A STUDY OF THE ARITHMETIC ABILITIES OF ALABAMA FRESHMEN MAJORING IN ELEMENTARY EDUCATION AND OF THE RELATION OF CERTAIN SOCIO-PSYCHOLOGICAL CHARACTERISTICS TO THOSE ABILITIES

177 D

By

Richard E. Bullington

A DISSERTATION

Submitted in partial fulfillment of the requirements for the degree of Doctor of Education in the College of Education in the University of Alabama

University, Alabama

1953

ACKNOWLEDGMENTS

The writer wishes to acknowledge his sincere appreciation and deep indebtedness to Dr. Esther J. Swenson, Professor of Education, Department of Elementary Education, University of Alabama, for her patient guidance, counsel, and encouragement which were invaluable to the writer. To Dr. Verner M. Sims, Professor of Educational Psychology, University of Alabama, and to Dr. H. B. Woodward, Jr., Professor of Education, University of Alabama, the writer wishes to express his gratitude for their most beneficial advice and pertinent instruction. The writer is deeply indebted to Dr. Danylu Belser, Professor of Education and Head of the Department of Elementary Education, University of Alabama, for her counsel, encouragement, and understanding and to Dr. Daisy Parton, Professor of Education, University of Alabama, for her suggestions, judgment, and aid in many aspects of this investigation.

The writer offers his sincere appreciation and gratitude to Dr. John R. McLure, Dean of the College of Education, University of Alabama, Dr. M. L. Orr, Head of the Education Department, Alabama College, Dr. B. R. Showalter, Professor of Elementary Education, Alabama Polytechnic Institute, Dr. R. H. Ervin, Dean of Instruction, State

Teachers College, Troy, Alabama, Dr. Carey V. Stabler, Dean, State Teachers College, Florence, Alabama, and Miss Alta Millican, State Teachers College, Jacksonville, Alabama for the effort and time they expended in facilitating arrangements for the administration of the tests to their respective groups of freshmen. The writer is also deeply indebted to the freshmen students of these institutions for their willingness to participate in the study.

The excellent cooperation of the library staff of the College of Education, University of Alabama, especially Mr. Waverly Barbe, was of immense aid and value to the writer in the completion of the study.

The writer is greatly appreciative of the assistance given by his wife and the many hours of labor she expended so that the opportunity to conduct this study would be possible.

Appreciation is also due the writer's student colleagues, Major Russell Stompler, Mr. J. S. Burbage, Jr., and Mr. Adolph Crew, for their encouragement, understanding, and constant association.

1953 R. E. B.

CONTENTS

Chapter | Page

Page

Page

TABLES

FIGURES

Number | Page

DIAGRAM

CHAPTER I

INTRODUCTION

Much research has been done in the subject matter field of arithmetic. Many research studies have had as their basic purpose the determination of the arithmetical skills and abilities of freshmen entering teachers colleges and colleges of education. Research studies in this field have in the past sought to determine the computational status of entering college freshmen and more recently a few investigations have been directed towards a determination of the basic mathematical understandings not only of entering college freshmen but of students at other levels of growth and development as well.

Research studies have dealt independently with the quantitative understanding, problem solving, and computational phases of arithmetic, with most of the emphasis being placed on the computational phase of arithmetic. None of the reported research in the field of arithmetic has determined the status of entering college freshmen in all of the mentioned phases of arithmetic. Only a small amount of research has attempted to consider the arithmetical status of the student in relation to other socio-psychological factors. In contrast, this study attempts to determine the status of a group of freshmen majoring in elementary education in three areas of arithmetic and compares their performance in relation to certain socio-psychological factors.

Statement of Problem. This investigation has two basic purposes. One purpose of this study is to determine, by use of standardized tests, the status of a representative group of Alabama college freshmen majoring in elementary education in the quantitative understanding, problem solving, and computational phases of arithmetic and to compare their performance in each of these three areas of arithmetic. That is, the performance of the group in quantitative understanding will be compared with their performance in problem solving; their performance in quantitative understanding with their performance in computation; and their performance in problem solving with their performance in computation.

A second purpose of this investigation is to consider the performance of the freshmen in the three stated areas of arithmetic in relation to certain socio-psychological characteristics as follows:

1. To determine if a relationship exists between the average performance of the freshmen in the quantitative understanding, problem solving, and computational phases of arithmetic and the type of community (rural or urban) from which they come.

2. To determine if a relationship exists between the average performance of the freshmen in the quantitative understanding, problem solving, and computational phases of arithmetic and the size of the high school they attended.

3. To determine if a relationship exists between the average performance of the freshmen in the quantitative understanding, problem solving, and computational phases of arithmetic and the size of the elementary school they attended.

4. To determine if a relationship exists between the average performance of the freshmen in the quantitative understanding, problem solving, and computational phases of arithmetic and the type of mathematical background they had in high school.

5. To determine if a relationship exists between the average performance of the freshmen in the quantitative understanding, problem solving, and computational phases of arithmetic and their indicated scholastic rating in high school.

6. To determine if a relationship exists between the average performance of the freshmen in the quantitative understanding, problem solving, and computational phases of arithmetic and whether or not they report employment which included the functional use of arithmetic.

7. To determine if a relationship exists between the average performance of the freshmen in the quantitative understanding, problem solving, and computational phases of arithmetic and their expressed attitude towards arithmetic.

8. To determine if a relationship exists between the average performance of the freshmen in the quantitative understanding, problem solving, and computational phases of arithmetic and their expressed need for a refresher course in arithmetic.

9. To determine the relative preferences of the freshmen for quantitative understanding, problem solving, and computation.

Importance of Problem and Justification for the Study. As has been previously stated, research in the field of arithmetic testing at the college freshmen level has dealt independently with the three phases of arithmetic under consideration. Most of the emphasis has been placed on the skill of the student to compute. An investigation of the literature pertinent to this study shows that little attention has been given to comparing the performance of students in the several phases of arithmetic. It was also found that little consideration has been given to determination of the relationship of the students' performances in arithmetic with socio-psychological characteristics. In the past decade increased attention has been given to number meaning, that is, understanding of the basic concepts and principles inherent in our number system. During the past five years a few studies have attempted to determine the degree of arithmetical understanding of individuals at several levels of growth and development. In a similar vein, a few studies have attempted to determine the ability of individuals, at several levels of growth and development, to solve problems. As a whole these studies have dealt independently with the three areas of arithmetic under consideration. However, these studies revealed the fact that entering college freshmen exhibited deficiencies in their ability to compute, to solve problems, and to perceive number relationships.

Studies concerned with the training of teachers have suggested a variety of curriculums that would adequately train teachers of arithmetic. Even though many recommendations have been made for a curriculum that would adequately train teachers to teach arithmetic, research has shown that teachers of arithmetic have exhibited deficiencies in the several phases of arithmetic. Such findings may indicate that there is still need for further evaluation of the arithmetic phase of the teacher training curriculum. The implications of this study are related to the training of teachers of arithmetic.

It is vitally important that research studies approach the problems in the field of arithmetic from new directions, moving towards the objective on new lines of thought. Research studies have definitely shown the inability of entering freshmen to perform satisfactorily in the computational phase of arithmetic. Since the most widely expressed learning theory of arithmetic at present holds to the concept that arithmetic consists of more than mere skill in computation, then it seems imperative to determine the status of future teachers of arithmetic at the elementary school level in the quantitative understanding and problem solving phases of arithmetic as well as the computational phase of arithmetic. If securing additional information on the problems involved in the arithmetical competence of future teachers of arithmetic is of value, then to make the attempt to see if relationships do exist between certain socio-psychological factors and competence in arithmetic is certainly also worthwhile. This study can be justified in that an attempt has been made to determine the status in three areas of arithmetic of a group of freshmen students who plan to teach at the elementary school level; to compare their competence in these three areas of arithmetic; and to determine the degree of relationship between certain socio-psychological characteristics and competence in arithmetic. No other study has attempted to do just this.

Scope of the Study. The freshmen students who participated in the investigation were those who attended the white state supported teacher education institutions in Alabama. The initial purpose of this investigation was to determine the arithmetical status of students at each of the four college class levels (i.e., freshmen, sophomore, junior, and senior). As more time, thought, and planning were given to the problem, it was decided to limit the determination of status in arithmetic to the college freshmen level.

There were three basic reasons for limiting the sample to only those elementary education majors who were freshmen: 1. If the arithmetic abilities of future teachers of arithmetic could be determined at the beginning of their training, the teacher training institutions would be in a better position to adjust their program in light of the needs of these beginning students. 2. By limiting the sample to freshmen students, it was possible to make a thorough study of the arithmetic abilities of a group of students as they completed their formal training in the public schools. 3. At any level above that of first term freshmen the students would have had such varied college experience in arithmetic, the teaching of arithmetic, and related courses that it would have been difficult to assess the effects of those experiences on the test scores.

CHAPTER II

REVIEW OF THE LITERATURE

The reader will recall that this study has two basic purposes: (1) to determine the status of a group of freshmen elementary education majors in three areas of arithmetic and to compare their performance in each of these areas, and (2) to relate the performance of this group of freshmen elementary education majors in arithmetic in light of several socio-psychological factors.

In the light of the two basic purposes of this study, a review was made of the research studies in arithmetic that have measured the status of college freshmen in the subject field of arithmetic. A review was made of the research studies that have made comparisons in problem solving and basic computation and also of the studies that have considered certain socio-psychological factors in relation to performance in arithmetic.

The training of teachers of arithmetic and the learning theories concerned with arithmetic are closely related to the basic purposes of this study. Therefore, the literature in each of these two particular aspects of arithmetic was reviewed.

The literature under consideration will be discussed under five specific groupings. These divisions will be considered in the following order:

1. Review of studies that have determined the status of college freshmen in the subject field of arithmetic.

2. Review of studies that have compared the performance of individuals in the several phases of arithmetic.

3. Review of studies that have been concerned with the socio-psychological and other variable factors affecting performance in arithmetic.

4. Review of the literature in the area of training teachers of arithmetic.

5. Review of the literature concerned with the learning theories of arithmetic.

Status of College Freshmen in Arithmetic

The first section of this chapter is concerned with the research studies that have made the attempt to determine the status of college freshmen in the computational, problem solving, and quantitative understanding phases of arithmetic.

Studies Concerned with Computational Status of College Freshmen. An examination of the pertinent research literature showed that the majority of investigations were concerned with the computational status of college freshmen.

As early as the year 1917, Drushel[1] conducted a general investigation to determine how much arithmetic was actually at the command of high school graduates when they enter Harris Teachers College after being away from arithmetical study for four years or more. This study not only showed the relative value of two methods employed to find the position of the decimal point in the quotient when the divisor or both dividend and divisor contain decimal places, but it also revealed the performance of this tested group of freshmen in one particular aspect of computation, the division of decimal numbers. Method (A) used the rule that there are as many places in the quotient as those in the dividend exceed those in the divisor. Method (B) considered the process of first rendering the divisor an integer by multiplying both dividend and divisor by 10 or some power of 10, then proceeding as with integral divisors. He found that: "The

---

1. J. A. Drushel, "A Study of the Amount of Arithmetic at the Command of High School Graduates Who Have Had no Arithmetic in Their High-School Course," Elementary School Journal, XVII (September, 1917), 219-231.

average accuracy by Method A is about 66, based on 559 attempts by 507 people, and by Method B about 99, based on 79 attempts by 69 people."[2]

Drushel concluded that in light of his study, the second method (B) should certainly replace the old first method (A).

In 1927, Touton, Heilman, and Terry[3] conducted a study to determine the computational abilities and disabilities of 504 college freshmen. The *Thorndike Intelligence Examination for High-School Graduates* was used in this study. This test dealt with the fundamental operations, problem solving, number series, completion, and some algebraic manipulation. The freshmen who participated in this study had elected to take in their high school curriculums at least one year of algebra and one year of geometry. This sample had a satisfactory distribution of mental capacities for college work. The authors of this study stated that the results indicated that this group of college freshmen had not mastered the

---

2. *Ibid.*, p. 660.

3. Frank C. Touton, Karl K. Heilman, and Esther Jeffery Terry, *Studies of Secondary School Graduates in Their Mastery of Certain Fundamental Processes*, University of Southern California Studies, Second Series, No. 1, Los Angeles, California: University of Southern California, 1927.

arithmetical processes involved in basic computation, nor did they possess the ability to analyze word problems. "These results suggest the conclusion that high-school graduates as a group lack the necessary ability to make relatively simple applications of the fundamental operations of arithmetic."[4]

Arnold,[5] in an effort to secure data to determine the nature of the arithmetic deficiencies of college students, tested two groups of students. One group of 83 freshmen was given the complete set of *Monroe's Diagnostic Tests in Arithmetic*, while the other group of 140 freshmen was administered the Arithmetic Computation and Arithmetic Reasoning sections of the *Stanford Achievement Test*. Arnold did not state in the report of his study why two groups of freshmen were given two different arithmetic tests. The results showed that a significant proportion of the freshmen who took *Monroe's Diagnostic Tests in Arithmetic* fell below the eighth-grade norms.

> In the Monroe tests an average of 29 per cent of the scores fell below the eighth-grade norms in all the tests. For the eleven tests involving

---

4. *Ibid.*, p. 55.

5. H. J. Arnold, "Arithmetical Abilities and Disabilities of College Students," *Elementary School Journal*, XXXI (December, 1930), 259-270.

> operations with integers, an average of 27 per cent dropped below this level. In the five tests dealing with operations with common fractions, an average of 34 per cent of the scores were below the eighth-grade levels, while in the five tests involving operations in multiplication and division of decimals, the average percentage of scores falling below the eighth-grade norms was 27.[6]

The results of the Stanford Achievement Test were very similar. The computation section of the Stanford test showed that 29 per cent of the students scored below the eighth-grade norm. In this test 7 per cent of the 140 college freshmen dropped below the seventh-grade norm and 5 per cent fell below the sixth-grade achievement level. The author of this study concluded that college freshmen as a group possessed certain disabilities in the fundamental operations of arithmetic which were significant enough to warrant special attention on the part of the college. Arnold suggested that drill in computation would do much to remove students' handicaps in college courses.

Guiler[7] made a study of the results of an arithmetic test given to 860 Miami University (Ohio) college

---

6. *Ibid.*, p. 264.

7. W. S. Guiler, "Computational Weaknesses of College Freshmen," *American Association Collegiate Registrars Journal*, XX (April, 1945), 367-382.

freshmen. The test used was sections E, F, G and H of the *Progressive Mathematics Test* (Advanced Form B). The purpose of this study was to obtain a measure of student status in computation. The results of this test showed that:

> . . .a significant proportion of the college freshmen. . .failed to demonstrate competency in many of the computational skills which are implied in the test items and which had been presumably mastered in the elementary school.[8]

This study by Guiler also included an analysis of the types of computational errors made by 860 college freshmen, but the primary finding of his investigation, as it relates to this study, was that a significant number of freshmen tested exhibited an unsatisfactory performance in the various computational skills.

Guiler,[9,10,11] reported in three articles the results of a test given to 925 freshmen enrolled in the School of

---

8. *Ibid.*, p. 372.

9. W. S. Guiler, "Difficulties Encountered by College Freshmen in Fractions," *Journal of Educational Research*, XXXIX (October, 1945), 102-115.

10. W. S. Guiler, "Difficulties Encountered by College Freshmen in Decimals," *Journal of Educational Research*, XL (September, 1946), 1-13.

11. W. S. Guiler, "Difficulties Encountered in Percentage by College Freshmen," *Journal of Educational Research*, XL (October, 1946), 81-95.

Education, Miami University (Ohio). The test used was the Christofferson-Rush-Guiler Analytical Survey Test in Computational Arithmetic. In the first of the series of three articles, he analyzed the difficulties encountered by college freshmen in fractions. In the second he analyzed the difficulties encountered by college freshmen in decimals, and in the third, the difficulties encountered by college freshmen in percentage.

In each of the analytical studies, Guiler attempted to determine the computational status of the 925 freshmen as well as the difficulties they encountered in computational arithmetic.

The conclusions concerning the nature and extent of difficulties encountered by these college freshmen in the fraction phase of the test were as follows:

> 1. Lack of comprehension of the process involved constituted the outstanding source of the difficulties encountered by college freshmen in their work with fractions. This type of difficulty was particularly pronounced in the multiplication and in the division of fractions. In this category most difficulty was encountered in division and least in addition.
>
> 2. The situation revealed by the analytical findings should be made a matter of serious concern. It should lead school officials to investigate the administrative and teaching techniques which may be responsible for the low level of competency of the college freshmen in fractions. Pending this inquiry, institutions of higher learning

> which accept students deficient in computational skills in fractions should feel obligated to institute instructional programs whereby the students concerned may overcome their computational handicaps.[12]

Guiler[13] found from the section of the analysis that dealt with the nature and extent of difficulties encountered by the freshmen in the decimal phase of the test, that college freshmen manifested weaknesses in certain phases of work with decimals, such as adding, subtracting, multiplying, and dividing decimals. These college freshmen experienced difficulty in the basic computations involved (e.g., changing fractions to decimals, placement of decimal point in the division of decimal numbers, changing mixed numbers to decimals, etc.). Guiler concluded that in light of the deficiencies noted, higher educational institutions should provide a systematic remedial program in order to help these deficient students overcome their difficulties.

Guiler[14] reported in the third series of analytical studies of difficulties encountered by college freshmen, the results of the computational phase which dealt with

---

12. Guiler, *op. cit.*, pp. 114-115.

13. Guiler, *op. cit.*, pp. 1-13.

14. Guiler, *op. cit.*, pp. 81-95.

percentage. The results of this study showed that a large proportion of the college freshmen tested exhibited weakness in the various abilities measured by the percentage phase of the Christofferson-Rush-Guiler *Analytical Survey Test in Computational Arithmetic*. Guiler concluded from the analysis of the test results that educators should find, on the basis of analysis of social usage, the abilities that are required in dealing effectively with the percentage aspects of our contemporary world.

