

## AN ABSTRACT OF THE THESIS OF

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Title ATTITUDES TOWARD MATHEMATICS AND BASIC MATHE-  
MATICAL UNDERSTANDING OF PROSPECTIVE ELEMEN-  
TARY SCHOOL TEACHERS AT BRIGHAM YOUNG UNIVERSITY

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(Major professor)

### Purpose

The purpose of this study was to investigate the effects of a required mathematics content course upon prospective elementary school teachers at Brigham Young University. The investigation consisted of three major areas: (1) attitudes toward mathematics, (2) basic mathematical understanding, and (3) the relationship between certain selected variables.

## Procedure

Pre- and post- tests of basic mathematical understanding and attitudes toward mathematics were given to the 186 students enrolled in a required mathematics content course at Brigham Young University during fall semester 1964.

A personal data sheet was completed by each student to obtain background information. A Test of Basic Mathematical Understanding developed by Vincent J. Glennon was used to measure the basic mathematical understandings possessed by the student and Wilbur H. Dutton's Arithmetic Attitude Scale was used to measure the students' attitudes toward mathematics.

A t-test for matched groups was used to determine if the changes in attitudes and mathematical understandings were significant. A product-moment correlation was used to determine if a relationship existed between certain selected variables. Item analysis was used to determine the areas of change in attitudes toward mathematics and basic mathematical understanding.

### Findings

There was a significant improvement in attitudes toward mathematics and basic mathematical understanding while the students were enrolled in this mathematics course. The t-ratio was significant at the .001 level of confidence.

The following variables were found to have a positive significant relationship at the .001 level of confidence:

1. Pre-test attitude scores and final grades.
2. Post-test attitude scores and final grades.
3. Pre-test scores on mathematical understanding and final

grades.

4. Post-test scores on mathematical understanding and final grades.

5. American College Test mathematics scores and pre-test scores on mathematical understanding.

The following variables were found to have no significant relationship at the .05 level of confidence:

1. Pre-test attitude scores and change in mathematical understanding.

2. Changes in attitudes and changes in mathematical understanding.

### Conclusions

The following conclusions were drawn from this study:

1. Most prospective elementary school teachers liked some aspects of mathematics and disliked others.

2. The attitudes of prospective elementary school teachers toward mathematics were improved by taking this course.

3. There was a significant gain in basic mathematical understanding by prospective elementary school teachers while they were taking this course.

4. Attitudes toward mathematics and basic mathematical understanding were significantly related to success in this course as measured by the final grade.

5. There was no significant relationship between attitudes toward mathematics and change in basic mathematical understanding while students were enrolled in this course.

6. The American College Test mathematics score is a good predictor of success in this course as measured by the final grade.

ATTITUDES TOWARD MATHEMATICS AND BASIC MATHEMATICAL  
UNDERSTANDING OF PROSPECTIVE ELEMENTARY SCHOOL  
TEACHERS AT BRIGHAM YOUNG UNIVERSITY

by

BURTON CLEON GEE

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Associate Professor of Science Education

In Charge of Major

Redacted for Privacy

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Dean, School of Education

Redacted for Privacy

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Dean of Graduate School

Date thesis is presented August 5, 1965

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# ATTITUDES TOWARD MATHEMATICS AND BASIC MATHEMATICAL UNDERSTANDING OF PROSPECTIVE ELEMENTARY SCHOOL TEACHERS AT BRIGHAM YOUNG UNIVERSITY

## I. INTRODUCTION

The appropriate mathematical education of elementary school teachers has long been a concern among educators at all levels. This concern has been increased in recent years as various mathematics programs have begun to exert an influence on the content of the elementary school mathematics curriculum and upon institutions preparing elementary school teachers.

Probably the greatest number of professional workers who use mathematics are employed as teachers. There are over 900,000 teachers in the elementary schools and most of them are expected to teach some aspect of mathematics. Few subjects taught in the elementary school require a better understanding on the part of the teacher than does mathematics. Yet it is probable that the elementary school teachers have less insight into the content of mathematics than any subject they are expected to teach.

Suggestions pertaining to the mathematical preparation of prospective elementary school teachers have been made by various individuals and groups. The most potentially influential recommendations have been made by the Panel on Teacher Training of the Committee on the Undergraduate Program in Mathematics (CUPM) of

the Mathematical Association of America.

CUPM recommends the equivalent of the following courses as the minimum college preparation for all elementary school teachers: (1) A two-course sequence devoted to the structure of the real number system and its subsystems, (2) a course devoted to the basic concepts of algebra, and (3) a course in informal geometry (42, p. 11).

Brigham Young University, prior to the fall semester of 1962, did not require any mathematics in the college preparation of prospective elementary school teachers. Beginning in 1962, a one semester course of three credit hours was required of all prospective elementary school teachers.

This course, Mathematics 305, was designed to meet the specific requirements of the first course in the CUPM recommendations. This one semester course is the only mathematics content course presently required of the prospective elementary school teacher at Brigham Young University.

### Purpose of the Study

The purpose of this study was to investigate the effects of this required course, Mathematics 305, upon the prospective elementary school teachers at Brigham Young University. The investigation included three major areas: (1) Attitudes toward mathematics, (2) basic mathematical understanding, and (3) the relationship

between certain selected variables.

More specifically, answers were sought for the following questions:

1. Does Mathematics 305 contribute to a change in attitude toward mathematics while the students are enrolled in the course?

2. Does Mathematics 305 contribute to a change in basic mathematical understanding while the students are enrolled in the course?

3. Is there any relationship between attitudes toward mathematics and success in Mathematics 305 as measured by course grades?

4. Is there any relationship between attitudes toward mathematics and change in basic mathematical understanding while students are enrolled in Mathematics 305?

5. Is there any relationship between change in attitudes toward mathematics and change in basic mathematical understanding while students are enrolled in Mathematics 305?

6. Is there any relationship between basic mathematical understanding and success in Mathematics 305 as measured by course grades?

7. Is there a relationship between basic mathematical

understanding and mathematics scores on the American College Test (A. C. T.)?

### Justification of Problem

Several groups and individuals have indicated the importance and significance of the elementary school teachers' attitudes toward mathematics and their apparent lack of basic mathematical understanding.

Both Shryock (60, p. 209) and Poffenberger (54, p. 172) have claimed that too many elementary school teachers dislike mathematics and cause their students to dislike the subject.

Dutton (23, p. 63), Smith (62, p. 477), and Collier (11, p. 262) have all indicated that far too many elementary school teachers have negative attitudes toward mathematics and that these attitudes were formed while the prospective teacher was a student in the elementary school.

Dyer (24, p. 16) indicated the existence of a vicious circle when he pointed out that future teachers pass through the elementary school learning to dislike mathematics; they drop mathematics in high school as soon as possible; they avoid mathematics in college, unless it is required; and they then return to the elementary school as teachers to teach a new generation to detest mathematics.

In a recent CUPM report (49, p. 7) it was indicated that what



elementary school teachers need is to have mathematical literacy so that this vicious circle, in which mathematical illiteracy has reproduced its own kind in the classroom, can be broken. This same report suggested that the teaching of elementary school mathematics has not been a failure, but a disaster.

Many mathematics educators have recommended that teacher preparation institutions offer special mathematics content courses specifically designed for elementary school teachers which emphasize the basic structure of mathematics and show the unifying concepts in this basic structure.

Dutton (20, p. 7) and Bruner (9, p. 11) have indicated that meaningful learning of mathematics is based upon the basic structure of the subject. Bruner also indicated that understanding the structure of a subject is understanding the subject in a way that permits other things to be related to it in a meaningful way (9, p. 7).

Hartung and others (34, 38, 39, 62, 66) have suggested that an increase in interest and appreciation in mathematics tends to accompany an increase in understanding the subject.

In light of the importance and significance attached to the two variables of attitudes and understanding and before other mathematics courses are required of the future teacher at Brigham Young University, it seems wise and desirable to investigate what effects Mathematics 305 is having upon these two variables.

The potentialities for inducing both positive or negative attitudes toward mathematics is present in any mathematics course. Therefore, any improvements in the mathematical education of prospective elementary school teachers at Brigham Young University should be based upon an adequate analysis of the future teachers' attitudes and understanding about mathematics and the various variables related to these factors.

### Significance of the Study

Studies have been made to determine the prospective teachers' attitudes toward mathematics and their basic mathematical understandings. There have been no studies published that have shown or indicated the effects of a mathematics content course, specifically designed for elementary teachers, upon these two factors.

The present study should do this, and in so doing, help the Mathematics Department and the College of Education at Brigham Young University determine the advisability and need of expanding the present mathematics requirement for prospective elementary teachers. The present requirement represents only one-fourth of the mathematics that is recommended by CUPM for the mathematical preparation of prospective elementary school teachers.

## Definition of Terms

### Attitude

An emotionalized tendency, organized through experience, to react positively or negatively toward an object. It is the sum total of man's inclinations and feelings, preconceived notions, ideas, fears, and convictions about an object.

### Attitude Scale

A scale or test used to determine the direction and intensity of an individual's attitude toward a given object.

### Attitude Score

A numerical score that indicates the direction and intensity of an individual's attitude.

### Scale Value

A numerical score that indicates the direction and intensity of a particular item on the attitude scale.

### Positive Attitude

An attitude that is represented in this study by an attitude score greater than 5.9.

### Neutral Attitude

An attitude represented in this study by an attitude score that

is greater than or equal to 5.0 and less than or equal to 5.9.

### Negative Attitude

An attitude represented in this study by an attitude score less than 5.0.

### Pre-Test

A test given in order to determine the status of the student in regards to some skill, aptitude, or achievement, as a basis for judging the effectiveness of a subsequent treatment.

### Post-Test

A test given in order to determine the status of the student in regards to some skill, aptitude, or achievement, as a basis for judging the effectiveness of a prior treatment.

### Positive Gain

A gain in which the student's score on the post-test is greater than his score on the pre-test.

### Negative Gain

A gain in which the student's score on the post-test is less than his score on the pre-test.

### Item Difficulty

The percent of the total sample that responded correctly to a

given item on a test.

### Correlation

The tendency of the variation of one variable to be accompanied by the variation of another variable. A cause-effect relation is not necessarily inferred between the two variables. Correlation is used to measure the relationship between two variables.

### Procedures

Pre- and post-tests on basic mathematical understanding and attitudes toward mathematics were given to all students enrolled in Mathematics 305 at Brigham Young University during fall semester 1964. A Test of Basic Mathematical Understanding developed by Vincent J. Glennon was used to measure the student's mathematical understanding and Wilbur H. Dutton's Arithmetic Attitude Scale was used to measure the student's attitude toward mathematics. A personal data sheet was completed by each student to obtain background information.

A t-test was used to determine the significance of any change in mathematical understanding and attitudes toward mathematics during the period of time the students were enrolled in Mathematics 305. A product-moment correlation coefficient was used to determine if a significant relation existed between certain selected variables.

### Basic Assumptions

The assumptions underlying this study are:

1. Basic mathematical understanding and attitudes toward mathematics can be measured objectively.
2. Glennon's Test of Basic Mathematical Understanding and Dutton's Arithmetic Attitude Scale are both valid and reliable.
3. Any changes in attitudes toward mathematics or basic mathematical understanding during the time of this study were the result of Mathematics 305 and not the result of some outside factor.

### Delimitations of the Study

This study was delimited as follows:

1. It was limited to the 186 students enrolled in Mathematics 305 during fall semester 1964 at Brigham Young University.
2. It was limited by the use of the specified measuring instruments.

### Hypotheses

The hypotheses tested in this study were:

1. Prospective elementary school teachers at Brigham Young University have neutral attitudes toward mathematics.

2. Mathematics 305 does not contribute to a change in attitude toward mathematics while the students are enrolled in the course.

3. There is no relationship between attitudes toward mathematics and student success in Mathematics 305 as measured by course grades.

4. Mathematics 305 does not contribute to a change in basic mathematical understanding while the students are enrolled in the course.

5. There is no relationship between attitudes toward mathematics and change in basic mathematical understanding while students are enrolled in Mathematics 305.

6. There is no relationship between change in attitudes toward mathematics and change in basic mathematical understanding while students are enrolled in Mathematics 305.

7. There is no relationship between basic mathematical understanding and success in Mathematics 305 as measured by course grades.

8. There is no relationship between basic mathematical understanding and mathematics scores on the American College Test.

## II. REVIEW OF RELATED LITERATURE

Published reports of studies dealing with the mathematical education of prospective elementary school teachers indicate the existence of three areas of concern. These areas are: (1) The general lack of knowledge and understanding of mathematics by these teachers, (2) the attitudes they have toward the subject that inhibits effective teaching, and (3) the lack of opportunity for the elementary school teacher to receive help or training in the areas of mathematical understanding and attitudes from their pre-service training program.

