteen concepts were randomly arranged to appear in the instrument. This arrangement and the entire MASD is contained in Appendix A.

After the concepts were fixed, the next step in the construction of the instrument was the selection of the adjective pairs. All of the previous comments on this selection were considered during this process. Some thought was given to representing the known factors. But it was anticipated that whatever pairs were chosen there was the strong possibility that the behavior of these pairs in this experimental setting would be different from previous behavior.

After due consideration, the pairs were selected. The three factors developed by Osgood and his colleagues were represented. Also the factor found by Nunnally was included. Finally, Kerlinger's suggestion to include an appropriate pair of unknown polarity was followed. These five factors were represented in the following way in the instrument:

1. Evaluative factor
   good-bad
   valuable-worthless
   wise-foolish
   kind-cruel
   successful-unsuccessful

2. Potency factor
   strong-weak
   mature-youthful
   severe-lenient
   masculine-feminine

3. Activity factor
   active-passive
   complex-simple
   excitable-calm
   interesting-boring
   fast-slow

4. Understandability factor
   understandable-mysterious
   predictable-unpredictable

5. Unknown factor
   progressive-traditional

These seventeen adjective pairs were randomly ordered for the MASD. This arrangement is contained in Appendix A.

After much preliminary reading and thought, the MASD came into being quite easily. There was much work done that was well documented and interesting to read. There was little work done in the specific area that this study was to touch. The decision to test by using the three areas first mentioned seemed to dictate the rest of the instrument. Choosing the more stable portions to include and then what to speculate with was all that was left to do. Having an instrument that was practical and easy to administer was the final consideration that established the final form of the MASD.

The instrument in its entirety is found in Appendix A. This form includes instructions for administration of the Mathematics Attitude Semantic Differential, the Description Information Page, the Mathematics Attitude Semantic Differential, the random item page, and the good-bad scale.

CHAPTER II

PROCEDURE

Methodology and Design

Assumptions and Format of Instrument

Since the central thrust of this study was the development of a suitable instrument with which to measure the attitudes toward mathematics held by college students enrolled in mathematics courses, a primary concern of the study was to establish the worth of this instrument.

To establish its worth, the data yielded by it were treated statistically. In part, statistical treatment is determined by level of measurement. Osgood (22, p. 93) discussed an important assumption when data gathered with a semantic differential are treated statistically. He assumed that the intervals both within a single scale and between different scales were equal. Osgood (22, p. 152) cited the doctoral dissertation by Norman Cliff at Princeton University, "The Relation of Adverb-Adjective Combinations to Their Components," 1956, as providing particularly relevant evidence of these scaling assumptions. Considering these data and other indications of his personal study with this type instrument, Osgood made the following conclusive statement concerning an approximate equality of intervals between scales: "It seems reasonable to conclude that the scaling properties assumed with the semantic differential have some basis other than mere assumption" (22, p. 152)

The basic "score" obtained from MASD was the sum of the subject's check-marks with which he indicated his judgment of a particular concept against a particular scale. Thus, the data were treated as measures on an interval scale.

Reliability

The reliability of an instrument is usually said to be the degree to which the same scores can be reproduced when the same objects are measured repeatedly (22, p. 126). In a study conducted by Osgood (22, p. 33), forty items sampled from a total of 1000 items were repeated on a single page at the end of the form. This sample included 40 different scales (of the fifty used in the experiment) and all 20 concepts, each appearing twice. Test and re-test scores were correlated across the 100 subjects and the 40 items, producing an N of 4000. The resulting coefficient was .85.

A similar procedure was used to establish reliability in this study. Since the Form II was used, some adjustment of the described procedure was implemented. In Osgood's study, each item was a concept followed by the adjective pair with the seven-step scale between. Each concept together with each pair can be considered an item of MASD. The fourteen concepts and the seventeen adjective pairs used in MASD yield 238 items. A sample of twenty of these items was randomly selected with the same restrictions used by Osgood:

> For checking reliability, 40 of these 1000 items, chosen at random, but with the restriction that no concept should be used more than twice and no scale more than once, were repeated as a final page of the mimeographed test booklet. The ordering of the concept-scale pairings was deliberately rotated rather than random; it was felt that this procedure would better guarantee independence of judgments, since the maximum number of items (19), would intervene between successive judgments of the same concept and the maximum number of items (49) would intervene between successive judgments on the same scale (22, p. 34).

This page of twenty items will be referred to as the random item page. The test-retest reliability measure was computed using the Pearson product-moment coefficient of correlation. The pair of scores needed for this computation was found by scoring the random item page and then scoring each item as it was marked in the instrument itself. This procedure was used to test the hypothesis that r = 0 (7, p. 187). This hypothesis will be stated formally shortly.

Validity

There are several different kinds of validity to consider. Osgood makes the following conclusive statement about the content validity of data gathered with the use of the semantic differential:

> Throughout our work with the semantic differential we have found no reasons to question the validity of the instrument on the basis of its correspondence with the results to be expected from common sense (22, p. 141).

There is reason to assume, then, that inherent in the instrument will be content validity.

Generally, an instrument is said to be valid when it measures what it is supposed to measure. Kerlinger suggests that a more refined and quantitative statement is that "an instrument is valid to the extent that scores on it correlate with scores on some criterion of that which is supposed to be measured" (18, p. 140). There are some established test results in the area of attitudes toward mathematics. They were secured from the Revised Math Attitude Scale developed by Aiken and Dreger (27, p. 242). This measure is in use (12, p. 4) and considered useful for decision making, so it is appropriate to ask whether MASD agrees with this source of information. Cronbach (11, p. 122) suggests that to obtain related data the two measures, the Revised Math Attitude Scale and MASD, should be used concurrently, that is, at very nearly the same time. In order to adhere to his suggestion the two tests were administered to the same subjects in a single setting. One half of the sample was given the Revised Math Attitude Scale first, followed immediately by MASD. The reverse procedure was used with the other half of the sample. The

Pearson product-moment correlation (r) was used to determine if there was a relationship between the scores obtained from the Revised Math Attitude Scale and the scores obtained from MASD. This procedure tests the hypothesis: $r = 0$ (7, p. 155). This hypothesis will be stated in a later section.

Another valuable way to establish the validity of an instrument is suggested by Edwards when he states:

> One of the best procedures in the preliminary evaluation of statements is to have several individuals respond to the statements as they would if they had favorable attitudes toward the objects under consideration. The same individuals may then be asked to respond to the statements as they would if they had unfavorable attitudes. If it is possible for them to give similar responses of acceptance or rejection when they assume different attitudes, then such statements are not likely to be of value in an attitude scale. Preliminary evaluation of statements in the manner prescribed can thus serve to eliminate many ambiguous as well as factual statements (14, p. 13).

Using this suggestion, the instrument was administered to a sample of subjects. Half of the subjects were asked to play the role of a student with a desirable attitude toward mathematics and mark the instrument accordingly. The other half was asked to mark the instrument as if they were students with an undesirable attitude toward mathematics. Immediately thereafter the entire group was asked to mark the scale again with the roles reversed. The participants were also asked to mark statements they considered ambiguous and make suggestions for improving the structure of the instrument. Kerlinger (18, p. 454) concurs that in order to test the hypothesis that items are valid measures of attitudes, the items may be built into an attitude scale and administered to groups presumed to be different in the specific attitude to be studied. He refers to this as the known-groups method.

This procedure was used with Group I in the sample. The three groups are identified later in this chapter. The score made by a student when he was marking the instrument with a desirable attitude will be referred to as the favorable score. The score made by a student when assuming an undesirable attitude will be referred to as the unfavorable score. The hypotheses suggested by the statistical treatment of the known-groups, the favorable-unfavorable data, will be set forth in the following section.

Construct validity was established by comparing the means of the scores of students categorized by an artificial dichotomy. The scale suggested by Brinton (6, p. 294) in his study of capital punishment was used to form the dichotomy. Two groups were determined by considering as a low group the subjects who checked the scale at the first, second, or third interval and by considering as a high group those subjects who checked the scale at the fifth, sixth, or seventh interval. Those subjects checking the fourth interval (the neutral position) on the scale were ignored. The high-low groups were compared across all concepts and all scales in an over-all fashion.

To compare the high-low groups generated by the above procedure, the Student's t statistic was used. The hypothesis tested by the t-test analysis was that the means of the two groups were equal (7, p. 10). The hypotheses suggested will be stated shortly.

Hypotheses

The following hypotheses represent statements of expectancy regarding MASD:

1. Data obtained from the known-groups suggest the following hypotheses:

   H_0: The correlation coefficient obtained from the favorable-unfavorable data will be zero ($r = 0$).

   H_1: The correlation coefficient obtained from the favorable-unfavorable data will not be zero ($r < 0$).

2. Test-retest reliability measure suggests the following hypotheses:

   H_0: The correlation coefficient obtained from the test-retest data will be zero ($r = 0$).

   H_1: The correlation coefficient obtained from the test-retest data will not be zero ($r > 0$).

3. Data obtained from the high-low groups suggest the following hypotheses:

   H_0: The difference between the means of the two groups will be zero.

   H_1: The mean of the high group will exceed the mean of the low group.

4. Correlation between the Revised Math Attitude Scale and MASD suggests the following hypotheses:

H_0: The correlation coefficient obtained from the scores of the two instruments will be zero ($r = 0$).

H_1: The correlation coefficient obtained from the scores of the two instruments will be unequal to zero ($r > 0$).

The hypothesis H_0, in every case, was to be rejected at the 0.05 level of significance using a one-tailed test.

Hypothesis 1 was tested using Group I. Group II and Group III were used to test Hypothesis 2 and Hypothesis 3. Group III was used to test Hypothesis 4. These groups will be discussed in detail later in the chapter.

Since the sample used for this study was drawn from the populations of two different universities, the following sub-hypotheses were tested.

The hypothesis

SH_0: There will be no difference in the mean scores of N.T.S.U. students and the mean scores of T.W.U. students.

was to be tested against the alternate hypothesis

SH_1: There will be a difference in the mean scores of N.T.S.U. students and the mean scores of T.W.U. students.

The hypothesis SH_0 was to be rejected at the 0.05 level of significance using a two-tailed test. These two hypotheses were tested using Group II and Group III.

Collection of Data

The data for this study were collected in three parts. Each part was secured from groups of students enrolled in mathematics classes at North Texas State University or

Texas Woman's University. The first group was composed of four classes of students. The students in a class in trigonometry and the first semester of a survey course in mathematics (for liberal arts majors) taught by Dr. Lee Kennedy accounted for two of the classes. These two classes will be referred to as Class A and Class B. The rest of the group came from a second semester of calculus and a second semester of the survey course taught by Dr. Turner Hogan. These two classes will be referred to as Class C and Class D. Classes A and B were tested on July 23, 1973 and Classes C and D were tested on July 27, 1973. These four classes will be noted as Group I.

The second segment of the sample was collected during the late summer and fall of 1973. Class E of this portion was a class of mathematics for elementary teachers held at North Texas State University, taught by Dr. George Willson. Class F was also a class of mathematics for elementary teachers taught by Dr. Juanita Prater at Texas Woman's University. Class G was a course in calculus taught by the writer at T.W.U. Class E was tested on August 6, 1973; Class F was tested on August 1, 1973; and Class G was tested on October 12, 1973. This group of three classes will be referred to as Group II.

The last portion of the data, Group III, was collected during the spring semester of 1974. Class H of this portion was a calculus class taught by the writer. Class J was also taught by the writer and was a class in elementary analysis. Class K was a course in mathematics for elementary teachers, also conducted by the writer. These three classes were held at Texas Woman's University. All three classes were tested on March 15, 1974. Class L, Class M, and Class N were courses in mathematics for elementary teachers held at North Texas and conducted by Dr. George Willson. These three classes were tested on April 8, 1974.

All testing was conducted during class periods allotted for the courses. This testing was necessarily performed on different days and in different locations. The availability of the subjects for testing and the testing schedule were determined by attendance and by the faculty members responsible for the class instruction.