> Pending this inquiry into social needs, we would do well to investigate the administrative and teaching techniques which may be responsible for the low level of competency of college freshmen in percentage.[15]

Christofferson[16] conducted a study to determine the ability of 70 Miami University (Ohio) freshmen in computational arithmetic at the beginning of the first semester of college work, and again at the end of two month's work as measured by the *Monroe Survey Test*. The results of the first test administered showed that nearly one-fourth of the students were below the arbitrary

---

15. *Ibid.*, p. 94.

16. H. C. Christofferson, "Arithmetic and College Freshmen," *Journal of Educational Research*, XXI (January, 1930), 78-80.

state (Ohio) standard of 78. This standard was set as a minimum score for anyone who deserved to pass the course in the teaching of arithmetic. Even though the author of this study was concerned with the effect of remedial work in computation on the ability of the freshmen to do arithmetic, he emphasized the fact that entering college freshmen exhibited disabilities in computational arithmetic.

Carson and Wheeler[17] conducted an experiment at the East Tennessee State Teachers College in which they not only made the attempt to determine the arithmetical efficiency of freshmen at the beginning of the fall quarter, but they also attempted to determine the effect of successive periods of remedial work on the arithmetical efficiency of this group of freshmen. Forms I, II, III, and IV of Woody McCall's Mixed Fundamentals in Arithmetic were administered to 163 freshmen. The administration of Form I of the test showed that 43 per cent of the freshmen were found to be below the eighth-grade standard. An analysis of the results exhibited deficiencies in number combinations, common fractions, and denominate numbers. Form II of the test was

---

17. T. E. Carson and L. R. Wheeler, "Rehabilitation in Arithmetic with College Freshmen," Peabody Journal of Education, VIII (July, 1930), 24-27.

administered to the 163 freshmen after four weeks of remedial work. Of the group tested 65 per cent of the class made eighth-grade standing. After another period of remedial work a third form of the test was given with the result that 95 per cent of the group tested were above eighth-grade standing.

Wilson and Kite[18] conducted an investigation which had as its purpose the determination of computational abilities in arithmetic for a group of 526 Boston University students. Tests in addition, subtraction, multiplication, and division of whole numbers were administered to this group of university students. The results of this investigation revealed the fact that two-thirds of the university students were deficient in addition, subtraction, multiplication, and division of whole numbers. The authors considered one or more incorrect answers on these tests of arithmetical fundamentals a failure. They felt that:

> It is a sad comment on the lower schools that two-thirds (66 per cent) of the university students, the flower of the lower schools, should fail on simple tests in addition, subtraction, and multiplication of whole numbers. These are the three most used processes.

---

18. G. M. Wilson and M. B. Kite, "Arithmetic Deficiencies," Journal of Higher Education, XIV (March, 1943), 321-322.

> These are to arithmetic and business what mastery of the keyboard is to type writing and a secretarial job.[19]

The review of this particular series of studies shows that for one purpose or another, the attempt was made to determine the computational status of college freshmen. The emphasis of all these studies was placed on the computational phase of arithmetic. Without exception, the investigations cited above indicated that the tested groups of college freshmen were not as proficient in arithmetic computation as they should have been.

Computational Status of College Freshmen Enrolled in Courses in the Physical Sciences and Higher Mathematics. Lueck[20] made a study to determine how much arithmetic and algebra students of first year college physics knew. The Compass Survey Test in Arithmetic and the Douglas Diagnostic Test in Elementary Algebra were given to 280 students of first year college physics in five Iowa colleges. The results of this study revealed that in arithmetic, only 28 per cent of the students exceeded a score of fifty in a test for which the perfect score was

---

19. *Ibid.*, p. 322.

20. W. R. Lueck, "How Much Arithmetic and Algebra do Students of First Year College Physics Really Know?" *School Science and Mathematics*, XXXII (December, 1932), 998-1005.

sixty. None had a perfect score. Seventy per cent exceeded a score of forty. The mean score was equal to the achievement of the lower half of the 7th grade. Thus, these students, as a group, were very close to seventh-grade ability in arithmetic.

When a comparison of the results was made between the students who were taking courses in college mathematics and the students who had no mathematical training beyond the mathematics received in high school, it was found that:

> Of the 280 students who took the previously mentioned tests, 120 had pursued or were taking courses in college mathematics. The remainder had no mathematical training beyond that received in high school. . . . The students who had pursued courses in college mathematics attained higher mean scores in both arithmetic and algebra. The difference between the means in arithmetic is 3.7 .96; in algebra it is 6.7 .92. In both cases the difference is more than three times its standard error. . . . For the group in question, college training has had a decided influence on achievement in algebra while its effect on arithmetic ability is less marked.[21]

However, it is conceivable that other factors in addition to college mathematics influenced the achievement of this group of tested college students in algebra and arithmetic.

---

21. Ibid., pp. 999-1000.

Keller and Shreve[22] conducted a study whereby they tried to determine, through the use of group tests, what mathematical skills and abilities the 557 entering freshmen had at their disposal, and how, through the use of diagnostic testing and remedial measures, these deficiencies could best be minimized in both the high school and university.

The tests were constructed by the authors, and the test items used in the tests involved the elementary arithmetic skills included in the trigonometry and algebra courses given at Purdue University. The results of this study showed that the students were quite inaccurate in their performance of the fundamental operations with whole numbers and simple fractions, as well as division of decimal numbers, problems in percentage, and the extraction of square root. Keller and Shreve proposed that we should build from the foundation of what students really know, and that we should devote study to a topic only in proportion to its difficulty for the student.

Mohr[23] made a study in which he attempted to discover the nature and extent of the arithmetical

---

22. M. W. Keller and D. R. Shreve, "Abilities of University Students in College Mathematics," School Science and Mathematics, XLII (January, 1942), 38-46.

23. J. P. Mohr, "Arithmetic Disabilities of Junior College Students," Education Digest, IX (September, 1943), 56-57.

deficiencies of freshmen junior-college students who had taken course work in the physical sciences. Mohr compared these deficiencies with the deficiencies of beginning pupils in high eighth grade. The eighth-grade pupils were given the _Metropolitan Achievement Test, Advanced Arithmetic Test_ (_Revised_), and the _Otis Quick Scoring Mental Ability Tests, Beta_. The junior-college freshmen were given the same tests, except that they took the Gamma form of the _Otis Quick Scoring Mental Ability Test_.

> When the tests had been checked, tabulated and grouped according to the type of fundamental operation or problem involved, it was seen that 311 junior-college men and 104 junior-college women had disabilities great enough to be serious. . . . The average grade level of achievement for the men was ninth grade and two months, while that of the women was eighth grade and one month, with a range from fifth grade and two months to eleventh grade and two months.[24]

When the mean scores for the junior college freshmen were compared with the mean scores of the entering eighth-grade pupils, the results showed the entering freshmen superior to entering high eighth-grade pupils in arithmetic ability. However, the conclusion drawn from

---

24. _Ibid_., p. 56.

this study by Mohr was that in spite of the higher mean score for the entering freshmen, the level of achievement of junior-college students was so low that great deficiencies existed. This conclusion resulted in the offering of formal training in arithmetic to many of the entering freshmen who desired to enroll in the physical sciences.

Over a period of several years, Kinzer and Kinzer[25] analyzed the results of an arithmetic fundamentals test administered to college freshmen enrolled in the first course in chemistry. They found that each quarter approximately one-third of the students examined could solve fewer than one-third of the problems given in the placement test.

Kinzer and Fawcett[26] made another study to determine the arithmetic status of college chemistry students. An analysis of the results of an arithmetic fundamentals test administered to 1,439 freshmen at Ohio State

---

25. John R. Kinzer and Lydia G. Kinzer, "College Chemistry Students Deficient in Arithmetic: Academic Data," Educational Research Bulletin, XXVII (January, 1948), 8-10.

26. J. R. Kinzer and H. P. Fawcett, "Arithmetic Deficiency of College Chemistry Students," Educational Research Bulletin, XXV (May, 1946), 113-114.

University, showed that 534 of the freshmen solved fewer than one-third of the problems. Remedial work in arithmetic was required of these 534 freshmen. However, the important aspect of their study, as it relates to this study, was the determination of the arithmetic status of the college freshmen enrolled in chemistry courses. The authors suggested that knowledge of arithmetic was one of the important determiners of success in chemistry.

Wolfe[27] conducted an investigation that had a two-fold purpose: (1) to determine the arithmetic status of a group of 794 freshmen in arithmetical topics prerequisite to trigonometry, and (2) to determine the status of the same group after a period of remedial work in the computational skills prerequisite to trigonometry. The test used in the study was constructed by the author. The mean per cent wrong for each item on the test was 37. The author considered this performance of the freshmen unsatisfactory and recommended a specific and individualized remedial program for the students who needed it.

The review of the series of studies that were concerned with the computational status of the college

---

27. Jack Wolfe, "Mathematical Skills of College Freshmen in Topics Prerequisite to Trigonometry," Mathematics Teacher, XXXIV (October, 1941), 164-170.

freshmen enrolled in courses in the physical sciences and higher mathematics showed that these tested groups of college freshmen were not as proficient in arithmetic computation as they should have been. The authors of these several studies concluded that the tested groups of freshmen exhibited many deficiencies in the computational phase of arithmetic, deficiencies that should not be characteristic of entering college freshmen.

Status of College Freshmen in Problem Solving. The author of the present study was able to find only two studies that dealt entirely with the problem solving status of college freshmen. In light of the numerous studies that have had as their purpose the determination of computational status of college freshmen, it is interesting to note that only two studies were found that dealt entirely with the problem solving status of college freshmen.

Christofferson[28] conducted an investigation in which the attempt was made to determine the problem solving ability of college freshmen. Ninety-nine freshmen took the Buckingham Scale for Problems in Arithmetic. An

---

28. H. C. Christofferson, "College Freshmen and Problem Solving in Arithmetic," Journal of Educational Research, XXI (January, 1930), 15-20.

analysis of the results showed that upon entrance, college freshmen had about eighth-grade ability in solving word problems. Christofferson found that a majority of the errors in solving word problems were computational in nature.

Orleans and Saxe[29] made an investigation in which they attempted to determine the commercial arithmetic knowledge among a sampling of students in the School of Business and Civic Administration of the College of the City of New York. The sample consisted of four groups of students: 326 candidates for admission to the commercial teachers' training curriculum, 137 freshmen, 68 students taking the beginning course in accounting, and 141 students completing the accountancy specialization curriculum. These students were considered to be representative of a highly selected group. The examination administered to this group of students was made up of fourteen verbal problems.

The average number of problems correct for the four groups were as follows: (1) commercial teacher training curriculum group (number right), 8.7; (2) for the freshmen

---

29. J. S. Orleans and E. Saxe, "How Much Commercial Arithmetic do Students in a College Collegiate School of Business Know?" Journal of Business Education, XVI (September, 1940), 14-22.

group, 4.2; (3) for the elementary accountancy group, 5.9; and (4) for the accountancy specialization group, 9.4. The mean for the entire group of students was 7.7.

The authors concluded from their study that:

> In general, the students' wrong answers are due to a relatively slight degree to arithmetic errors. The major difficulties are lack of knowledge of business terminology; lack of knowledge of business computational procedures; lack of knowledge of how to think through a problem; lack of knowledge of how to evaluate the answer in terms of the conditions of the problems; and lack of realization of the importance of checking one's work as well as the reasonableness and accuracy of the answer in terms of the conditions of the problem.[30]

A review of the few studies that were concerned with the status of college studentsin problem solving showed that these students were not as proficient in the problem solving phase of arithmetic as they should have been.

Status of College Students in Arithmetical Understandings. A review of the literature showed that studies which have been concerned with the status of individuals in the understanding of basic arithmetical concepts were limited in number.

Perhaps a primary cause for this limitation of studies in the understanding phase of arithmetic has been

---

30. Ibid., p. 22.

the lack of testing devices to measure arithmetical understandings. The development of measuring devices to determine adequately the degree of understanding of individuals at various levels of growth and development is a slow process. When more devices are available to determine the degree of mathematical understandings, one can anticipate an increased amount of research in this area.

Glennon,[31] from extensive research in the area of mathematical understandings, answers the question of "why" the lag of devices for measuring mathematical or arithmetical understandings. He stated that there are six causes for the lag in the development of adequate methods and devices for measuring understandings or meanings in arithmetic. These causes listed by Glennon are as follows:

1. The first cause comes from an outgrowth of the changing status of arithmetic in the curriculum of elementary schools during the several phases of an evolving culture. Arithmetical aims and objectives have been characterized by speed and accuracy in selected and

---

31. Vincent J. Glennon, Testing Meanings in Arithmetic. Supplementary Educational Monographs, No. 70. Chicago: University of Chicago Press, 1949.

restricted parts of the total field. Consequently, measuring devices have been limited to tests of speed and accuracy in computational skills and various problem situations.

2. A second cause of the lag in the development of adequate methods and devices for measuring growth in understandings in arithmetic rests in the tremendous impact of physiological psychology on methods of teaching.

3. The mental security experienced by teachers and supervisors from the practice of telling, drilling, and testing, has caused a lag in the development of satisfactory devices for measuring growth in understandings and meanings.

4. The thinking on the part of educators that arithmetic is a series of arbitrary associations, each association existing as an entity in itself and having no relation to other associations, has caused a lag in the development of satisfactory devices for measuring growth in understandings and meanings.

5. A fifth cause for the lag in the development of adequate methods and devices for measuring growth in arithmetical understandings is the degree to which available tests clash with and channel the aims and objectives of learning in arithmetic. Teachers too often show a tendency to teach for the learnings that they know are included in standardized tests.

6. A lack of a list of basic arithmetical understandings and meanings has caused a lag in the development of satisfactory devices for measuring growth in understandings and meanings.

Perhaps one of the best examples of a study that was made in the area of meaningful arithmetic was an investigation conducted by Glennon[32] himself. In this investigation he attempted to determine the degree to which growth of understanding in the field of basic mathematics (arithmetic) was being accomplished.

He constructed a test from a comprehensive list of arithmetical understandings, understandings which were approved by authorities in the field of arithmetic. The test items measured only mathematical understandings that were basic to the generally taught computational processes in Grades 1 through 6. The 80 multiple-choice test items were constructed in such a way as to contain no computing. Thus, mechanical computation was eliminated from the test items. The test was administered to 1,139 individuals on seven educational levels. These levels

---

32. Vincent J. Glennon, "A Study of the Growth and Mastery of Certain Basic Mathematical Understandings on Seven Educational Levels." Unpublished Doctor's dissertation. Cambridge, Massachusetts: Graduate School of Education, Harvard University, 1948.

included seventh-grade pupils, eighth-grade pupils, ninth-grade pupils, twelfth-grade pupils, teachers college freshmen, teachers college seniors, and teachers-in-service. An analysis of the results showed that there was an increase in achievement of basic arithmetical concepts (understandings) on increasing grade levels; that the difference in achievement of basic arithmetical concepts between seventh and eighth graders was not significant; courses taken by college seniors in the psychology and teaching of arithmetic did not result in growth in understanding of basic mathematics; courses taken by teachers-in-service in the psychology and teaching of arithmetic did not result in growth in understanding of basic mathematics; that years of teaching experience did not result in growth in understanding of basic mathematics; that individuals teaching on the higher elementary school levels showed a slight tendency to have greater understanding of basic mathematics than individuals teaching the lower elementary grades; that there was a tendency for basic arithmetical understandings that are difficult for one grade level to be difficult on other grade levels; that there was a tendency for basic arithmetical understandings that were easy on one grade level to be easy on other grade levels; that 12.5 per cent of the understandings basic to computational processes taught in the elementary school were mastered on the average by seventh grade pupils tested, 14 per cent for the eighth grade pupils tested, 18 per cent for the ninth grade pupils tested, 37 per cent for the twelfth grade pupils tested, 44 per cent for the teachers college freshmen tested, 43 per cent for the teachers college seniors tested, and 55 per cent for the teachers-in-service tested.

The study by Glennon[33] emphasizes the lack in understanding of basic mathematical concepts on seven educational levels. Perhaps his study is most significant in that he found teachers of children lack a degree of understanding to do an adequate job in teaching for arithmetical meaning. Also, teachers college seniors graduate with insufficient understandings, in fact their understandings in mathematics were no better than teachers college freshmen. It is impossible to expect children in the elementary grades to understand basic arithmetical concepts when their teachers are lacking in this meaningful phase of arithmetic.

Comparisons in the Several Areas of Arithmetic

One of the purposes of this study was to compare the performance of college freshmen in these three areas of arithmetic. With this purpose in mind, a thorough review

---

33. Ibid.

of the literature was made to find such comparisons. The author did not expect to find studies that included a comparison of understanding with problem solving and computation for the reason that emphasis on the understanding aspect of arithmetic is relatively new, and consequently measuring devices to determine the status of understanding have not been available. However, he did expect to find studies that compared the performance of individuals in problem solving with their performance in computation. The review was not restricted to comparisons at the college freshmen level. This effort resulted in one significant finding. Research in this particular aspect of arithmetic (comparisons in the several areas of arithmetic) has been extremely limited. Two studies were found that had considered a comparison between problem solving and computation. The results of both these studies were published in 1932.

Stevens[34] reported the results of an investigation which had as its purpose the determination of correlations existing among tests of general reading ability, arithmetic reading ability, "intelligence," arithmetic problem solving ability, and ability in the fundamental operations

---

34. B. A. Stevens, "Problem Solving in Arithmetic," Journal of Educational Research, XXV (April-May, 1932), 253-260.

of arithmetic. The statistical treatment of the test results attempted to give evidence on the question whether high abilities in solving reasoning problems in arithmetic were accompanied more frequently by high reading abilities than by high abilities in the fundamental operations in arithmetic.