### The Mathematical Preparation of Prospective Elementary School Teachers

#### State Certification Requirements

The lack of teachers' knowledge and understanding of mathematics, reported in several of the studies which follow, is frequently attributed to the almost complete lack of a mathematics requirement in the teacher certification regulations in the various states. There is no conclusive evidence that indicates that to require a mathematics course in state certification regulations has a salutary effect on teachers' competence in this area.

A study made in 1954 by Blyer (6, p. 571) indicated that only



19 states required four years of preparation beyond high school to receive elementary school certification. At that time, it was the general practice in most states to issue an emergency certificate to anyone who would agree to teach. Since that time, however, there has been a steady increase in the amount of college preparation required to qualify for a regular elementary school teaching certificate. Four years of education is now the prevailing type of program for the preparation of elementary school teachers (57, p. 301). There is a trend, in some states, toward a five-year program.

It has been the general practice in many states to certify elementary school teachers without requiring any mathematics beyond the eighth grade. Some states have legislated specific mathematics requirements for elementary school certification.

In 1962, McDowell (47, p. 10) indicated that 29 states had certification that did not include mathematics as a requirement for the initial elementary certificate. In a more recent (1965) report by Woeller and Wood (76, p. 1-153) it was found that 29 states still had certification that did not include mathematics as a requirement for the initial elementary certificate.

### College and University Requirements

It has been a widespread practice to permit anyone wishing to teach in the elementary school to matriculate in an elementary

teacher education program without any high school mathematics.

In 1958 (34, p. 303), a survey of 96 teacher preparation institutions showed that 33 percent of the institutions required either one or two years of high school mathematics for admission to the elementary teacher education program. Fifty percent of the schools required one course in high school mathematics. If the student did not meet this requirement, he was required to pass a proficiency examination in mathematics before being permitted to matriculate.

The Commission on Mathematics of the College Entrance Examination Board (69, p. 49) and CUPM both recommend two complete years of high school mathematics as a prerequisite for entering the elementary teacher education program.

The teacher training institutions have been gradually increasing the college mathematics required of the prospective elementary school teacher. Layton (43, p. 379) reported in 1949 that only 25 percent of 85 institutions of higher education preparing elementary school teachers required some college mathematics in their teacher education curriculum. The mean mathematics content requirement of the four-year elementary curriculum was 1.6 semester hours, as compared with means of 4.3 semester hours each for art and geography, and 11.5 semester hours for English.

Grossnickle (34, p. 210) made a study in 1951 in which he sent a questionnaire to 147 state teachers colleges who were members of

the American Association of Colleges for Teacher Education. He found that 76 percent of the colleges had no college mathematics requirement for the prospective elementary teacher.

In 1957, Stipanowich (65, p. 240) used a jury of 70 mathematics education specialists affiliated with 66 institutions of higher education in 32 states to make a study of this problem. His study was made to determine which of several practices currently employed in college training programs for prospective elementary teachers were favored by these experts. Stipanowich concluded that most schools were not providing an adequate preparation in mathematics subject matter for students preparing to teach in the elementary school.

CUPM (47, p. 10) made a study in 1962 of 906 colleges and universities that had programs in elementary education. Of the 762 usable responses, 22 percent indicated they had no requirement in mathematics for prospective elementary teachers. Sixty-nine percent required four or fewer semester hours of mathematics. More than 50 percent of the responding institutions offered no course specifically designed for prospective elementary teachers. In many schools, courses in elementary algebra and elementary trigonometry were the only courses in college mathematics available to those students.

During the spring of 1965 there were at least six colleges in the United States that required a minimum of 12 semester hours of

mathematics content of all prospective elementary teachers (47, p. 209).

With some degree of unanimity, writers point out that more mathematics in teacher education programs will prove to be the solution to the problem of obtaining adequately prepared teachers of mathematics in the elementary school (60, p. 209).

Spitzer (63, p. 26) said that all the authorities that have written on the subject believed that a good background in mathematics should be an essential part of the preparation of elementary school teachers. He also claimed there is no evidence that the typical background course in mathematics actually contributes to superior teaching of mathematics. A study by Shryock (61, p. 1562) on what topics in mathematics were understood by future elementary school teachers showed no significant difference between mean scores between prospective teachers who had taken no mathematics in college and those that had at least one college course. This one course was not designed specifically for prospective elementary teachers.

Weaver (72, p. 258) recommended, in 1956, a special mathematics course designed specifically for prospective elementary school teachers. He also recommended that such a course be followed by a methods course on the teaching of mathematics.

CUPM (64, p. 18) also recommends that the mathematics courses required of prospective elementary school teachers should be

designed specifically for the future teacher and should not be the regular freshman mathematics courses in algebra and trigonometry. The recommendations of the National Association of State Directors of Teacher Education and Certification (NASDTEC) and the American Association for the Advancement of Science (AAAS) tend to agree with the recommendations made by CUPM (47, p. 11).

A study made by Harper (37, p. 546) indicated that teachers could profit from a course in "modern mathematics" even though they had taken more than six hours of other college mathematics.

Garstens (30, p. 541) said that just because elementary education students come to college with minimal background in mathematics, highly unmotivated in the subject, and in most cases having an actual fear of it, is no indication that the student is not competent to study some fundamental mathematics. Dreger claimed there is no relationship between fear of mathematics and basic intelligence (15, p. 350).

This same idea was suggested by Bruner (9, p. 12) when he said that the foundations of any subject may be taught to anybody at any age in some form. Bruner also indicated that good teaching that emphasizes the structure of the subject is probably more valuable for the less able student than for the gifted student (9, p. 9). Bruner did not infer that it would harm the gifted student.

## Summary

The review of literature on the mathematical education of prospective elementary school teachers revealed the existence of four stages in the development of college offerings for such students.

In the first stage there was no mathematics of any kind required in the education program. In the second stage the mathematical content was provided entirely by a methods course. In the third stage, colleges and universities began introducing mathematics requirements in their general education programs. The fourth stage is the arrival of mathematics courses specifically designed for the prospective elementary school teacher.

The importance and magnitude of the problem of the mathematical education of prospective elementary school teachers can be seen when it is pointed out that approximately 45,000 new elementary school teachers are coming out of the educational institutions each year (36, p. 31). The new teachers will spend about 16 percent of their school day teaching mathematics when only two percent of their undergraduate course work was in this area (36, p. 33).

### The Mathematical Understanding of Prospective Elementary School Teachers

A teacher cannot teach mathematics effectively unless his knowledge and understanding of the subject goes well beyond the

scope he is expected to teach. There exists evidence that prospective elementary school teachers do not even understand the mathematics they are expected to teach.

A study by Glennon (31, p. 393) in 1949 showed that 144 teachers' college freshmen understood only 44 percent of the mathematics taught in the first seven grades in the elementary school. The same study showed that 172 teachers' college seniors understood only 43 percent of the same material.

Weaver (72, p. 257) used the same test as Glennon and found an average understanding of 56 percent while considering 348 prospective teachers. Weaver had made an earlier study (71, p. 112-117) in which he found evidence of the teachers' lack of understandings vital to meaningful mathematics instruction in the elementary school.

A study by Orleans (50, p. 506) indicated there are few processes, concepts, or relationships in mathematics that appear to be understood by a large percentage of elementary teachers. Schaaf (58, p. 537-43) also presented evidence that elementary school teachers do not understand the mathematical concepts which they are expected to teach. A similar study by Phillips (53, p. 48-52) showed a lack of achievement in mathematics by prospective elementary school teachers.

A study by Fulkerson (29, p. 141) indicated that teachers of methods courses in the teaching of mathematics were having to spend

much of their time in an effort to overcome deficiencies in mathematical principles and processes which the student should have presumably mastered before entering the methods course. He concluded that far too many future elementary school teachers have an insufficient knowledge of mathematics to teach the subject effectively.

Bean (5, p. 447-50), using the same test as Glennon and Weaver, showed there was a lack of basic mathematical understanding by in-service elementary school teachers. His study showed there was a small cumulative increase in mathematical understanding as teachers gained in teaching experience. He indicated a peak was reached between 11 and 15 years of teaching.

In a study by Carroll (10, p. 494), it was shown that prospective elementary school teachers possessed a few more than 50 percent of the mathematical understandings agreed upon by experts as the ones which the future teacher should know.

Dutton (22, p. 196), Creswell (13, p. 250), and Harper (37, p. 546) all came to the conclusion that the general level of mathematical understanding held by prospective elementary school teachers is in need of improvement.

Melson (48, p. 51-3) reported a study made in 1963 involving 41 new applicants for elementary school teaching positions. Most of the applicants professed to having had a course in mathematics for elementary school teachers. Each of the applicants was given a test



on the most common concepts included in the newer mathematics programs. The median score was 36 percent.

### Summary

The review of literature on the mathematical understanding of prospective elementary school teachers indicated that many of them do not possess those basic mathematical understandings which they are expected to teach in the elementary school.

If poor understandings and deficiencies in mathematics were confined to the group of elementary teachers, the ultimate results would not be so serious. However, the problem becomes extremely serious when the effects are extended to all the boys and girls who will eventually come under the influence of these teachers.

### Attitudes Toward Mathematics of Prospective Elementary School Teachers

Much has been written that suggests the importance of favorable attitudes toward a subject which a teacher is expected to teach. Remmers (55, p. 362) has suggested that unless a person has a favorable attitude toward a set of instructional objectives and sets them up as desirable goals for himself, the educative process will be relatively ineffective.

Several studies have established that students tend to develop

the same attitudes as expressed by their teachers. Lerch (44, p. 119) indicated that a child's success in mathematics is more basically dependent upon his teachers' attitudes than it is upon classroom procedure.

Aiken and Dreger (2, p. 22-24) concluded in their study that students' attitudes toward mathematics are related to remembered impressions of their teachers. They also concluded that a relationship exists between a student's present attitude toward mathematics and his experience with former mathematics teachers. A somewhat similar study reported by Poffenberger and Norton (54, p. 171-76) indicated that the elementary school teacher plays a very significant part in the development of their students' attitudes toward mathematics.

Davis (14, p. 111) pointed out that a teacher's attitudes and feelings are transmitted to the student and have the strongest influence on how well the student likes the subject, how hard he works in it, the quality of his work, and his use of the subject in years to come. This last point alone should suffice to direct a great deal of attention to the communication of attitudes between teacher and student.

There is ample evidence that indicates that prospective elementary school teachers generally have had unfavorable attitudes toward mathematics. The most elaborate studies in this area have been made by Dutton working at the University of California at Los

Angeles. In 1951 (19, p. 84-90) he surveyed the attitudes of prospective elementary school teachers toward mathematics and found that 74 percent of the prospective teachers sampled had unfavorable attitudes toward mathematics.

In another study by Dutton (21, p. 24-31) an objective attitude scale was developed to measure a student's attitude toward mathematics. In this study he found that the over-all attitudes of the students were favorable toward mathematics. However, most students indicated a like for some aspects of mathematics and a dislike for others. A similar study made by Dutton (17, p. 418-24) showed the attitudes toward mathematics in 1954 were almost identical with the attitudes of another group of students in 1962.

Smith (62, p. 474-77) used Dutton's attitude scale with a group of prospective elementary teachers while they were enrolled in a methods course on the teaching of mathematics. His data showed that his group had a more favorable attitude toward mathematics than did the group studied by Dutton. Smith concluded that too many prospective elementary school teachers have negative attitudes toward a subject they will be expected to teach.

Shryock (60, p. 209) also concluded that too many prospective elementary school teachers disliked mathematics. He also concluded that the teacher was the cause for their pupils hating and fearing mathematics.

The number of prospective elementary teachers that have a negative attitude toward mathematics becomes extremely significant when studies made by White (75, p. 2303), Smith (62, p. 477), Josephena (41, p. 57), and Dutton (17, p. 421) all indicate that most prospective teachers developed their attitudes toward mathematics while they were attending elementary school.

Shippy (59, p. 126) suggested that unfavorable attitudes toward a subject will change to favorable attitudes when specific skills, habits, and understandings are acquired. Dutton made the same suggestion with respect to attitudes toward mathematics (23, p. 64).

Johnson (39, p. 116) indicated that attitudes toward mathematics may be enhanced by understanding the basic structure of the subject. Hardgrove (36, p. 32) stated that confidence comes to teachers of mathematics by knowing the structure of the subject. Hartung (38, p. 39) claimed that an increase in interest and appreciation tends to accompany an increase in understanding.