The following tables exhibit some particular data about the sample. The first table, Table I, contains census data relevant to the segments of the sample. The second table, Table II, relates information pertaining to the majors of the students participating in the study. The following list defines these major fields:

a - Education Specialties, such as Music Education, Reading, and Bilingual Education
b - Elementary Education
c - Health, Physical Education, and Recreation
d - Health Sciences, such as Medical Technology and Nursing
e - Household Arts & Sciences, such as Interior Design, and Child Care
f - Mathematics
g - Physical Therapy
h - Science
i - Special Education
j - Others, such as Library Science, Computer Science, and Art

TABLE I

CENSUS DATA BY GROUPS

	Sex		Classification					Age			
	M	F	Fr.	So.	Jr.	Sr.	Gr.	17-20	21-25	26-30	over 30
A	1	9	4	2	3	1	0	4	5	1	0
B	0	20	4	10	2	4	0	12	7	1	0
C	0	11	2	0	7	1	1	7	4	0	0
D	0	23	3	3	9	7	1	9	11	1	2
Group I	1	63	13	15	21	13	2	32	27	3	2
E	5	14	0	0	3	11	5	2	12	3	2
F	0	33	0	0	13	14	6	4	21	3	5
G	3	20	9	9	4	1	0	20	2	1	0
Group II	8	67	9	9	20	26	11	26	35	7	7
H	3	14	10	3	4	0	0	12	5	0	0
J	1	13	7	4	2	1	0	11	3	0	0
K	0	8	0	4	3	1	0	5	2	0	1
L	6	19	0	0	17	7	1	9	11	2	3
M	3	18	0	0	16	3	2	3	17	0	1
N	2	27	0	0	16	8	5	7	18	1	3
Group III	15	99	17	11	58	20	8	47	56	3	8
Grand Total	24	229	39	35	99	59	21	105	118	13	17

TABLE II

MAJORS BY GROUPS

	a	b	c	d	e	f	g	h	i	j
A	0	1	1	0	0	0	4	3	0	1
B	3	5	1	4	3	0	0	0	0	4
C	0	0	0	1	0	4	0	5	1	0
D	3	4	4	1	6	0	0	0	1	4
Group I	6	10	6	6	9	4	4	8	2	9
E	3	16	0	0	0	0	0	0	0	0
F	8	12	0	1	0	0	0	0	9	3
G	0	0	0	0	0	0	23	0	0	0
Group II	11	28	0	1	0	0	23	0	9	3
H	0	0	0	2	0	0	14	0	0	1
J	1	0	0	3	0	2	4	1	0	3
K	1	4	0	0	0	0	0	0	3	0
L	2	18	0	4	0	0	0	0	0	1
M	1	18	0	0	0	0	0	0	2	0
N	1	26	0	0	0	0	0	0	1	1
Group III	6	66	0	9	0	2	18	1	6	6
Grand Total	23	104	6	16	9	6	45	9	17	18

The data collected from each group and the procedure will be discussed below.

Group I

Group I was the known-groups sample. Each student scored two tests. One with the subject assuming a "good" attitude and one with the subject assuming a "bad" attitude toward mathematics. The adjectives "good" and "bad" were not defined for the students. Half of each class was asked to mark the instrument with a "good" attitude first and then immediately after mark the instrument with a "bad" attitude. The other half of the class was asked to do the reverse. As each student turned in the first test, he was handed another test to score with the opposite attitude. The good-bad scale discussed earlier was included at the end of the test. Each student was asked to mark this scale before marking the instrument. This device was used to help the student take on the attitude he was to assume.

The students were asked to include remarks about their reaction to the instrument. Often they remarked about the difficulty of role-playing. Some such examples are:

> I would like to take a test like this if I could just be myself.

> ...difficult to imagine...how one with a bad attitude would answer.

> What is the relevancy of the role playing?

Perhaps there is some evidence in these remarks of the students being conscientious and trying to do what was asked of them. In every case the score on the test with the assumed "good" attitude was higher than the score on the assumed "bad" attitude.

Some other interesting comments supplied by the participants in this sample were:

> I was sort of scared...
>
> ...at least it didn't have any math problems to be solved.
>
> Perhaps the approach taken toward mathematics by my teacher left the impression on me of its being worthless.

Sixty-seven students took the test package. Three packages had to be omitted because of improper scoring. Hence, Group I numbers 64.

After analysis of this sample's responses, it was assumed that the instrument was reasonable in form and that the instructions were sufficiently clear to have a subject score the instrument properly.

Group II

The personnel in Group II were asked to mark the instrument with their true impressions. Included at the end of the instrument was the random item page discussed earlier. The good-bad scale was also included.

This group of students was also permitted to comment on the instrument. Some interesting remarks were:

> The only statement I might have about this survey is that the adjectives used seem to apply more to people, rather than to an abstract idea

like mathematics. Perhaps there is a definite purpose to this, but I feel that it caused some confusion in answering the survey!

I am from a country other than U.S. Our method of mathematics is the "old" way--I like it very much and I try to teach it in my classroom.

Why use masculine and feminine?

As this investigator began to sample one of the classes, the instructor remarked that the scores of these students on an attitude toward mathematics test should be low because they performed poorly in mathematics. This was probably evidence of an assumption that attitude toward mathematics and performance in mathematics are related. This, of course, is not necessarily true. In fact, after this instrument is perfected, some research in this area would be beneficial.

The package for Group II was taken by 75 students. All of the packages were scored properly. There was one incomplete package in Class G. This package did not contain the good-bad scale. There was one incomplete package in Class F. This package did not contain the random item page. These facts will be noted when necessary in the following discussion.

Group III

This portion of the sample, Group III, was given the MASD and the Revised Math Attitude Scale of Aiken described earlier. The MASD package included the random item page and the good-bad scale. Half of the students in each class took MASD first and Aiken's test second. The other half of each class did the reverse. In every case, one test was immediately followed by the other.

A Description Information Sheet was used with the MASD in Group I and Group II. Certain facts about the participant were collected with this page. A revised Description Information Sheet was used in Group III. The revision was made in order to collect the information in a more precise manner. The original Description Information Sheet is included in Appendix B. The revised Description Information Sheet is included with the complete MASD in Appendix A. This was the only change in the MASD during the collection of the data.

Some interesting remarks included by students in this group were:

> My over-all attitude is bad because I have an envious attitude towards people who comprehend a science which is fundamental.

> ...not because I don't like it--because I am not good at it.

> improving with Willson (because of him).

Perhaps these remarks pertain to the relevance of attitude and performance in mathematics.

Aiken's Revised Math Attitude Scale was a Likert-type summated scale. Here, again, the subjects were asked to mark one and only one of the five replies possible for each of the statements, the one that most nearly represented the participant's true feelings. Their choices consisted of SA

(Strongly Agree), A (Agree), U (Undecided), D (Disagree), or SD (Strongly Disagree). The choices were weighted from 5 for favorable choices to 1 for unfavorable choices. The data then consisted of the summated scores of the weights for the choices. Data from summated rating scales are commonly treated as being from an interval scale, as was done with these scores.

This package was taken by 113 students. Every package was scored correctly. There was one incomplete package in Class N. This package did not contain the Revised Math Attitude Scale. This will be noted when appropriate in the following discussion.

The testing was conducted, in every case, by the writer. In some instances the instructor of the class was present. The testing was always done during the scheduled time for each class and in the scheduled classroom.

Statistical Tests

There is one central thrust in this study--to establish a valid, reliable instrument with which to measure the attitudes toward mathematics held by students enrolled in college courses in mathematics. This was accomplished by testing the hypotheses stated previously. There was a second, related goal--to analyze the sample used to develop the instrument. This second goal was accomplished by testing the secondary hypotheses and by simply inspecting the sample itself.

The sets of students from Group I were compared. This was accomplished by statistically treating two groups of scores. One was the scores of students marking the MASD with a desirable attitude on the first of the two tests taken by each student. The second was the collection of scores of students marking the MASD with a desirable attitude on the second test taken by the participant. The Student's t-test as described by Bruning and Kintz (7, p. 10) was used to make this comparison. The procedure was repeated using the undesirable test scores of the same two groups of students. This was done to determine if the order of testing affected the scores on the MASD.

Hypothesis 1 was then tested using data from Group I. The two scores of each student were paired and the correlation coefficient was generated (7, p. 153). This source of data was used to test Hypothesis 1.

> H_0: The correlation coefficient obtained from the favorable-unfavorable data will be zero ($r = 0$).

was to be tested against the alternate hypothesis

> H_1: The correlation coefficient obtained from the favorable-unfavorable data will not be zero ($r < 0$).

To test Hypothesis 2, the test-retest method, as presented in Bruning and Kintz (7, p. 187), was used. The test-retest method is used to establish the reliability of measurement.

> H_0: The correlation coefficient obtained from the test-retest data will be zero ($r = 0$).

was to be tested against the alternate hypothesis

> H_1: The correlation coefficient obtained from the test-retest data will not be zero ($r > 0$).

The two sets of scores needed to run the test-retest method were obtained by pairing the score made by a given student on the random item page with the score made by the same student on each item on the random item page within the instrument. These data were generated by the students in Group II and the students in Group III.

The high-low groups were obtained from the scores of the students in Group II and Group III on the good-bad scale. The favorable group was made up of students who scored themselves at 5, 6, or 7 on the good-bad scale. The unfavorable group was made up of students who scored themselves at 1, 2, or 3 on the good-bad scale. The group of students who scored 4 on the good-bad scale were ignored. These two sets of scores were then compared using the t-test for the difference between two independent means (7, p. 9). These data were used to test Hypothesis 3.

> H_0: The difference between the means of the two groups will be zero.

was to be tested against the alternate hypothesis

> H_1: The mean of the high group will exceed the mean of the low group.

Each student in Group III took the Revised Math Attitude Scale and the MASD. Half of each of the six classes composing this group took MASD first and the Revised Math Attitude Scale second. The other part of each class did the reverse. The set of MASD scores taken as a first test was compared with the set of MASD scores taken as a second test. This comparison was accomplished by using the Student's t-test for a difference between two independent means (7, p. 9). The procedure was repeated using the scores from the Revised Math Attitude Scale taken by each student in this group. This treatment was similar to that undertaken with Group I. Again, this procedure was followed to ascertain if the order the tests were taken affected the scores.

The correlation between the Revised Math Attitude Scale and MASD was determined with Group III. The pair of scores generated by each student was used to find the correlation coefficient (7, p. 153). This source was used to test Hypothesis 4.

> H_0: The correlation coefficient obtained from the scores of the two instruments will be zero ($r = 0$).

was to be tested against the alternate hypothesis

> H_1: The correlation coefficient obtained from the scores of the two instruments will be unequal to zero ($r > 0$).

In order to analyze the sample, several comparisons were made. Since the sample was drawn from students enrolled at N.T.S.U. and T.W.U., it would be helpful to know if these two groups of students could have been drawn from the same population.

An analysis was made of common classes taught at N.T.S.U. and T.W.U. to determine how portions of the sample enrolled in like courses compared. To accomplish this end, analysis of variance as described by Bruning and Kintz was implemented (7, p. 22). This design is basically an extension of the t-test to experiments involving three or more groups.

The courses tested at both N.T.S.U. and T.W.U. were classes of mathematics for elementary teachers. From Group II, these were Class E and Class F. From Group III, the common classes of mathematics for elementary teachers were Class K, Class L, Class M, and Class N. From this group of six classes, Class F and Class K were T.W.U. classes. The other four classes of mathematics for elementary teachers were taught at N.T.S.U.

Common classes taught at T.W.U. and N.T.S.U. were compared to see if the classes taught at each of these universities were alike in terms of MASD scores. Classes E, L, M, and N were classes in mathematics for elementary teachers taught at N.T.S.U. These four classes were compared. Class G and Class H were classes in calculus taught at T.W.U. Class J was a class in pre-calculus mathematics and should have a student population somewhat like the calculus student, so Class J was compared with Class G and Class H. In these two clusters of classes, one group of four classes and one group of three classes, analysis of variance was again used (7, p. 22).

Classes F and K were classes in mathematics for elementary teachers taught at T.W.U. These two classes were compared. Since in this instance, the comparison unit consisted of only two classes, the t-test was used.

The comparisons across N.T.S.U. and T.W.U., and within these two universities were made to test the hypotheses SH_0 and SH_1.

> SH_0: There will be no difference in the mean scores of N.T.S.U. students and the mean scores of T.W.U. students.

was to be tested against the alternate hypothesis

> SH_1: There will be a difference in the mean scores of N.T.S.U. students and the mean scores of T.W.U. students.

To understand the sample better, the mean, median, and standard deviation of each class within each group was computed and will be exhibited in Chapter III.

The scores used to generate these results can be found in Appendix D.

Assumptions and Limitations

In this study Group I, Group II, and Group III were considered to be samples from the same population having been drawn at different times. The population to which the writer wished to apply the results of this study was all those individuals enrolled in mathematics classes at North Texas State University and Texas Woman's University. Generlizations to other populations cannot be justified statistically at this time.

The purpose of this study as stated earlier was to establish a valid and reliable instrument with which to measure attitudes toward mathematics held by students enrolled in college mathematics classes. It was anticipated that the results of this study would provide information to establish the instrument.

CHAPTER III

ANALYSIS OF DATA

Introduction

The analysis of data is presented in three main sections. The first section contains the analysis of data related to the comparison of the classes of the sample. The second section contains the analysis of data related to the reporting of specific semantic differential data. The third section reports the analysis of data concerning the establishment of the instrument and the treatment of the hypotheses.

In order to compare groups, the mean, median, and standard deviation for each part of each group will be exhibited. This comparison was carried further by using analysis of variance and the t-test for independent means to compare common classes from N.T.S.U. and T.W.U. and common classes within N.T.S.U. and T.W.U. This material was used to test hypotheses SH_0 and SH_1.

Using Group I, a report on how often the favorable and the unfavorable tests of a given student were marked in a similar way was developed. Using Group II, a coefficient matrix will be exhibited to show relations between the bipolar pairs. This evidence was established to find if the factors used in previous research were behaving similarly in this material.