The relationships under consideration were measured in five different localities in order to be sure that the findings were not merely local in significance. The sample included a group of 195 elementary school children (4th, 5th, 6th, and 7th grades) from the Henrietta-Caroleen school system in North Carolina: 495 elementary school pupils (4th, 5th, 6th, and 7th grades) from Shelby, North Carolina; 156 elementary school pupils (3rd, 4th, 5th, and 6th grades of the Lincoln School of Teachers College; a group of 239 pupils in grades three to six inclusive of Public School No. 157, New York City; and a group of 2004 pupils selected at random from grades three to six of the Florida Public Schools.

> Examination of the correlations existing among tests of general reading ability, arithmetic reading ability, 'intelligence,' arithmetic problem solving ability, and ability in the fundamental operations of arithmetic, seems to show that ability in fundamental operations is more closely correlated with ability in problem solving than is general reading ability.[35]

---

35. Ibid., p. 260.

Even though the investigation by Stevens included a determination of correlations existing among tests concerned with factors other than ability in the fundamental operations of arithmetic, his investigation is important to this study in that it does correlate problem solving ability with skill and ability in the computational phase of arithmetic.

Englehart[36] made an investigation that had as its basic purpose the determination of the relative contributions of intelligence, computation ability, and reading ability, to individual differences in arithmetical problem solving ability. The study made the attempt to answer the following question:

> What per cents of the variance of arithmetic problem solving ability of fifth-grade pupils as measured by Test 1 of the New Stanford Arithmetic Test, Form X, are due to variation in intelligence as measured by the Otis Self Administering Test of Mental Ability, Intermediate Examination, Form C, to variation in reading ability as measured by the New Stanford Reading Test, Form X, and to variation in computational ability as measured by Test 2 of the New Stanford Arithmetic Test, Form X?[37]

---

36. Max D. Englehart, "The Relative Contribution of Certain Factors to Individual Differences in Arithmetical Problem Solving Ability," *Journal of Experimental Education*, I (September, 1932), 19-27.

37. *Ibid.*, p. 19.

The series of tests used in the study were administered to 568 fifth-grade pupils of the Decatur, Illinois, Public Schools. An analysis of the data showed that:

1. Of the variance in arithmetical problem solving ability, 1.33 per cent was due to variation in reading as measured, or in other words, increasing variation in reading ability tends to decrease variation in arithmetical problem solving ability.

2. Of the variance in arithmetical problem solving ability, 25.69 per cent was due to variation in intelligence as measured.

3. Of the variance in arithmetical problem solving ability, 33.59 per cent was due to the influence of other causes. These causes included that which was related to problem solving ability over and above intelligence, reading, and computation.

4. Of the variance in arithmetical problem solving ability, 42.05 per cent was due to variation in computation ability as measured.

> The inference may be drawn from this analysis of the variance in arithmetical problem solving ability that intelligence and computation ability are important factors in causing individual differences in problem solving ability.

> Since nothing can be done about intelligence, it would seem worth while to seek improvement in the solving of problems by providing instruction and drill in computation.[38]

This investigation by Englehart is of particular importance to the present study in that one of the aspects considered in the relative contribution to individual differences in problem solving ability was the factor of basic computation. From this early study it is interesting to note that the highest per cent of the variance in arithmetical problem solving ability was associated with variation in computational ability.

A review of the investigations that considered comparisons in the several areas of arithmetic showed that research of this type has been limited. The comparisons made between problem solving and computation revealed that ability in computation was more closely correlated with ability in problem solving than was general reading ability, and that almost one-half of the variance in arithmetical problem solving ability was due to variation in computation ability.

---

38. Ibid., p. 26.

Relationship of Socio-Psychological Factors to Performance in Arithmetic

A few research studies have been made which considered several socio-psychological factors similar to those investigated in the present study.

Kinzer and Kinzer[39] reported in two separate articles the results of an investigation which determined the arithmetic status of college chemistry students. Their first article reported the arithmetic status of college chemistry students, while their second article presented data concerned with several psychological factors that influenced success in college chemistry. The authors had an idea that perhaps there were certain psychological factors which influenced success in college chemistry and arithmetic. They found that the students who stated that they planned to study between 25 and 50 hours each week were able to make higher grades than the group of students who planned to study 19 hours or less. The mean marks of the two groups were significantly different. The average mark of the students who liked mathematics and chemistry was higher than the average mark of the

---

39. John R. Kinzer and Lydia G. Kinzer, "College Chemistry Students Deficient in Arithmetic," Educational Research Bulletin, XXVIII (March, 1949), 74-76.

students who disliked mathematics and chemistry, although the difference between the two means was not significant (the t value was only .85). This study also revealed the fact that there was no significant difference between veterans and non-veterans. Although only one of the psychological factors (the factor of attitude towards arithmetic) in the study by Kinzer and Kinzer was similar to one of these factors in the present study, the important fact is that their study considered certain psychological characteristics.

A study by Cooke and Fields[40] had as its basic purpose the determination of the effect that a comprehensive course in arithmetic would have on the achievement of students in algebra and geometry. Their study is indirectly related to this study in that it considered the effect of one type of mathematics course on the achievement of pupils in another. They were interested in determining the desirability of having a comprehensive review-course in arithmetic immediately preceding the beginning study of algebra and geometry. The method of research used by Cooke and Fields was the review of

---

40. D. H. Cooke, and C. L. Fields, "Relation of Arithmetical Ability to Achievement in Algebra and Geometry," Peabody Journal of Education, IX (May, 1932), 355-361.

opinions of authorities and related investigations. In the light of these opinions and conclusions of the related investigations, the authors suggested a need for having an intensive review of the entire field of arithmetic immediately preceding a beginning study of algebra.

A study by Braverman[41] had as its purpose the determination of the effect that course work in some higher mathematics (algebra) would have on the arithmetic ability of a group of high school students. In light of the variable factors considered in this study, his study is related to the present study. In June, 1936, a test in arithmetic was administered to all pupils who had had a year's work in the traditional or modified algebra course. In each case, a pupil's score in June, 1936 was compared with the same pupil's score from the same test taken in September, 1935. The pupils who had taken the course in algebra had significantly higher scores on the second taking of the arithmetic test. From the data, the author concluded that after a year's exposure to algebra, there was significant improvement in the pupils' ability in arithmetic.

---

41. B. Braverman, "Does a Year's Exposure to Algebra Improve a Pupil's Ability in Arithmetic?" Mathematics Teacher, XXXII (November, 1939), 301-312.

An investigation by Guiler and Hoffman[42] was also concerned with the effect of different types of mathematics courses on computational ability in arithmetic. Four types of mathematics courses were included in the investigation. Type 1 was a course in which 35 minutes of each two of the class periods each week were spent on remedial work in computational arithmetic, the remaining 15 minutes in each of the two class periods each week being used for making assignments in algebra; the other three class periods each week were spent on the regular work in algebra. Type 2 was a course in which all of the time was spent exclusively on elementary algebra. Type 3 was a course in applied mathematics in which all of the time was spent on the regular work of the course. Type 4 was a course entitled junior business training in which all of the time was spent on the regular work of the course. Two equivalent forms of the Christofferson-Rush-Guiler *Analytical Survey Test in Computational Arithmetic* were used. It was found that the pupils who had the course in algebra which included remedial work in computational arithmetic made much greater improvement in

---

42. W. S. Guiler and H. B. Hoffman, "Effect of Different Types of Mathematics Courses on Computational Ability," *Educational Administration and Supervision*, XXIX (November, 1943), 449-456.

computation than did the pupils enrolled in any of the other type courses. The pupils who had the course in applied mathematics made substantial gain in computational ability, but neither the elementary algebra course nor the junior business training course had more than a slight effect on the improvement of computational skills in arithmetic.

The studies concerned with socio-psychological factors have shown that some relationship did exist between several of these factors and the competence of the individual in arithmetic. Furthermore, these studies showed that one type of mathematics course could effect the achievement of pupils in another.

The studies concerned with socio-psychological factors have been to a greater or lesser extent, related to the several subsidiary problems (comparisons in terms of socio-psychological factors) listed under the general statement of the problem.

Perhaps some significance can be attached to the fact that the frequency of all these research studies which dealt in one way or another with arithmetic, when considered in terms of date of publication, was bi-modal. Starting with the year 1917 the frequency of the studies reached a peak with the year 1932. From 1932 the number of studies related to this study decreased until the year 1940 when a second peak in frequency was reached with the year 1946. From 1946 to the present, the number of studies decreases. It was also interesting to note that the majority of these studies were concerned, for one purpose or another, with the computational phase of arithmetic.

It does not necessarily follow that the general arithmetical research studies followed this particular bi-modal distribution. However, it was interesting to note that the research studies which dealt with the subject field of arithmetic (arithmetic status of college freshmen and related arithmetical comparisons) were distributed in a bi-modal curve.

Training Teachers of Arithmetic

The findings of any study which measures arithmetical understandings and abilities of prospective teachers of arithmetic are closely related to teacher training. In light of this relatedness, a review of the pertinent studies and discussions concerned with the training of teachers of arithmetic is presented in the pages to follow.

Effect of Courses in Teaching of Arithmetic on Arithmetic Ability. If entering college freshmen have exhibited disabilities in arithmetic, what have teacher training institutions done to improve the abilities of these students? Have studies been conducted by teacher training institutions that have determined the effect of their respective programs on the arithmetic ability of their students? The author of this present study found only one reported study that attempted to determine the effect of a teacher training program on the arithmetic abilities of prospective teachers.

In the year 1930, Foberg[43] conducted a study in which he tried to find an answer to the question: Does the student's studying of the processes by which arithmetic is taught to children increase or decrease his command of arithmetic operations?

Three-hundred freshmen students were given the Monroe Standardized Survey Scale in Arithmetic, Form I of Scale II. At the close of the semester, these students were again administered the same test using Form III of Scale II. The students who took the tests were divided into the following groups: those who took the course in the Teaching of Numbers; those who took the course in the

---

43. J. A. Foberg, "Effect of Courses in the Teaching of Arithmetic upon Arithmetic Skills." Journal of Educational Research, XXI (January, 1930), 74-76.

Teaching of Arithmetic; and those who took no course in mathematics during the semester. Some of the significant facts found from the results of both these two tests were:

1. There is a heavy load of arithmetic disability, since 26 per cent of the entire number of cases involved in the study were below Grade VIII standard in both tests, and 27 per cent of those who took courses in Teaching of Numbers and Teaching of Arithmetic were below Grade VIII standard in the second test.

2. The students who took the course in the Teaching of Numbers are definitely less able in arithmetic, since only 37 per cent of them were above Grade VIII median in both tests, as contrasted with 58 per cent of the Teaching of Arithmetic group who were above Grade VIII median in both tests; and 34 per cent were below Grade VIII median in both tests, as contrasted with 23 per cent of the Teaching of Arithmetic group, who were below Grade VIII median on both tests.

3. The students who took no course in the Teaching of Numbers or Arithmetic, are about on the same level of ability as the students who took the course in Teaching of Arithmetic, as shown by comparing the per cents of the two groups that were above Grade VIII median on both tests. The group taking the course in the Teaching of Arithmetic during the semester however, showed a much higher percentage of gain in arithmetic skill at the end of the semester than did those who took no courses in teaching.

4. There seems to be some positive effect of the study of courses in Teaching of Arithmetic upon skills in arithmetic, since in the group that did

> not take any such course 60 per cent did poorer work on the second test than on the first test, as contrasted with 35 per cent in the groups that did take such courses.[44]

From an analysis of the test results the conclusion was reached by Foberg that the two courses in the Teaching of Numbers and the Teaching of Arithmetic had a positive effect upon arithmetical skills of the students enrolled in them. However, this positive effect was not great enough to overcome the initial arithmetic disabilities in many of the students. Foberg stated that there was a great need for remedial courses in arithmetic, since a large proportion of the entire group tested in his investigation fell below the eighth-grade median even after taking the course in Teaching of Numbers or Teaching of Arithmetic.

Practices of Teacher Training Institutions in the Area of Arithmetic. Along with studies that have been made to determine the status of freshmen in arithmetic, investigations have been conducted to determine the practices of teacher training institutions in the area of arithmetic. From these findings that have dealt with teacher training in arithmetic, many suggestions have

---

44. *Ibid.*, pp. 75-76.

been made as to the type of arithmetic courses prospective teachers of arithmetic should take. The types of courses suggested have been considered in terms of the background and understandings needed by students if they are to become competent teachers of arithmetic.

Buckingham,[45] in 1930, conducted an investigation in which he determined the nature of teacher training practices in arithmetic. He found that the vast majority of the courses in arithmetic for prospective teachers were elementary in character, with most of the attention being devoted to the arithmetic of the grades. In light of this finding he recommended that at least two dominant courses in arithmetic should be given:

> The first one should be of a survey character. It should endeavor to place arithmetic in its proper social setting. It would, of course, be partly historical in character, and from it the students would be expected to develop an appreciative attitude toward the subject. The second course should deal with the particular subject matter which the student will be called upon to teach.[46]

---

45. B. R. Buckingham, "The Training of Teachers of Arithmetic," _Report of the Society's Committee on Arithmetic. Twenty-ninth Yearbook of the National Society for the Study of Education, Part I_, Chapter VI. Chicago: University of Chicago Press, 1930.

46. _Ibid._, p. 331.

Bond,[47] in an extensive study that dealt with the professional treatment of subject matter of arithmetic, found that there were three different points of view in regard to the training of prospective teachers of arithmetic. These points of view are listed as follows:

1. One point of view held by many professional individuals is that advanced academic work in mathematics is the most important and basic factor in training prospective teachers to become good teachers of arithmetic.

2. Another point of view held by other individuals is based on the assumption that if prospective teachers are well-trained in a professional outlook, later when the teacher is on the job, he will be able to discover the pertinent materials of instruction and adapt these materials to his classroom needs.

3. There are others who believe that the time devoted to the training of teachers in arithmetic should be used in mastering the elementary materials, with adequate attention given to the methods of teaching them.

---

47. E. A. Bond, Professional Treatment of the Subject Matter of Arithmetic for Teacher-Training Institutions. Contributions to Education, No. 525. New York: Bureau of Publications, Teachers College, Columbia University, 1934.

He found that institutions embued with the philosophy of the first point of view gave courses in advanced mathematics up to and including calculus. These institutions devoted little time to the professional treatment of arithmetic. He found that institutions embued with the philosophy of the second point of view offered courses in general education and gave only a very small amount of work or no work at all in arithmetic. Institutions which operated in light of the third point of view offered review courses in arithmetic at the level of that which was taught to elementary school children.

In a study that was concerned with the professional education of elementary teachers in the field of arithmetic, Robinson[48] recommended the nature and types of research needed in the area of professional courses in arithmetic. His recommendations of needed research suggests that he was interested in determining the ability of prospective teachers in arithmetic as well as the type of course work prospective teachers should experience in their professional preparation. He suggested the following possible lines of investigation:

---

48. Arthur E. Robinson, The Professional Education of Elementary Teachers in the Field of Arithmetic. Contributions to Education, No. 672. New York: Bureau of Publications, Teachers College, Columbia University, 1936.

1. An analysis of the subject matter of arithmetic for the elementary school course. The objective was to give the prospective teacher of arithmetic a complete understanding of the basic concepts of arithmetic. Under no condition was the content to be organized so that it consisted only of a mere review of materials.

2. An analysis of advanced mathematical content should be accomplished so that these advanced materials could be integrated with the content or subject matter of arithmetic. Thus, the prospective teacher of arithmetic would then have a broad and significant control of the arithmetic he would teach.

3. A testing program should be organized to determine the abilities and disabilities in mathematical content of the students enrolled in the professional schools for teachers.

In an investigation that attempted to determine the arithmetical ability possessed by entering teachers college freshmen, Taylor[49] found that a large proportion of the college freshmen were unable to compute with speed and accuracy, and that they understood only a few of the

---

49. E. H. Taylor, "Preparation of Teachers of Arithmetic in Teachers Colleges," Mathematics Teacher, XXX (January, 1937), 10-14.

meanings, concepts, and processes of arithmetic. He also found that of all the hours of arithmetic offered, more than 50 per cent of these semester hours of arithmetic were given in courses devoted to methods, and 11.6 per cent of the hours offered were administered by departments of education.

His study revealed the fact that of the elementary school major graduates studied, one-third had not studied arithmetic in college, and that a large proportion of the other two-thirds took courses which were primarily devoted to methods.

In a study that dealt with the professional preparation of teachers, Wren[50] suggested that the basic fundamental skills of the prospective teachers must be determined, and when deficiencies were found, it should be the duty of the institution to construct remedial programs for the correction of the defects. He stated that:

> The teacher-training program must provide opportunities for enriched understandings of the nature of number and of our decimal system of numeration; of one-to-one correspondence and place value; of zero as a symbol for the empty column as well as a number and as a point on a number scale; of

---

50. F. L. Wren, The Professional Preparation of Teachers of Arithmetic. Supplementary Educational Monographs, No. 66. Chicago: University of Chicago Press, 1948, 80-90.

> the efficiency of our methods of computing; of the interrelationships of the fundamental operations (the relationships of addition and subtraction to counting and to each other, multiplication to addition, division to subtraction, and of multiplication to division); of the generalizations of processes and concepts, such as recognition of the common properties of ratios, common fractions, decimals, and per cents; of the simplicity of form and the power of expression which characterized the formula and the graph; of the use of number in the basic considerations of form, shape, and size; and of the properties of fundamental geometric figures as a basis for understanding structure and design.[51]

In a discussion which dealt with the preparation needed by teachers of arithmetic, Yorke[52] suggested that prospective teachers of arithmetic need some specific work in the field of mathematics. He suggested that the prospective teacher should have a course in what to teach, based on the functional theory of education that the processes of arithmetic taught must be those most used in life.