Collier (11, p. 268) suggested that teacher education institutions would be most helpful if they would provide a reasonable background in mathematics for the future elementary school teacher. He also indicated that he felt that this would help replace the fear of the subject held by many of these students with at least a sympathetic understanding of the subject. Wright (77, p. 161) reported that in-service teachers did change their attitude while subject matter was

being acquired.

Dutton (17, p. 424) concluded that efforts to redirect the negative attitudes of prospective elementary teachers have not been very effective.

### Summary

The review of literature on attitudes toward mathematics of prospective elementary school teachers indicated several significant aspects of the problem:

1. Students' attitudes tend to be greatly influenced by their teachers' attitudes. The teachers' attitudes are decisive, for it is these which influence the attitudes of the student for years to come.
2. Most prospective elementary school teachers formed their attitudes toward mathematics while they were in elementary school.
3. Many prospective elementary school teachers have negative attitudes toward mathematics.
4. The real problem appears to be the task of breaking this vicious circle and educating teachers properly so they, themselves, will like mathematics and enjoy teaching it.

### Correlation Studies

The attitudes toward mathematics and the basic mathematical

understanding of prospective elementary school teachers can be better understood and evaluated in proper perspective if certain relationships are known to exist between these two factors and other selected variables.

A review of the literature indicated there is a significant relationship between the following variables:

1. Mathematical understanding and college scholarship as indicated by honor point average (10, p. 495).
2. Mathematical understanding and grades in high school and college mathematics courses as reported by the student (10, p. 495).
3. Mathematical understanding and scholastic aptitude as measured by the total score on the A.C.E. test (10, p. 495).
4. The teacher's mathematical understanding and the pupil's efficiency in the use of abilities to master mathematics as measured by the California Achievement Test (4, p. 386).
5. The attitude of the teacher and his success as a teacher (56, p. 399).
6. The age of an individual and the stability of his attitudes (35, p. 784).
7. The teacher's attitude toward school subjects and

his student's attitude toward that same subject. There was a greater correlation between the teacher's attitude toward mathematics and his student's attitude toward mathematics than there was between their attitudes toward spelling, reading, or language (26, p. 2753).

The review of the related literature indicated there is no significant relationship between the following variables:

1. Fear of mathematics and basic intelligence (15, p. 350).
2. Years of teaching experience and mathematical understanding (31, p. 395).

### Summary

The review of the related literature for this study has revealed the following:

1. Many prospective elementary school teachers do not possess the basic mathematical understandings needed to teach mathematics in the elementary school.
2. Many prospective elementary teachers have unfavorable attitudes toward mathematics.
3. Improvement has been made in the basic mathematical understandings and the attitudes toward mathematics possessed by prospective elementary school teachers.

4. It is important that future teachers have an attitude and a frame of mind toward mathematics which will make it possible for them to teach, in some intellectually honest form, the content of the elementary school's mathematics curriculum.

5. Many authorities agree that the best way this attitude and frame of mind can be developed in the future teacher is by demonstrating to them that they, themselves, can comprehend the mathematical foundations upon which the elementary school mathematics is structured.



### III. DESIGN OF THE STUDY

This study was designed to determine the effects of Mathematics 305, a required mathematics content course, upon prospective elementary school teachers at Brigham Young University. It was designed to investigate the changes in attitudes toward mathematics, the changes in basic mathematical understanding, and the relationship between certain selected variables while these students were enrolled in Mathematics 305.

#### Description of the Setting

Brigham Young University is located in Provo, Utah and is operated by the Church of Jesus Christ of Latter-Day Saints. It is on the approved list of the major recognized accrediting organizations. The University is organized into 13 colleges, a graduate school, a research division, and a division of adult education and extension services. In 1964, the University conferred 1,899 bachelor's degrees, 269 master's degrees, and 13 doctoral degrees. There were 369 elementary school teaching certificates awarded at the 1964 graduation.

There were 17,808 regular daytime students along with 1,164 unduplicated evening school students enrolled during fall semester 1964. Sixty percent of the students came from outside the state of

Utah, including 50 different states and 59 foreign countries. Fifty-three percent of the students were males and seven percent were graduate students.

### Sample for the Study

The sample consisted of prospective elementary school teachers enrolled in Mathematics 305, Basic Concepts of Mathematics, during fall semester 1964. The sample included 186 students in six sections, taught by three instructors, each teaching two sections. All sections were grouped together to form the sample.

### Description of Mathematics 305

Mathematics 305, Basic Concepts of Mathematics, is a three semester hour mathematics content course required for all prospective elementary school teachers at Brigham Young University. This course was designed specifically for prospective elementary school teachers and has no college mathematics as a prerequisite.

The course content is basically that recommended by various professional groups and organizations concerned with the mathematical preparation of teachers. The course outline is shown in Appendix D. It follows very closely a specific course outlined by the Committee on the Undergraduate Program in Mathematics (CUPM) of the Mathematical Association of America (16, p. N2-N10).

Mathematics 305 was designed to emphasize the basic structure of mathematics and to show the unifying concepts in this basic structure so that prospective elementary school teachers will have a better understanding of mathematics and the nature of mathematical reasoning. By emphasizing the basic structure of mathematics and the underlying concepts of this structure it is hoped that the prospective elementary school teachers will also improve in their attitudes toward mathematics. Mathematics 305 is not a refresher course nor is it designed to achieve desirable computational efficiencies.

Mathematics 305 is taught by faculty members of the Mathematics Department at Brigham Young University who have demonstrated a competence and an interest in both the fields of mathematics and teacher education. This procedure follows the recommendations made by CUPM (36, p. 32) and other groups concerned with the mathematical preparation of prospective elementary school teachers (30, p. 541-42).

### Description of Data Gathering Instruments

#### Personal Data Sheet

A 15-item personal data sheet (Appendix A) was used to obtain background information from each member of the sample.

### A Test of Basic Mathematical Understanding

This test (Appendix B) was developed by Vincent J. Glennon at Harvard University in 1948 (32, p. 312) to measure the extent of growth and mastery of certain basic mathematical understandings possessed by (1) teachers' college freshmen, (2) teachers' college seniors, and (3) teachers-in-service.

This test has probably been used more frequently than any other comparable test to measure the mathematical understanding, not achievement, of various groups (4, p. 386; 5, p. 447-50; 32, p. 315; 72, p. 255-61).

Dutton (20, p. 24) claimed that a careful study of most standardized achievement tests in mathematics, containing subtests on problem solving or reasoning, revealed the inadequacies of those tests to measure mathematical understanding.

The mathematical understandings considered in the Glennon test are the understandings basic to the several computational processes commonly taught in the elementary school. The test is an objective-type test consisting of 42 multiple choice items covering the five areas of (1) the decimal system of notation, (2) basic understanding of integers and processes, (3) basic understanding of fractions and processes, (4) basic understanding of decimals and processes, and (5) basic understanding of the rationale of computation.

Typical responses were listed among the multiple choice items. The items were all constructed in such a manner as to eliminate or at least minimize the effect of rote computational facility as a determiner of success. The curricular validity was determined by making use of the combined judgements of 16 well-informed experts in the subject matter covered by the test.

The student's score on the test is the total number of correct responses made by the student.

#### Arithmetic Attitude Scale

The Arithmetic Attitude Scale (Appendix C) was developed by Wilbur H. Dutton at the University of California at Los Angeles in 1951 (21, p. 24-31). It is a 22-item objective-type test developed by using the methods developed by Thurstone at the University of Chicago (68, p. 36-45).

The participant checks only those statements with which he agrees. The scale values of each item which are used to objectively score the responses do not appear on the scale and are unknown to the participant. The average of the scale values of the statements checked become the participant's attitude score. The average scale value endorsed by an individual thus becomes a measure of his attitude toward mathematics.

Scale values range from 1 (extreme dislike) to 10.5 (extreme

like). An attitude score greater than or equal to 5.0 and less than or equal to 5.9 is considered neutral. A scale value greater than 5.9 is considered positive, and a scale value less than 5.0 is considered negative. The scaling method is such that equal differences in scores have the same meaning on all parts of the scale. This makes it possible to determine if an individual has a positive or negative attitude toward mathematics and to what degree it is positive or negative (12, p. 111). The responses on the scale may be studied for an individual or for a group.

The reliability of this attitude scale was measured by the test-and-retest procedure as being .94 (17, p. 418). This attitude scale has been used in several published studies (17, 21, 27, 46, 62, 75).

#### American College Test (A. C. T. )

This test battery consists of four tests covering the fields of English, mathematics, social studies, and natural science. Only the scores from the mathematics section were used in this study to determine if any relationship existed between the A. C. T. scores and the students' basic mathematical understanding.

The mathematics section is a 40-item, 50 minute test that measures general mathematical reasoning ability. It emphasizes the solution of practical quantitative problems such as are encountered

in almost any field of college instruction. It also includes a sampling of the formal mathematical techniques developed in high school mathematics (45, p. 5).

All entering freshmen and all transfer students who have earned less than 32 semester hours of college credit must take this test battery before they are admitted to the University. These test scores are used for the purpose of sectioning students into introductory college courses.

### Course Grades

The course grades were used in this study to determine if any relationship exists between attitudes toward mathematics and success in Mathematics 305. They were also used to determine if any relationship exists between basic mathematical understanding and success in Mathematics 305.

Letter grades of A through D, which may be accompanied by a "+" or "-", indicate that a student received credit in the course. An E is used to indicate that no credit was allowed.

The grade given to each student was determined by the combined scores of several teacher-made tests given during the semester and a departmental final examination given at the completion of the course. Each instructor assigned grades independently of the other instructors.

### Procedures for Obtaining Data

Students registered for Mathematics 305 during fall semester 1964 completed a personal data sheet, a Test of Basic Mathematical Understanding, and an Arithmetic Attitude Scale. The personal data sheet and the Arithmetic Attitude Scale were administered during the first regular class period of the semester. The Test of Basic Mathematical Understanding was administered during the second class period. The last regular class period of the semester was used to again administer the Arithmetic Attitude Scale and the Test of Basic Mathematical Understanding.

The data-gathering instruments were administered by a faculty member other than the regular instructor of that particular section of the course. The purpose of the study was explained to each group and they were assured that none of the data obtained would be used or seen by their instructor until after the course grades were determined and assigned.

The A. C. T. scores were obtained from a master list available at the University testing center. The official grade rolls were photo-copied to obtain the course grade for each of the participants.

### Data Analysis

The statistical analyses used in this study were approved by



the Department of Statistics at Oregon State University. Keysort cards were used to facilitate the analyses.

A t-test for matched groups by the direct-difference method as outlined by Underwood (70, p. 164-71) was used to determine if the changes in attitudes and mathematical understandings were significant.

The correlations used in this study are product-moment correlation coefficients. They were obtained by the method outlined by Ferguson (28, p.91-93) for the use of raw scores.

The product-moment correlation coefficient  $r$  indicates the degree to which there exists a linear relationship between the variables being considered.

Item analysis was used to determine the number of times each item was checked on both the pre- and post- attitude scale. It was also used to determine the difficulty index of each item on both the pre- and post- tests of mathematical understanding.

The difficulty index indicates how difficult each item was for the entire group taking the test. The index for each item was found by calculating the percent of the total sample that responded correctly to the item.

#### IV. FINDINGS OF THE STUDY

##### Description of the Sample

The personal background of the 186 students in the study is shown in Table I.

The percentage of males in the sample was the same as the percentage of males that received an elementary school teaching certificate through Brigham Young University in 1964. The majority of the students were juniors in college with a major in elementary education and with no teaching experience. Eight of the ten students who had done full-time teaching had been fully certificated while the other two had taught with provisional certification.

A summary of the mathematics background of the students is shown in Table II.

All the students in the sample had taken some high school mathematics. Of the 67 students who had taken general mathematics while in high school, 11 had taken only general mathematics. Ninety-one percent of the students had taken first-year algebra and out of these 169 students, 18 had taken only first-year algebra. Twenty-six percent of the students had taken second-year algebra. Twenty-two percent of the students had taken first-year algebra, second-year algebra, and geometry while in high school.