Then all other hypotheses were tested. This was done by treating, in Group I, the favorable and unfavorable sets of scores. In Group II, the random item page score was tested in the test-retest method and the high-low groups were correlated. The random item page, the high-low groups, the scores from the MASD, and the scores from the Revised Math Attitude Scale from Group III were treated statistically.

In this third section the Student's t-test and the Pearson product-moment r statistic were used. Before determining a t-value, the homogeneity of the two distributions was assessed by using an F test. A brief discussion of these techniques is appropriate. Kerlinger (18, p. 259) presents the conditions necessary, in his opinion, to validate the t-test. There are three such conditions. The most famous but apparently not the most important assumption behind the use of these parametric statistics is the <u>assumption of normality</u>. Robson (25, p. 72) concurs with Kerlinger that it has been demonstrated that the t-test is extremely robust with respect to violation of this assumption. There can be considerable deviation from normality without the result of the t-test being affected.

Popham further supports these feelings with the following:

> In practice it usually is considered satisfactory if the sample data do not depart drastically from normality...As one often has difficulty in drawing purely random samples in educational situations, a more reasonable guide would be to make sure that the sample has not been drawn in such a fashion that it is a biased representation of the population under study...In general the assumptions noted above are quite lenient. One can depart quite markedly from them and still obtain a t value which can be correctly interpreted (23, p. 139).

In this study, it was assumed that the sample did not deviate from normalcy in an extreme way. Hence, the condition of normality was believed to be met and the resulting t-tests were accepted as valid.

The next most important assumption discussed by Kerlinger is known as the _homogeneity of variance_ assumption. This assumption can be tested by a statistical technique known as the F ratio in which the larger estimate of variance is divided by the smaller estimate of variance. The quantity that results is known as F and is interpreted for statistical significance from a table similar to the t-table. The smaller the F the more tenable the assumption that the variances of scores for the two variables are equal.

Kerlinger reports that these two assumptions have both been examined rather thoroughly by empirical methods. Artificial populations have been set up, samples drawn from them, and t and F tests performed. The evidence to date is that the importance of normality and homogeneity is overrated, a view that is shared by Kerlinger.

A third assumption is that the measures to be analyzed are continuous measures with equal intervals. This condition is met with the semantic differential. Previous work by Osgood and others has established that semantic differential data are interval. These observations were discussed in Chapter II.

These remarks of Kerlinger (18, p. 260) were helpful in choosing proper statistical tests to treat the data in this study:

> To the readers who have been alarmed by some statistics books the best advice probably is: Use parametric statistics, as well as the analysis of variance, routinely, but keep a sharp eye on data for gross departures from normality, homogeneity of variance, and equality of intervals. Be aware of measurement problems and their relation to statistical tests...

The scores used in the various comparisons to be presented may be found in Appendix D.

Profile of Groups

Means, Medians, and Standard Deviations

Each student in Class A, Class B, Class C, and Class D took two tests. One assuming a favorable attitude and one assuming an unfavorable attitude. The means, medians, and standard deviations for each class are reported for the favorable tests, and then for the unfavorable tests. These were computed from raw scores from MASD. There are 14 concepts and 17 bipolar pairs on the instrument. This generates 238 items for the subject to score. The score on each of these items may range from one to seven, with four being a neutral position. This, then, produces a possibility of a low score of 238 and a high score of 1666. If a subject were to mark each item with a 4, the neutral score, the result would be a score of 952. Thus, a score above 952 could be considered evidence of a better attitude toward mathematics than a score of under 952. Notice in the following table, the means and medians of each of the favorable groups are over 952. The means and medians of the unfavorable groups fall, in every case, below the neutral score of 952.

Of the 64 subjects in Group I, only two scores on the favorable test were below or equal to the 952 score. Both of these subjects were in Class D, a survey course in mathematics for the liberal arts major. Of the 64 subjects, 15 scored above the neutral score of 952 for their test assuming an unfavorable attitude. There were 2 such scores in Class A, a course in elementary analysis; there were 7 such scores in Class B, the survey course; there were 2 such scores in Class C, the second semester of calculus; and there were 3 such scores in Class D, the largest class in the group, another section of the survey course.

Thus, if one were to define a "good" attitude as a score on MASD above the score of 952, a "bad" attitude as a score below 952, and a score of 952 as neutral, then it was easier for this group of students to assume a good attitude than a bad one. These scores are all contained in

Appendix D.

The means, medians, and standard deviations of Group I are contained in the following table.

TABLE III

MEANS, MEDIANS, AND STANDARD DEVIATIONS GROUP I

Class	Mean	Median	Standard Deviation
Favorable			
A	1222.00	1272.00	162.21
B	1170.00	1164.50	112.39
C	1161.43	1191.00	109.35
D	1236.92	1239.00	124.36
Group I	1186.55	1202.50	125.81
Unfavorable			
A	860.00	886.50	149.43
B	883.05	891.00	113.79
C	852.39	848.00	141.65
D	841.91	875.00	112.15
Group I	861.35	878.00	122.13

The means, medians, and standard deviations for Group II are reported in Table IV. These subjects were tested with their honest feelings. This group is also reported by classes and then as a whole. Class E was a class in mathematics for elementary teachers, as was Class F. Class G was a calculus class. The first class was from N.T.S.U. The last two classes were from T.W.U.

TABLE IV

MEANS, MEDIANS, AND STANDARD DEVIATIONS GROUP II

Class	Mean	Median	Standard Deviation
E	1064.68	1037.00	120.63
F	1097.18	1105.00	102.63
G	1107.52	1116.00	81.09
Group II	1092.12	1105.00	100.29

The means, medians, and standard deviations for Group III from the MASD instrument are exhibited in Table V. This group was also tested for its true feelings. Class H was a calculus class. Class J was a class in elementary analysis. Class K, Class L, Class M, and Class N were classes in mathematics for elementary teachers. Class H, Class J, and Class K were classes at T.W.U. Class L, Class M, and Class N were classes at N.T.S.U. These means, medians, and standard deviations are reported by classes and then for the entire group.

TABLE V

MEANS, MEDIANS, AND STANDARD DEVIATIONS GROUP III MASD

Class	Mean	Median	Standard Deviation
H	1133.65	1112.00	98.63
J	1141.57	1132.00	133.81
K	1137.87	1137.00	82.26
L	1060.80	1083.00	101.32
M	1076.14	1078.00	89.12
N	1062.48	1050.00	117.03
Group III	1090.25	1096.50	109.70

The means, medians, and standard deviations for Group III, as these statistics occurred on the Revised Math Attitude Scale, are reported in Table VI. Again, these rates are reported by classes and then for the group as a whole.

TABLE VI

MEANS, MEDIANS, AND STANDARD DEVIATIONS
GROUP III REVISED MATH
ATTITUDE SCALE

Class	Mean	Median	Standard Deviation
H	63.94	63.00	18.87
J	69.21	73.00	20.85
K	74.75	73.50	9.77
L	59.80	64.00	22.75
M	59.85	58.00	18.51
N	59.67	57.50	20.65
Group III	62.63	65.00	20.15

The mean, median, and standard deviation from the MASD for Group II and Group III treated as an entity are exhibited in Table VII.

TABLE VII

MEAN, MEDIAN, AND STANDARD DEVIATION
GROUP II AND GROUP III MASD

Mean	1090.99	Median	1102.00	Standard Deviation	105.79

Comparisons Within the Sample

In order to generalize the inferences gained in this study, it was necessary to compare the N.T.S.U. student and the T.W.U. student. This was done using data from Group II and Group III. In Group II, there was a class of mathematics for elementary teachers from each of the universities. These classes were Class E and Class F. The former held at N.T.S.U. and the latter at T.W.U. In Group III, there was also classes in mathematics for elementary teachers held at each of the schools. Class K was taught at T.W.U. Class L, Class M, and Class N were the same course taught at N.T.S.U. The four classes from N.T.S.U. were taught by the same teacher. The two classes from T.W.U., Class F and Class K, were taught by different instructors.

To compare the six classes mentioned, analysis of variance was used as described by Turney and Robb (32, p. 130). An F ratio equal to or greater than 2.29 would have indicated significant difference among these six group means. The reported F value was smaller than required at the 0.05 level for the appropriate degrees of freedom. It was concluded, therefore, that there was no significant difference between the scores on MASD for N.T.S.U. and T.W.U. students. This analysis is reported in the following table.

TABLE VIII

ANALYSIS OF VARIANCE FOR SIX CLASSES OF COMMON COURSES FROM N.T.S.U. AND T.W.U.

Source	SS	df	ms	F
Total	1473783.33	134		
Between Groups	58615.60	5	11723.12	1.06
Within Groups	1415167.73	129	10970.29	

In order to compare the common classes at N.T.S.U., Class E, Class L, Class M, and Class N were compared, again using analysis of variance (32, p. 130). Each of these four classes was a class in mathematics for elementary teachers. Class E was from Group II, the other three classes were from Group III. All four of these classes were taught by the same teacher.

Here again the F value was smaller than required for significance at the 0.05 level for the appropriate degrees of freedom. An F ratio equal to or greater than 2.68 would have indicated significant difference among these four group means. It was concluded, therefore, that there was no significant difference between the classes tested at N.T.S.U. The following table exhibits the results of this analysis.

TABLE IX

ANALYSIS OF VARIANCE FOR FOUR CLASSES FROM N.T.S.U.

Source	SS	df	ms	F
Total	1033907.40	93		
Between Groups	3207.46	3	1069.15	.09
Within Groups	1030699.94	90	11452.22	

From the classes tested at T.W.U. there were two sections of calculus and one section of elementary analysis in the sample. Class G and Class H were classes of calculus. Class J was an elementary analysis course. The student who takes elementary analysis will take the calculus soon after. So the scores from the elementary analysis class were compared with the scores from the calculus sections. All three classes were taught by the same teacher. Class G was in Group II. Class H and Class J were from Group III. Analysis of variance was used to compare these three classes (32, p. 130)

Here, also, the reported F value was smaller than required for significance at the 0.05 level for the appropriate degrees of freedom. An F ratio equal to or greater than 3.15 would have indicated significant difference among these three group means. It was concluded that there was no significant difference between these three classes. The following table exhibits the results of this analysis.

TABLE X

ANALYSIS OF VARIANCE FOR THREE CLASSES FROM T.W.U.

Source	SS	df	ms	F
Total	545277.21	53		
Between Groups	12132.15	2	6066.08	.58
Within Groups	533145.06	51	10453.82	

There were two classes of mathematics for elementary teachers taught at T.W.U. One was Class F from Group II and the other was Class K in Group III. These two classes were taught by different teachers. The Student's t-test was used to compare Class F and Class K.

The value required to demonstrate statistical significance at the 0.05 level is shown in parenthesis. Since both reported values for this case were less than the tabled values for the appropriate degrees of freedom, it was concluded that there was no significant difference between Class F and Class K. The following tables exhibit the F value and the t value for these two classes.

TABLE XI

F VALUE FOR CLASS F
AND CLASS K

N of each Class	F	df	Table Value
F 33 K 8	1.55	32/7	(3.41)

TABLE XII

t VALUE FOR CLASS F
AND CLASS K

N of each Class	t	df	Table Value
F 33 K 8	1.040	39	(1.684)

After considering the comparisons made between and within classes from N.T.S.U. and T.W.U., it was concluded that there was no significant difference between or within these classes. The conclusions gained from this study can, therefore, justifiably be generalized to these two schools.

Specific Semantic Differential Data

In this section some data that appeared because of the nature of the semantic differential will be reported. The first such material was found from the data generated by Group I. In this group, each participant scored two copies of the MASD package. One was marked with an acceptable attitude, and one was marked with the participant assuming an unacceptable attitude. This situation presented the possibility of studying an interesting and important aspect of the instrument--differentiability. Does the MASD perform differently for persons with different attitudes? The scores from these two tests were paired and tested statistically, also. These results will be reported later. But here an investigation was undertaken to see how the instrument was performing on an item basis.

The pair of tests for each participant from Group I was compared. Each time a subject marked an item, a concept together with a bipolar pair, the same way on the favorable and the unfavorable test scored by this individual was counted. Since there were seventeen pairs and fourteen concepts in each test, there was a possibility for each subject to do this 238 times. There were 64 sets of tests. Thus, it was possible for this duplication to happen 15,232 times. Table XIII reports the number of times this was actually done.

In the table, the pair is identified and then the number of times a duplication occurred is reported. The position in which the pair appears in the instrument is given, along with the factor represented by the pair. The factors represented are:

P - potency
E - evaluation
A - activity
U - understandability
T - traditional-progressive

TABLE XIII

DUPLICATE COUNT FOR GROUP I

Pair	Duplicates	Order	Factor
Feminine-masculine	431	9	P
Mature-youthful	218	17	P
Cruel-kind	182	10	E
Weak-strong	157	14	P
Active-passive	156	15	A
Excitable-calm	84	4	A
Slow-fast	81	7	A
Lenient-severe	76	2	P
Wise-foolish	64	8	E
Bad-good	46	5	E
Unpredictable-predictable	46	12	U
Traditional-progressive	38	3	T
Successful-unsuccessful	31	6	E
Complex-simple	29	16	A
Valuable-worthless	24	13	E
Understandable-mysterious	21	1	U
Interesting-boring	4	11	A

It was possible to duplicate 15,232 times. This actually happened 1,688 times or only 11.08 percent of the time. After consideration, it was concluded that this was not excessive. Hence, the form of the instrument was acceptable.