A second professional course suggested by Yorke was one concerned with methods, techniques, and materials. He

---

51. Ibid., p. 85.

52. G. C. Yorke, "Preparation Needed by Teachers of Arithmetic," Education, LXIX (February, 1949), 373-375.

felt that courses in mathematics, such as calculus, trigonometry, statistics, etc., should be taken by prospective teachers of arithmetic.

> The experience needed by prospective teachers of arithmetic should include ample opportunity for the observation of master teachers in this field; demonstration of the best classroom procedure, methods, and techniques by arithmetic experts; some simple research and experimentation; and practice teaching adequately supervised in accordance with the principles of mental hygiene.[53]

Mayor,[54] in an article which dealt with special training for teachers of arithmetic, suggested that prospective teachers of arithmetic should take one course that includes topics dealing with the number system; the use of symbols in problem solving; tables and graphs; elementary topics in statistics; ideas of approximate computation; logarithms; recreational arithmetic; compound interest; annuities and basic topics in life insurance; and trigonometric ratios in indirect measurement. For a second course, he suggested topics dealing with problems involved in the teaching of arithmetic, with considerable emphasis on the teaching of meaning.

---

53. Ibid., p. 375.

54. J. R. Mayor, "Special Training for Teachers of Arithmetic," School Science and Mathematics, XLIX (October, 1949), 539-548.

From a study which had as its purpose the determination of the degree of growth and mastery of basic mathematical understandings possessed by teachers college freshmen, teachers college seniors, and teachers-in-service, Glennon[55] found that there was no significant difference in the amount of mathematical understandings possessed by students who have had courses in the psychology and teaching of arithmetic and students who have not taken such courses.

Glennon stated that little emphasis has been placed on the professional study of arithmetic as a science of numbers, as a system of related ideas, and as a series of number relationships. He concluded that:

> . . .the values of teaching for understanding have not been appreciated to the point of modifying the teaching and the curriculum to include the understandings, meanings, principles and generalizations basic to the number system.[56]

In a discussion which dealt with a proposed course of arithmetic, Newsom[57] considered the mathematical

---

55. Vincent J. Glennon, "Study in Needed Redirection in the Preparation of Teachers of Arithmetic," Mathematics Teacher, XLII (December, 1949), 389-396.

56. Ibid., p. 396.

57. C. V. Newsom, "Mathematical Background Needed by Teachers of Arithmetic," The Teaching of Arithmetic. Fiftieth Yearbook of the National Society for the Study of Education, Part II, pp. 232-250. Chicago: The University of Chicago Press, 1951.

background needed by teachers of arithmetic. It was suggested by the author that topics should be restricted to the type of arithmetic that will be taught to the children in the classroom. Newsom felt that in a professional course, the process of arithmetic should be treated in terms of actual utility, and that such a background course should demand breadth of study and student exploration. He proposed that a professional course in arithmetic should include such factors as: (1) positional notation, (2) the properties of integers, (3) the four basic arithmetical operations, (4) fractions, (5) the arithmetic of measurement, (6) evaluation of formulas, (7) ratio and proportion, (8) business arithmetic, and (9) statistical concepts and probability.

Grossnickle[58] made an extensive investigation which dealt with the training of teachers of arithmetic. The method used in the study included a review of the literature on the subject, questionnaire returns from 129 state teachers colleges, and an analysis of college catalogs. From this investigation, Grossnickle found that:

---

58. F. E. Grossnickle, "Training of Teachers of Arithmetic," The Teaching of Arithmetic. Fiftieth Yearbook of the National Society for the Study of Education, Part II, pp. 203-231. Chicago: The University of Chicago Press, 1951.

1. Two-thirds of the colleges which offered a general curriculum in elementary education only required 2.0 semester hours of background mathematics.

2. The most common type of background mathematics required was a course in general mathematics.

3. One-third of the colleges did not require a course in the teaching of arithmetic, while half of the colleges which did require a course in the teaching of arithmetic, included this phase in a general methods course taught by an education specialist and not by a member of the mathematics department.

4. Of the teachers colleges which required no background course in mathematics, only half checked on the student's competency in arithmetic.

5. Even though the training program for elementary teachers during the last twenty-five years has increased in length from two to four years, the amount of training required in mathematics had decreased.

In light of the findings made, Grossnickle recommended a series of changes in the teacher training program. The recommendations that considered the type of arithmetic training prospective elementary school teachers should experience were as follows:

1. Prospective teachers in elementary education who have had no work in mathematics since the eighth grade

should be required to take a background course in mathematics prior to taking the course in the teaching of arithmetic.

2. Every elementary school classroom teacher should be required to take a course in the teaching of arithmetic. A course of this type should include the social applications of arithmetic as well as the mathematical meanings of the subject.

Arithmetical Competence of Teachers of Arithmetic. A few studies have been made to determine the competence or ability of elementary school teachers in the subject area of arithmetic. It can be assumed that the findings of such studies are related to a large degree to the nature and quality of the training in arithmetic elementary school teachers received as college students.

Guiler[59] attempted to discover the extent and nature of computational errors made by teachers who taught elementary school arithmetic. He felt that many of the learning difficulties of pupils could be overcome if the teachers themselves were more expert in the abilities concerned in solving examples of types frequently found in life situations. In this particular study, the Guiler-Christofferson Diagnostic Survey Test in

---

59. W. S. Guiler, "Computational Errors Made by Teachers of Arithmetic," Elementary School Journal, XXXIII (September, 1932), 51-58.

Computational Arithmetic was given to 37 students attending Miami University (Ohio) in the first term of summer school. Twenty-two of these summer school students had taught arithmetic in the public schools of Ohio.

The test results for the 22 summer school students who had taught arithmetic in the elementary school showed that there was considerable variation in achievement. One-half of the teachers reached or exceeded the median standard for college sophomores, while the median standard for college freshmen was not reached by five of the 22 teachers. Four of the teachers fell below the standard for the ninth-grade; and the score of one teacher was less than the standard for the fifth-grade. Although little significance can be given to the results obtained from such a small sample, it is interesting to note the arithmetic status of a group of teachers who had taught arithmetic in the elementary school.

Robinson,[60] in his study of the professional education of elementary teachers in the field of arithmetic, also attempted to determine the types of deficiencies of elementary school teachers in the fundamental principles of arithmetic. The results from teachers' examinations

---

60. Robinson, *op. cit.*, p. 181.

received, from special examinations given to employed teachers, from observations of the teaching of arithmetic to elementary school children, and from conferences with the teachers whose teaching was observed showed that:

> . . .elementary school teachers have at best only a mechanical knowledge of arithmetic even though they are fairly proficient in their skills in the manipulation of its various mechanical processes. Anything like a clear and versatile knowledge of the fundamental principles of arithmetic and their mathematical significances is all but totally lacking on the part of such teachers. Because of this fact, it is difficult to see how the arithmetic they teach or would be called upon to teach to elementary school children could be anything more than mechanical.[61]

Robinson goes on to say that the professional school for teachers is responsible to a considerable extent for the poor showing of teachers in the subject field of arithmetic. He concludes that:

> The professional school is permitting to be administered in its classrooms a professional course in arithmetic that is quite elementary as judged from its use of instructional materials. . . . Furthermore, the school is permitting a course in arithmetic to be given that is still best

---

61. *Ibid*., p. 181.

> characterized as a 'Methods of Teaching and Review' course. . . . As a result, it is difficult to find in the various schools professional courses in arithmetic for any particular level of teaching that are definitely comparable in the essential elements of a course of instruction, such as, aims or objectives, instructional materials, time allotments, etc.[62]

A review of the literature pertinent to the training of teachers of arithmetic showed that little has been reported by teacher training institutions to determine the effect of their professional arithmetic program on the arithmetic abilities of their students. The review showed that studies have been made to determine the practices of teacher training institutions in the area of arithmetic, and that many recommendations have been made as to the type of professional courses prospective teachers should receive to become competent teachers of arithmetic. A few studies attempted to determine the arithmetical competence of elementary school teachers. The results of such studies would indicate that teacher training institutions have not accomplished one of their objectives, the training of competent teachers of arithmetic.

---

62. *Ibid.*, p. 182.

Theoretical Background for Choice of Test Instrument

A relationship exists between the literature concerned with learning theories of arithmetic and the basic purpose of this study, i.e., to determine the status of college freshmen in three areas of arithmetic. The instrument used to determine the status of college freshmen in arithmetic had to be chosen in terms of the learning theory held by the author of this study. Since there have been numerous learning theories of arithmetic held by different groups of educators, it is necessary that some consideration be given to these several theories in order to contrast them with the theory assumed by the author.

The choice of the *Functional Evaluation of Mathematics Test* was made in the light of the meaningful theory of arithmetic. The author holds to the theory that arithmetic is more than just computation, or more than just problem solving. Arithmetic, as conceived by the author, consists of the understanding of the basic and underlying principles inherent in our number system. Arithmetic is an integrated system of understandable processes, ideas, concepts, and principles. Basically, this is the meaning theory of arithmetic.

The test used in this study measured the ability of an individual to perceive number relationships and it measured the ability of the individual in the fundamental processes of arithmetic (computation and solving of word problems). In other words, the Functional Evaluation of Mathematics Test measured arithmetic as viewed by those who hold to the meaningful theory of arithmetic.

Theories Concerned with How Children Learn Arithmetic. In consideration of the meaningful theory held by the author, it is desirable to briefly review the several theories that have been held in the past and to review in some detail the nature of meaningful arithmetic.

Brownell[63] has reduced the numerous theories of learning arithmetic to three: (1) the drill theory of arithmetic; (2) the incidental theory of arithmetic; and (3) the meaning theory of arithmetic.

Those who hold to the drill theory of arithmetic considered arithmetic, for the purpose of learning and teaching, nothing more than a large group of relatively unrelated facts and independent skills.

> The main points in the theory are: (1) arithmetic, for the purpose of learning and teaching, may be analyzed into a great many units or

---

63. W. A. Brownell, "Psychological Considerations in the Learning and the Teaching of Arithmetic," Teaching of Arithmetic. Tenth Yearbook of the National Council of Teachers of Mathematics, pp. 1-31. New York: Bureau of Publications, Teachers College, Columbia University, 1935.

> elements of knowledge and skill which are comparatively separate and unconnected; (2) the pupil is to master these almost innumerable elements whether he understands them or not; (3) the pupil is to learn these elements in the form in which he will subsequently use them; and (4) the pupil will attain these ends most economically and most completely through formal repetition.[64]

Apparently, those who held to the drill theory considered arithmetic in terms of computation. The pupil was obligated to learn how to compute, and to increase his skill in computing, it was necessary that he be subjected to continuous drill on the number symbols involved in computation. It followed that if arithmetic was primarily considered as a process of computing, then the most economical way to learn these processes was through continued repetition.

The drill theory was the prevalent theory of learning arithmetic in the early 1930's. This fact no doubt explains to a large degree why so much emphasis was placed on computation during that time. A review of the literature showed that many of these early studies that dealt with the arithmetic ability of entering college freshmen were concerned with only the computational status of the freshmen.

---

64. *Ibid.*, p. 2.

There were those who held to the incidental theory of learning. This theory of how arithmetic should be learned and taught was, in part, a reaction against the traditional classroom practices of teachers who practiced the drill theory. Those who held to the incidental theory did not necessarily think of arithmetic as mere computation. According to the incidental theory, it was believed that children through natural behavior in situations which are not necessarily arithmetical could achieve skill in the processes and proficiency in understanding quantitative situations. Brownell described the incidental theory as follows:

> According to these theories, which differ chiefly in detail, children will learn as much arithmetic as they need, and will learn it better, if they are not systematically taught arithmetic. The assumption is that children will themselves, through 'natural' behavior in situations which are only in part arithmetical, develop adequate number concepts, achieve respectable skill in the fundamental operations, discover vital uses for the arithmetic they learn, and attain real proficiency in adjusting to quantitative situations. The learning is through incidental experience.[65]

The meaning theory of arithmetic, even though it does contain several features of the other theories, is

---

65. *Ibid.*, p. 12.

not eclectic, because it contains properties or features that are peculiar to itself.

According to Brownell:

> The meaning theory conceives of arithmetic as a closely knit system of understandable ideas, principles, and processes. According to this theory, the test of learning is not mere mechanical facility in 'figuring.' The true test is an intelligent grasp upon number relations and the ability to deal with arithmetical situations with proper comprehension of their mathematical as well as their practical significance.[66]

It was pointed out by Brownell that there is room in the meaning theory of learning for certain fundamental features of both the drill and incidental theories of learning. There is a definite need for drill after the various related ideas and processes are understood. Drill, after the basic arithmetical concepts and understandings are comprehended, is needed to increase proficiency, to fix for retention, and to rehabilitate after disuse. Also, the meaning theory recognizes the values of childrens' experiences as a method of reinforcing number ideas, motivating the learning of new arithmetic abilities, and extending the application of knowledge of

---

66. *Ibid.*, p. 19.

number beyond the limitation of the textbook. Thus, certain features of both the drill and incidental theory of learning are readily utilized and logically included within the scope of the meaning theory.

In his discussion of the relative merits of the psychological functions of arithmetic, Brueckner[67] stated that the computational function of arithmetic merely stressed proficiency in the mechanics of arithmetic, i.e., facility and accuracy in computation on the part of the students. The computational function, as it had been used as an end in itself, placed little to no emphasis on number meaning or the understanding of arithmetical concepts.

> Routine drill is often aimless, random activity on the part of the pupil. He does not care what happens because the activity has no meaning or significance to him.[68]

Thus, drill does not yield insight into the meaning of number when used as an operation in itself. However, drill does assist the pupil to form efficient habits of

---

67. L. J. Brueckner, "Functions of Instruction in Arithmetic," National Education Association Journal, XX (October, 1931), 239-241.

68. Ibid., p. 240.

number manipulation and drill will help maintain the mechanics of arithmetic at a level of usefulness.

Meaningful Arithmetic. As has been previously pointed out, the author justified the choice of the test used in this study by briefly considering the meaningful theory of arithmetic as opposed to the drill and incidental theories. As the meaningful theory of arithmetic is the theory accepted by the author, and as the choice of the test used in the study was made in the light of the meaningful theory of arithmetic, it becomes desirable that some additional consideration be given to the literature pertinent to the meaningful concept of arithmetic.

Over the past twenty years, the literature concerned with arithmetic learnings has exhibited a change in theory, a trend from advocating repetition to a trend towards meaningful arithmetic.

This change in thinking is exemplified by reviewing the contents of the three Yearbooks of The National Council of Teachers of Mathematics which dealt with arithmetic. The first of the Yearbooks[69] which dealt

---

69. Curriculum Problems in Teaching Mathematics. Second Yearbook of the National Council of Teachers of Mathematics. New York: Bureau of Publications, Teachers College, Columbia University, 1927.

with arithmetic was published in 1927. A review of the contents of the Second Yearbook, Curriculum Problems in Teaching Mathematics, showed that the drill theory of learning arithmetic dominated the discussions that dealt with arithmetic. The second publication[70] of the National Council of Teachers of Mathematics which dealt with arithmetic was published in 1935. A review of the contents of the Tenth Yearbook, Teaching of Arithmetic, showed a change in the nature of the discussions. It was noted that the contents included discussions that were concerned not only with the drill theory of arithmetic, but also the incidental and meaningful theories of arithmetic. The contents of the Tenth Yearbook revealed the introduction of a theory that soon was to threaten the very foundations of the drill theory. The third publication[71] of the National Council of Teachers of Mathematics was initially published in 1941. A review

---

70. The Teaching of Arithmetic. Tenth Yearbook of the National Council of Teachers of Mathematics. New York: Bureau of Publications, Teachers College, Columbia University, 1935.

71. Arithmetic in General Education. Sixteenth Yearbook of the National Council of Teachers of Mathematics. New York: Bureau of Publications, Teachers College, Columbia University, 1941.

of the contents of the Sixteenth Yearbook, Arithmetic in General Education, showed a complete acceptance of the meaningful theory of arithmetic. Thus, in a period of 14 years, the emphasis on learning theories of arithmetic changed from the drill to the meaningful theory.

In a discussion that dealt with the nature of meaningful arithmetic, Brownell[72] stated that the first problem was to identify the meanings which make arithmetic a coherent mathematical subject. These meanings fall into three groups: (1) meanings of quantitative terms and of the number system, (2) meanings of the fundamental operations, and (3) meanings of the processes of computation.

> If arithmetic is to be meaningful, children must understand whole numbers in terms of 1's, and 100's and 1000's, and so on. But they will not understand numbers this way if their activities are restricted to pointing off the places in a few large abstract numbers. Instead, they need abundant experience in actually constructing numbers, many more experiences of course with two-place than with three-place numbers, and more experiences with three-place numbers than with four-place numbers.[73]

---

72. W. A. Brownell, "When is Arithmetic Meaningful?" Journal of Educational Research, XXXVIII (November, 1945), 481-498.

73. Ibid., p. 485.

Each of the meanings identified and grouped by Brownell were included and repeated in the <u>Functional Evaluation in Mathematics Test</u> used in this study.

In a second discussion that dealt with the place of meaning in the teaching of arithmetic, Brownell[74] stated that meaningful arithmetic is not concerned with mere mechanical manipulation of numbers; it is not a process which makes proficiency in computation an end in itself.

> To be of use, computational habits must first of all be retained. As has. . .been stated, skills which are learned mechanically, with a minimum of learning, quickly deteriorate. To keep them alive, one must practice them ceasingly. However, the conditions of life afford little opportunity for continuous practice, and once the unremitting drill of the school is withdrawn, the skills suffer. To be of use, moreover, computational habits must be adaptable to a wide variety of circumstance, and mechanical skills, even when they are retained, cannot meet the test. Therefore, whether the criterion be retention or functional value, meaningless arithmetic defaults on its one claim - the assuring of competence in computation.[75]

<u>Rationale of Test Used in This Study</u>. The <u>Functional Evaluation in Mathematics Test</u> (by Brownell and Sueltz)

---

74. W. A. Brownell, "The Place of Meaning in the Teaching of Arithmetic," <u>Elementary School Journal</u>, XLVII (January, 1947), 256-265.