Table I. Summary of the Personal Background of the 186 Students in the Study.

| Background of Students | Number of Students | Percent of Students |
|------------------------|--------------------|---------------------|
| Sex:                   |                    |                     |
| Male                   | 18                 | 10                  |
| Female                 | 168                | 90                  |
| Age:                   |                    |                     |
| 18-24                  | 165                | 89                  |
| 25-30                  | 12                 | 7                   |
| Over 30                | 9                  | 5                   |
| Status:                |                    |                     |
| Sophomore              | 43                 | 23                  |
| Junior                 | 101                | 54                  |
| Senior                 | 36                 | 19                  |
| Graduate               | 5                  | 3                   |
| Faculty                | 1                  | .5                  |
| Major:                 |                    |                     |
| Elementary Education   | 175                | 94                  |
| Other                  | 11                 | 6                   |
| Teaching Experience:   |                    |                     |
| None                   | 171                | 92                  |
| Student teaching       | 12                 | 7                   |
| Substitute teaching    | 3                  | 2                   |
| Full-time teaching     | 10                 | 5                   |

Table II. Mathematics Background of the 186 Students in the Sample.

| High School Mathematics<br>Background | Number of<br>Students | Percent of<br>Students |
|---------------------------------------|-----------------------|------------------------|
| General Mathematics                   | 67                    | 36                     |
| First-Year Algebra                    | 169                   | 91                     |
| Second-Year Algebra                   | 49                    | 26                     |
| Geometry                              | 124                   | 67                     |
| Trigonometry                          | 19                    | 10                     |
| Business Mathematics                  | 16                    | 9                      |
| Calculus                              | 1                     | 1                      |
| College Mathematics<br>Background     | Number of<br>Students | Percent of<br>Students |
| None                                  | 152                   | 82                     |
| Intermediate Algebra                  | 8                     | 4                      |
| College Algebra                       | 17                    | 9                      |
| Calculus                              | 5                     | 3                      |
| Differential Equations                | 1                     | 1                      |

There were 34 students who had taken some college mathematics. Seventeen of these had taken college algebra and five had gone beyond college algebra while in college.

Forty-five percent of the students were taking a science course concurrently with Mathematics 305. Eight of these 83 students were taking both a physical and a biological science course. The average change in attitude toward mathematics and mathematical understanding was the same for those taking a science course as it was for those not taking a science course.

A summary of the number of students that expressed a like or dislike for mathematics during their pre-college education is shown in Table III.

Table III. Summary of the Number of Students that Expressed a Like or Dislike for Mathematics During Their Pre-College Education.

|                      | Liked Mathematics<br>the Most |                | Liked Mathematics<br>the Least |                |
|----------------------|-------------------------------|----------------|--------------------------------|----------------|
|                      | <u>Number</u>                 | <u>Percent</u> | <u>Number</u>                  | <u>Percent</u> |
| Elementary<br>School | 35                            | 19             | 54                             | 29             |
| Secondary<br>School  | 22                            | 12             | 65                             | 35             |

Thirty-five students indicated they liked mathematics better than any other subject when they were in elementary school. When these same 35 students attended secondary school, ten of them still liked mathematics better than any other subject but five liked it less than any other subject in the secondary school.

There were 54 students that indicated they liked mathematics less than any other subject when they attended elementary school. When these 54 students attended secondary school, 36 still liked mathematics less than any other subject and one of the 54 students liked

mathematics more than any other subject.

The average grade received by the students in Mathematics 305 was a C+. The average grade received by all juniors at Brigham Young University in all of their classes during this same time was a B-. A grade distribution for Mathematics 305 is shown in Table IV. Of the 13 students who received an A or an A- grade in Mathematics 305, ten had taken first-year algebra, second-year algebra, and geometry while they were in high school.

Table IV. Frequency Distribution of Mathematics 305 Grades.

| Final Grades | Number of Students | Percent of Students |
|--------------|--------------------|---------------------|
| A            | 11                 | 6                   |
| A-           | 2                  | 1                   |
| B+           | 7                  | 4                   |
| B            | 25                 | 13                  |
| B-           | 15                 | 8                   |
| C+           | 24                 | 13                  |
| C            | 50                 | 27                  |
| C-           | 22                 | 12                  |
| D+           | 4                  | 2                   |
| D            | 14                 | 8                   |
| D-           | 5                  | 3                   |
| E            | 7                  | 4                   |

## Summary

The majority of the students in the sample were juniors majoring in elementary education with no teaching experience. All were working toward elementary school certification with the exception of the six graduate students who had already received an elementary school teaching certificate.

The high school mathematics background survey showed that 91 percent of the students had taken first-year algebra, 26 percent had taken second-year algebra, and 67 percent had taken high school geometry. Eighty-two percent had taken no college mathematics prior to enrolling in Mathematics 305.

Nineteen percent of the students liked mathematics better than any other subject in the elementary school as compared to 12 percent in the secondary school. Four percent liked mathematics better than any other subject at the time they enrolled for Mathematics 305.

## Attitudes Toward Mathematics

An analysis was made of the pre- and post- attitude scales to determine to what extent Mathematics 305 contributed to a change in attitudes toward mathematics while the prospective elementary school teachers were enrolled in the course. The analysis was also made to

determine what specific attitudes toward mathematics were changed during this same period of time.

A summary of the findings on the Arithmetic Attitude Scale is shown in Table V.

### Pre-Test

Every item on the pre-test of the Arithmetic Attitude Scale was checked by at least one student. Item 18 (Sometimes I enjoy the challenge presented by an arithmetic problem) was checked most frequently. Sixty-eight percent, or 126 students, checked item 18 which is a positive item (7.0 scale value).

The next most frequently checked item was item 16 (I don't feel sure of myself in arithmetic). Sixty-five percent of the students checked this item which is negative (3.7 scale value).

The next two items checked most frequently were items 17 and 7. Item 17 (The completion and proof of accuracy in arithmetic gave me satisfaction and feelings of accomplishment) is a positive item with a 9.0 scale value. Item 7 (I am afraid of doing word problems) is a negative item with a 2.0 scale value.

These four most frequently checked items indicate that even though most of the students have a fear of mathematics they have found satisfaction and feelings of accomplishment when they have been able to work through a problem.



Table V. Summary of the Findings on the Arithmetic Attitude Scale.

| Item   | Scale Value | Pre-Test        |               | Post-Test       |               | Net Gain |
|--|-------------|-----------------|---------------|-----------------|---------------|----------|
|  |             | No. of Students | % of Students | No. of Students | % of Students |          |
| 1. I avoid arithmetic because I am not very good with figures.   | 3.2         | 74              | 40            | 35              | 19            | -21      |
| 2. Arithmetic is very interesting.   | 8.2         | 82              | 44            | 135             | 73            | 29       |
| 3. Arithmetic is something you have to do even though it is not enjoyable.                                     | 3.3         | 54              | 29            | 24              | 13            | -16      |
| 4. I like arithmetic because the procedures are logical.   | 7.9         | 67              | 36            | 106             | 57            | 21       |
| 5. I would rather do anything else than do arithmetic.   | 1.0         | 30              | 16            | 9               | 5             | -11      |
| 6. Arithmetic thrills me and I like it better than any other subject.  | 10.5        | 7               | 4             | 9               | 5             | 1        |
| 7. I am afraid of doing word problems.   | 2.0         | 95              | 51            | 83              | 45            | -6       |
| 8. Working with numbers is fun.  | 8.7         | 83              | 45            | 123             | 66            | 21       |
| 9. I get no satisfaction from studying arithmetic.   | 2.6         | 22              | 12            | 8               | 4             | -8       |
| 10. I never get tired of working with numbers.   | 9.8         | 15              | 8             | 16              | 9             | 1        |
| 11. I detest arithmetic and avoid using it at all times.   | 1.0         | 2               | 1             | 3               | 2             | 1        |
| 12. I like arithmetic because it is practical.   | 7.7         | 85              | 46            | 96              | 52            | 6        |
| 13. I have a growing appreciation of arithmetic through understanding its values, applications, and processes. | 8.2         | 88              | 47            | 173             | 93            | 46       |
| 14. I have never liked arithmetic.   | 1.5         | 29              | 16            | 21              | 11            | -5       |
| 15. I have always liked arithmetic because it has presented me with a challenge.                               | 9.5         | 46              | 25            | 49              | 26            | 1        |
| 16. I don't feel sure of myself in arithmetic.   | 3.7         | 120             | 65            | 88              | 47            | -18      |
| 17. The completion and proof of accuracy in arithmetic gave me satisfaction and feelings of accomplishment.    | 9.0         | 113             | 61            | 141             | 76            | 15       |
| 18. Sometimes I enjoy the challenge presented by an arithmetic problem.  | 7.0         | 126             | 68            | 137             | 74            | 6        |
| 19. I am completely indifferent to arithmetic.   | 5.2         | 5               | 3             | 0               | 0             | -3       |
| 20. I like working all types of arithmetic problems.   | 9.6         | 14              | 8             | 25              | 13            | 5        |
| 21. I like arithmetic but I like other subjects as well.   | 5.6         | 93              | 50            | 115             | 62            | 12       |
| 22. I have always been afraid of arithmetic.   | 2.5         | 65              | 35            | 49              | 26            | -9       |

Two of the three items checked the least number of times on the pre-test are the extreme items on both ends of the attitude scale.

Item 11 (I detest arithmetic and avoid using it at all times) is on the extreme negative side of the scale with a scale value of 1.0. Item 6 (Arithmetic thrills me and I like it better than any other subject) is on the extreme positive end of the scale with a scale value of 10.5.

Items 10 (I never get tired of working with numbers) and 20 (I like working with all types of arithmetic problems), the items next to item 6 on the extreme positive side of the scale, were among the five items checked the least number of times.

This indicates the general absence, in the students, of extreme feelings toward mathematics.

### Post-Test

All items on the attitude scale were checked at least once on the post-test with the exception of item 19 (I am completely indifferent toward arithmetic). Of the five students who had checked this item on the pre-test, all had a positive gain in attitude when the pre- and post-tests were compared.

Item 13 (I have a growing appreciation of arithmetic through understanding its values, applications, and processes) was the item checked most frequently on the post-test. Ninety-three percent of the students checked this item. Items 17 (The completion and proof of

accuracy in arithmetic gave me satisfaction and feelings of accomplishment) and 18 (Sometimes I enjoy the challenge presented by an arithmetic problem), the two positive items checked most frequently on the pre-test, were the next two items checked most frequently on the post-test.

The negative item checked most frequently on the post-test was item 16 (I don't feel sure of myself in arithmetic). It was the eighth most frequently checked item and was checked by 47 percent of the students. This indicates a shift toward the positive end of the attitude scale even though some students still felt unsure of themselves in arithmetic.

The five items checked the least number of times on the post-test were items 19, 11, 9, 5, and 6. Item 5 (I would rather do anything else than do arithmetic) and item 9 (I get no satisfaction from studying arithmetic) were not among the five items checked the least number of times on the pre-test. This indicates a shift away from the negative side of the attitude scale.

#### Comparison of the Pre- and Post- Tests

A comparison of the items checked most frequently on the pre- and post- tests revealed that items 17 (The completion and proof of accuracy in arithmetic gave me satisfaction and feelings of accomplishment) and 18 (Sometimes I enjoy the challenge presented by an

arithmetic problem) were among the five items checked most frequently on both tests. Items 7 (I am afraid of doing word problems), 16 (I don't feel sure of myself in arithmetic), and 21 (I like arithmetic but I like other subjects just as well) were the other three items checked most frequently on the pre-test. Items 2 (Arithmetic is very interesting), 8 (Working with numbers is fun), and 13 (I have a growing appreciation of arithmetic through understanding its values, applications, and processes) were the other three items checked most frequently on the post-test.

Table VI lists the five items checked most **frequently** on the pre- and post- attitude scales. Only two of the five items on the pre-test were positive items while all five of the items on the post-test were positive items. This indicates a shift toward the positive side of the attitude scale.

A comparison of the items that were checked the least number of times on each of the tests revealed that items 6 (Arithmetic thrills me and I like it better than any other subject), 11 (I detest arithmetic and avoid using it at all times), and 19 (I am completely indifferent to arithmetic) were among the five items checked the least number of times on both tests. Items 10 (I never get tired of working with numbers) and 20 (I like working all types of arithmetic problems) were the other two items checked the least number of times on the pre-test. Items 5 (I would rather do anything else than do arithmetic) and 9 (I

Table VI. The Five Items Checked Most Frequently on the Pre- and Post- Attitude Scales.

| Item             | Scale Value | Number of Students | Percent of Students |
|------------------|-------------|--------------------|---------------------|
| <u>Pre-test</u>  |             |                    |                     |
| 18               | 7.0         | 126                | 68                  |
| 16               | 3.7         | 120                | 65                  |
| 17               | 9.0         | 113                | 61                  |
| 7                | 2.0         | 95                 | 51                  |
| 21               | 5.6         | 93                 | 50                  |
| <u>Post-test</u> |             |                    |                     |
| 13               | 8.2         | 173                | 93                  |
| 17               | 9.0         | 141                | 76                  |
| 18               | 7.0         | 137                | 74                  |
| 2                | 8.2         | 135                | 73                  |
| 8                | 8.7         | 123                | 66                  |

get no satisfaction from studying arithmetic) were the other two items checked the least number of times on the post-test.