The second set of semantic differential data to be reported was generated from Group II. Using this group, a correlation matrix was constructed. This was done by correlating each of the bipolar pairs with every other bipolar pair. This correlation is reported in Table XIV. The correlation is given in the order in which the pairs appear in the instrument. Included below is the factor which each pair was chosen to represent.

This order is:

1. Understandable-mysterious U
2. Lenient-severe P
3. Traditional-progressive T
4. Excitable-calm A
5. Bad-good E
6. Successful-unsuccessful E
7. Slow-fast A
8. Wise-foolish E
9. Feminine-masculine P
10. Cruel-kind E
11. Interesting-boring A
12. Unpredictable-predictable U
13. Valuable-worthless E
14. Weak-strong P
15. Active-passive A
16. Complex-simple A
17. Mature-youthful P

Also, the pair good-bad was correlated with the raw scores of Group II. The resulting r was .857. The N in this sample was 75 so a critical-ratio z-test was done. The z was 7.373. Since the z was so large, the r was significant at the 0.05 level. Because of this significance, the row in the matrix for the pair good-bad is of special interest. This is the fifth row.

The matrix is exhibited in the following table. Each pair is represented by the number which corresponds to the order in which it appears in the MASD, the same number as it appeared in the list just stated. Table XIV is the coefficient matrix. Table XV, which follows, contains the z scores for each entry in Table XIV.

In Table XIV the decimal is deleted before each entry and the negative entries are underlined. The reported correlation, in each case, is significant at the 0.05 level if the entry is greater than the table value of 0.3799. In Table XV the decimal is deleted between the first and second digits and, again, the negative entries are underlined.

In order to better understand what was happening in the correlation of the adjective pairs, Table XVI was prepared. This table exhibits the manner in which the adjective pairs were clustering in this study. Again, the numbers refer to the order the adjective pairs were presented in the instrument. Both positive and negative significant correlation were reported.

TABLE XIV

COEFFICIENT MATRIX
GROUP II

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
2.	35															
3.	13	17														
4.	27	07	20													
5.	71	19	05	44												
6.	73	24	05	47	85											
7.	27	03	35	41	51	53										
8.	48	21	21	53	77	75	50									
9.	07	13	07	08	11	13	08	09								
10.	51	46	02	18	65	59	37	60	11							
11.	61	24	11	57	71	72	45	67	06	51						
12.	56	17	15	07	45	37	06	27	04	41	31					
13.	58	16	12	41	78	81	43	77	05	57	73	35				
14.	35	17	29	39	65	66	61	76	13	61	58	23	58			
15.	39	07	23	45	58	58	48	59	18	41	61	17	51	70		
16.	39	37	25	06	24	23	06	11	08	37	19	39	07	11	02	
17.	10	02	11	05	03	01	08	16	06	07	03	05	09	23	33	57

Decimal deleted before each entry.
Negative entries underlined.
Significant at 0.05 level if greater than 0.3799.

TABLE XV

z VALUE FOR COEFFICIENT
MATRIX GROUP II

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
2.	29															
3.	<u>11</u>	<u>15</u>														
4.	<u>23</u>	07	<u>17</u>													
5.	61	17	05	<u>38</u>												
6.	63	21	05	<u>40</u>	73											
7.	23	03	31	<u>36</u>	43	45										
8.	41	18	19	<u>45</u>	65	64	43									
9.	<u>05</u>	11	<u>06</u>	07	<u>09</u>	<u>11</u>	<u>07</u>	<u>07</u>								
10.	44	39	01	<u>15</u>	55	51	32	51	<u>10</u>							
11.	63	21	10	<u>49</u>	61	62	39	58	05	43						
12.	48	15	<u>13</u>	<u>05</u>	39	31	05	23	03	35	27					
13.	50	14	11	<u>35</u>	67	70	37	66	<u>04</u>	49	62	30				
14.	29	14	25	<u>33</u>	56	57	53	65	<u>11</u>	52	49	21	49			
15.	33	06	19	<u>39</u>	50	49	41	50	<u>15</u>	35	53	15	43	60		
16.	<u>33</u>	<u>32</u>	22	05	<u>21</u>	<u>19</u>	<u>05</u>	<u>09</u>	<u>07</u>	<u>31</u>	<u>15</u>	<u>34</u>	<u>05</u>	<u>09</u>	02	
17.	<u>09</u>	<u>01</u>	10	<u>05</u>	03	01	07	13	<u>05</u>	<u>07</u>	02	<u>04</u>	07	19	28	49

Decimal deleted between first and second digits.
Negative entries underlined.

TABLE XVI

SIGNIFICANT CORRELATION FROM THE COEFFICIENT MATRIX

	Positive Correlation	Negative Correlation
1.	5, 6, 8, 10, 11, 12, 13, 15	16
2.	10	
3.		
4.		5, 6, 7, 8, 11, 13, 14, 15
5.	1, 6, 7, 8, 10, 11, 12, 13, 14, 15	4
6.	1, 5, 7, 8, 10, 11, 13, 14, 15	4
7.	5, 6, 8, 11, 13, 14, 15	4
8.	1, 5, 6, 7, 10, 11, 13, 14, 15	4
9.		
10.	1, 2, 5, 6, 8, 11, 12, 13, 14, 15	
11.	1, 5, 6, 7, 8, 10, 13, 14, 15	4
12.	1, 5, 10, 16	
13.	1, 5, 6, 7, 8, 10, 11, 14, 15	4
14.	5, 6, 7, 8, 10, 11, 13, 15	4
15.	1, 5, 6, 7, 8, 10, 11, 13, 14	4
16.	17	1, 12
17.	16	

From this preliminary work it appeared that there were several factors working in this study. The pairs 6, 8, 11, 13, and 15 have the same positive correlation. Each of these pairs correlate with each other significantly, and in addition, correlate highly with 1, 5, 7, 10, and 14. It seemed that these ten pairs were working together to form a cluster, to use Osgood's term (22, p. 96). The following is a list of these two sets of five ordered pairs, together with the factors they were chosen to represent:

6.	Successful-unsuccessful	Evaluative
8.	Wise-foolish	Evaluative
11.	Interesting-boring	Activity
13.	Valuable-worthless	Evaluative
15.	Active-passive	Activity
1.	Understandable-mysterious	Understandability
5.	Bad-good	Evaluative
7.	Slow-fast	Activity
10.	Cruel-kind	Evaluative
14.	Weak-strong	Potency

The ordered pair 4 had a significant negative correlation with eight of the ten pairs mentioned above. This pair was excitable-calm. It was chosen to represent the Activity factor. The pairs 16 and 17 correlate significantly with each other. These two pairs were complex-simple and mature-youthful. The former represents Activity and the latter Potency. The pairs 2 and 12 both correlate with the pair 10. Twelve is the bipolar pair unpredictable-predictable for Nunnally's factor of Understandability. The pair second in the instrument was lenient-severe, which represented the Potency factor.

The pairs 3 and 9 do not correlate significantly with any other pairs. The third pair was traditional-progressive which was suggested by Kerlinger. The ninth pair was feminine-masculine. This pair was chosen to represent the Potency factor.

If any conclusion could be drawn at this point, it must be that there was more than one factor working in this semantic space. It also appears that the pairs were clustering in a different way from the manner in which they clustered in other work done with the semantic differential in different settings. Certainly more statistical treatment of these and other similar data should be done.

Testing Hypotheses

In this section, the material will be directly concerned with the instrument itself. Here the testing of the hypotheses stated in Chapter II will be reported.

Hypothesis 1

The first hypothesis was to be tested using the known-groups data from Group I. During the testing, each member of the sample took two tests. One assuming a favorable attitude and one assuming an unfavorable attitude. Half of the sample took the "good" test first, immediately followed with the "bad" test. The other half of the sample did the reverse. This procedure was followed to offset the effect, if any, of the order of the tests. To understand the effect of the order of these two tests, a t-test was run on the set of "good" tests taken by the entire sample, and then on the set of "bad" tests taken by the entire sample. The negative t indicated that the mean for the "bad" tests taken as a first test was smaller than the mean for the "bad" tests taken as a second test. In each case a t value equal to or greater than 1.671 would have indicated significant difference between the means involved. Both reported values were less than this figure. The conclusion was that the order in which the students took the tests did not affect their scoring. These results are included in the following tables.

TABLE XVII

DIFFERENCE BETWEEN MEAN SCORES ON THE "GOOD" TESTS OF GROUP I

	N	t	df
"Good" tests taken as first test	32	.611	62
"Good" tests taken as second test	32		

TABLE XVIII

DIFFERENCE BETWEEN MEAN SCORES ON THE "BAD" TESTS OF GROUP I

	N	t	df
"Bad" tests taken as first test	32	-.703	62
"Bad" tests taken as second test	32		

Then Hypothesis 1 was tested. In this instance

H_0: The correlation coefficient obtained from the favorable-unfavorable data will be zero ($r = 0$).

was to be tested against the alternate hypothesis

H_1: The correlation coefficient obtained from the favorable-unfavorable data will not be zero ($r < 0$).

The results on each pair of tests scored by each student in Group I were paired and tested with the Pearson product-moment correlation coefficient (7, p. 153). Each pair of test scores was treated as an ordered pair. The first entry in each pair was the score generated by the "good" test. The second entry was the score on the "bad" test. Thus, the collection of "good" tests were being correlated with the collection of "bad" tests. The number for this test result was 64. The degrees of freedom was 62. The resulting r was -.461. For 60 degrees of freedom (the closest value for 62 degrees of freedom) the result .250 was significant at the 0.05 level. The result -.461, then, indicated a significant negative correlation between the "good" and "bad" tests of each student in Group I.

This result implied that H_0 could be rejected at the 0.05 level of significance. There was, therefore, significant negative correlation between the set of scores made when a desirable attitude was assumed and the set of scores made when an undesirable attitude was assumed. This evidence supported the assumption that the MASD discriminates between groups of people who have different attitudes. It was concluded that the MASD differentiates attitudes held toward mathematics by college students enrolled in mathematics classes. This conclusion substanstiated the validity of the MASD. The scores used in this analysis are included in Appendix D.

Hypothesis 2

In this section the test-retest data generated by Group II and Group III were treated to test

H_0: The correlation coefficient obtained from the test-retest data will be zero ($r = 0$).

against the alternate hypothesis

H_1: The correlation coefficient obtained from the test-retest data will not be zero ($r > 0$).

Here again the Pearson product-moment coefficient was used (7, p. 153).

The test-retest data were composed of the score made by each student on the random item page included in every MASD package taken by the participants in Group II and Group III, together with the score made by the same student on each item included on this special page as marked in the instrument itself.

The following table contains the results of correlating these two scores for each member of Group II and Group III. Then the two groups were treated as an entity and the procedure was repeated. The standard error of measurement is also included for each of the three sets of data. The scores used in this analysis are presented in Appendix D.

TABLE XIX

CORRELATION OF TEST-RETEST DATA

	N	r	Standard Error of Measurement
Group II	74	+.752	49.944
Group III	113	+.751	54.740
Total	187	+.750	52.875

The reported r values were significant at the 0.05 level in every case. It was concluded that the hypothesis H_0 was rejected. There was, then, significant correlation between the scoring that each student performed on the MASD itself and on the random item page which followed the MASD. This analysis supported the reliability of the instrument.

<u>Hypothesis 3</u>

In order to test Hypothesis 3, the high groups and low groups differentiated by the good-bad scale included in the MASD package were treated using the Student's t-test (7, p. 10). This was done with the scores from Group II and then with the scores from Group III. The following table contains the results of these procedures.

TABLE XX

ANALYSIS OF HIGH-LOW GROUPS FROM MASD

N	t	df
Group II High 50 Low 18	+4.705	66
Group III High 71 Low 34	+5.466	103

The same dichotomy used in Table XX was used again to separate the participants of Group III into two sets. These sets were treated again using the Student's t-test (7, p. 10). This time the scores used were the scores from the Revised Math Attitude Scale. The following table contains the results of this procedure.

TABLE XXI

ANALYSIS OF HIGH-LOW GROUPS REVISED MATH ATTITUDE SCALE

N	t	df
Group III High 71 Low 34	+10.049	103

The t values reported in Table XX and Table XXI were significant at the 0.05 level in every case. The scores used in both instances are presented in Appendix D. This analysis was done to test

> H_0: The difference between the means of the two groups will be zero.

against the alternate hypothesis

> H_1: The mean of the high group will exceed the mean of the low group.

It was concluded that the hypothesis H_0 was rejected.

There was, then, significant difference between the high and low groups of Group II and Group III. This significant difference was also shown by the Revised Math Attitude Scale. This further supports the discriminatory value of MASD. This also furnishes evidence of similarity between the MASD and a test already in use. These observations help to substantiate the validity of MASD.