75. <u>Ibid</u>., p. 261.

used in this study is composed of three parts or sections. The first part (Test 4) measures the ability of the individual to think in terms of quantitative relationships. Included in these relationships are the principles and meanings inherent in meaningful learning. The test items include such factors as simple principles of the number system, understanding of fractions and decimals, and algebraic and geometric understandings. It was found by the authors of the test that in the realm of understanding, the experiences and backgrounds of the pupils have played an important role. Thus, pupils who did poorly on the test usually were those whose education was confined largely to abstract computations or they were the pupils who lacked real experiential background. This first test has "multiple-choice" answers. The authors found that very few of the pupils tested guessed at the correct answer. It was found that when the pupils tested read and actually used their thought processes, they tended to answer in the light of their knowledge and understanding.

The second section of the test (Test 5) measures the ability of the individual to solve word problems. The problems that go to make up the test are related to the kinds of things pupils do or read about. The authors state that the word problems included in the Problem Solving Test consist of the most important problem-goals that teachers recognize.

The third section of the test (Test 6) measures the computational ability of the pupil. The authors of the test state that the gradations for the computational test used in the study are less fine because a larger number of major computational types had to be represented.

The nature and function of meaningful arithmetic, as contrasted with meaningless arithmetic, is not merely concerned with mechanical manipulation of numbers. Instead, meaningful arithmetic is concerned with the understanding of basic arithmetical concepts and principles such as those which were tested in the present study.

Summary

An examination of the literature pertinent to this study revealed that a majority of the investigations conducted to determine the status of college freshmen in arithmetic were computational in nature. Through this review of the literature, it was found that a significant proportion of the freshmen tested were inferior to the average eighth-grade student in computational skill. Further examination of the literature pertinent to this study has shown that studies made to determine the status of freshmen in problem solving and in the understanding of basic arithmetical concepts have been limited in number. These studies indicated that the tested groups of freshmen were lacking in proficiency in both the problem solving and quantitative understanding phases of arithmetic.

A review of the investigations concerned with comparisons in the several areas of arithmetic revealed that research of this type has been quite limited. The few studies made in the light of these comparisons showed that ability in computation was more closely related to problem solving ability than was general reading ability, and that in one study almost one-half of the variance in arithmetical problem solving ability was due to variation in computation.

A review of the studies made to determine the relationship between several socio-psychological factors and the performance of students in arithmetic indicated that some relationship did exist between these factors and the competence of the students in arithmetic.

When a study of the dates of these investigations was made, it was found that these investigations were distributed in a bi-modal curve. Starting with the year 1917 and continuing to the present, it was found that the two peak years in frequency of studies were 1932 and 1946.

An examination of the literature has shown that little has been reported by the teachers colleges to determine the effect of their training programs in arithmetic on the arithmetic competence of their students. However, the review of literature has revealed that a number of investigations have attempted to determine the practices of teachers colleges in the subject field of arithmetic and that many recommendations have been made pertaining to the type of course work prospective teachers of arithmetic should experience to become competent teachers of arithmetic. In several cases, studies were made that attempted to determine the arithmetical status or competence of elementary school teachers. The results of these studies seemed to indicate that many of the tested elementary school teachers lacked competence in arithmetic.

It was pointed out that the test used in this study had to be chosen in terms of the learning theory of arithmetic held by the author. In order to clarify the learning theory of the author it became necessary that consideration be given to these several theories and that some discussion of the concept of arithmetic held by the author be included. This section of the chapter emphasized the meaning theory of arithmetic because it is the one which is basic to this study.

CHAPTER III

METHODS AND TECHNIQUES EMPLOYED IN STUDY

A two-fold purpose of this present investigation was presented in Chapter I. One basic purpose of this study was to determine the status of a group of freshmen elementary education majors in the quantitative understanding, problem solving, and computational phases of arithmetic. A second purpose was to consider the arithmetical performance of this freshmen group in the light of certain socio-psychological factors or characteristics.

A review of the literature pertinent to this study was presented in Chapter II. From this review it was found that many studies had been conducted which attempted to determine the computational status of entering college freshmen. Only a few studies were found that considered the status of freshmen in the problem solving phase of arithmetic or that compared the performance of freshmen in the problem solving and computational phases of arithmetic. None of these studies attempted to determine the status of a single group of freshmen in the quantitative understanding, problem solving, and computational phases of arithmetic. The emphasis appeared to be placed on computation.

As was pointed out in Chapter II, the author accepts the "meaning" theory of arithmetic and believes that arithmetic instruction must emphasize number meaning as well as problem solving and computation. Therefore it became necessary to find a test which measured these three aspects of arithmetic.

Selection of Measuring Instrument. The Upper Level section of the test series, Functional Evaluation in Mathematics by Brownell and Sueltz, was chosen as the measuring device to determine the status of the freshmen group of elementary education majors in the quantitative understanding, problem solving and computational phase of arithmetic. Functional Evaluation in Mathematics is made up of two levels, the Elementary Level (Grades 4-6) and the Upper Level (Grades 7-9). The Upper Level test was used in this investigation. The three tests comprising this level are designed to measure the arithmetic abilities of students at the seventh, eighth, and ninth-grade levels. The Upper Level consists of Test 4, Quantitative Understanding; Test 5, Problem Solving; and Test 6, Basic Computation. Copies of the tests are included in Appendix A.

The phases of arithmetic measured by this test series coincides with the theory of arithmetic held by the author. Test 4, Quantitative Understanding, is made up of items which test various principles, meanings, concepts, and relationships inherent in meaningful learning and understanding. It consists of a wide range of materials, including items from principles of the number system to algebraic and geometric understandings. Test 5, Problem Solving, includes problems that are related to the functions of everyday life. In the problem solving test, careful consideration is given to gradation of relationships and reasoning in problem situations. Test 6, Basic Computation, measures the students' competence in the mechanics of computation. All the tests are designed to measure the students' knowledge and ability to use arithmetic and mathematics in functional situations.

The reliability coefficient of the quantitative understanding test is .89; for the problem solving test, .83; and for the computation test, .84. The test norms are based on test results from all major sections of the United States.

In summary, the Upper Level section of the test series, Functional Evaluation in Mathematics by Brownell and Sueltz, was chosen because these tests seemed to represent a reliable measure of the phases of arithmetic which coincided with the concept of arithmetic held by the author and the purpose of the present study. By use of such a measuring instrument, the author sought to determine the status of the freshmen elementary education majors in the quantitative understanding, problem solving, and computational phases of arithmetic.

Conducting the Pilot Study. During the summer school session of 1952, plans were made to conduct a pilot study. The purpose of the pilot study was to have a working model of the main investigation.

A preliminary data sheet was devised (Appendix B) and attached to the test forms. Tests 4, 5, and 6 (Upper Level section of the test series Functional Evaluation in Mathematics) were administered to a group of undergraduate students majoring in elementary education. The sample consisted of 48 undergraduate students enrolled in the College of Education, University of Alabama.

Prior to the start of the 1952-53 school year, these tests were scored and the results analyzed statistically in the light of the data sheet information.

A study of the statistical analysis and the data sheets, plus a study of the techniques and procedures used in the pilot study, revealed a few weaknesses in the original planning of the investigation.

A thorough review and study of the pilot investigation showed that the data sheet was quite inadequate. This initial data sheet did not provide the information needed to answer adequately the subsidiary questions listed under the second purpose of the study, i.e., to consider the performance of the tested group of freshmen in relation to certain socio-psychological characteristics.

A study of the technique used in the test administration showed that a time-period of one and one-half hours was not sufficient to give meaningful and clear-cut directions.

Even though the tests were designed as power tests rather than speed tests, it was found that a periodic reminder of the time used disturbed the group. Each of the three tests had a working time of 25 minutes.

As a result of the pilot investigation, pertinent and time-saving changes were made. A new and more complete data sheet (Appendix C) was constructed. Instead of a one and one-half hour block of time, plans were made by the writer for a two-hour block of time.

From such a preliminary investigation the author was able to gain valuable insight into aspects of the investigation not previously considered. Errors and flaws in planning and techniques not initially observed became quite obvious. Final plans for the main study, as a result of the experience gained through the pilot study, were made with a greater feeling of confidence and security.

<u>Conducting the Investigation</u>. Early in the fall semester of 1952, letters were written to each of the white state supported institutions of higher learning in Alabama. These letters explained the basic purpose of the study and requested permission to administer the arithmetic tests to freshmen students majoring in elementary education. Each of the institutions of higher learning granted permission for the tests to be given. After additional correspondence between the author and the representatives of these institutions, final arrangements were made for the administration of the tests. The period of testing started November 18, 1952 and was concluded the second week of December, 1952.

The tests were administered by the author of the investigation. In one case, however, the author obtained only 13 per cent of the possible cases. These test scores were not included in the study for fear of a biased sample. In a second case, the number of freshmen who had indicated choice of a major in elementary education was so small, that it did not seem desirable to spend the time necessary to test these students.

<u>Analyzing the Test Scores</u>. After the administration of the test series to the group of 212 freshmen students, the tests were hand-scored by the author. By using the table of standard scores and percentile ranks included in

the test manual, the raw scores were converted into three sets of standard scores. One set was based on the standard scores of the seventh grade, one set on the standard scores of the eighth grade, and one set on the standard scores of the ninth grade. These three sets of standard scores were used in the statistical analysis.

Distribution tables (Appendix D) of the test scores were constructed and the formulas suggested by Odell[1] were used to determine the mean standard scores, standard deviations, and significance of differences between mean standard scores and standard deviations.

Summary of Methods and Techniques Employed in Study. The Upper Level section of the test series, Functional Evaluation in Mathematics by Brownell and Sueltz, was administered to 212 freshmen majoring in elementary education. The tests used measured the ability of the freshmen to perceive quantitative relationships, measured their ability to solve word problems, and measured their skill in computation. The test series used in this investigation was designed for students at the seventh, eighth, and ninth-grade levels. This particular test was chosen because it represented a reliable measure of the

---

1. C. W. Odell, An Introduction to Educational Statistics. New York: Prentice-Hall, Inc., 1946.

phases of arithmetic which coincided with the concept of arithmetic held by the author.

From the experience gained through conducting a pilot study, the writer was able to gain valuable insight into the aspects of the investigation not considered.

Arrangements were made with the state supported teacher-education institutions of Alabama whereby the author was granted permission to test the freshmen students majoring in elementary education.

Through the use of the table of standard scores and percentile ranks included in the test manual, the raw scores were converted into three sets of standard scores. These three sets of standard scores were constructed in terms of seventh, eighth, and ninth-grade performance by the standardization population.

Distribution tables were made and the formulas to determine the average performances and spreads of scores were used.

The following chapter presents the findings of this investigation in two major sections. The first section is concerned with the arithmetic abilities of the tested freshmen group and a comparison of their performance in the several phases of arithmetic under consideration. The second section considers the arithmetic abilities of the students in relation to certain socio-psychological characteristics.

CHAPTER IV

FINDINGS FOR THE STUDY

Up to this point the discussion has centered around: (1) the statement of the problem and the justification and scope of the study; (2) the review of the literature pertinent to this investigation; and (3) the method and techniques employed in the gathering and the treatment of the data. The findings for the tested group of Alabama freshmen are presented in this chapter.

The data presented in this chapter were derived from a statistical treatment of the test scores of the freshmen elementary education majors tested in this study. The Brownell and Sueltz Functional Evaluation in Mathematics test was administered in November, 1952 to 212 freshmen students majoring in elementary education. The sample included approximately 88 per cent of the freshmen elementary majors who attended five of the state supported institutions of higher learning in Alabama. These freshmen took Test 4, Quantitative Understanding; Test 5, Problem Solving; and Test 6, Basic Computation. Form A of the test was used in each case.

The findings for the tested group of elementary education majors are presented in this chapter under two main headings. The data in the first section of the chapter are presented so as to describe not only the status of the freshmen in the quantitative understanding, problem solving, and computational phases of arithmetic but also so as to compare the performance of the freshmen in these three areas of arithmetic. The data are presented in the second section of the chapter so as to relate the performance of the freshmen to several socio-psychological characteristics.

Arithmetic Abilities of the Tested Group of Alabama Freshmen

The findings presented in the first part of this chapter are concerned with the abilities of the students in the quantitative understanding, problem solving, and computational phases of arithmetic and a comparison of their competence in each of these three areas.

Status of Group in Three Areas of Arithmetic. A study of the findings showed that the performance of the freshmen more nearly equaled the ninth-grade norms than either the norms of the eighth or seventh grades. Therefore, a considerable portion of the discussion will deal with the performance of the students in terms of ninth-grade norms.

Table 1 compares the tested group of students in quantitative understanding (Test 4), problem solving

(Test 5), and computation (Test 6) with ninth-grade norms. Presented in Table 1 are the distributions of ninth-grade scaled scores, cumulated percentages, mean standard scores, percentile equivalents, and standard deviations for the 212 freshmen in these three areas of arithmetic.

An inspection of the distributions for the three areas of arithmetic shows that in quantitative understanding the distribution of scores approximated a normal distribution, while in problem solving and computation there was a slight tendency for the distributions to be skewed positively. That is, in problem solving and computation the scores tended to gather at the lower end of the distributions and spread out gradually toward the high end of the distributions.

Further study of the distributions presented in Table 1 shows that on the quantitative understanding test the greatest frequency of cases was at the interval 48-50. That is, in quantitative understanding the interval on the scale at which most of the scores fell approximated the median performance of ninth-grade pupils. The "empirical" mode for the freshmen in quantitative understanding was 49. In problem solving the "empirical" mode was 46. In this instance, most scores fell at interval 45-47. In problem solving, the point at which most

TABLE 1

DISTRIBUTION OF NINTH-GRADE SCALED SCORES AND CUMULATED PERCENTAGES FOR FRESHMEN IN THREE AREAS OF ARITHMETIC

Test 4 Quantitative Understanding			Test 5 Problem Solving			Test 6 Basic Computation		
	f	Per cent		f	Per cent		f	Per cent
72-74	5	100	72-74	3	100	72-74	1	100
69-71	6	98	69-71	7	99	69-71	3	99
66-68	2	95	66-68	7	96	66-68	9	98
63-65	12	94	63-65	10	92	63-65	8	94
60-62	20	88	60-62	11	88	60-62	18	90
57-59	28	79	57-59	19	83	57-59	12	81
54-56	18	66	54-56	18	73	54-56	15	75
51-53	24	57	51-53	28	65	51-53	19	68
48-50	41	46	48-50	20	51	48-50	30	59
45-47	10	26	45-47	49	42	45-47	24	45
42-44	22	22	42-44	23	19	42-44	31	35
39-41	14	11	39-41	8	8	39-41	19	20
36-38	3	5	36-38	6	6	36-38	14	11
33-35	3	3	33-35	1	1	33-35	4	4
30-32	4	2	30-32	2	2	30-32	5	2
N = 212			N = 212			N = 212		

	Test 4	Test 5	Test 6
N	212	212	212
Mean	52.27	51.40	49.36
Percentile equivalent	58	54	46
Standard deviation	8.58	8.61	9.09

scores fell was lower than the ninth-grade median performance. On the computation test the "empirical" mode was 43. In this instance, most scores fell at the 42-44 interval. Thus, the point at which the most scores fell was considerably lower than the median performance of the ninth-graders.

A study of the cumulated percentages shows that in quantitative understanding 46 per cent of the scores were at or below the median performance of the ninth grade. In problem solving, 51 per cent of the scores were at or below the median ninth-grade performance, while in computation, 59 per cent of the scores were at or below the ninth-grade median. In other words, the smallest percentage of scores at or below the ninth-grade median occurred in the quantitative understanding phase of arithmetic, while the largest percentage of scores at or below the ninth-grade median occurred in the computational phase of arithmetic.

The mean standard score in quantitative understanding of 52.27 corresponded to a ninth-grade percentile rank of 58. This means that the average performance of the freshmen in quantitative understanding was somewhat above the median performance of the ninth-grade pupils on whom the norms were based.

For the problem solving test, the mean standard score 51.40 corresponded to a ninth-grade percentile rank of 54; that is, on the problem solving test, the freshmen exhibited an average performance that was only slightly above the median performance of the ninth-graders who took the same test.

The mean standard score of 49.36 in computation corresponded to a ninth-grade percentile rank of only 46. In other words, the average performance for the freshmen who took the problem solving test was slightly below the median performance of the ninth-grade pupils.

In a normal distribution 99.73 per cent of the entire distribution of scores lie within the limits of a mean score plus and minus three standard deviations. An inspection of Table 1 shows that in quantitative understanding (Test 4) the mean standard score of 52.27 plus three standard deviations of 8.58 (78.01) and the mean standard score of 52.27 minus three standard deviations of 8.58 (26.53) includes the entire distribution of scaled scores. That is, in quantitative understanding, the entire distribution of scaled scores fell between limits of a normal distribution. This is also true for the distributions of scores on problem solving (S.D. = 8.61) and computation (S.D. = 9.09). That is, all three areas of arithmetic yielded distributions which lie within the limits of the mean standard score plus and minus three standard deviations.