Table VII lists the five items checked the least number of times on the pre- and post- attitude scales. Items 10 and 20 are on the extreme positive side of the attitude scale and items 5 and 9 are on the extreme negative side of the attitude scale. This also indicates a shift toward the positive side of the attitude scale.

The data in Table V reveals that all positive items on the attitude scale were checked more frequently on the post-test than on the

Table VII. The Five Items Checked the Least Number of Times on the Pre- and Post- Attitude Scales.

| Item             | Scale Value | Number of Students | Percent of Students |
|------------------|-------------|--------------------|---------------------|
| <u>Pre-test</u>  |             |                    |                     |
| 11               | 1.0         | 2                  | 1                   |
| 19               | 5.2         | 5                  | 3                   |
| 6                | 10.5        | 7                  | 4                   |
| 20               | 9.6         | 14                 | 8                   |
| 10               | 9.8         | 15                 | 8                   |
| <u>Post-test</u> |             |                    |                     |
| 19               | 5.2         | 0                  | 0                   |
| 11               | 1.0         | 3                  | 2                   |
| 9                | 2.6         | 8                  | 4                   |
| 5                | 1.0         | 9                  | 5                   |
| 6                | 10.5        | 9                  | 5                   |

pre-test. This same table reveals, with the exception of item 11 (I detest arithmetic and avoid using it at all times), that all the negative items on the attitude scale were checked more frequently on the pre-test than on the post-test. Two students checked item 11 on the pre-test and three students checked it on the post-test.

The positive items showing the greatest gain were items 13 (I have a growing appreciation of arithmetic through understanding its values, applications, and processes) and 2 (Arithmetic is very interesting). The negative items showing the greatest negative gain were items 1 (I avoid arithmetic because I am not very good with figures)

and 16 (I don't feel sure of myself in arithmetic). This indicates a gain in confidence and interest in mathematics as well as a growing appreciation for the subject. The net gain on each item is indicated in the last column of Table V.

Most students liked some aspects of mathematics and disliked others. Table VIII, a comparison of the positive and negative statements checked on the pre- and post- attitude scales, shows that 72 percent of the students had ambivalent feelings toward mathematics on both of the tests. This same table shows an increase in the number of students that checked only positive items and a decrease in those that checked only negative items when comparing the pre- with the post- test.

Table VIII. Comparison of Positive and Negative Statements Checked on the Pre- and Post- Attitude Scales.

| Attitude<br>Scale | Number of Students |                  |                          |
|-------------------|--------------------|------------------|--------------------------|
|                   | Positive<br>Only   | Negative<br>Only | Positive and<br>Negative |
| Pre               | 36                 | 16               | 134                      |
| Post              | 48                 | 4                | 134                      |

The direction of attitude change toward mathematics and the number of students involved is summarized in Table IX. Seventy percent

Table IX. Direction of Attitude Change Toward Mathematics.

| Type of Change | Number of Students | Percent of Students |
|----------------|--------------------|---------------------|
| Increase       | 130                | 70                  |
| Decrease       | 39                 | 21                  |
| No change      | 17                 | 9                   |

of the students showed an increase in their attitude scores, 21 percent showed a decrease, and nine percent showed no change. The average attitude score for all students on the pre-test was 5.9 as compared to 6.8 on the post-test. The average gain was .9 scale units.

The frequency distribution of attitude scores on the pre- and post-tests shows that all students had scores that fell within the range of 2.0 to 8.9 on the scale. This distribution is shown in Table X.

Table X. Frequency Distribution of Attitude Scores on the Pre- and Post- Tests.

| Range   | Pre-Test           |                     | Post-Test          |                     |
|---------|--------------------|---------------------|--------------------|---------------------|
|         | Number of Students | Percent of Students | Number of Students | Percent of Students |
| 8 - 8.9 | 25                 | 13                  | 32                 | 17                  |
| 7 - 7.9 | 37                 | 20                  | 64                 | 34                  |
| 6 - 6.9 | 32                 | 17                  | 54                 | 29                  |
| 5 - 5.9 | 34                 | 18                  | 16                 | 9                   |
| 4 - 4.9 | 27                 | 15                  | 10                 | 5                   |
| 3 - 3.9 | 21                 | 11                  | 8                  | 4                   |
| 2 - 2.9 | 10                 | 5                   | 2                  | 1                   |



All positive ranges had an increase in the number of students and all negative ranges had a decrease when comparing the frequency distribution of attitude scores on the pre- and post- tests. The greatest increase was 14 percent which was in the 7 to 7.9 range. The least increase was in the two extreme ranges (2 to 2.9 and 8 to 8.9).

Fifty-one percent of the students had a positive attitude score on the pre-test as compared to 81 percent on the post-test or a shift toward the positive side of the scale of 30 percentage points.

Eighteen percent, or 34 students, had a neutral attitude score on the pre-test. Of these 34 students, one had a decrease in attitude score, four remained the same, and the other 29 showed an increase in attitude score when comparing the pre- and post- tests. Nine percent, or 16 students, had a neutral attitude on the post-test.

Thirty-one percent of the students had a negative attitude score on the pre-test. Of these 58 students four had a decrease in attitude score, three showed no change, and 51 showed an increase when the two tests were compared. Eleven percent, or 20 students, had a negative score on the post-test. This is a shift toward the positive part of the attitude scale of 20 percentage points.

The number of students having positive, neutral, and negative attitudes toward mathematics is shown in Table XI. This table indicates that prospective elementary school teachers at Brigham Young University do not generally have neutral attitudes toward mathematics.

Table XI. Summary of the Number of Students Having Positive, Neutral, and Negative Attitude Scores on the Pre- and Post- Attitude Scale.

|          | Pre-Test           |                     | Post-Test          |                     | Net Gain |
|----------|--------------------|---------------------|--------------------|---------------------|----------|
|          | Number of Students | Percent of Students | Number of Students | Percent of Students |          |
| Positive | 94                 | 51                  | 150                | 81                  | 30       |
| Neutral  | 34                 | 18                  | 16                 | 9                   | - 9      |
| Negative | 58                 | 31                  | 20                 | 11                  | -20      |

Eighteen percent of the students had neutral attitudes toward mathematics at the beginning of the course and only nine percent had neutral attitudes at the completion of the course.

#### T-Test

The computation of the t-ratio used to determine if there was a significant change in the students' attitudes is shown in Appendix E.

The t-ratio of 8.9 with 185 degrees of freedom is significant at the .001 level of confidence. This indicates that a significant improvement in attitudes did take place while the students were enrolled in Mathematics 305.

### Summary

Some significant aspects of the attitude study are as follows:

1. Most students had ambivalent feelings toward mathematics.
2. Positive items on the attitude scale were checked more frequently on the post- than on the pre- test.
3. Negative items on the attitude scale were checked more frequently on the pre- than on the post- test.
4. There were more students with a positive attitude toward mathematics at the completion of the course than at the beginning.
5. Most students had either a positive or a negative attitude toward mathematics. Few students were neutral in their feelings toward the subject.
6. An improvement in attitudes toward mathematics was shown by most students.
7. The t-test indicated a significant positive change in the students' attitudes toward mathematics.

### Basic Mathematical Understanding

An analysis was made of the pre- and post- tests of basic mathematical understanding to determine to what extent Mathematics 305

contributed to a change in mathematical understanding while the prospective elementary school teachers were enrolled in the course. The analysis of the tests was also made to determine which mathematical understandings, basic to the several computational processes commonly taught in the elementary school, were affected during that same period of time.

A summary of the findings on the pre- and post- tests of basic mathematical understanding is shown in Table XII.

#### Findings on the Pre-Test

A score on the test of mathematical understanding is the total number of correct responses. The range of the scores on the pre-test was from 12 to 41 with 42 being a perfect score. The average score was 26.7 which is 64 percent of a perfect score.

The ten most difficult items on the pre-test are shown in Table XIII. Of these ten items, four were in section four which deals with the understanding of decimals and processes involving decimals. Three of the ten most difficult items were in section five which deals with understanding the rationale of computation. Section two, understanding of integers and processes involving integers, had two items; and section three, understanding of fractions and processes involving fractions, had only one item among the ten most difficult items. Section one, which deals with the decimal system of notation, was the least

Table XII. Summary of the Pre- and Post- Tests of Basic Mathematical Understanding.

|                    | Item | Pre-Test           |                     | Post-Test          |                     | Net Gain |
|--------------------|------|--------------------|---------------------|--------------------|---------------------|----------|
|                    |      | Number of Students | Percent of Students | Number of Students | Percent of Students |          |
| <u>Section I</u>   | 1    | 183                | 98                  | 185                | 99                  | 1        |
|                    | 2    | 170                | 91                  | 168                | 90                  | - 1      |
|                    | 3    | 142                | 76                  | 157                | 84                  | 8        |
|                    | 4    | 173                | 93                  | 177                | 95                  | 2        |
|                    | 5    | 158                | 85                  | 169                | 91                  | 6        |
|                    | 6    | 145                | 78                  | 159                | 86                  | 8        |
|                    | 7    | 133                | 72                  | 136                | 73                  | 1        |
|                    | 8    | 96                 | 52                  | 76                 | 41                  | -11      |
| <u>Section II</u>  | 9    | 183                | 98                  | 178                | 96                  | - 2      |
|                    | 10   | 147                | 79                  | 157                | 84                  | 5        |
|                    | 11   | 87                 | 47                  | 80                 | 43                  | - 4      |
|                    | 12   | 137                | 74                  | 154                | 83                  | 9        |
|                    | 13   | 87                 | 47                  | 119                | 64                  | 17       |
|                    | 14   | 44                 | 24                  | 64                 | 34                  | 10       |
|                    | 15   | 184                | 99                  | 183                | 98                  | - 1      |
|                    | 16   | 137                | 74                  | 154                | 83                  | 9        |
| <u>Section III</u> | 17   | 160                | 86                  | 164                | 88                  | 2        |
|                    | 18   | 184                | 99                  | 185                | 99                  | 0        |
|                    | 19   | 132                | 71                  | 143                | 77                  | 6        |
|                    | 20   | 147                | 79                  | 156                | 84                  | 5        |
|                    | 21   | 139                | 75                  | 152                | 82                  | 7        |
|                    | 22   | 116                | 62                  | 125                | 67                  | 5        |
|                    | 23   | 53                 | 29                  | 57                 | 31                  | 2        |
|                    | 24   | 103                | 55                  | 112                | 60                  | 5        |
| <u>Section IV</u>  | 25   | 156                | 84                  | 160                | 86                  | 2        |
|                    | 26   | 86                 | 46                  | 93                 | 50                  | 4        |
|                    | 27   | 81                 | 43                  | 93                 | 50                  | 7        |
|                    | 28   | 83                 | 45                  | 105                | 56                  | 11       |
|                    | 29   | 99                 | 53                  | 111                | 60                  | 7        |
|                    | 30   | 133                | 72                  | 133                | 72                  | 0        |
|                    | 31   | 119                | 64                  | 119                | 64                  | 0        |
|                    | 32   | 118                | 63                  | 128                | 69                  | 6        |
|                    | 33   | 37                 | 20                  | 45                 | 24                  | 4        |
|                    | 34   | 131                | 70                  | 132                | 71                  | 1        |
| <u>Section V</u>   | 35   | 59                 | 32                  | 90                 | 48                  | 16       |
|                    | 36   | 93                 | 50                  | 136                | 73                  | 23       |
|                    | 37   | 98                 | 53                  | 156                | 84                  | 31       |
|                    | 38   | 23                 | 12                  | 49                 | 26                  | 14       |
|                    | 39   | 97                 | 52                  | 119                | 64                  | 12       |
|                    | 40   | 40                 | 22                  | 52                 | 28                  | 6        |
|                    | 41   | 129                | 69                  | 149                | 80                  | 11       |
|                    | 42   | 128                | 69                  | 156                | 84                  | 15       |

Table XIII. Comparison of the Ten Most Difficult Items on the Pre- and Post- Tests of Mathematical Understanding.

| Test         | Item | Section | Number of<br>Correct Responses | Percent of<br>Students |
|--------------|------|---------|--------------------------------|------------------------|
| <u>Pre-</u>  |      |         |                                |                        |
|              | 38   | 5       | 23                             | 12                     |
|              | 33   | 4       | 37                             | 20                     |
|              | 40   | 5       | 40                             | 22                     |
|              | 14   | 2       | 44                             | 24                     |
|              | 23   | 3       | 53                             | 29                     |
|              | 35   | 5       | 59                             | 32                     |
|              | 27   | 4       | 81                             | 43                     |
|              | 28   | 4       | 83                             | 45                     |
|              | 26   | 4       | 86                             | 46                     |
|              | 11   | 2       | 87                             | 47                     |
| <u>Post-</u> |      |         |                                |                        |
|              | 33   | 3       | 45                             | 24                     |
|              | 38   | 5       | 49                             | 26                     |
|              | 40   | 5       | 52                             | 28                     |
|              | 23   | 3       | 57                             | 31                     |
|              | 14   | 2       | 64                             | 34                     |
|              | 8    | 1       | 76                             | 41                     |
|              | 11   | 2       | 80                             | 43                     |
|              | 35   | 5       | 90                             | 48                     |
|              | 26   | 4       | 93                             | 50                     |
|              | 27   | 4       | 93                             | 50                     |

difficult section on the pre-test.