Hypothesis 4

In this section the data gathered from Group III using the MASD and the Revised Math Attitude Scale were treated again. Here the hypothesis

> H_0: The correlation coefficient obtained from the scores of the two instruments will be zero ($r = 0$).

was tested against the alternate hypothesis

> H_1: The correlation coefficient obtained from the scores of the two instruments will be unequal to zero ($r > 0$).

During the testing, each participant took both tests, MASD and the Revised Math Attitude Scale. Half of the sample took the MASD first immediately followed by the Revised Math Attitude Scale. The other part of the sample did the reverse. This procedure was followed to offset the effect, if any, of the order of the tests. A t-test was run on the MASD scores of the entire sample, and then on the Revised Math Attitude Scale scores of the entire sample. The results are included in the following tables.

TABLE XXII

DIFFERENCE BETWEEN MEAN SCORES ON THE MASD GROUP III

	N	t	df
MASD taken as first test	57	-.958	110
MASD taken as second test	55		

TABLE XXIII

DIFFERENCE BETWEEN MEAN SCORES ON THE REVISED MATH ATTITUDE SCALE GROUP III

	N	t	df
Revised Math Attitude Scale taken as first test	55	.047	110
Revised Math Attitude Scale taken as second test	57		

A t value greater than or equal to 1.658 was necessary to show significant difference at the 0.05 level. Both reported t values were below this level. The negative t indicated that the mean for the MASD scores taken as a first test was smaller than the mean for the MASD scores taken as a second test. The conclusion was that the order in which the students took the tests did not affect their scoring.

The results on each of the two tests scored by each student in Group III were paired and tested with the Pearson product-moment correlation coefficient (7, p. 153). Each pair of test scores was treated as an ordered pair. The first entry in each pair was the score generated by the Revised Math Attitude Scale. The second entry was the score on the MASD. Thus, the collection of Revised Math Attitude Scale scores was being tested against the MASD scores. The number for this test result was 111. The resulting r was +.643. For 100 degrees of freedom (the closest value for 111 degrees of freedom) a result greater than or equal to .1946 indicated significance at the 0.05 level. The reported result of .643, therefore, implied a significant correlation between the MASD and the Revised Math Attitude Scale.

These results indicated that the hypothesis H_0 was rejected at the 0.05 level of significance. There was, therefore, significant correlation between the set of scores made on a test already in use and the MASD. That there was not a perfect or near perfect positive correlation was an indication that the MASD was measuring constructs different from those measured by the Revised Math Attitude Scale. These conclusions further substantiated the validity of the MASD.

The scores used in these analyses were included in Appendix D.

Summary

The analysis of the data can be summarized as follows:

1. The portions of the sample drawn from the two different universities were similar. Also there was significant sameness between the classes used within each of the universities. This is evidenced by the fact that SH_0 was not rejected.

2. The reliability of the MASD was substantiated by the treatment of Hypothesis 2. The results of the treatment of Hypotheses 1, 3, and 4 support the validity of the instrument. This analysis also shows evidence of the discriminatory value of the MASD.

CHAPTER IV

SUMMARY AND CONCLUSIONS

Summary

Many types of mathematics courses at the college level have enhancing students' attitudes toward mathematics as one of the main goals. This is especially true of survey courses for liberal arts majors and mathematics courses for prospective elementary teachers. Recently included in this type class is a course in mathematics for health science majors. Such courses, designed for a special major and requiring little application of sophisticated mathematics, seem to be appearing more and more often each academic year.

In courses of this type, the mathematics instructor is to provide the students with sufficient information to eradicate the multitudinous deficiencies with which they enter the course. This task, of course, turns out to be impossible. Thus, the game plan becomes something akin to opening windows instead of stuffing sausages (always a better choice) and attitude begins to play a major role. The prior experiences of students with mathematics looms as large, if not larger, then the students' intellectual capabilities.

After reading about and experiencing the importance of the role of student attitude in the learning situation, in particular, in the mathematics classroom at the university level, some consideration was given as to how change in attitude, if indeed this phenomenon can occur, might by measured. After perusal of the literature, it was determined that there was actually a paucity of instrument with which to measure such attitudes; especially instruments sensitive enough to measure change; and an abundance of research in which a claim was made that such a change had been found when the instrument with which the measuring was accomplished had been inadequately tested for its merits.

The few instruments that were in use had some common deficiencies, namely, they were rather global in scope, in that they measured only one of the many complex and interesting facets of attitudes, and many of these aspects were not measured at all. Also, there were some particulars of the student experience with mathematics that were simply not tapped by these instruments.

Thus, the purpose of this study was to develop a reliable and valid instrument for measuring attitudes toward mathematics in college mathematics classes. The vehicle used to accomplish this end was the semantic differential.

Much material has been written, read, and published about the semantic differential. It is an efficient, interesting, and helpful tool with which to measure some of the many facets of meaning. It has been used in varied ways since Charles Osgood, George Suci, and Percy Tannenbaum began concentrating on the development of an objective measure of meaning. Their book, The Measurement of Meaning, presents a progress report of that research.

There is much to read of research concerning the semantic differential reported since the appearance in the 1950's of The Measurement of Meaning. This tool has been used in many fields, to measure and report many different aspects of meaning. There has been little use of this device in the field of education. Especially has this application been lacking in the field of research being done with mathematics in higher education.

Thus, the need for an instrument to measure attitudes toward mathematics, the highly developed use of the semantic differential, and the almost total absence of this interesting tool in this complex field of attitudes toward mathematics prompted this study. The title given the instrument was the Mathematics Attitude Semantic Differential. It has been referred to as MASD.

The sample for this study was chosen from the university where the writer is a member of the mathematics faculty, Texas Woman's University, and a near-by university in the same town, North Texas State University. The sample was selected and tested during the summer and fall of 1973, and the spring of 1974. The subjects were students who were enrolled in mathematics classes at each of these universities. Each time the instrument was administered, the students were assured that their scores would have no influence on their grades. They were asked to participate candidly, carefully, and anonymously. There was evidence that this advice was heeded.

The sample consisted of three parts: Group I, Group II, and Group III. Group I was tested during the summer of 1973. It consisted of four classes from T.W.U. Each member of this group was asked to score two copies of the Mathematics Attitude Semantic Differential (MASD). During one administration of the instrument, the subject assumed a desirable attitude. During the other administration the subject assumed an undesirable attitude. This was done to determine the discriminatory nature of the MASD. There were 64 students in Group I.

The students in Group II were given a MASD package and asked to express their true feelings. This package contained a description information sheet, a set of instructions for taking the MASD, the MASD, a good-bad scale, and a random item page. Each of these portions of the package has been described previously. Data were secured from this group to establish the reliability and validity of the instrument. There were 75 students in Group II. They were enrolled in both universities. This testing was accomplished during the late summer and fall of 1973.

The members of Group III were given the same package described for Group II. In addition these students were given the Revised Math Attitude Scale, devised by Aiken. This subsample was drawn to verify the data collected with Group II and also to correlate the MASD with an established instrument. Data from Group III were collected during the spring of 1974. As with Group II, students in Group III were enrolled in both universities. There were 113 students in Group III.

The analysis of data was presented in three sections. The first of which was in relation to the groups of the sample. The second of which was in regard to specific semantic differential data. The last of which was concerned with the testing of the hypotheses.

In order to analyze the sample, the mean, median, and standard deviation of each class in the sample were exhibited.

Since the groups in the sample were neither randomly selected nor randomly assigned, a sub-hypothesis was tested to determine whether subsets of the groups were equivalent. This secondary hypothesis, stated in null form, was that there would be no significant difference between the mean scores of the different classes within the groups of the sample.

In order to test this hypothesis, analysis of variance was used. The first set of classes analysized were the common classes from N.T.S.U. and T.W.U. Then the set of classes from N.T.S.U. were compared. The sets of common classes from T.W.U. were analyzed. In each case the value of F for the appropriate degrees of freedom was less than the tabled value for the 0.05 level of significance. The two classes of mathematics for elementary teachers from T.W.U. were compared using the Student's t-test. In this instance the resulting t value for the appropriate degrees of freedom was less than the values from the table at the 0.05 level of significance.

After considering the comparisons made between and within classes from N.T.S.U. and T.W.U., it was concluded that any difference between the groups would be little more than chance differences and the groups were samples drawn at different times from the same population. The conclusions gained from this study can, therefore, justifiably be generalized to these two universities. Though these results cannot be generalized beyond these two universities, the findings do lend themselves to a suggestion of wider applicability.

There were two types of specific semantic differential data discussed. The first had to do with the number of times a participant marked an item the same on the test taken when assuming a desirable attitude and taken when assuming an undesirable attitude. This procedure of counting duplications was carried out with Group I. It was determined that this duplication happened only 11.08 percent of the time. This finding reinforced the discriminatory value of the MASD.

The second type of semantic differential data was a correlation matrix derived from Group II. This matrix contained every adjective pair from the MASD correlated with every other pair. There were seventeen pairs in the MASD, so there were 136 such correlations. The pair good-bad was correlated with the raw scores from this group. The resulting r was .857 which was significant at the 0.05 level. From the matrix, it was noted that nine other pairs correlated significantly with the pair good-bad. This group of ten bipolar adjectives was originally chosen to represent four different factors. There was also some other clustering. It was concluded that there was more than one factor acting in this material, and that the factors found in previous research were not necessarily behaving in the same way in this setting.

Then the hypotheses directly concerning the instrument itself were tested. The first hypothesis was to be tested using the known-groups data from Group I. This hypothesis had to do with the discriminatory value of the MASD. Stated in the null form, this hypothesis was that there would be no correlation between the favorable and unfavorable data. This hypothesis was included to substantiate the validity of the MASD.

Preliminary to testing this hypothesis, a procedure was followed to discover the effect, if any, of the order of taking the two tests, one with a desirable attitude and one with an undesirable attitude. Half of the students in Group I marked the MASD with a desirable attitude first and then immediately scored a MASD assuming an undesirable attitude. The other half of the sample did the reverse. The Student's t-test was used to compare the set of "good" scores on the MASD taken as a first test with the set of "good" scores on the MASD taken as a second test. The procedure was then repeated using the two sets of "bad" scores on the MASD. In each case, the critical value of t for 62 degrees of freedom was less than the 1.671 needed for significance at the 0.05 level. The conclusion was that the order in which the student took the tests did not affect their scoring.

Then the hypothesis was tested. The set of desirable scores was correlated with the set of undesirable scores. There was negative correlation. The result, in absolute value, was greater than the result .250 which was significant at the 0.05 level for 62 degrees of freedom. The null hypothesis was, therefore, rejected at this level of significance. Hence, there was significant negative correlation between the set of scores made when a desirable attitude was assumed and the set of scores made when an undesirable attitude was assumed. This evidence supported the assumption that the MASD discriminates between groups of people who have "good" and "bad" attitudes. This conclusion supports the validity of the MASD.

The test-retest data generated by Group II and Group III were used to test the second hypothesis. In the null form, this hypothesis proposed that the correlation coefficient obtained from the test-retest data would be zero. The test-retest data consisted of the score made by each student on the random item page included in every MASD package taken by the participants in Group II and Group III, together with the score made by the same student on the same items in the instrument itself.

The r value for Group II on the test-retest data, the r value for Group III, and the r value for the two groups treated as an entity were significant in every case. The null hypothesis was rejected at the 0.05 level of significance. There was, then, significant correlation between the scoring that each student performed on the MASD itself and on the random item page which followed the MASD. This analysis supported the reliability of the instrument.

In order to test the third hypothesis, the high groups and low groups, as differentiated by the good-bad scale included in the MASD package, were treated using Student's t-test. This was done with the scores from Group II and then with the scores from Group III. Using Group III again, the same set of high-low participants was used, but this time the set of scores treated were those produced on the Revised Math Attitude Scale. The hypothesis stated in the null form was that the means of the two groups would be equal. The degrees of freedom for Group II was 66. In both cases for Group III, the degrees of freedom was 103. The reported t values in every case were significant beyond the 0.05 level. It was concluded that the null hypothesis was rejected. There was, then, significant difference between the high and low groups of Group II and Group III. This significant difference was also shown by the Revised Math Attitude Scale. This further supported the discriminatory value of MASD, and also furnished evidence of similarity between the MASD and an instrument already in use. These observations help to support the validity of the MASD.

The fourth hypothesis was concerned with the correlation of the MASD with the Revised Math Attitude Scale. Stated in the null form, this hypothesis was that the correlation coefficient obtained from the scores of these two instruments would be zero.

During the testing, each participant took both tests, MASD and the Revised Math Attitude Scale. Half of the sample took MASD first, immediately followed by the Revised Math Attitude Scale. The other part of the sample did the reverse. This procedure was followed to offset the effect, if any, of the order in which the tests were taken. A t-test was implemented on the set of MASD scores taken as a first test and the set of MASD scores taken as a second test. This procedure was then repeated with the Revised Math Attitude Scale scores of the entire sample. Both of the t values were significant for 109 degrees of freedom at the 0.05 level. The conclusion was that the order in which the students took the tests did not affect their scoring.