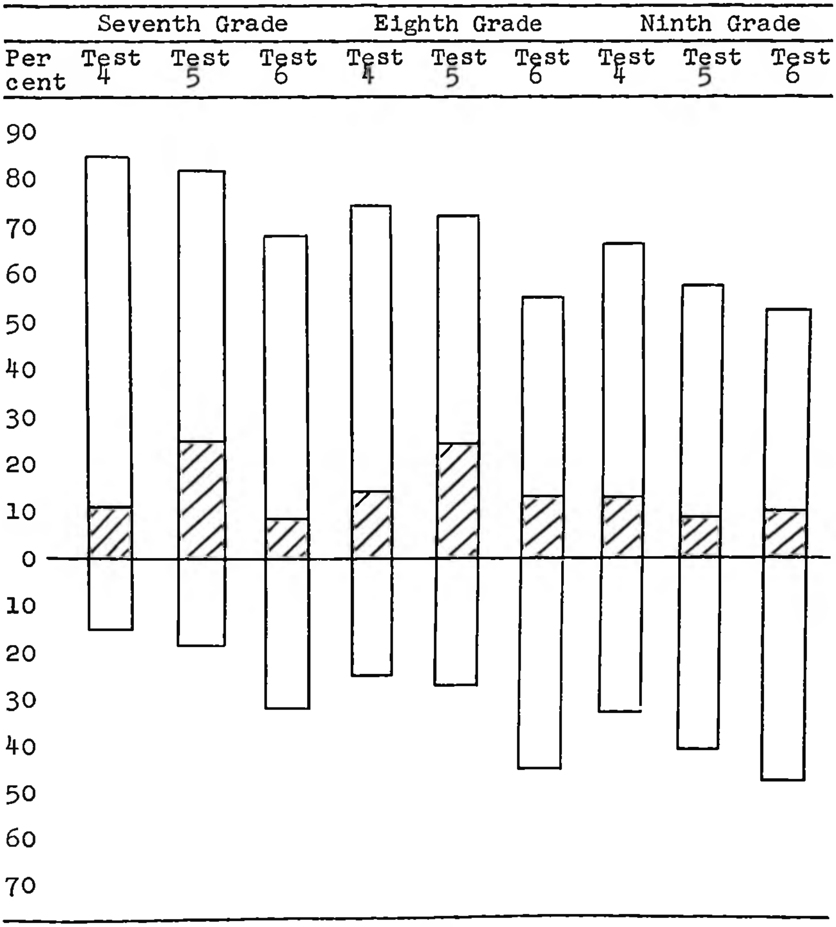
So far the discussion has dealt with the arithmetical status of the students in relation to ninth-grade norms. In order to present a more complete picture of the arithmetical status of this group of students, some consideration will be given to their standing in relation to seventh and eighth-grade norms.

Figure I shows the percentage of freshmen scoring below, at, and above the seventh, eighth, and ninth-grade median performances. A study of Figure I shows that in quantitative understanding approximately five-sixths (83 per cent) of the tested group of freshmen reached or exceeded the median performance of the seventh-grade pupils, while about one-sixth (17 per cent) fell below the median performance of the seventh-grade. On the problem solving test, about four-fifths (81 per cent) of the students had scores that reached or exceeded the seventh grade median, while approximately one-fifth (19 per cent) of the students dropped below this median. In computation, a little over two-thirds (68 per cent) of the freshmen group reached or exceeded the seventh-grade median, while almost one-third (32 per cent) of the freshmen dropped below this median.

In terms of eighth-grade norms, almost three-fourths of the students on the quantitative understanding test reached or exceeded the median performance, while a little

FIGURE I

PERCENTAGE OF SCORES BELOW, AT, AND ABOVE MEDIAN PERFORMANCE OF THE SEVENTH, EIGHTH, AND NINTH GRADES



*The shaded portion of the graph represents the percentage of the test scores that fell at the median performance of seventh, eighth, and ninth grades.

over one-fourth (26 per cent) dropped below the median standard score of the eighth grade. In problem solving, a little under three-fourths (72 per cent) of the students reached or surpassed the median performance of the eighth-grade pupils, while a little over one-fourth (28 per cent) dropped below this median. In the computational phase of arithmetic, over one-half (53 per cent) of the students reached or surpassed the eighth grade median, but almost one-half (47 per cent) fell below the median.

On the quantitative understanding test, approximately two-thirds (66 per cent) of the students reached or exceeded the median standard score of the ninth grade, a little less than three-fifths (58 per cent) reached or exceeded the ninth-grade median in problem solving, and about one-half (51 per cent) of the students reached or surpassed the ninth-grade median in computation. Almost one-third (34 per cent) of the freshmen group fell below the median performance of the ninth grade in quantitative understanding, over two-fifths (42 per cent) dropped below the ninth-grade median in problem solving, and almost one-half (49 per cent) dropped below the ninth-grade median in computation.

Figure I shows that a great majority of the freshmen reached or exceeded the median performance of the seventh-grade pupils in the quantitative understanding, problem solving, and computational phases of arithmetic, that a majority of the students reached or exceeded the eighth-grade median in these three areas of arithmetic, and that almost as many of the students fell below the ninth-grade median as reached or exceeded this median. It can be observed that the performance of the students in these three areas of arithmetic were considerably above the median performances of the seventh and eighth grades, but came close to matching the performance of the ninth-grade pupils.

As was mentioned above, the standard deviations for the total group of freshmen in these three areas of arithmetic were similar in that the entire distributions of scores fell within the limits of a normal distribution. At this point in the discussion it is desirable to consider the performance of the middle two-thirds of the study population in terms of seventh, eighth, and ninth-grade norms.

In a normal distribution the mean score, plus and minus one standard deviation, will include approximately the middle two-thirds of a group. In discussing the findings presented in Figure II, the middle two-thirds will be considered as the "central group" of the test distribution.

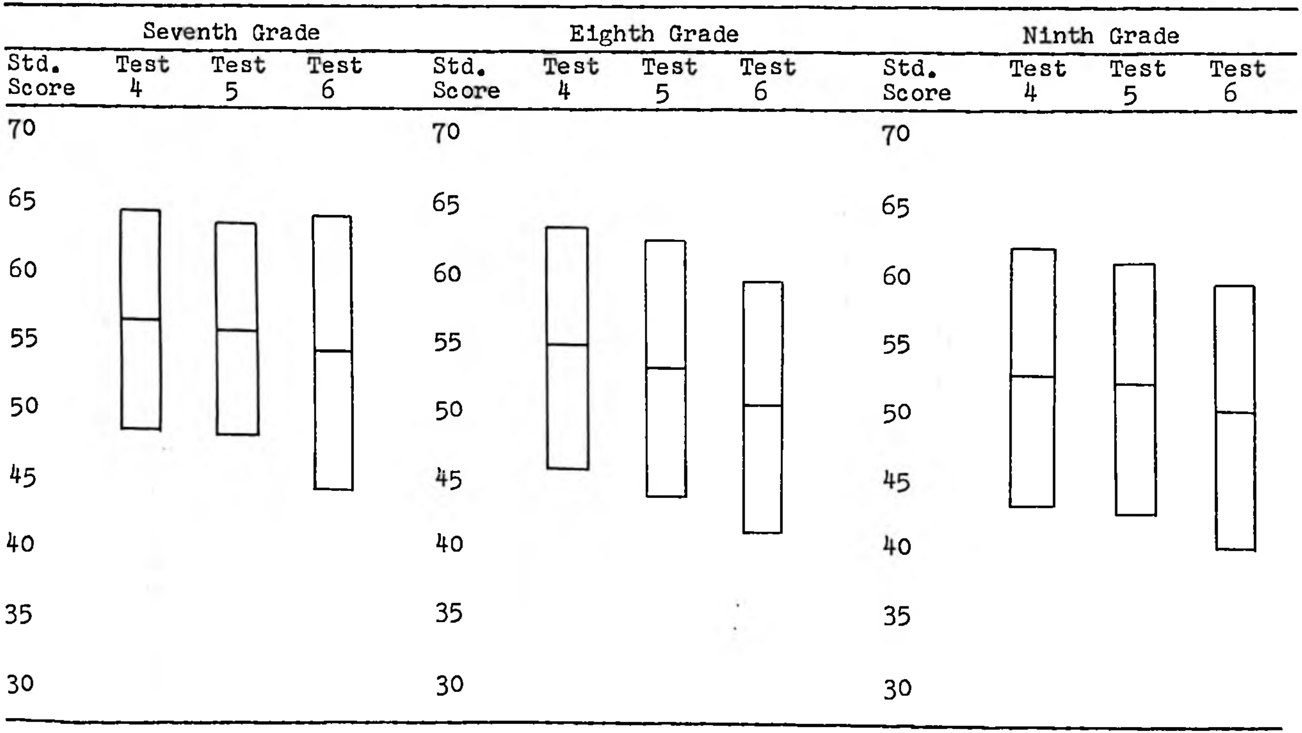
Figure II shows the status of the "central groups" of the freshmen in relation to seventh, eighth, and ninth-grade performances and also the average performances of the freshmen in relation to these norms. The highest performance was shown by the "central groups" which were compared with the seventh-grade norms, the next highest performance by the "central groups" which were compared with the eighth-grade norms, and the lowest performance by the "central groups" which were compared with the ninth-grade norms. A similar trend was found for the mean standard scores. In each of these three areas of arithmetic the highest mean standard scores for the freshmen were found when their average performances were compared with seventh-grade norms, the next highest average performance when compared with the eighth-grade norms, and the lowest average performance when compared with the ninth-grade norms.

Figure II also shows that the students varied considerably in their performance in each of these three areas of arithmetic. Whether the performances of the freshmen are compared to seventh, eighth, or ninth-grade norms, a study of Figure II shows that the students exhibited marked variation in performance in each of these three areas of arithmetic. On quantitative understanding, the scores of the "central group" ranged 1.4

FIGURE II

STATUS OF "CENTRAL GROUP" OF FRESHMEN IN RELATION TO SEVENTH, EIGHTH, AND NINTH-GRADE NORMS

(1) Top horizontal line represents the mean standard score plus one standard deviation.
(2) Middle horizontal line represents mean standard score.
(3) Bottom horizontal line represents the mean standard score minus one standard deviation.



standard deviations above the median standard score of seventh graders and .2 of a standard deviation below this median. When compared with the eighth-grade norms, the test scores of the "central group" ranged 1.3 standard deviations above the eighth-grade median standard score and .4 of a standard deviation below this median. When compared with the ninth-grade norms, the test scores of the same group ranged 1.1 standard deviations above the ninth-grade median and .6 of a standard deviation below this median.

On the problem solving test, the middle two-thirds of the scores ranged 1.3 standard deviations above the seventh-grade median standard score, 1.2 standard deviation above the eighth-grade median standard score, and 1.0 standard deviation above the ninth-grade median standard score. In problem solving, the test scores of the "central groups" ranged .3 of a standard deviation below the median standard score of seventh graders, .6 of a standard deviation below the median standard score of the eighth graders, and .7 of a standard deviation below the median standard score of ninth graders.

In computation, the "central group" scores ranged 1.4 standard deviations above the seventh-grade median, .9 of a standard deviation above the eighth-grade median, and .8 of a standard deviation above the ninth-grade median; while the test scores ranged .5 of a standard deviation below the seventh-grade median, .8 of a standard deviation below the eighth-grade median, and 1.0 standard deviation below the ninth-grade median.

A study of the "central groups" showed that great variance in individual performance existed in each of the three areas of arithmetic under consideration whether the performances were considered in terms of seventh, eighth, or ninth-grade norms. In the quantitative understanding and problem solving phases of arithmetic, some members of the population exhibited performances that approximated the highest performances of the seventh, eighth, and ninth graders, while on the computation test, some members of the population exhibited performances that approximated the lowest performances of the seventh, eighth, and ninth graders. The important aspect of the findings presented in Figure II, is that in each of the three areas of arithmetic, the freshmen varied considerably in individual performance. In some instances, they equaled the highest and lowest performances of the seventh, eighth, and ninth-grade pupils who took the test.

It can be stated in summary, that in these three areas of arithmetic the status of the freshmen approximated typical ninth-grade performance.

A summary of the findings show that a larger percentage of the students reached or exceeded the seventh and eighth-grade median scores than the ninth-grade median score. It was found that a larger percentage of the students dropped below the seventh, eighth, and ninth-grade medians in the computational phase of arithmetic than in the other two phases. The lowest percentage of the students who dropped below the seventh, eighth, and ninth-grade medians did so in the quantitative understanding phase of arithmetic.

A study of the standard deviations showed that in each of these three areas of arithmetic the entire distribution of scaled scores fell within the limits of a normal distribution.

It was found that the students varied considerably in their performance on each phase of arithmetic. The middle two-thirds of each distribution showed that in the quantitative understanding and problem solving phases, some of the freshmen exhibited performances that equaled the top performances of a corresponding middle group of seventh, eighth, and ninth-grade pupils. In computation some of the students exhibited performances that equaled the lowest performance of these junior high school pupils.

Comparison of Performance in Three Areas of Arithmetic. Up to this point in the chapter, the discussion has been concerned with the status of the freshmen in relation to seventh, eighth, and ninth-grade pupils. It was found from a study of Table 1 that certain differences existed in performance in the three tests. The purpose of this section of the chapter is to test the statistical significance of these differences, i.e., to determine whether these differences are true or can be attributed solely to accidents of sampling.

Table 2 shows the difference among the mean standard scores on the quantitative understanding, problem solving and computation tests. Table 2 shows that the mean standard scores on quantitative understanding (Test 4) and problem solving (Test 5) were each significantly higher than the mean standard score on computation (Test 6). The difference between the mean standard scores for the quantitative understanding and basic computation tests was statistically significant at the 1 per cent level. For the problem solving and basic computation tests the difference between the mean standard scores was statistically significant at the 5 per cent level. The difference between the mean standard scores on the quantitative understanding and problem solving tests was not statistically significant, but the higher mean standard score was in favor of quantitative understanding. In other words, Table 2 shows that this group of 212 freshmen exhibited greater competence in the quantitative understanding and problem solving phases of arithmetic than

TABLE 2

SIGNIFICANCE OF DIFFERENCES BETWEEN MEAN STANDARD SCORES

	Test 4 Quantitative Understanding	Test 5 Problem Solving	Test 6 Computation
N	212	212	212
Mean	52.27	51.40	49.36
Standard Deviation	8.58	8.61	9.09

	Difference between Means	S. E. of Difference	t-ratio
$Mean_{Test\ 4} - Mean_{Test\ 5}$	1.08	.850	1.27
$Mean_{Test\ 4} - Mean_{Test\ 6}$	2.87	.876	3.16**
$Mean_{Test\ 5} - Mean_{Test\ 6}$	1.79	.869	2.06*

*Beyond .05 level of significance

**Beyond .01 level of significance

they did in the computational phase of arithmetic, but there was no statistically significant difference in competence between quantitative understanding and problem solving.

A study of the findings presented in Table 2 showed that the students exhibited a higher average performance in the quantitative understanding and problem solving phases of arithmetic than they did in the computational phases of arithmetic. The data presented in Figure I supplement this finding. An inspection of Figure I shows that the greater percentage of freshmen to reach or exceed the median performances of the seventh, eighth, and ninth-grade pupils and the smaller percentage of students to drop below these median performances occurred on the quantitative understanding and problem solving tests indicating that the freshmen encountered most difficulty with computation.

The spread of scores in each distribution has been reported earlier in the form of standard deviations. When the reliability of the difference between standard deviations was determined for the greatest existing difference, it was found that this difference between spread of scores was not statistically significant. The t-ratio of this greatest difference for spread of scores was 1.79. To be statistically significant the t-ratio would have to be at least 1.97.

In summary, it was found that the students showed greater ability in perceiving quantitative relationships and in solving word problems than in computation. This group of freshmen students exhibited about the same facility for solving word problems as they did in perceiving quantitative relationships.

This group of freshmen elementary education majors did not show significant differences in amount of variation among the test distributions.

Relationship of Socio-Psychological Characteristics to Performance in Arithmetic

The second section of this chapter is concerned with the relationship of certain socio-psychological characteristics of the study population to their performance in three areas of arithmetic. The arithmetical performance of the freshmen will be considered in relation to eight socio-psychological characteristics.

Comparison of Performance for Students from Urban and Rural Communities. Table 3 shows the average performances of the students from rural and urban communities. In quantitative understanding, the mean standard score for the students who came from urban centers was 53.32. In problem solving the mean standard score was 51.61, and in computation the mean standard score was 50.49. For the students who came from rural communities, the mean standard

TABLE 3

COMPARISON OF PERFORMANCE FOR FRESHMEN FROM RURAL AND URBAN AREAS

	Test 4		Test 5		Test 6	
	Urban	Rural	Urban	Rural	Urban	Rural
N	109	103	109	103	109	103
Mean	53.32	50.96	51.61	50.65	50.49	48.32
S. D.	7.89	9.27	8.34	8.91	9.03	9.33

Significance of Difference between Means

	Difference between Means	S. E. of Difference	t-ratio
Urban - Rural (Test 4)	2.36	1.19	1.98*
Urban - Rural (Test 5)	.96	1.15	.834
Urban - Rural (Test 6)	2.17	1.26	1.72

*Beyond .05 level of significance

score was 50.96 in quantitative understanding, 50.65 in problem solving, and 48.32 in computation. Except in quantitative understanding where the average performance of the freshmen from urban centers exceeded the ninth-grade median score of 50 by almost one-third of a standard deviation, the mean performance for both rural and urban students approximated the median ninth-grade performance.

Inspection of Table 3 shows that on each of these three tests the 109 urban students had the higher mean standard scores. However, only on the quantitative understanding test was the difference between the mean standard scores statistically significant. This difference was significant at the 5 per cent level.

An inspection of the standard deviations presented in Table 3 shows that in quantitative understanding, the standard deviation was 7.89 for students who came from urban centers and 9.27 for students who came from rural communities. In problem solving, the standard deviation was 8.34 for urban students and 8.91 for rural students, while in computation the standard deviation was 9.03 for urban students and 9.33 for rural students.

Study of Table 3 shows that the total range of scores on the test distributions fell within the limits of a normal distribution. Inspection of the standard deviations shows that on each of the three tests, the students from rural and urban communities exhibited wide but normal differences in individual performance.