The ten least difficult items on the pre-test are shown in Table XIV. There were four items each, in sections one and two; sections three and four each had one item; and section five did not have any items in the list of the ten least difficult items on the pre-test.

Table XIV. Comparison of the Ten Least Difficult Items on the Pre- and Post- Tests of Mathematical Understanding.

| Test         | Item | Section | Number of<br>Correct Responses | Percent of<br>Students |
|--------------|------|---------|--------------------------------|------------------------|
| <u>Pre-</u>  |      |         |                                |                        |
|              | 15   | 2       | 184                            | 99                     |
|              | 18   | 3       | 184                            | 99                     |
|              | 1    | 1       | 183                            | 98                     |
|              | 9    | 2       | 183                            | 98                     |
|              | 4    | 1       | 173                            | 93                     |
|              | 2    | 1       | 170                            | 91                     |
|              | 17   | 2       | 160                            | 86                     |
|              | 5    | 1       | 158                            | 85                     |
|              | 25   | 4       | 156                            | 84                     |
|              | 10   | 2       | 147                            | 79                     |
| <u>Post-</u> |      |         |                                |                        |
|              | 1    | 1       | 185                            | 99                     |
|              | 18   | 3       | 185                            | 99                     |
|              | 15   | 2       | 183                            | 98                     |
|              | 9    | 2       | 178                            | 96                     |
|              | 4    | 1       | 177                            | 95                     |
|              | 5    | 1       | 169                            | 91                     |
|              | 2    | 1       | 168                            | 90                     |
|              | 17   | 3       | 164                            | 88                     |
|              | 25   | 4       | 160                            | 86                     |
|              | 6    | 1       | 159                            | 86                     |

A comparison of the ten most difficult items with the ten least difficult items indicates that section five, dealing with the rationale of computation was the most difficult section on the pre-test. Section one, understanding the decimal system of notation, was the least difficult section on the pre-test. Forty-eight students responded correctly to all eight items in section one. Only seven students responded

correctly to all eight items in section five.

### Findings on the Post-Test

The scores on the post-test had a range of 14 to 42 with two students having a perfect score of 42. The average score was 29.2 which is 70 percent of the possible 42.

The ten most difficult items on the post-test are shown in Table XIII. The ten least difficult items are shown in Table XIV.

A comparison of the ten most difficult items with the ten least difficult items indicates that section five, dealing with the understanding of the rationale of computation, was the most difficult section. The least difficult section of the post-test was section one which deals with understanding of the decimal system of notation. Forty students responded correctly to all eight items in section one while 14 students responded correctly to all eight items in section five.

### Comparison of Pre- and Post- Tests

The average scores on the pre- and post- tests of mathematical understanding indicate an average positive gain of 2.5 units per student. The greatest gain made by a single student was 13 units while the least gain made by a single student was a -5. The range showed an upward shift when comparing the pre- with the post- test. A frequency distribution of the scores on the test of mathematical



understanding for both the pre- and post- tests is shown in Table XV.

Table XV. Frequency Distribution of Scores on the Test of Basic Mathematical Understanding.

| Range   | Pre-Test           |                     | Post-Test          |                     |
|---------|--------------------|---------------------|--------------------|---------------------|
|         | Number of Students | Percent of Students | Number of Students | Percent of Students |
| 40 - 42 | 4                  | 2                   | 6                  | 3                   |
| 37 - 39 | 12                 | 7                   | 14                 | 8                   |
| 34 - 36 | 16                 | 9                   | 34                 | 18                  |
| 31 - 33 | 22                 | 12                  | 26                 | 14                  |
| 28 - 30 | 30                 | 16                  | 28                 | 15                  |
| 25 - 27 | 30                 | 16                  | 39                 | 21                  |
| 22 - 24 | 28                 | 15                  | 18                 | 10                  |
| 19 - 21 | 24                 | 13                  | 13                 | 7                   |
| 16 - 18 | 11                 | 6                   | 7                  | 4                   |
| 13 - 15 | 8                  | 4                   | 1                  | 1                   |
| 10 - 12 | 1                  | 1                   | 0                  | 0                   |

Nine of the ten most difficult items on the pre-test were among the ten most difficult items on the post-test. Item eight, dealing with place-value, was not among the ten most difficult items on the pre-test but was among the ten most difficult items on the post-test. Item eight showed a net gain of -11 percentage points. Item 28, dealing with division by decimal fractions, was among the ten most difficult items on the pre-test but was not among the ten most difficult items on the post-test. Item 28 showed a net gain of 11 percentage points.

The ten items found to be the least difficult on the pre-test were also found to be the least difficult on the post-test with the exception of items six and ten. Item six, dealing with place-value, was not among the ten least difficult items on the pre-test but was among them on the post-test. Item ten, dealing with division by integers, was among the ten least difficult items on the pre-test but was not among them on the post-test.

The direction of change in mathematical understanding is summarized in Table XVI. Seventy percent of the students showed an increase in their mathematical understanding, 20 percent showed a decrease, and nine percent showed no change during the course.

Table XVI. Direction of Change in Mathematical Understanding.

| Type of Change | Number of Students | Percent of Students |
|----------------|--------------------|---------------------|
| Increase       | 131                | 70                  |
| Decrease       | 38                 | 20                  |
| No Change      | 17                 | 9                   |

The net gain for each of the items on the test of mathematical understanding is shown in the last column of Table XII. The items

showing the greatest gain are in section five which deals with the rationale of computation. The items showing the least gain are in section one which deals with understanding the decimal system of notation.

### T-Test

The computation of the t-ratio used to determine if there was a significant change in the students' basic mathematical understandings, when comparing the pre- and post- tests, is shown in Appendix F.

The t-ratio of 8.9 with 185 degrees of freedom is significant at the .001 level of confidence. This indicates that a significant improvement in basic mathematical understanding did take place while the students were enrolled in Mathematics 305.

### Summary

Some significant aspects of the study of basic mathematical understanding are as follows:

1. The greatest gain was shown in the section on the understanding of the rationale of computation. This section was found to be the most difficult section on both the pre- and post- tests.
2. The least gain was shown in the section on the understanding of the decimal system of notation. This was the section found to be the least difficult on both the pre- and post- tests.

3. The average score on the pre-test of basic mathematical understanding was 26.7 or 64 percent. The average on the post-test was 29.2 or 70 percent.

4. Improvement in basic mathematical understanding was made by most students.

5. The t-test indicated a significant positive change in basic mathematical understanding.

### Correlation Studies

An analysis was made of the pre- and post- tests of basic mathematical understanding, the pre- and post- tests on attitudes toward mathematics, and certain selected variables to determine what variables were related while the prospective elementary school teachers were enrolled in Mathematics 305.

A summary of the findings in the correlation studies is shown in Table XVII.

### Pre-Test Attitude Scores and Final Grades

The correlation  $r$  between the scores on the pre-attitude scale and the final grades in Mathematics 305 was .51. This  $r$ -value is significant at the .001 level of confidence. This indicates a significant positive relation between the attitude scores on the pre-test and

Table XVII. Summary of the Findings in the Correlation Studies.

| Variable  | r       |
|---|---------|
| Pre-test attitude scores<br>Final grades in Mathematics 305                       | .51 *   |
| Post-test attitude scores<br>Final grades in Mathematics 305                      | .61 *   |
| Pre-test attitude scores<br>Change in mathematical understanding                  | -.13 ** |
| Post-test attitude scores<br>Change in mathematical understanding                 | -.07 ** |
| Change in attitude<br>Change in mathematical understanding                        | .11 **  |
| Pre-test scores in mathematical understanding<br>Final grades in Mathematics 305  | .61 *   |
| Post-test scores in mathematical understanding<br>Final grades in Mathematics 305 | .65 *   |
| A. C. T. scores<br>Pre-test scores in mathematical understanding                  | .65 *   |

\* Significant at the .001 level of confidence

\*\* Not significant at the .05 level of confidence

the final grades. Those students having the highest attitude scores on the pre-test were generally those receiving the highest grades in the course. Those having the lowest attitude scores were generally those receiving the lowest grades.

Table XVIII shows a comparison of the average attitude scores and the final grades. There was an increase in the average attitude scores as the grade level increased with the exception of the D and E grade level. The D and E grade levels showed just the opposite relationship.

Table XVIII. A Comparison of Average Attitude Scores and Final Grades.

| Grade | Average Attitude Score |       |
|-------|------------------------|-------|
|       | Pre-                   | Post- |
| A     | 7.5                    | 7.9   |
| B     | 7.0                    | 7.5   |
| C     | 5.6                    | 6.7   |
| D     | 3.5                    | 4.4   |
| E     | 5.4                    | 5.4   |

#### Post-Test Attitude Scores and Final Grades

The correlation between the scores on the post-attitude scale and the final grades was .61. This is significant at the .001 level of confidence. This indicates a significant relation between these two variables. This relationship is shown in Table XVIII. Again there was an increase in average attitude scores as the grade level increased with the exception of the D and E grade levels. The D

and E grade levels showed the same relationship as on the pre-attitude scale.

There was an increase in average attitude scores at each of the grade levels when the pre- and post- tests were compared with the exception of the E grade level where there was no change indicated. The greatest change took place at the C grade level and the least change took place at the A and E grade levels.

#### Pre-Test Attitude Scores and Changes in Mathematical Understanding

The correlation between these two variables was  $-.13$ . This is not significant at the  $.05$  level of confidence. This indicates there is no significant relation between pre-attitude test scores and the changes in mathematical understanding.

#### Post-Test Attitude Scores and Changes in Mathematical Understanding

The correlation between these two variables was  $-.07$  which is not significant at the  $.05$  level of confidence. This indicates there is no significant relation between the post-attitude scores and the changes in mathematical understanding.

#### Changes in Attitude and Changes in Mathematical Understanding

The correlation between these variables was  $.11$  which is not significant at the  $.05$  level of confidence. This indicates there is

no significant relation between changes in attitude and changes in mathematical understanding.

A comparison of Table IX and Table XVI (the direction of change in attitudes and mathematical understanding) indicates that the same proportion of the sample showed the same direction of change on both the attitude scale and test of mathematical understanding. Further analysis of those students that made positive gains on both tests showed that 93 students, or 50 percent of the sample, made a positive gain in both attitudes and basic mathematical understanding.

The small  $r$  - value indicates that even though half of the students in the sample showed a positive gain in both areas, those making the greatest gain in one area did not necessarily make the greatest gain in the other area.

#### Pre-Test Scores on Mathematical Understanding and Final Grades

The correlation between these two variables was .61. This is a significant correlation at the .001 level of confidence. This indicates a positive relation between the pre-test scores on mathematical understanding and final grades.

Those students with the highest scores on the pre-test on mathematical understanding were generally the same students receiving the highest grades in the course. Those students with the lowest test scores were generally those receiving the lowest grades.



This relation is illustrated in Table XIX.

Table XIX. A Comparison of Average Scores in Mathematical Understanding and Final Grades.

| Grade | Average Score |       |
|-------|---------------|-------|
|       | Pre-          | Post- |
| A     | 35.4          | 36.6  |
| B     | 30.4          | 32.5  |
| C     | 25.4          | 28.4  |
| D     | 21.9          | 24.2  |
| E     | 19.2          | 22.0  |

#### Post-Test Scores on Mathematical Understanding and Final Grades

There was a correlation between these variables of .65 which is significant at the .001 level of confidence. Therefore, there is a significant positive relation between the post-test scores on mathematical understanding and the final grades. This relation is also shown in Table XIX.

Each grade level showed an increase in mathematical understanding as the grade level increased. There was also an increase in mathematical understanding at each grade level when comparing the two tests.

### A. C. T. Scores and Pre-Test Scores on Mathematical Understanding

These two variables had a correlation of .65 which is significant at the .001 level of confidence. This indicates a significant positive relation between the scores on the mathematics section of the A. C. T. and the pre-test scores on mathematical understanding. Those students having the highest A. C. T. scores generally had the highest scores on mathematical understanding.