The collection of Revised Math Attitude Scale scores was then tested against the MASD scores. The degrees of freedom were 111. The resulting r was greater than necessary for significance at the 0.05 level. There was, then, significant correlation between the MASD and the Revised Math Attitude Scale. These results indicated that the null hypothesis was rejected at the 0.05 level of significance. There was, therefore, significant correlation between the set of scores made on a test already in use and MASD. This conclusion further substantiated the validity of the MASD.

The statistical treatment of these hypotheses certainly supported the validity and reliability of the MASD.

Conclusions

The central thesis of this study was to develop a reliable and valid instrument for measuring attitudes toward mathematics held by students enrolled in college mathematics classes. The first step in this process was the development of the instrument itself. Then it was necessary to hypothesize about the reliability and validity of the instrument. Lastly, a sample was chosen with which to test these hypotheses.

After studying the participants used in this study, it was concluded that there was no significant difference between the segments of the sample. Hence, the information generated by this study can be generalized to the students enrolled in courses in mathematics at North Texas State University and Texas Woman's University. Also, even though these findings cannot be generalized beyond these two universities, the results do lend themselves to a suggestion of wider applicability.

That the MASD is a reliable instrument was substantiated by the results of the test-retest data. The significant correlation between the scoring that each student performed on the MASD itself and on the random item page which followed the MASD supported this premise. The coefficient of correlation for the MASD from the random item page was significant at the 0.05 level. This was accepted as evidence of the reliability of the MASD.

The validity of the MASD was investigated in three ways. First, with the known-groups data. The set of tests taken with students assuming an acceptable attitude was correlated with the set of tests taken with the same students assuming an unacceptable attitude. The resulting r was significant beyond the 0.05 level. This evidence supported the assumption that the instrument does distinguish between persons with positive and negative attitudes. This conclusion substantiated the validity of the MASD.

Next, validity was investigated by comparing the high-low groups differentiated by the good-bad scale included in the MASD package. Here the participants imposed a dichotomy themselves. The t value for Group II and the t value for Group III were significant beyond the 0.05 level. It was concluded that there was significant difference between these two groups of students who saw themselves as having opposite attitudes. The high and low groups from Group III, were also significantly different when the Revised Math Attitude Scale scores were treated. These findings further supported the discriminatory value of MASD, and also showed evidence of similarity between the MASD and an instrument already in use. These observations point out the validity of the MASD.

Finally, the MASD was correlated with the Revised Math Attitude Scale. The resulting correlation coefficient was significant beyond the 0.05 level. There was, therefore, significant correlation between the MASD and a similar test already in use. Here, again, the validity of the MASD was supported.

Thus, it was surmised that the MASD has potential as a reliable, valid instrument. It has discriminatory value. This study has supplied evidence that the MASD is a provocative instrument, sensitive enough to measure the amount of difference in attitude that would interest a researcher, teacher, or personnel director.

Implications for Future Research

Further treatment of the data collected in this study should be pursued. For instance, the correlation matrix should be treated with the D statistic as Osgood suggests in the Appendix to The Measurement of Meaning. This and similar work should be done to uncover the factors working in this setting.

Some procedures should be followed to study the effect of a time lag using the MASD. Again, this work could be similar to the study conducted by Osgood where intervals of thirty minutes, one day, one week, and three weeks were used (22, p. 133).

The MASD could be used to research data collected from groups of students with notoriously bad attitudes toward mathematics. These might be groups of students who are college graduates, but completely circumvented mathematics while earning their degrees. Especially, elementary majors who do this. Another such group would be students who are forced to change their majors because mathematics courses were being used as screening devices within a particular degree plan.

Much research needs to be done in order to begin to understand the interaction of attitude and performance in mathematics. There is a deficiency in the literature concerning efficient study of this important aspect of teaching mathematics at the college level. Here the MASD could be used effectively and interestingly to upgrade the quality of research in this provocative area.

Of course, included in future proposals for use of the MASD would be a study in which the instrument would be used to see if attitude has been improved when this is a particular goal of a mathematics course or sequence of courses. Here, again, the MASD can be an aid to improving the quality of research.

The list of potential uses for the Mathematics Attitude Semantic Differential is interesting and lengthy.

A SELECTED BIBLIOGRAPHY

(1) Aichele, Douglas B., and Robert E. Reys, eds. Readings in Secondary School Mathematics. Boston: Prindle, Weber & Schmidt, Inc., 1971.

(2) Aiken, Lewis R. "Attitudes Toward Mathematics." Review of Educational Research, XL (October, 1970), 551-596.

(3) Aiken, Lewis R. "Research on Attitudes Toward Mathematics." Arithmetic Teacher, XIX (March, 1974), 229-234.

(4) Aiken, Lewis R. "Two Scales of Attitude Toward Mathematics." Journal For Research in Mathematics Education, V (March, 1974), 67-71.

(5) Allison, Roger B. "Using Adverbs as Multipliers in Semantic Differentials." Journal of Psychology, LVI (1963), 115-117.

(6) Brinton, James E. "Deriving an Attitude Scale from Semantic Differential Data." Public Opinion Quarterly, XXV (1961), 289-295.

(7) Bruning, James L., and B. L. Kintz. Computational Handbook of Statistics. Glenview, Ill.: Scott, Foresman and Company, 1968.

(8) Cambridge Conference on School Mathematics. Goals for School Mathematics. Boston, Mass.: Houghton Mifflin Company, 1961.

(9) Cliff, Norman. "Adverbs as Multipliers." Psychological Review, LXVI (1959), 27-44.

(10) Corcoran, Mary, and E. Glenadine Gibb. "Appraising Attitudes in the Learning of Mathematics." Evaluation in Mathematics. Twenty-Sixth Yearbook for the National Council of Teachers of Mathematics. Washington, D. C.: The National Council of Teachers of Mathematics, 1961, 105-122.

(11) Cronbach, Lee J. Essentials of Psychological Testing. New York: Harper and Row, Publishers, 1970.

(12) Duthitt, Cameron B. "The Effects of a Laboratory on Attitudes in College Freshman Mathematics." Texas Mathematics Teacher, XIX (May-June, 1972), 4-7.

(13) Dutton, Wilbur H., and L. J. Adams. Arithmetic for Teachers. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1961.

(14) Edwards, Allen Louis. Techniques of Attitude Scale Construction. New York: Appleton-Century-Crofts, Inc., 1957.

(15) Gage, H. L., ed. Handbook of Research on Teaching. Chicago: Rand McNally & Company, 1963.

(16) Johnson, Donavan A. "Attitudes in the Mathematics Classroom." School Science and Mathematics, LVII (February), 113-120.

(17) Johnson, Donavan A., and Gerald R. Rising. Guidelines for Teaching Mathematics. 2nd ed. Belmont, California: Wadsworth Publishing Company, Inc., 1972.

(18) Kerlinger, Fred N. Foundations of Behavioral Research. New York: Holt, Rinehart and Winston, Inc., 1964.

(19) McCallon, Earl L., and John D. Brown. "A Semantic Differential Instrument for Measuring Attitude Toward Mathematics." The Journal of Experimental Education, XXXIX (Summer, 1971), 69-70.

(20) Nunnally, Jum C. Popular Conceptions of Mental Health. New York: Holt, Rinehart and Winston, Inc., 1961.

(21) Nunnally, Jum C. "Analysis of Profile Data." Psychological Bulletin, LIX (1962), 311-319.

(22) Osgood, Charles E., George J. Suci, and Percy H. Tannenbaum. The Measurement of Meaning. Urbana: University of Illinois Press, 1957.

(23) Popham, W. James. Educational Statistics. New York: Harper and Row, Pub., 1967.

(24) Remmers, Hermann Henry, and N. L. Gage. Educational Measurement and Evaluation. Rev. Ed. New York: Harper and Brothers, 1955.

(25) Robson, Colin. Experiment, Design and Statistics in Psychology. Baltimore: Penguin Education, 1973.

(26) Romberg, Thomas A. "Current Research in Mathematics Education." Review of Educational Research, XXXIX (October, 1969), 473-491.

(27) Shaw, Marvin E., and Jack M. Wright. Scales for the Measurement of Attitudes. New York: McGraw-Hill Book Company, 1967.

(28) Siegel, Sidney. Nonparametric Statistics for the Behavioral Sciences. New York: McGraw-Hill Book Company, Inc., 1956.

(29) Snider, James G., and Charles E. Osgood, eds. Semantic Differential Technique. Chicago: Aldine Publishing Company, 1969.

(30) Stern, George G. "Measuring Noncognitive Variables in Research on Teaching." Handbook of Research on Teaching. Edited by N. L. Gage. Chicago: Rand McNally & Company, 1963.

(31) Tannenbaum, Percy H. "Initial Attitude Toward Source and Concept as Factors in Attitude Change Through Communication." Public Opinion Quarterly, XX (1956), 413-425.

(32) Turney, Billy L., and George P. Robb. Statistical Methods for Behavioral Science. New York: Intext Educational Publishers, 1968.

APPENDIX A

MATHEMATICS ATTITUDE SEMANTIC DIFFERENTIAL

MATHEMATICS ATTITUDE SEMANTIC

DIFFERENTIAL (MASD)

The purpose of this instrument is to measure the meanings of certain concepts to various persons by having them judged against a series of descriptive scales. The device used is called a semantic differential. It was developed and used extensively to measure meanings in attitude assessment, the study of personality traits, in aesthetics, in advertising, and in other mass communications. This version of the semantic differential assesses attitudes toward mathematics.

On each of the following pages there is a different word or phrase for you to describe. Your description will be made by marking the list of words on the page. Each pair of words forms a scale. By making a check mark along the scale, you can indicate what you associate with the particular concept. You are to rate the work or phrase on each of these scales in order.

If you feel that the word or phrase at the top of the page is highly related with one end of the scale, you would place a check mark as follows:

good _X_:___:___:___:___:___:___ bad

or good ___:___:___:___:___:___:_X_ bad.

If you feel that the word or phrase is moderately related to one or the other end of the scale, you would place your check mark as follows:

weak ___: X :___:___:___:___:___ strong

or weak ___:___:___:___:___: X :___ strong.

If the word or phrase seems only slightly related to one side as opposed to the other, you would check as follows:

active ___:___: X :___:___:___:___ passive

or active ___:___:___:___: X :___:___ passive.

The direction toward which you check, of course, depends upon which of the two ends of the scale seem most characteristic of the word or phrase you are judging.

If you consider the word or phrase to be neutral on the scale, both sides of the scale equally associated with the word or phrase, or if the scale is completely irrelevant, unrelated to the word or phrase, then you should place your check mark in the middle space:

slow ___:___:___: X :___:___:___ fast.

Remember: never put more than one check mark on any scale. And, also, be sure to check every item. If you feel that a pair of adjectives does not apply, or if you are undecided, place the check mark in the center space. Do not leave the line blank.

Do not spend more than a few seconds marking each scale. Do not try to remember how you checked similar items earlier in the instrument. Make each response a

<u>separate</u> <u>and</u> <u>independent</u> <u>judgment</u>. Do not worry or puzzle over individual items. It is your first impressions, the immediate "feelings" about the items, that is needed. On the other hand, do not be careless, because we need your true impressions. You might work quicker if you first form a picture in your mind of the word or phrase mentioned at the top of each page, and after that check each scale rapidly.

We do not need your name on the instrument. We do, however, need the descriptive information asked for on the following page.

Thank you very much for your cooperation.

DESCRIPTION INFORMATION

Course: ______________________

Age: ____________ Sex: Male Female

Major: ____________________________

Classification: Fr. Soph. Jr. Sr. Grad.