Further observation shows that differences did exist in the standard deviations among the test distributions. When the reliability of the difference between standard deviations was determined for the case where the difference between the standard deviations was greatest, it was found that the greatest difference was 1.38. The t-ratio for the difference between standard deviations was 1.91. This difference "approximates" significance at the 5 per cent level. To have been significant at the 5 per cent level with 211 degrees of freedom, the t-ratio would have to be at least 1.97. Because the number of cases under consideration remained the same, it follows that the smaller differences between the remaining standard deviations were not statistically significant. Even though on the quantitative understanding, problem solving, and computation tests the wider spread of scores favored the students from rural areas, none of these differences was statistically significant.

In summary, the average performances of the students who came from rural and urban communities approached closely the median performance of ninth-graders in the problem solving and computational phases of arithmetic. The students who came from urban centers excelled the median performance of ninth-grade pupils in quantitative understanding.

The students who came from urban centers exhibited greater competence in the quantitative understanding phase of arithmetic than did the rural students. However, in the problem solving and computation phase of arithmetic the difference in average performance between the freshmen from rural and urban communities was not statistically significant.

On no test was there a significant difference in spread of scores in the test distributions between the freshmen who came from rural and urban communities.

Comparison of Performance for Freshmen Whose High School Graduating Classes Differed in Size. Table 4 shows the average performance of the students in three areas of arithmetic for students whose graduating classes were small, average, and large in size. In this study a graduating class of not more than 50 students was considered small. A graduating class that ranged from 50 to 150 students was considered average in size, and a graduating class over 150 students was considered large in size. It was assumed that the size of the high school graduating class would indicate roughly the size of the high school (It was felt that the students could give a more accurate estimation of the size of their graduating

TABLE 4

COMPARISON OF PERFORMANCE FOR FRESHMEN WHO GRADUATED FROM HIGH SCHOOLS DIFFERING IN SIZE

	Test 4			Test 5			Test 6		
	Small	Avg.	Large	Small	Avg.	Large	Small	Avg.	Large
N	93	75	44	93	75	44	93	75	44
Mean	51.74	51.99	54.30	50.93	50.72	53.09	49.12	49.45	51.75
S. D.	9.12	8.94	7.53	8.82	9.15	7.89	9.03	9.24	9.21

Significance of Difference between Means

	Difference between Means	S. E. of Difference	t-ratio
Average - Small (Test 4)	.25	1.41	.177
Small - Average (Test 5)	.21	1.40	.150
Small - Average (Test 6)	.33	1.42	.232
Large - Small (Test 4)	2.56	1.48	1.73
Large - Small (Test 5)	2.16	1.51	1.42
Large - Small (Test 6)	2.30	1.68	1.37
Large - Average (Test 4)	2.31	1.54	1.50
Large - Average (Test 5)	2.37	1.60	1.48
Large - Average (Test 6)	2.63	1.76	1.49

class than they could for the whole high school.). It is advisable when studying Table 4, that the reader think in terms of size of high school as well as size of the graduating class.

Table 4 shows that the mean standard scores for the students who graduated from small high schools were 51.74 on the quantitative understanding test, 50.93 on the problem solving test, and 49.12 on the computation test. For the students who graduated from high schools average in size, the mean standard score was 51.99 in quantitative understanding, 50.72 in problem solving, and 49.45 in computation. For those who graduated from large high schools, the mean standard scores were 54.30 on the quantitative understanding test, 53.09 on the problem solving test, and 51.75 on the computation test. In the quantitative understanding phase of arithmetic, the students who graduated from large high schools exhibited a mean standard score that surpassed the ninth-grade median by almost one-half standard deviation. However, in the remaining cases, the average performances of the students were about the same as the median performance of ninth-grade pupils.

An inspection of Table 4 shows that on the quantitative understanding, problem solving, and basic computation tests, the highest average performance was achieved by the 44 freshmen whose high school graduating classes were large (or who graduated from a large high school). However, when comparing the average performance of the 44 freshmen who graduated from a large high school with the average performances of the freshmen who graduated from average and small high schools, it was found that the difference between the mean standard scores was not statistically significant. The 75 freshmen who graduated from high schools of average size had an average performance that was slightly higher than the average performance of the 93 freshmen who graduated from small high schools. This was true for each of the three areas of arithmetic. However, in none of the cases was the difference between the means statistically significant. The author recognizes the fact that possible errors may exist in the estimated size of the high schools. The accuracy of the estimates of the size of the high school graduating class depends on the accuracy of the memory of the students and their ability to estimate quantitative situations.

A study of the standard deviations shows that on the quantitative understanding test, the standard deviation was 9.12 for those who graduated from small high schools, 8.94 for those who graduated from average sized high schools, and 7.53 for those who graduated from large high schools. In problem solving, the standard deviation was 8.82 for small high schools, 9.15 for average sized high schools, and 7.89 for large high schools. In computation, the standard deviation ran somewhat higher: 9.03 for small high schools, 9.24 for average sized high schools, and 9.21 for large high schools. Further study of spreads of scores shows that on each of the three tests, the students who graduated from small, average, and large high schools exhibited wide but normal differences in individual performance.

Inspection of Table 4 shows that on each of the three tests, the students who graduated from high schools of average size had the wider spread of scores on the test distributions. Though the significance of the difference between standard deviations is not shown in Table 4, the reliability of the difference between standard deviations was determined for the several instances where the difference between the standard deviations was greatest. The highest t- ratio obtained was 1.51. For a difference between two standard deviations to have been statistically significant at the 5 per cent level, the t- ratio (for 117, 135, or 166 degrees of freedom) would have had to be at least 1.97. Therefore, the differences between the spreads of scores in the test distributions for the freshmen who graduated from high schools of average size and the freshmen who graduated from large or small high schools were not statistically significant.

A summary of the findings shows that generally the average performances of the students who graduated from high schools of different sizes approximated a ninth-grade median score of 50.

It was found from these findings that there was no difference in average performance of the freshmen in terms of the size of their high school graduating classes. For the group of freshmen in this study, there seemed to be no relationship between the size of the high school or graduating class and the average performance of the students.

In each of the three areas of arithmetic and for each of the possible comparisons among the freshmen who graduated from high schools of different sizes, there were no significant differences among the spreads of scores in the test distributions.

Comparison of Performance for Freshmen Who Attended Elementary Schools Differing in Size. The findings for the freshmen who attended small, average, and large elementary schools are shown in Table 5. In this study an elementary school was considered small if its enrollment

TABLE 5

COMPARISON OF PERFORMANCE FOR FRESHMEN WHO ATTENDED ELEMENTARY SCHOOLS DIFFERING IN SIZE

	Test 4			Test 5			Test 6		
	Small	Avg.	Large	Small	Avg.	Large	Small	Avg.	Large
N	68	97	48	68	97	48	68	97	48
Mean	49.56	53.28	54.88	50.63	52.47	50.56	47.66	50.76	50.43
S. D.	8.37	8.73	8.07	8.07	9.15	7.80	6.87	9.63	8.40

Significance of Difference between Means

	Difference between Means	S. E. of Difference	t- ratio
Average - Small (Test 4)	3.72	1.35	2.75**
Average - Small (Test 5)	1.84	1.41	1.30
Average - Small (Test 6)	3.10	1.30	2.38*
Large - Small (Test 4)	5.32	1.55	3.43**
Small - Large (Test 5)	.07	1.54	.043
Large - Small (Test 6)	2.77	1.48	1.87
Large - Average (Test 4)	1.60	1.47	1.08
Average - Large (Test 5)	1.91	1.46	1.30
Average - Large (Test 6)	.32	1.56	.205

*Beyond .05 level of significance

**Beyond .01 level of significance

was 200 pupils or less; average in size if the enrollment ranged from 200 to 400 students; and large in size if the enrollment ranged from 400 to 800 students. It is recognized by the author that errors may exist in the estimation of size of the school. Approximately six years have elapsed since these students last attended an elementary school and it is possible that in some cases their memories may have been inaccurate. It is also possible that some of these students may have been poor in estimating quantitative situations.

It can be observed from a study of Table 5 that on the test of quantitative understanding the students who attended large elementary schools had a mean standard score of 54.88. In other words, the average performance for this group of students was almost one-half of a standard deviation above the median standard score of ninth-grade pupils. Further inspection of Table 5 shows that on the quantitative understanding and problem solving tests, the freshmen who attended elementary schools small in size exhibited an average performance that approximated the ninth-grade median. The freshmen who attended large and average size elementary schools showed about the same average performances in problem solving and computation as typical ninth-grade pupils.

A study of Table 5 shows that on the quantitative understanding and computation tests, the 97 freshmen who attended an average size elementary school had statistically significant higher mean standard scores than the 68 freshmen who attended a small elementary school. The difference in quantitative understanding was statistically significant at the 1 per cent level and in computation at the 5 per cent level. In problem solving, the difference between the mean standard scores for the same two groups was not statistically significant. However, the higher mean standard score was in favor of the students who attended average size elementary schools.

In the quantitative understanding phase of arithmetic, the 48 students who attended large elementary schools had a statistically significant higher mean standard score than the 68 freshmen who attended small elementary schools. The difference was statistically significant at the 1 per cent level. In the problem solving and computation phases of arithmetic, the differences between the mean standard scores for the freshmen who attended large and small elementary schools were not statistically significant. On the problem solving test, there was almost no difference in average performance, while on the computation test, the higher mean performance favored the group who attended large elementary schools.

Table 5 shows that in the three areas of arithmetic under consideration, the differences between the mean standard scores for the large and average sized elementary schools were not statistically significant. In quantitative understanding the higher mean standard score favored the freshmen who attended large elementary schools; in problem solving the higher mean score favored the students who attended average size elementary schools; and in computation the average performance of all groups was about the same.

An inspection of the standard deviations presented in Table 5 shows that in quantitative understanding, the standard deviations were 8.37, 8.73, and 8.07 for the students who attended small, average sized, and large elementary schools respectively. For the students who attended small, average sized, and large elementary schools, the standard deviations were 8.07, 9.15, and 7.80 in problem solving. In computation, the standard deviations were 6.87, 9.63, and 8.40 for those who attended small, average sized, and large elementary schools. Further study shows that not only did the three groups of students exhibit marked differences in individual performance, but they also exhibited differences in spreads of scores among the test distributions.

The reliability of the difference between standard deviations was determined for the standard deviations with the greatest differences. In the computational phase of arithmetic a statistically significant difference was found between the standard deviations for the freshmen who attended small and average sized elementary schools, with the wider spread of scores favoring the group who attended average sized elementary schools. The difference was statistically significant at the 1 per cent level. In the remaining possible comparisons, the differences between the standard deviations were not statistically significant. However, in each of the three areas of arithmetic, there was a tendency for the wider spread of scores to be in favor of the students who attended average sized elementary schools.

To summarize the findings it can be stated that regardless of elementary school size, the mean standard scores did not deviate much from ninth-grade median performances.

As a whole, these findings indicate only a slight relationship between the size of the elementary school and the performances exhibited by the freshmen in the three areas of arithmetic. The freshmen who attended elementary schools of average size tended to exhibit a higher average performance in the three areas of arithmetic than the freshmen who attended elementary schools small in size, but only in the quantitative understanding and computational phases of arithmetic were these differences statistically significant.

There were no significant differences in average performances between the group of freshmen who attended average sized elementary schools and the group of freshmen who attended large elementary schools.

When comparing the average performances of the freshmen who attended large elementary schools with the performances of the freshmen who attended small elementary schools, it was found that in the quantitative understanding phase of arithmetic, the freshmen who attended large elementary schools obtained the higher average performance. However, in the problem solving and computational phase of arithmetic, the differences between the average performances were not statistically significant.

On the quantitative understanding, problem solving, and basic computation tests, there was no significant difference in spreads of scores for the freshmen who attended elementary schools of different sizes except for the freshmen who attended small and average size elementary schools. This statistically significant difference in spread of scores was on the basic computation test and the wider spread favored the students who attended average size elementary schools.

Comparisons of Performance for Students Who Had Different Backgrounds of High School Mathematics. Table 6 shows the findings for students who had different backgrounds of mathematics in high school. These differences in mathematics background can be grouped into four categories: Category 1 consists of the 39 freshmen who took only a high school course in general mathematics; Category 2, the 17 freshmen who took high school courses in general mathematics and commercial mathematics; Category 3, the 51 freshmen who took high school courses in general mathematics and algebra; and Category 4, the 103 freshmen who took high school courses in general mathematics, algebra, and geometry.

A study of Table 6 shows that in quantitative understanding, the group of students who had general mathematics, algebra, and geometry (Category 4) exhibited an average performance that was one-half of a standard deviation above the ninth-grade median. On the computation test, the average performance of the freshmen who had general mathematics (Category 1) dropped one-half of a standard deviation below the ninth-grade median. However, except for the two instances just mentioned, the average performances of the freshmen in these three areas of arithmetic were about the same as the median performances of ninth-graders. In fact, the students who

TABLE 6

COMPARISON OF PERFORMANCE FOR FRESHMEN WHO HAD DIFFERENT BACKGROUNDS OF MATHEMATICS IN HIGH SCHOOL

	Test 4				Test 5				Test 6			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
N	39	17	51	103	39	17	51	103	39	17	51	103
Mean	48.66	52.11	48.11	56.32	49.15	52.47	50.00	53.29	45.46	49.35	47.53	52.66
S. D.	5.97	7.89	7.95	8.70	8.37	7.41	8.31	9.03	8.61	7.62	8.88	9.03

Significance of Difference between Means

	Difference between Means	S. E. of Difference	t- ratio
(4) - (3) Test 4	7.91	1.41	5.61**
(4) - (3) Test 5	3.29	1.47	2.23*
(4) - (3) Test 6	5.14	1.53	3.35**
(4) - (1) Test 4	7.66	1.29	5.93**
(4) - (1) Test 5	4.14	1.61	2.57*
(4) - (1) Test 6	7.20	1.65	4.36**
(1) - (3) Test 4	.25	1.48	.168
(3) - (1) Test 5	.85	1.78	.477
(3) - (1) Test 6	2.06	1.86	1.10

TABLE 6--Continued

	Difference between Means	S. E. of Difference	t- ratio
(2) - (3) Test 4	3.70	2.26	1.63
(2) - (3) Test 5	2.47	2.18	1.13
(2) - (3) Test 6	1.83	2.27	.806
(2) - (1) Test 4	3.45	2.19	1.95
(2) - (1) Test 5	3.32	2.29	.400
(2) - (1) Test 6	3.89	2.35	1.58
(4) - (2) Test 4	4.21	2.15	1.95
(4) - (2) Test 5	.82	2.05	.400
(4) - (2) Test 6	3.31	2.09	1.58

*Beyond .05 level of significance

**Beyond .01 level of significance

(1) General Mathematics

(2) General Mathematics and Commercial Mathematics

(3) General Mathematics and Algebra

(4) General Mathematics, Algebra, and Geometry

took general mathematics and algebra (Category 3) had a mean standard score in problem solving that exactly equaled the median performance of ninth-grade pupils.

Any relationships that exist among the several different mathematical backgrounds and the average performance of the students in the three areas of arithmetic must be considered in terms of the course content as well as the number of courses.

A study of Table 6 shows that in each of the three areas of arithmetic, the freshmen who had Category 4 mathematics background exhibited throughout the highest average performances. The differences between the average performances for the freshmen who had Category 4 mathematics background and the freshmen who had Category 3 mathematics background were statistically significant. On the quantitative understanding and computation tests, the differences were statistically significant at the 1 per cent level; on the problem solving test, at the 5 per cent level. In the comparison of the group who had general mathematics, algebra, and geometry (Category 4) with the group who had only general mathematics (Category 1) in high school, the differences between average performances were statistically significant. On the quantitative understanding and computation tests, the differences were significant at the 1 per cent level and in problem solving, at the 5 per cent level. For the freshmen who had Category 4 mathematics background and the freshmen who had Category 2 mathematics background, the difference between the average performances was not statistically significant.

The students who took general mathematics and commercial mathematics (Category 2) in high school showed a higher average performance in each of the three areas of arithmetic than either the freshmen who took general mathematics and algebra (Category 3) or general mathematics (Category 1) in high school. However, none of these differences was statistically significant.

In problem solving and computation, the freshmen who took general mathematics and algebra (Category 3) in high school showed a higher average performance than the freshmen who took general mathematics (Category 1) in high school. However, these differences between mean standard scores were not statistically significant. The performance of the two groups of students in quantitative understanding was about the same.

In reference to the standard deviations presented in Table 6, it can be observed that, with one exception, the standard deviations run about the same as for other groupings reported earlier. The standard deviations were 5.97 (Category 1), 7.89 (Category 2), 7.95 (Category 3), and 8.70 (Category 4) in quantitative understanding. In problem solving, the standard deviations were 8.37 (Category 1), 7.41 (Category 2), 8.31 (Category 3), and 9.03 (Category 4), while in computation the standard deviations were 8.61 (Category 1), 7.62 (Category 2), 8.88 (Category 3), and 9.03 (Category 4). It is interesting to note the smaller variation indicated for the Category 1 group in quantitative understanding (5.97). A study of the standard deviations shows that some differences existed in spreads of scores among the test distributions.

An inspection of Table 6 shows that the students who had general mathematics, algebra, and geometry (Category 4) in high school exhibited the widest spread of scores in the test distributions. In only one case, however, was the difference between spreads of scores statistically significant. The freshmen who had Category 4 mathematics background in high school had a statistically significant wider spread of scores in quantitative understanding than the freshmen who had Category 1 mathematics background in high school. This difference was statistically significant at the 1 per cent level.

Diagram I summarizes the performance of the freshmen in relation to their high school mathematics background. Diagram I shows the ranking of the highest to the lowest performances of the freshmen in terms of the type mathematics background they experienced in high school.