### Summary

The following variables were found to have a positive significant relationship at the .001 level of confidence:

1. Pre-test attitude scores and final grades.
2. Post-test attitude scores and final grades.
3. Pre-test scores on mathematical understanding and final grades.
4. Post-test scores on mathematical understanding and final grades.
5. A. C. T. scores and pre-test scores on mathematical understanding.

The following variables were found to have no significant relationship at the .05 level of confidence:

1. Pre-test attitude scores and changes in mathematical understanding.
2. Changes in attitudes and changes in mathematical understanding.

## V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

### Summary

This study was made to determine the effects of a required mathematics content course, Mathematics 305, upon prospective elementary school teachers. The two basic areas considered were attitudes toward mathematics and basic mathematical understandings.

The major findings growing out of the study are as follows:

1. Most prospective elementary school teachers at Brigham Young University have ambivalent feelings toward mathematics.
2. Fifty-one percent of the students in the sample had a positive attitude toward mathematics at the beginning of the course as compared with 81 percent at the completion of the course.
3. Thirty-one percent of the students in the sample had a negative attitude toward mathematics at the beginning of the course as compared with 11 percent at the completion of the course.
4. The section on the rationale of computation was found to be the most difficult section in mathematical understanding on both pre- and post- tests. The decimal system of notation was found to be the least difficult section on both tests.
5. Positive gains in mathematical understanding were made by

most students. The greatest gains were shown in the section on the rationale of computation and the least gains were shown in the section on the decimal system of notation.

6. At the completion of Mathematics 305, the future elementary school teacher knew only 70 percent of the understandings basic to the several computational processes commonly taught in the elementary school.

7. Hypothesis one states that prospective elementary school teachers at Brigham Young University have neutral attitudes toward mathematics. This hypothesis is rejected. However, a few students do have neutral attitudes toward the subject.

8. Hypothesis two states that Mathematics 305 does not contribute to a change in attitudes toward mathematics while the students are enrolled in the course. This hypothesis is rejected.

9. Hypothesis three states there is no relationship between attitude toward mathematics and student success in Mathematics 305 as measured by course grades. This hypothesis is rejected.

10. Hypothesis four, Mathematics 305 does not contribute to a change in basic mathematical understanding while the student is enrolled in the course, is rejected.

11. Hypothesis five, there is no relationship between attitudes

toward mathematics and change in basic mathematical understanding while students are enrolled in Mathematics 305, is accepted.

12. Hypothesis six states there is no relationship between change in attitudes toward mathematics and change in basic mathematical understanding while students are enrolled in Mathematics 305. This hypothesis is accepted.

13. Hypothesis seven states there is no relationship between basic mathematical understanding and success in Mathematics 305 as measured by course grades. This hypothesis is rejected.

14. Hypothesis eight states there is no relationship between basic mathematical understanding and mathematics scores on the American College Test. This hypothesis is rejected.

### Conclusions

From the findings of this study at Brigham Young University, the following conclusions might be drawn:

1. Most prospective elementary teachers like some aspects of mathematics and dislike others.

2. The attitudes of prospective elementary school teachers toward mathematics can be significantly improved by taking Mathematics 305, a required mathematics course specifically designed for them.

3. There is a significant gain in basic mathematical understanding by prospective elementary school teachers while they are taking Mathematics 305.

4. The mathematical understandings that are basic to the several computational processes commonly taught in the elementary school and held by prospective elementary school teachers at Brigham Young University are in need of further improvement.

5. Attitudes toward mathematics and basic mathematical understanding are significantly related to success in Mathematics 305 as measured by the final grade in the course.

6. There is no significant linear relationship between attitudes toward mathematics and change in basic mathematical understanding while students are enrolled in Mathematics 305.

7. The American College Test mathematics score is a good predictor of success in Mathematics 305.

### Recommendations

As a result of the present study, the following recommendations seem appropriate:

1. The Mathematics Department at Brigham Young University should develop, and offer as an elective, a new mathematics course which would be a continuation of Mathematics 305. This new class

should have Mathematics 305 as a prerequisite and should have the same general content as the second course outlined by the Committee on the Undergraduate Program in Mathematics of the Mathematical Association of America (16, p. N1-N10). This would permit the students who have lost their fear of mathematics to continue a study of mathematics at a level they are able to comprehend.

2. A study, similar to the present study, should be made with this new class to determine its effect upon the prospective elementary school teacher. If this new class is determined a success, the College of Education at Brigham Young University should then require six semester hours of mathematics content of all prospective elementary school teachers.

3. Make a follow-up study of the students taking a required content course in mathematics to determine the lasting effects of the course. This should be done as the future teacher continues through the remainder of his college preparation and on into a teaching situation.

4. An attitude scale should be used at the beginning of each semester to determine which students in Mathematics 305 have negative attitudes toward mathematics. The instructor of the course should then counsel with each of these students in an attempt to improve the student's attitude toward the subject.

5. A study should be made to determine to what extent



Mathematics 305 is preparing the future teacher to teach the mathematics presently being taught in the elementary school.

6. A study, similar to the present study, should be made with in-service elementary school teachers who are taking Mathematics 305 through the evening school or in-service institutes.

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## APPENDICES

## APPENDIX A

## PERSONAL DATA SHEET

Instructions: The purpose of the information requested below is to obtain personal data about students currently taking Mathematics 305. Please check (✓) those items which are true in your case.

1. Name \_\_\_\_\_  
                                    last                                    first                                    middle
2. Section number \_\_\_\_\_
3. Sex  
      \_\_\_\_\_ Male  
      \_\_\_\_\_ Female
4. Age  
      \_\_\_\_\_ 18-24  
      \_\_\_\_\_ 25-30  
      \_\_\_\_\_ Over 30
5. Status  
      \_\_\_\_\_ Freshman  
      \_\_\_\_\_ Sophomore  
      \_\_\_\_\_ Junior  
      \_\_\_\_\_ Senior  
      \_\_\_\_\_ Graduate  
      \_\_\_\_\_ Other (identify \_\_\_\_\_)

## 6. Major

- \_\_\_\_\_ General Elementary Education
- \_\_\_\_\_ Human Development and Family Relationship
- \_\_\_\_\_ Other (identify \_\_\_\_\_)

## 7. Teaching experience

- \_\_\_\_\_ None
- \_\_\_\_\_ Student Teaching
- \_\_\_\_\_ Substitute teacher for \_\_\_\_\_ years.
- \_\_\_\_\_ Regular full-time teacher for \_\_\_\_\_ years.
- \_\_\_\_\_ Other (identify \_\_\_\_\_)

## 8. High school mathematics background

- \_\_\_\_\_ None
- \_\_\_\_\_ General mathematics
- \_\_\_\_\_ First-year algebra
- \_\_\_\_\_ Second-year algebra
- \_\_\_\_\_ Geometry
- \_\_\_\_\_ Trigonometry
- \_\_\_\_\_ Calculus
- \_\_\_\_\_ Business mathematics
- \_\_\_\_\_ Other (identify \_\_\_\_\_)

## 9. College mathematics background

- \_\_\_\_\_ None
- \_\_\_\_\_ Intermediate algebra

\_\_\_\_\_ College algebra

\_\_\_\_\_ Other(s) (identify \_\_\_\_\_)

10. Colleges or universities attended

\_\_\_\_\_ B. Y. U. for \_\_\_\_\_ years

\_\_\_\_\_ Other(s) (identify \_\_\_\_\_)

for \_\_\_\_\_ years or credit hours

11. I am taking a science course this semester

\_\_\_\_\_ No

\_\_\_\_\_ Yes (identify \_\_\_\_\_)

12. Elementary school subject liked most \_\_\_\_\_

Elementary school subject liked least \_\_\_\_\_

13. High school subject liked most \_\_\_\_\_

High school subject liked least \_\_\_\_\_

## APPENDIX B

## A TEST OF BASIC MATHEMATICAL UNDERSTANDING

Copyright by

Vincent J. Glennon  
Revised EditionDirections:

Do not write in this booklet.

This is a test to see how well you understand arithmetic.  
You do not have to do any written work to find the answers.

Read each statement carefully and decide which of the answers is the correct answer. Write the letter which identifies this answer on the line provided on the answer sheet.

Sample item:

Which of the following numbers has the largest value?

A. 23      B. 9      C. 35      D. 45      E. 11

45 is the correct answer so you write D on the line provided on the answer sheet.

Try each question but do not stay too long on any one question. If you cannot find the answer you may go on to the next question. Your score will be the number of correct responses.

You may go all the way through the test without stopping.

Remember -- DO NO WRITTEN WORK TO FIND THE ANSWERS.

Begin at the top of the next page.

Section I. The Decimal System of Notation

1. If you rearrange the figures in the number 43, 126 which of the following arrangements would give the smallest number?  
A. 64,321    B. 21,346    C. 12,346    D. 14,632    E. 13,246
2. Which of the following has a 3 in the hundreds' place?  
A. 23,069    B. 85,231    C. 49,563    D. 39,043    E. 42,304
3. About how many tens are there in 6542?  
A. 6.5    B.  $65\frac{1}{2}$     C. 654    D. 6,540    E. 65,000
4. In the number 7,255 the 5 on the left represents a value how many times as large as the 5 on the right?  
A. 1 (same value)    B. 2    C. 5    D. 10    E. 100
5. Which of the following has a 4 in the ten thousands' place?  
A. 423,102    B. 643,142    C. 438,116    D. 374,942  
E. 763,420
6. In the number 3,944 the 4 on the right represents a value how many times as large as the 4 on the left?  
A.  $1/10$     B.  $1/2$     C. 5    D. 1 (same value)    E. 10
7. About how many hundreds are there in 34,820?  
A.  $3\frac{1}{2}$     B. 35    C. 350    D. 3,500    E. 35,000
8. In the number 7,843 the 4 represents a value how many times as large as the 8?  
A.  $1/10$     B.  $1/20$     C.  $1/2$     D. 2    E. 20

Section II. Basic Understanding of Integers and Processes

9. If you had a bag of 365 marbles to be shared equally by 5 boys, which would be the quickest way to determine each boys' share?
- A. Counting    B. Adding    C. Subtracting    D. Multiplying  
E. Dividing
10. When a whole number is divided by a whole number other than 1, how does the answer compare with the whole number divided?
- A. Larger    B. Smaller    C. Same    D.  $1/2$  as large  
E. Can't tell
11. If the zeros in the two numbers in this example were left off, how would the answer be changed? 60 divided by 3720.
- A. The answer would be ten times as large.  
B. The answer would be one hundred times as large.  
C. The answer would be one-tenth as large.  
D. The answer would be one-hundreth as large.  
E. The answer would not change.
12. How would the answer to this example be changed, if a zero were added to the right of each number?
- |        |
|--------|
| 364    |
| 2936   |
| 14     |
| + 4381 |
- A. The answer would be ten times as large.  
B. The answer would be one hundred times as large.  
C. The answer would not change.  
D. Cannot tell until you add both ways.  
E. The answer would be one thousand times as large.
13. What would be the effect on the answer if you added two zeros to 439 and took away the zero from 450?
- |       |
|-------|
| 439   |
| x 450 |
- A. The answer would be ten times as large.  
B. The answer would be one hundred times as large.  
C. The answer would remain the same.  
D. The answer would be one-tenth as large.  
E. The answer would be one-hundreth as large.

14. What would be the effect on the answer if you added (annexed) two zeros to 92 and changed 4500 to 450?

$$92 \overline{)4500}$$

- A. The answer would be ten times as large.
  - B. The answer would be one-tenth as large.
  - C. The answer would be one hundred times as large.
  - D. The answer would be one-hundreth as large.
  - E. The answer would be one-thousandth as large.
15. If the numbers in a large addition problem were changed so that the top number was placed at the bottom and the bottom number was placed at the top, how would the answer be affected?
- A. Answer would be larger.
  - B. Answer would be smaller.
  - C. Answer would not change.
  - D. Could not do the problem.
  - E. Cannot tell until you add both ways and compare.
16. What would be the effect on the answer if you added (annexed) two zeros to 39?

$$859 \overline{)39}$$

- A. The answer would be one hundred times as large.
- B. The answer would be one-hundreth as large.
- C. The answer would be one-thousandth as large.
- D. The answer would not change.
- E. You could not do the example.