Year graduated from high school: _________

Number of years of mathematics studied in high school: _____

Type mathematics student (high school):

Successful Average Unsuccessful

Type general student (high school):

Successful Average Unsuccessful

Number of courses in mathematics attempted in college:

(not including this course) _________

Number of courses in mathematics passed successfully in

college: (not including this course) _________

Grade in highest level mathematics course completed: ______

Describe this highest level mathematics course:

Survey for Liberal Arts Majors Mathematics Education

Elementary Analysis College Algebra Calculus

Other: ___________________________

GEOMETRY

understandable	___:___:___:___:___:___:___	mysterious
lenient	___:___:___:___:___:___:___	severe
traditional	___:___:___:___:___:___:___	progressive
excitable	___:___:___:___:___:___:___	calm
bad	___:___:___:___:___:___:___	good
successful	___:___:___:___:___:___:___	unsuccessful
slow	___:___:___:___:___:___:___	fast
wise	___:___:___:___:___:___:___	foolish
feminine	___:___:___:___:___:___:___	masculine
cruel	___:___:___:___:___:___:___	kind
interesting	___:___:___:___:___:___:___	boring
unpredictable	___:___:___:___:___:___:___	predictable
valuable	___:___:___:___:___:___:___	worthless
weak	___:___:___:___:___:___:___	strong
active	___:___:___:___:___:___:___	passive
complex	___:___:___:___:___:___:___	simple
mature	___:___:___:___:___:___:___	youthful

MATHEMATICIANS ARE:

understandable	___:___:___:___:___:___:___	mysterious
lenient	___:___:___:___:___:___:___	severe
traditional	___:___:___:___:___:___:___	progressive
excitable	___:___:___:___:___:___:___	calm
bad	___:___:___:___:___:___:___	good
successful	___:___:___:___:___:___:___	unsuccessful
slow	___:___:___:___:___:___:___	fast
wise	___:___:___:___:___:___:___	foolish
feminine	___:___:___:___:___:___:___	masculine
cruel	___:___:___:___:___:___:___	kind
interesting	___:___:___:___:___:___:___	boring
unpredictable	___:___:___:___:___:___:___	predictable
valuable	___:___:___:___:___:___:___	worthless
weak	___:___:___:___:___:___:___	strong
active	___:___:___:___:___:___:___	passive
complex	___:___:___:___:___:___:___	simple
mature	___:___:___:___:___:___:___	youthful

WORD PROBLEMS

understandable	___	___	___	___	___	___	___	mysterious
lenient	___	___	___	___	___	___	___	severe
traditional	___	___	___	___	___	___	___	progressive
excitable	___	___	___	___	___	___	___	calm
bad	___	___	___	___	___	___	___	good
successful	___	___	___	___	___	___	___	unsuccessful
slow	___	___	___	___	___	___	___	fast
wise	___	___	___	___	___	___	___	foolish
feminine	___	___	___	___	___	___	___	masculine
cruel	___	___	___	___	___	___	___	kind
interesting	___	___	___	___	___	___	___	boring
unpredictable	___	___	___	___	___	___	___	predictable
valuable	___	___	___	___	___	___	___	worthless
weak	___	___	___	___	___	___	___	strong
active	___	___	___	___	___	___	___	passive
complex	___	___	___	___	___	___	___	simple
mature	___	___	___	___	___	___	___	youthful

MY FAVORITE ELEMENTARY MATHEMATICS TEACHER WAS:

understandable	___:___:___:___:___:___:___	mysterious
lenient	___:___:___:___:___:___:___	severe
traditional	___:___:___:___:___:___:___	progressive
excitable	___:___:___:___:___:___:___	calm
bad	___:___:___:___:___:___:___	good
successful	___:___:___:___:___:___:___	unsuccessful
slow	___:___:___:___:___:___:___	fast
wise	___:___:___:___:___:___:___	foolish
feminine	___:___:___:___:___:___:___	masculine
cruel	___:___:___:___:___:___:___	kind
interesting	___:___:___:___:___:___:___	boring
unpredictable	___:___:___:___:___:___:___	predictable
valuable	___:___:___:___:___:___:___	worthless
weak	___:___:___:___:___:___:___	strong
active	___:___:___:___:___:___:___	passive
complex	___:___:___:___:___:___:___	simple
mature	___:___:___:___:___:___:___	youthful

CALCULUS

understandable	___:___:___:___:___:___:___	mysterious
lenient	___:___:___:___:___:___:___	severe
traditional	___:___:___:___:___:___:___	progressive
excitable	___:___:___:___:___:___:___	calm
bad	___:___:___:___:___:___:___	good
successful	___:___:___:___:___:___:___	unsuccessful
slow	___:___:___:___:___:___:___	fast
wise	___:___:___:___:___:___:___	foolish
feminine	___:___:___:___:___:___:___	masculine
cruel	___:___:___:___:___:___:___	kind
interesting	___:___:___:___:___:___:___	boring
unpredictable	___:___:___:___:___:___:___	predictable
valuable	___:___:___:___:___:___:___	worthless
weak	___:___:___:___:___:___:___	strong
active	___:___:___:___:___:___:___	passive
complex	___:___:___:___:___:___:___	simple
mature	___:___:___:___:___:___:___	youthful

IN A PRACTICAL SENSE, MATHEMATICS IS:

understandable	___:___:___:___:___:___:___	mysterious
lenient	___:___:___:___:___:___:___	severe
traditional	___:___:___:___:___:___:___	progressive
excitable	___:___:___:___:___:___:___	calm
bad	___:___:___:___:___:___:___	good
successful	___:___:___:___:___:___:___	unsuccessful
slow	___:___:___:___:___:___:___	fast
wise	___:___:___:___:___:___:___	foolish
feminine	___:___:___:___:___:___:___	masculine
cruel	___:___:___:___:___:___:___	kind
interesting	___:___:___:___:___:___:___	boring
unpredictable	___:___:___:___:___:___:___	predictable
valuable	___:___:___:___:___:___:___	worthless
weak	___:___:___:___:___:___:___	strong
active	___:___:___:___:___:___:___	passive
complex	___:___:___:___:___:___:___	simple
mature	___:___:___:___:___:___:___	youthful

MODERN MATH

understandable	___	___	___	___	___	___	___	mysterious
lenient	___	___	___	___	___	___	___	severe
traditional	___	___	___	___	___	___	___	progressive
excitable	___	___	___	___	___	___	___	calm
bad	___	___	___	___	___	___	___	good
successful	___	___	___	___	___	___	___	unsuccessful
slow	___	___	___	___	___	___	___	fast
wise	___	___	___	___	___	___	___	foolish
feminine	___	___	___	___	___	___	___	masculine
cruel	___	___	___	___	___	___	___	kind
interesting	___	___	___	___	___	___	___	boring
unpredictable	___	___	___	___	___	___	___	predictable
valuable	___	___	___	___	___	___	___	worthless
weak	___	___	___	___	___	___	___	strong
active	___	___	___	___	___	___	___	passive
complex	___	___	___	___	___	___	___	simple
mature	___	___	___	___	___	___	___	youthful

MOST HIGH SCHOOL MATHEMATICS CLASSROOMS ARE:

understandable	___	___	___	___	___	___	___	mysterious
lenient	___	___	___	___	___	___	___	severe
traditional	___	___	___	___	___	___	___	progressive
excitable	___	___	___	___	___	___	___	calm
bad	___	___	___	___	___	___	___	good
successful	___	___	___	___	___	___	___	unsuccessful
slow	___	___	___	___	___	___	___	fast
wise	___	___	___	___	___	___	___	foolish
feminine	___	___	___	___	___	___	___	masculine
cruel	___	___	___	___	___	___	___	kind
interesting	___	___	___	___	___	___	___	boring
unpredictable	___	___	___	___	___	___	___	predictable
valuable	___	___	___	___	___	___	___	worthless
weak	___	___	___	___	___	___	___	strong
active	___	___	___	___	___	___	___	passive
complex	___	___	___	___	___	___	___	simple
mature	___	___	___	___	___	___	___	youthful

ARITHMETIC

understandable	___:___:___:___:___:___:___	mysterious
lenient	___:___:___:___:___:___:___	severe
traditional	___:___:___:___:___:___:___	progressive
excitable	___:___:___:___:___:___:___	calm
bad	___:___:___:___:___:___:___	good
successful	___:___:___:___:___:___:___	unsuccessful
slow	___:___:___:___:___:___:___	fast
wise	___:___:___:___:___:___:___	foolish
feminine	___:___:___:___:___:___:___	masculine
cruel	___:___:___:___:___:___:___	kind
interesting	___:___:___:___:___:___:___	boring
unpredictable	___:___:___:___:___:___:___	predictable
valuable	___:___:___:___:___:___:___	worthless
weak	___:___:___:___:___:___:___	strong
active	___:___:___:___:___:___:___	passive
complex	___:___:___:___:___:___:___	simple
mature	___:___:___:___:___:___:___	youthful

HISTORICALLY, MATHEMATICS IS:

understandable	___	___	___	___	___	___	___	mysterious
lenient	___	___	___	___	___	___	___	severe
traditional	___	___	___	___	___	___	___	progressive
excitable	___	___	___	___	___	___	___	calm
bad	___	___	___	___	___	___	___	good
successful	___	___	___	___	___	___	___	unsuccessful
slow	___	___	___	___	___	___	___	fast
wise	___	___	___	___	___	___	___	foolish
feminine	___	___	___	___	___	___	___	masculine
cruel	___	___	___	___	___	___	___	kind
interesting	___	___	___	___	___	___	___	boring
unpredictable	___	___	___	___	___	___	___	predictable
valuable	___	___	___	___	___	___	___	worthless
weak	___	___	___	___	___	___	___	strong
active	___	___	___	___	___	___	___	passive
complex	___	___	___	___	___	___	___	simple
mature	___	___	___	___	___	___	___	youthful

MOST ELEMENTARY MATHEMATICS CLASSROOMS ARE:

understandable	___:___:___:___:___:___:___	mysterious
lenient	___:___:___:___:___:___:___	severe
traditional	___:___:___:___:___:___:___	progressive
excitable	___:___:___:___:___:___:___	calm
bad	___:___:___:___:___:___:___	good
successful	___:___:___:___:___:___:___	unsuccessful
slow	___:___:___:___:___:___:___	fast
wise	___:___:___:___:___:___:___	foolish
feminine	___:___:___:___:___:___:___	masculine
cruel	___:___:___:___:___:___:___	kind
interesting	___:___:___:___:___:___:___	boring
unpredictable	___:___:___:___:___:___:___	predictable
valuable	___:___:___:___:___:___:___	worthless
weak	___:___:___:___:___:___:___	strong
active	___:___:___:___:___:___:___	passive
complex	___:___:___:___:___:___:___	simple
mature	___:___:___:___:___:___:___	youthful

COMPUTATIONAL SKILLS

understandable	___:___:___:___:___:___:___	mysterious
lenient	___:___:___:___:___:___:___	severe
traditional	___:___:___:___:___:___:___	progressive
excitable	___:___:___:___:___:___:___	calm
bad	___:___:___:___:___:___:___	good
successful	___:___:___:___:___:___:___	unsuccessful
slow	___:___:___:___:___:___:___	fast
wise	___:___:___:___:___:___:___	foolish
feminine	___:___:___:___:___:___:___	masculine
cruel	___:___:___:___:___:___:___	kind
interesting	___:___:___:___:___:___:___	boring
unpredictable	___:___:___:___:___:___:___	predictable
valuable	___:___:___:___:___:___:___	worthless
weak	___:___:___:___:___:___:___	strong
active	___:___:___:___:___:___:___	passive
complex	___:___:___:___:___:___:___	simple
mature	___:___:___:___:___:___:___	youthful

MY FAVORITE HIGH SCHOOL MATHEMATICS TEACHER WAS:

understandable	___:___:___:___:___:___:___	mysterious
lenient	___:___:___:___:___:___:___	severe
traditional	___:___:___:___:___:___:___	progressive
excitable	___:___:___:___:___:___:___	calm
bad	___:___:___:___:___:___:___	good
successful	___:___:___:___:___:___:___	unsuccessful
slow	___:___:___:___:___:___:___	fast
wise	___:___:___:___:___:___:___	foolish
feminine	___:___:___:___:___:___:___	masculine
cruel	___:___:___:___:___:___:___	kind
interesting	___:___:___:___:___:___:___	boring
unpredictable	___:___:___:___:___:___:___	predictable
valuable	___:___:___:___:___:___:___	worthless
weak	___:___:___:___:___:___:___	strong
active	___:___:___:___:___:___:___	passive
complex	___:___:___:___:___:___:___	simple
mature	___:___:___:___:___:___:___	youthful

ALGEBRA

understandable	___	___	___	___	___	___	___	mysterious
lenient	___	___	___	___	___	___	___	severe
traditional	___	___	___	___	___	___	___	progressive
excitable	___	___	___	___	___	___	___	calm
bad	___	___	___	___	___	___	___	good
successful	___	___	___	___	___	___	___	unsuccessful
slow	___	___	___	___	___	___	___	fast
wise	___	___	___	___	___	___	___	foolish
feminine	___	___	___	___	___	___	___	masculine
cruel	___	___	___	___	___	___	___	kind
interesting	___	___	___	___	___	___	___	boring
unpredictable	___	___	___	___	___	___	___	predictable
valuable	___	___	___	___	___	___	___	worthless
weak	___	___	___	___	___	___	___	strong
active	___	___	___	___	___	___	___	passive
complex	___	___	___	___	___	___	___	simple
mature	___	___	___	___	___	___	___	youthful

GEOMETRY

traditional ___:___:___:___:___:___:___ progressive

WORD PROBLEMS

excitable ___:___:___:___:___:___:___ calm

HISTORICALLY, MATHEMATICS IS:

bad ___:___:___:___:___:___:___ good

MATHEMATICIANS ARE:

active ___:___:___:___:___:___:___ passive

CALCULUS

understandable ___:___:___:___:___:___:___ mysterious

ALGEBRA

mature ___:___:___:___:___:___:___ youthful

MY FAVORITE ELEMENTARY MATHEMATICS TEACHER WAS:

cruel ___:___:___:___:___:___:___ kind

WORD PROBLEMS

traditional ___:___:___:___:___:___:___ progressive

MODERN MATH

lenient ___:___:___:___:___:___:___ severe

IN A PRACTICAL SENSE, MATHEMATICS IS:

cruel ___:___:___:___:___:___:___ kind

MY FAVORITE ELEMENTARY MATHEMATICS TEACHER WAS:

understandable ___:___:___:___:___:___:___ mysterious

COMPUTATIONAL SKILLS

valuable ___:___:___:___:___:___:___ worthless

CALCULUS

unpredictable ___:___:___:___:___:___:___ predictable

HISTORICALLY, MATHEMATICS IS:

weak ___:___:___:___:___:___:___ strong

MATHEMATICIANS ARE:

successful ___:___:___:___:___:___:___ unsuccessful

MOST ELEMENTARY MATHEMATICS CLASSROOMS ARE:
complex ___:___:___:___:___:___:___ simple

GEOMETRY
interesting ___:___:___:___:___:___:___ boring

MY FAVORITE HIGH SCHOOL MATHEMATICS TEACHER WAS:
wise ___:___:___:___:___:___:___ foolish

ARITHMETIC
slow ___:___:___:___:___:___:___ fast

MOST HIGH SCHOOL MATHEMATICS CLASSROOMS ARE:
feminine ___:___:___:___:___:___:___ masculine

What is your over-all attitude toward mathematics?

good ___:___:___:___:___:___:___ bad

APPENDIX B

ORIGINAL DESCRIPTION INFORMATION SHEET

DESCRIPTION INFORMATION

Course: ____________________

Age: ____________ Sex: Male Female

Major: ______________________

Classification: Fr. Soph. Jr. Sr. Grad.