### Section III. Basic Understandings of Fractions and Processes

17. Which of the following fractions is the largest?
- A.  $\frac{1}{7}$    B.  $\frac{5}{7}$    C.  $\frac{3}{7}$    D.  $\frac{11}{7}$    E.  $\frac{6}{7}$
18. Which of the following fractions is the smallest?
- A.  $\frac{1}{9}$    B.  $\frac{1}{5}$    C.  $\frac{1}{2}$    D.  $\frac{1}{7}$    E.  $\frac{1}{3}$
19. When a whole number is multiplied by a common (proper) fraction, how does the answer compare with the whole number?
- A. Larger
  - B. Smaller
  - C. Same
  - D. Cannot tell
  - E. Half as large



20. As the numerator of a fraction decreases and the denominator remains the same, the value of the fraction:
- A. Remains the same    B. Increases    C. Decreases  
D. Approaches one    E. Cannot tell
21. As the denominator of a fraction decreases and the numerator remains the same, the value of the fraction:
- A. Decreases    B. Increases    C. Remains same  
D. Approaches one    E. Cannot tell
22. When a whole number is divided by a common (proper) fraction, how does the answer compare with the whole number?
- A. Larger    B. Smaller    C. Same    D. Cannot tell  
E. Varies
23. Which sentence best tells why the answer is larger than 5?
- $$5 \div 3/4 = 6 \frac{2}{3}$$
- A. Because inverting the divisor turned the  $3/4$  upside down.  
B. Because multiplying always makes the answer larger.  
C. Because the divisor  $3/4$  is less than 1.  
D. Because dividing by proper and improper fractions makes the answer larger than the number divided.  
E. Inverting a fraction puts the larger number on top.
24. When a common (proper) fraction is multiplied by a common fraction, how does the answer compare with the fraction multiplied?
- A. Larger    B. Smaller    C. Same    D. Cannot tell  
E. Varies

Section IV. Basic Understanding of Decimals and Processes

25. How would you write the decimal "eighty and eight hundredths" ?
- A. .8008    B. 80.800    C. 80.08    D. 80.008    E. 8008.08

26. Which decimal tells how long line Y is when compared to line X?

line X  line Y 

A. .5    B. .625    C. 1.25    D. .75    E. .33

27. About how many hundredths are there in .635?

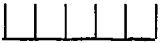

A.  $1/2$     B. 6.35    C. 63.5    D. 635    E. 6350

28. How would the answer be changed if you changed 6.5 to .65 and 84.5 to 845?

$$84.5 \overline{) 6.5}$$

- A. The answer would be the same.  
 B. The answer would be ten times as large.  
 C. The answer would be one hundred times as large.  
 D. The answer would be one-tenth as large.  
 E. The answer would be one-hundredth as large.

29. Which decimal tells how long line Y is when compared to line X?

line X  line Y 

A. 1.25    B. 1.50    C. 20    D. 2.40    E. 2.50

30. What would be the effect on the answer if you changed 368 to 3680 and 24 to 2.4?

- A. The answer would be smaller.  
 B. It would not change the answer.  
 C. It would be the same as adding a zero to the answer.  
 D. The answer would be one-tenth as large.  
 E. Cannot tell until you do the example both ways.

31. How would the answer be affected if you moved the decimal point one place to the left in both numbers?

43.5

- A. The answer would be one-tenth as large.  
 B. The answer would be one-hundredth as large.  
 C. The answer would be one hundred times as large.  
 D. It would be the same as subtracting 100 from the answer.  
 E. The answer would have the same value.

32. How would the answer be affected if you moved the decimal point in 485.3 one place to the right?

$$62 \overline{)485.3}$$

- A. The answer would be ten times as large.
- B. The answer would be 10 larger.
- C. The answer would be one-tenth larger.
- D. The answer would have a zero at the right.
- E. The value of the answer would be the same.

33. About how many tenths are there in .055 ?

- A. 0    B.  $\frac{1}{2}$     C. 5    D. 10    E. 50

34. Why is the answer smaller than the top number ?

$$\begin{array}{r} 8 \\ \times .5 \\ \hline \end{array}$$

- A. Because 8 is more than 5.
- B. Because you are finding how many .5's in 8.
- C. Because .5 is less than 8 .
- D. When you multiply by a decimal the answer is always smaller than the top number.
- E. Because multiplying by .5 is the same as finding one-half of the number.

#### Section V. Basic Understandings of the Rationale of Computation

35. Which one of the following would give the correct answer to this example?     $2.1 \times 21$

- A. The sum of  $1 \times 2.1$  and  $21 \times 2.1$
- B. The sum of  $10 \times 2.1$  and  $2 \times 2.1$
- C. The sum of  $10 \times 2.1$  and  $20 \times 2.1$
- D. The sum of  $1 \times 2.1$  and  $20 \times 2.1$
- E. None of the above

36. Which statement best tells why we "invert the divisor and multiply" when dividing a fraction by a fraction?

- A. It is an easy method of finding a common denominator and arranging the numerators in multiplication form.
- B. It is an easy method for dividing the denominators and multiplying the numerators of the two fractions.
- C. It is a quick, easy and accurate method of arranging two fractions in multiplication form.

- D. Dividing by a fraction is the same as multiplying by the reciprocal of the fraction.
- E. It is a quick method of finding the reciprocals of both fractions and reducing to lowest terms (cancelling).

37. Why do we move the second partial product one place to the left when we multiply by the 6 ?

729

$\times 68$

- A. Because the answer has to be larger then 729.
- B. Because the 6 means 6 tens.
- C. Because 6 is the second figure in 68.
- D. Because we learned to multiply that way.
- E. Because the 6 represents a greater value than the 8 represents.

38. When you multiply by 4 in 48 you will get a number that is how large compared with the final answer ?

485

$\times 48$

- A. One-twelfth as large.
- B. One-tenth as large.
- C. One-half as large.
- D. Five-sixths as large.
- E. Twice as large.

39. The answer to this example will be how large when compared with the 69 ?

827

$\times 69$

- A. Twice as large.
- B. Sixty-nine times as large.
- C. One sixty-ninth as large.
- D. Eight hundred twenty seven times as large.
- E.  $1/827$  as large.

40. In this example you multiply by the 6, then by the 3. How do the two results (partial products) compare ?

749

$\times 36$

- A. The second represents a number one-half as large as the first.
- B. The second represents a number twice as large as the first.
- C. The second represents a number five times as large as the first.
- D. The second represents a number ten times as large as the first.
- E. The second represents a number twenty times as large as the first.

41. Which statement best explains the 4 in the answer?

$$\begin{array}{r} 26 \overline{)1248} \\ \underline{104} \phantom{00} \\ 208 \phantom{00} \\ \underline{208} \phantom{00} \\ 0 \phantom{00} \end{array}$$

- A. The 4 means that there are forty-eight 26's in 1248.
- B. The 4 in the answer means that there are four 26's in 1248.
- C. The 4 in the answer means that 2 goes into 12 four times, and 5 would be too large.
- D. The 4 means that there are at least forty 26's in 1248.
- E. The 4 means that the answer will come out even.
42. Here is an example in subtraction of mixed numbers in which it is necessary to "regroup". Which statement best explains the regrouping?

$$\begin{array}{r} 5 \frac{3}{8} \\ - 2 \frac{5}{8} \\ \hline \end{array}$$

- A. You cannot subtract  $\frac{5}{8}$  from  $\frac{3}{8}$ , so you take 1 from the 5 and put it in front of the 3 making 13.
- B. You cannot subtract  $\frac{5}{8}$  from  $\frac{3}{8}$ , so you add the 3 and the 8 which makes  $11\frac{1}{8}$ .
- C. You cannot subtract  $\frac{5}{8}$  from  $\frac{3}{8}$ , so you turn them around and subtract  $\frac{3}{8}$  from  $\frac{5}{8}$ .
- D. You cannot subtract  $\frac{5}{8}$  from  $\frac{3}{8}$ , so you take 1 from the 5 and add it to  $\frac{3}{8}$  making  $\frac{4}{8}$ .
- E. You cannot subtract  $\frac{5}{8}$  from  $\frac{3}{8}$ , so you take 1 from the the 5 and change it to  $\frac{8}{8}$ , then add the  $\frac{8}{8}$  to the  $\frac{3}{8}$  making  $11\frac{1}{8}$ .

MAKE SURE YOUR NAME IS ON THE ANSWER SHEET

## APPENDIX C

## ARITHMETIC ATTITUDE SCALE

Name \_\_\_\_\_ Date \_\_\_\_\_

Place a check (✓) before those statements which tell how you feel about arithmetic. Select only those items which express your true feelings.

- \_\_\_ 1. I avoid arithmetic because I am not very good with figures.
- \_\_\_ 2. Arithmetic is very interesting.
- \_\_\_ 3. Arithmetic is something you have to do even though it is not enjoyable.
- \_\_\_ 4. I like arithmetic because the procedures are logical.
- \_\_\_ 5. I would rather do anything else than do arithmetic.
- \_\_\_ 6. Arithmetic thrills me and I like it better than any other subject.
- \_\_\_ 7. I am afraid of doing word problems.
- \_\_\_ 8. Working with numbers is fun.
- \_\_\_ 9. I get no satisfaction from studying arithmetic.
- \_\_\_ 10. I never get tired of working with numbers.
- \_\_\_ 11. I detest arithmetic and avoid using it at all times.
- \_\_\_ 12. I like arithmetic because it is practical.
- \_\_\_ 13. I have a growing appreciation of arithmetic through understanding its values, applications, and processes.
- \_\_\_ 14. I have never liked arithmetic.
- \_\_\_ 15. I have always liked arithmetic because it has presented me with a challenge.
- \_\_\_ 16. I don't feel sure of myself in arithmetic.
- \_\_\_ 17. The completion and proof of accuracy in arithmetic gave me satisfaction and feelings of accomplishment.
- \_\_\_ 18. Sometimes I enjoy the challenge presented by an arithmetic problem.

- \_\_\_ 19. I am completely indifferent to arithmetic.
- \_\_\_ 20. I like working all types of arithmetic problems.
- \_\_\_ 21. I like arithmetic but I like other subjects just as well.
- \_\_\_ 22. I have always been afraid of arithmetic.

## APPENDIX D

## COURSE OUTLINE OF MATHEMATICS 305

- I. Language and nature of deductive reasoning.
  - A. Statements
  - B. Conjunctions
  - C. Disjunctions
  - D. Negation
  - E. Implication
- II. Sets and relations
  - A. Terminology
  - B. Intersection, union, and complementation
  - C. Cartesian product
  - D. Relations-notations and examples
  - E. Equivalence relations
- III. System of whole numbers
  - A. Definition of a number system
  - B. Operations
    - 1. Addition
    - 2. Multiplication
  - C. Properties of the operations
    - 1. Closure
    - 2. Commutativity
    - 3. Associativity
    - 4. Distributivity
  - D. Identity elements
  - E. Order relation



#### IV. System of integers

- A. Definition
- B. Inverse operations
- C. Operations on integers
  - 1. Addition
  - 2. Multiplication
  - 3. Subtraction
- D. Order

#### V. System of rational numbers

- A. Definition
- B. Equivalence classes
- C. Operations
  - 1. Addition
  - 2. Multiplication
  - 3. Subtraction
  - 4. Division
- D. Order

#### VI. Number theory

- A. Divisors and multiples
- B. Fundamental theorem of arithmetic
- C. Least common multiple
- D. Greatest common divisor
- E. Prime numbers
- F. Tests for divisibility

#### VII. System of numeration

- A. Exponents
- B. Place value

- C. Algorithms
- D. Bases other than ten
  - 1. Addition
  - 2. Multiplication
  - 3. Subtraction
  - 4. Division

## APPENDIX E

## COMPUTATION OF T-RATIO FOR CHANGE IN ATTITUDE

$$n = 186$$

$$\Sigma d^2 = 488.48$$

$$\Sigma d = 166.2$$

$$(\Sigma d)^2 = 27622.44$$

$$t = \frac{\Sigma d}{\sqrt{\frac{n \Sigma d^2 - (\Sigma d)^2}{n - 1}}}$$

$$t = \frac{166.2}{\sqrt{\frac{186 (488.48) - 27622.44}{185}}}$$

$$t = \frac{166.2}{18.49} = 8.9 \text{ with 185 degrees of freedom}$$

## APPENDIX F

COMPUTATION OF T-RATIO FOR CHANGE IN BASIC  
MATHEMATICAL UNDERSTANDING

$$n = 186$$

$$\Sigma d^2 = 3899$$

$$\Sigma d = 469$$

$$(\Sigma d)^2 = 219961$$

$$t = \frac{\Sigma d}{\sqrt{\frac{n\Sigma d^2 - (\Sigma d)^2}{n - 1}}}$$

$$t = \frac{469}{\sqrt{\frac{186(3899) - 219961}{185}}}$$

$$t = \frac{469}{52.26} = 8.9 \text{ with 185 degrees of freedom}$$