Year graduated from high school: ________

Number of years of mathematics studied in high school: ____

Type mathematics student:

Successful Average Unsuccessful

Type general student:

Successful Average Unsuccessful

Number of courses in mathematics attempted in college: ____

Number of courses in mathematics passed successfully in college: ________

Grade in highest level mathematics course attempted: ______

Indicate this course: Survey for Liberal Arts Majors

Mathematics Education Elementary Analysis

College Algebra Calculus Other: ________

APPENDIX C

REVISED MATH ATTITUDE SCALE

REVISED MATH ATTITUDE SCALE

Directions: Each of the statements on this opinionnaire expresses a feeling which a particular person has towards 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.

SD	D	U	A	SA	1.	I am always under a terrible strain in a math class.
SD	D	U	A	SA	2.	I do not like mathematics, and it scares me to have to take it.
SD	D	U	A	SA	3.	Mathematics is very interesting to me, and I enjoy math courses.
SD	D	U	A	SA	4.	Mathematics is fascinating and fun.
SD	D	U	A	SA	5.	Mathematics makes me feel secure, and at the same time it is stimulating.
SD	D	U	A	SA	6.	My mind goes blank, and I am unable to think clearly when working math.
SD	D	U	A	SA	7.	I feel a sense of insecurity when attempting mathematics.
SD	D	U	A	SA	8.	Mathematics makes me feel uncomfortable, restless, irritable, and impatient.
SD	D	U	A	SA	9.	The feeling that I have toward mathematics is a good feeling.
SD	D	U	A	SA	10.	Mathematics makes me feel as though I'm lost in a jungle of numbers and can't find my way out.

SD D U A SA 11. Mathematics is something I enjoy a great deal.

SD D U A SA 12. When I hear the word math, I have a feeling of dislike.

SD D U A SA 13. I approach math with a feeling of hesitation, resulting from a fear of not being able to do math.

SD D U A SA 14. I really like mathematics.

SD D U A SA 15. Mathematics is a course in school which I have always enjoyed studying.

SD D U A SA 16. It makes me nervous to even think about having to do a math problem.

SD D U A SA 17. I have never liked math, and it is my most dreaded subject.

SD D U A SA 18. I am happier in a math class than in any other class.

SD D U A SA 19. I feel at ease in mathematics, and I like it very much.

SD D U A SA 20. I feel a definite positive reaction to mathematics; it's enjoyable.

APPENDIX D

INDIVIDUAL SCORES OF SUBJECTS PARTICIPATING IN THE STUDY

GROUP I

Subjects by Classes	Acceptable Attitude Score (MASD)	Unacceptable Attitude Score (MASD)
Class A		
1	1406	926
2	1333	1124
3	1160	880
4	1296	767
5	994	938
6	1111	767
7	1248	670
8	954	893
9	1300	1004
10	1418	631
Class B		
11	1407	636
12	1247	996
13	1052	788
14	1226	913
15	1263	720
16	1136	801
17	1140	912
18	1063	885
19	1260	870
20	1108	980
21	1030	971
22	1037	846
23	1189	897
24	1269	826
25	1302	977
26	1027	995
27	1049	693
28	1297	881
29	1219	1013
30	1079	1061

Subjects by Classes	Acceptable Attitude Score (MASD)	Unacceptable Attitude Score (MASD)
Class C		
31	1152	888
32	1026	914
33	1335	1020
34	1281	639
35	1360	766
36	1239	875
37	1122	905
38	1176	788
39	1222	1081
40	1347	643
41	1346	742
Class D		
42	1203	858
43	1227	786
44	1145	1130
45	1251	899
46	1053	788
47	952	719
48	1041	848
49	1257	898
50	1121	903
51	1046	917
52	1161	888
53	1231	876
54	890	786
55	1191	779
56	1249	782
57	1207	631
58	1202	1050
59	1054	1004
60	1275	820
61	1091	939
62	1084	820
63	1383	760
64	1399	724

GROUP II

Subjects by Classes	MASD	Random Item Page	Interior Score	Good-Bad Scale
Class E				
65	992	83	81	5
66	1044	87	82	7
67	950	78	72	4
68	983	90	93	5
69	1184	102	100	7
70	1286	111	98	6
71	1136	106	86	6
72	1198	100	101	6
73	1116	89	95	7
74	980	82	86	5
75	1179	84	95	7
76	1284	104	112	7
77	902	76	78	2
78	947	71	79	2
79	1041	84	87	3
80	988	93	85	4
81	969	66	87	4
82	1013	73	87	6
83	1037	86	85	5
Class F				
84	1006	78	79	2
85	1102	89	83	5
86	1223	102	115	7
87	1192	108	106	5
88	1219	110	107	6
89	1059	83	93	5
90	1017	82	82	5
91	1105	87	89	6
92	1132	98	97	6
93	876	61	63	2
94	1131	96	96	5
95	1079	94	94	1
96	1047	83	81	5

Subjects by Classes	MASD	Random Item Page	Interior Score	Good-Bad Scale
97	951	80	82	1
98	1096	94	100	2
99	1199	105	104	6
100	1169	108	95	6
101	1170	84	96	6
102	1141	98	84	7
103	1152	98	91	7
104	1191	111	102	7
105	1133	83	95	6
106	1113	85	98	2
107	1340	116	111	6
108	889	78	66	3
109	1024	74	82	3
110	1012	66	85	2
111	1071	93	87	1
112	1165	89	94	5
113	975	88	89	2
114	1208	110	104	7
115	1069	111	94	2
116	951	-	-	4
Class G				
117	1010	78	87	4
118	1202	99	100	-
119	1010	92	91	5
120	1117	100	101	6
121	1119	93	97	3
122	995	76	71	6
123	1109	94	90	5
124	1054	85	85	5
125	1107	96	98	7
126	1105	95	90	3
127	1081	89	93	5
128	1176	104	115	7
129	1212	104	96	7
130	1229	104	104	7
131	1022	95	84	5
132	1159	93	93	5
133	922	79	82	4
134	1144	95	93	7
135	1047	91	93	7
136	1121	89	95	7
137	1116	87	81	2
138	1201	91	100	7
139	1215	95	94	6

GROUP III

Subjects by Classes	MASD	Random Item Page	Interior Score	Good-Bad Score	Revised Math Attitude Scale
Class H					
140	1142	82	96	3	43
141	1083	83	89	1	22
142	1131	78	92	4	78
143	1096	87	90	3	41
144	1035	100	96	7	70
145	1210	97	109	7	85
146	1339	112	104	7	94
147	1256	105	105	7	84
148	948	82	77	3	50
149	1112	92	99	3	53
150	1074	86	88	6	72
151	1043	76	89	3	63
152	1216	99	94	6	76
153	1192	104	95	6	61
154	1245	97	101	6	81
155	1038	87	95	3	51
156	1112	94	90	6	63
Class J					
157	1111	74	87	6	65
158	1153	98	91	6	77
159	1017	113	81	3	100
160	883	81	76	1	37
161	1330	109	106	7	86
162	1364	119	117	7	81
163	1030	70	84	6	77
164	1102	86	96	3	41
165	1063	90	81	6	64
166	1038	84	78	3	32
167	1167	97	96	6	61
168	1255	100	101	7	87
169	1198	96	97	5	69
170	1271	109	98	7	92

Subjects by Classes	MASD	Random Item Page	Interior Score	Good-Bad Score	Revised Math Attitude Scale
Class K					
171	1161	106	98	6	74
172	1266	102	109	6	80
173	1227	100	92	6	70
174	1063	87	87	5	74
175	1118	96	91	6	73
176	1019	86	83	5	61
177	1156	88	90	7	95
178	1093	94	79	6	71
Class L					
179	994	82	92	6	73
180	994	82	81	3	50
181	1097	96	95	3	34
182	1176	95	90	7	100
183	1164	89	87	2	58
184	1083	92	90	6	78
185	1150	107	110	3	64
186	1131	94	89	5	71
187	953	91	82	2	39
188	1247	110	114	7	100
189	1119	97	97	6	79
190	1103	90	93	5	67
191	978	79	73	2	39
192	956	79	78	5	42
193	841	62	64	1	20
194	1156	94	104	3	51
195	-	-	-	7	84
196	973	83	82	4	49
197	1132	98	99	5	78
198	904	70	74	1	21
199	1003	92	86	1	34
200	961	78	85	2	41
201	1033	81	93	6	70
202	1174	103	102	6	70
203	1049	87	90	7	85

Subjects by Classes	MASD	Random Item Page	Interior Score	Good-Bad Score	Revised Math Attitude Scale
Class M					
204	1163	98	90	4	46
205	1159	94	92	7	82
206	1040	87	84	5	46
207	925	70	75	3	35
208	1047	103	93	2	35
209	1129	102	97	7	83
210	1008	82	82	2	40
211	1054	84	80	6	74
212	1053	86	82	5	65
213	1122	92	108	7	88
214	1050	85	87	3	48
215	1031	87	84	4	55
216	1143	88	94	6	72
217	1030	88	82	3	46
218	1171	98	101	7	97
219	1078	90	84	6	58
220	1113	96	81	6	73
221	1121	95	95	5	65
222	818	79	79	2	41
223	1205	107	107	5	42
224	1139	87	87	6	66
Class N					
225	968	76	87	5	40
226	1066	85	91	2	30
227	1000	84	86	6	82
228	1175	92	94	6	75
229	1178	104	97	6	78
230	888	70	74	4	34
231	1101	94	95	5	-
232	1111	86	85	5	45
233	916	86	82	1	27
234	1180	101	104	6	82
235	1040	80	80	7	83
236	945	92	75	5	67
237	949	75	81	2	38
238	1066	84	88	3	48
239	1042	84	94	1	39
240	1398	123	113	7	83
241	1077	97	90	6	48
242	1224	98	107	7	90
243	1198	95	91	7	91

Subjects by Classes	MASD	Random Item Page	Interior Score	Good-Bad Score	Revised Math Attitude Scale
244	959	92	87	7	51
245	1106	96	94	4	58
246	890	75	68	4	37
247	1030	75	80	1	44
248	1120	100	90	5	57
249	903	79	74	5	44
250	1035	94	81	6	78
251	1013	87	86	6	64
252	1184	103	102	7	92
253	1050	96	89	5	66

VITA

Rose Marie Smith

Candidate for the Degree of

Doctor of Education

Thesis: THE DEVELOPMENT OF A SEMANTIC DIFFERENTIAL TO MEASURE ATTITUDES TOWARD MATHEMATICS

Major: Higher Education

Biographical:

Personal Data: Born in Beaumont, Texas, March 3, 1934, the daughter of Cornelius Martin and Rose Sells O'Brien.

Education: Graduated from high school, Beaumont, Texas, in May, 1952; received the Bachelor of Science in Education degree from Lamar University, Beaumont, with a major in music, in 1955; awarded National Science Foundation In-Service Institute, Texas Woman's University, Denton, 1964; awarded National Science Foundation Summer Institute, Texas Woman's University, Denton, in 1965 and 1966; received a Master of Arts degree from Texas Woman's University, Denton, with a major in mathematics, in 1968; awarded National Science Foundation Institute for College Teachers of Mathematics, Vanderbilt University, Nashville, Tennessee, in 1969; completed requirements for the Doctor of Education degree in May, 1975.

Professional Experience: Mathematics teacher, Grapevine, Texas, 1955-56; mathematics, music teacher, Grapevine, Texas, 1959-66; graduate assistant in mathematics, Texas Woman's University, Denton, Texas, 1966-67, Instructor in Mathematics, Texas Woman's University, Denton, Texas, 1967--

Professional and Honorary Organizations: National Council of Teachers of Mathematics, Texas Council of Teachers of Mathematics, North Texas Council of Teachers of Mathematics, Texas Association of College Teachers (TACT), Phi Delta Kappa, Mathematics Association of America.