DIAGRAM I

A RANKING OF PERFORMANCE FROM HIGHEST TO LOWEST IN RELATION TO HIGH SCHOOL MATHEMATICS BACKGROUND

	Ranks		
	Test 4	Test 5	Test 6
General mathematics, algebra, and geometry (Category 4)	1	1	1
General mathematics and commercial mathematics (Category 2)	2	2	2
General mathematics and algebra (Category 3)	4	3	3
General mathematics (Category 4)	3	4	4

Generally, the freshmen who took general mathematics, algebra, and geometry in high school showed higher competence in these three areas of arithmetic than the freshmen who had taken other patterns of high school mathematics. Diagram I shows that the freshmen who had a background in general mathematics, algebra, and geometry ranked highest in each of these three areas of arithmetic. The freshmen who had a background in general mathematics and commercial mathematics ranked second in each of the three areas of arithmetic. In the problem solving and computational phases of arithmetic the freshmen who had a background in general mathematics and algebra ranked third, and the freshmen who had a background in general mathematics ranked fourth in the problem solving and computational phases of arithmetic. In the quantitative understanding phase of arithmetic, the freshmen who had general mathematics ranked third in average performance, and the freshmen who had a background of general mathematics and algebra ranked fourth in average performance.

A summary of these findings show that the average performances of the students who had different backgrounds of mathematics in high school approached closely a ninth-grade median score of 50. Only in two instances was there an exception to this finding. On the computation test, the average performance of the freshmen who had only general mathematics in high school did not reach the ninth-grade median, while in quantitative understanding, the students who had general mathematics, algebra, and geometry exhibited an average performance that clearly surpassed the median performance of ninth graders.

It was found that the students who had Category 4 mathematics background in high school exhibited greater competence in quantitative understanding, problem solving, and computation than the freshmen who took general mathematics and algebra (Category 3), general mathematics and commercial mathematics (Category 2), or general mathematics (Category 1) in high school.

Generally, the differences among spreads of scores in the three areas of arithmetic were not statistically significant. The only exception occurred in quantitative understanding where the difference in spread of scores between the students who took general mathematics (Category 1) and general mathematics, algebra, and geometry (Category 4) in high school was statistically significant. The freshmen who had Category 4 mathematics background in high school had the statistically significant wider spread of scores.

It must be pointed out that several factors are involved in the particular performance exhibited by these four groups of students. The factors involved include not only the number of courses taken, but include the nature or type of the course and the combination of the several types of course content.

Comparison of Performance for Freshmen Who Indicated That They were Superior, Good, and Average Students in High School. Table 7 shows the findings in three areas of arithmetic for the 38 freshmen who indicated that they were "A" students in high school, for the 122 freshmen who indicated that they were "B" students in high school, and for the 52 freshmen who indicated that they were "C" students in high school.

The findings presented in Table 7 show several interesting facts when consideration is given to the status of the students in relation to ninth-grade norms. In quantitative understanding, the mean standard score was 58.84 for the college freshmen who indicated that they were "A" students in high school. In problem solving, the mean standard score was 57.03 for this group of freshmen, and in computation the mean standard score was 54.52. The average performances of the students who indicated that they were "A" students in high school exceeded the ninth-grade median nine-tenths of a standard deviation in quantitative understanding, seven-tenths of a standard deviation in problem solving, and five-tenths of a standard deviation in computation. In other words, in each

TABLE 7

COMPARISON OF PERFORMANCE FOR FRESHMEN WHO INDICATED THAT THEY WERE SUPERIOR (A) STUDENTS, GOOD (B) STUDENTS, AND AVERAGE (C) STUDENTS IN HIGH SCHOOL

	Test 4			Test 5			Test 6		
	"A" Student	"B" Student	"C" Student	"A" Student	"B" Student	"C" Student	"A" Student	"B" Student	"C" Student
N	38	122	52	38	122	52	38	122	52
Mean	58.84	52.02	48.96	57.03	51.30	47.73	54.52	49.75	45.39
S. D.	7.56	8.42	8.40	9.09	8.52	7.35	8.58	8.97	8.07

Significance of Difference between Means

	Difference between Means	S. E. of Difference	t- ratio
"A" student - "B" student	6.82	1.45	4.70**
"A" student - "B" student	5.73	1.67	3.43**
"A" student - "B" student	4.77	1.63	2.92**
"B" student - "C" student	3.06	1.39	2.20*
"B" student - "C" student	3.57	1.28	2.78**
"B" student - "C" student	4.36	1.39	3.13**
"A" student - "C" student	10.44	1.70	6.14**
"A" student - "C" student	9.30	1.80	5.18**
"A" student - "C" student	9.13	1.80	5.07**

*Beyond .05 level of significance

**Beyond .01 level of significance

of these three areas of arithmetic the average performance of the freshmen who indicated that they were "A" students in high school was considerably higher than the median performance of ninth-graders. The average performance for those who indicated that they were "B" students in high school approximated the median performance of ninth-grade pupils. The average performance for the students who indicated that they were "C" students in high school was somewhat below the median score of ninth-graders in the problem solving and computational phases of arithmetic. In the computational phase of arithmetic, the mean standard score dropped almost one-half of a standard deviation below the ninth-grade median. Table 7 shows that in each of these three areas of arithmetic, the "A" students had a higher average performance than the ninth-grade pupils, the "B" students had an average performance that approximated the median ninth-grade performance, and that the average performance of the "C" students was below the ninth-grade median.

An inspection of Table 7 shows that the students who indicated that they were "A" students in high school had the highest mean standard scores in each of the three areas of arithmetic. The differences between the mean standard scores for the "A" students and "B" students, and for the "A" students and "C" students were statistically significant at the 1 per cent level. In other words, the "A" students exhibited greater competence in each of the three areas of arithmetic than either the "B" students or "C" students.

Further inspection shows that the freshmen who indicated that they were "B" students in high school had statistically significant higher mean standard scores than the students who indicated that they were "C" students in high school. In the quantitative understanding phase of arithmetic the difference between performances was statistically significant at the 5 per cent level, while in the problem solving and computational phases of arithmetic the differences were statistically significant at the 1 per cent level. Thus, the "B" students did not exhibit as high an average performance as the "A" students, but they exhibited a higher average performance than the freshmen who were "C" students in high school.

Table 7 shows that on the quantitative understanding test, the standard deviation was 7.56 for the students who indicated that they were "A" students in high school, 8.42 for "B" students, and 8.40 for "C" students. On the problem solving test the standard deviation was 9.09 for "A" students, 8.52 for "B" students, and 7.35 for "C" students. On the computation test the standard deviation was 8.58 for "A" students, 8.97 for "B" students, and 8.07 for "C" students. It can be seen from a study of these standard deviations that differences existed not only in individual performance but also in the spreads of scores among the test distributions as well.

In each of the three areas of arithmetic, the freshmen who indicated that they were "A" students in high school had the narrowest spread of scores on the quantitative understanding test, the widest spread of scores on the problem solving test, and next to the widest spread of scores on the basic computation test. The freshmen who indicated that they were "B" students in high school had the narrowest spread of scores on the quantitative understanding test, next to the widest spread of scores on the problem solving test, and the widest spread of scores on the basic computation test. The freshmen who indicated that they were "C" students in high school had next to the widest spread of scores on the quantitative understanding test, the widest spread of scores on the problem solving test, and the narrowest spread of scores on the computation test.

However, when the reliability of the differences between standard deviations was determined, it was found that none of the differences between spread of scores was statistically significant. The t-ratio for this greatest difference was 1.30. For the difference to have been statistically significant, the t-ratio (with 88, 158, or 172 degrees of freedom) would have had to be at least 1.98.

In summary, the findings show that the performance of the freshmen who indicated that they were "A" students exceeded a ninth-grade median score of 50. Those who indicated that they were "B" students had an average performance that approximated ninth-grade median performance, and the performance of the freshmen who indicated that they were "C" students was below the median performance of ninth graders.

In the light of the average performances, all comparisons showed statistically significant differences. In other words, greatest competence in each of the three areas of arithmetic under consideration was exhibited by the freshmen who indicated that they were superior students in high school, the next highest performance by those who indicated that they were good students in high school, and the poorest performance by those who indicated that they were average students.

There was no statistically significant difference in the spread of scores in the test distributions in any of the possible comparisons. In other words, there was no apparent relationship between the academic ratings of the students and the spread of scores in the test distributions.

Performance of Freshmen Who Reported Vocational Experience Compared with That of Those Who Reported No Vocational Use of Arithmetic. The findings for the freshmen who reported employment which included the functional use of arithmetic and for those who did not report employment are presented in Table 8. A majority of the freshmen who indicated that they have had employment which included the functional use of arithmetic stated that they worked as sales clerks in grocery stores and ten cent stores. The freshmen who had this type of employment indicated that they made change and were responsible for keeping a running account of the sales they made. Others indicated that they worked as cashiers in grocery stores, dry good stores, and hardware stores. Others indicated that they worked in the high school principals' offices, where they made extensive use of arithmetic in the many reports characteristic of such an office. A few indicated that they had experienced employment which included bookkeeping, and several of the freshmen stated that they had been employed by banks as statement clerks.

When considering the status of these two groups, Table 8 shows that the mean standard score for the freshmen who reported employment was 52.92 in the quantitative understanding phase of arithmetic, 53.51 in problem solving, and 50.67 in computation. The mean standard

TABLE 8

COMPARISON OF PERFORMANCE FOR FRESHMEN WHO REPORTED EMPLOYMENT AND FOR THOSE WHO DID NOT REPORT EMPLOYMENT

	Test 4		Test 5		Test 6	
	Have Worked	Non-Workers	Have Worked	Non-Workers	Have Worked	Non-Workers
B	108	103	108	103	108	103
Mean	52.92	52.13	53.51	49.39	50.67	47.87
S. D.	8.94	8.76	9.30	7.41	9.81	8.49

Significance of Difference between Means

	Difference between Means	S. E. of Difference	t-ratio
Worked - did not work (Test 4)	.79	1.22	.647
Worked - did not work (Test 5)	4.12	1.16	3.55**
Worked - did not work (Test 6)	2.80	1.26	2.22*

*Beyond .05 level of significance

**Beyond .01 level of significance

score for those who did not report employment was 52.13 in quantitative understanding, 49.39 in problem solving, and 47.87 in computation. It should be noted that for the freshmen who did not report employment, the mean standard score in the problem solving phase of arithmetic was about the same as the ninth-grade median score of 50, and that in computation the average performance of those who reported employment closely approached the ninth-grade median.

Table 8 shows that in quantitative understanding, problem solving, and computation, the freshmen who indicated that they have had employment which included the functional use of arithmetic had higher mean standard scores than the freshmen who did not report such employment. However, only on the problem solving and computational tests were the differences between mean standard scores statistically significant. In the problem solving phase of arithmetic, the difference between mean standard scores was statistically significant at the 1 per cent level. On the computation test, the difference between the mean standard scores was statistically significant at the 5 per cent level, while the difference between the mean standard scores on the quantitative understanding test was not statistically significant.

Table 8 shows that on the test of quantitative understanding, the students who reported employment had a standard deviation of 8.94 and those who did not report employment a standard deviation of 8.76. On the problem solving test the standard deviation was 9.30 for those who reported employment and 7.41 for those who did not report employment. On the basic computation test the standard deviation was 9.81 for those who reported employment and 8.49 for those who did not.

In each of the three areas of arithmetic, the student who reported employment which included the functional use of arithmetic exhibited a wider spread of scores than the students who did not report such employment. However, only on the problem solving test was the difference between standard deviations found to be statistically significant. In this case, the difference between the spreads of scores in the test distributions was significant at the 1 per cent level.

A summary of the findings presented in Table 8 shows that the arithmetical status of the group who reported employment and for the group who did not report employment was similar to the median performance of ninth-grade pupils.

The freshmen who reported employment which included the use of arithmetic exhibited greater competence on the problem solving and basic computation tests than the freshmen who did not report such employment. Thus, there appears to be a relationship between those who reported that they had been employed and their competence in these two areas of arithmetic. However, on the quantitative understanding test there was little difference in the average performances of these two groups of freshmen.

Even though the wider spread of scores in the test distributions seemed to favor the freshmen who reported employment, only on the problem solving test was the difference in spread of scores statistically significant.

Comparison of Performance of Freshmen in Relation to Their Expressed Attitude Towards Arithmetic. The findings for the 117 students who indicated a liking for arithmetic, the 27 freshmen who felt indifferent towards arithmetic, and the 62 freshmen who indicated a dislike for arithmetic are presented in Table 9.

In quantitative understanding and problem solving, the group who indicated that they like arithmetic exhibited mean standard scores that exceeded the ninth-grade median score of 50 over one-third of a standard deviation, while in computation the mean standard score of this group approximated the ninth-grade median. For those who indicated that they felt indifferent towards arithmetic, the mean standard score of 54.11 exceeded the ninth-grade median almost one-half of a standard deviation in quantitative understanding, while in problem

TABLE 9

COMPARISON OF PERFORMANCE IN RELATION TO ATTITUDE TOWARDS ARITHMETIC

	Test 4			Test 5			Test 6		
	Liked	Indif-ferent	Dis-liked	Liked	Indif-ferent	Dis-liked	Liked	Indif-ferent	Dis-liked
N	117	27	62	117	27	62	117	27	62
Mean	53.66	54.11	50.67	54.15	51.22	46.92	51.89	50.56	45.05
S. D.	9.09	8.37	7.98	8.82	8.70	6.42	8.97	9.51	7.08

Significance of Difference between Means

	Difference between Means	S. E. of Difference	t-ratio
Liked - disliked (Test 4)	2.99	1.32	2.26*
Liked - disliked (Test 5)	7.24	1.16	6.24**
Liked - disliked (Test 6)	6.85	1.23	5.56**
Indifferent - Liked (Test 4)	.45	1.84	.244
Liked - indifferent (Test 5)	2.93	1.88	1.55
Liked - indifferent (Test 6)	1.33	2.03	.655
Indifferent - disliked (Test 4)	3.44	1.93	1.78
Indifferent - disliked (Test 5)	4.31	1.88	2.29*
Indifferent - disliked (Test 6)	5.52	2.06	2.67**

*Beyond .05 level of significance

**Beyond .01 level of significance

solving and computation the mean standard scores of this group of students approximated the ninth-grade median. In quantitative understanding, those who indicated a dislike for arithmetic had a mean standard score of 50.67 which approximated ninth-grade median performance, while in problem solving a mean standard score of 46.92 was about one-third of a standard deviation below ninth-grade median performance. In computation, the mean standard score of 45.05 was almost one-half of a standard deviation below ninth-grade median performance. In other words, the students who indicated that they liked arithmetic or felt indifferent towards arithmetic had an average performance that either approximated or surpassed the median performance of ninth-grade pupils, while in problem solving and computation, the students who indicated that they disliked arithmetic exhibited an average performance that dropped below ninth-grade median performances.

An inspection of this table shows that on the quantitative understanding, problem solving, and basic computation tests, the freshmen who indicated a liking for arithmetic performed better than the freshmen who indicated a dislike for arithmetic. The difference between the average standard scores on the quantitative understanding test was statistically significant at the

5 per cent level. On the problem solving and basic computation tests, the differences were statistically significant at the 1 per cent level.

When a comparison was made between the average performances of the freshmen who felt indifferent towards arithmetic and the freshmen who disliked arithmetic, it was found that in the problem solving and computational phases of arithmetic the freshmen who felt indifferent towards arithmetic performed better than those who disliked arithmetic. In the problem solving phase of arithmetic, the difference was statistically significant at the 5 per cent level. In the computational phase of arithmetic, the difference between mean standard scores was significant at the 1 per cent level. In the quantitative understanding phase of arithmetic the difference between the mean standard scores for the freshmen who felt indifferent towards arithmetic and the freshmen who disliked arithmetic was not statistically significant. In this instance, the advantage favored the freshmen who reported indifference towards arithmetic (the t-ratio was 1.78). In order for this difference to have been statistically significant, the t-ratio with 88 degrees of freedom would have to be at least 1.99. However, it must be remembered that the number of freshmen who felt indifferent towards arithmetic was comparatively small

(27), and to have a difference that would be statistically significant, the difference between the mean standard scores would have had to be quite large.

There was no statistically significant difference in the three areas of arithmetic between the freshmen who liked and felt indifferent towards arithmetic, though in the problem solving and computational phases of arithmetic the advantage favored the freshmen who liked arithmetic.

In reference to the standard deviations presented in Table 9, it can be observed that in quantitative understanding those who liked arithmetic had a standard deviation of 9.09. For those who felt indifferent towards arithmetic the standard deviation was 8.37, and for those who disliked arithmetic, 7.98. In problem solving, those who liked arithmetic had a standard deviation of 8.82. The standard deviation for those who felt indifferent towards arithmetic was 8.70, and 6.42 for those who disliked arithmetic. In computation, the standard deviation was 8.97 for those who liked arithmetic, 9.51 for those who felt indifferent towards arithmetic, and 7.08 for those who disliked arithmetic. It can be seen that on each of the three tests, the three groups of students who indicated their particular attitude towards arithmetic exhibited wide but typical differences in individual performance.

A study of the standard deviations (spread of scores in the test distributions) shows that on the quantitative understanding and problem solving tests the freshmen who liked arithmetic had a wider spread of scores than the freshmen who either felt indifferent towards or disliked arithmetic. On the basic computation test, the freshmen who felt indifferent towards arithmetic had a wider spread of scores than either the freshmen who liked or disliked arithmetic. However, when the reliability of difference between standard deviations was determined for the greatest differences, it was found that in only one case was the difference between standard deviations statistically significant. In this instance, the greatest difference between standard deviations was in problem solving and the students who expressed a liking for arithmetic exhibited a statistically significant wider spread of scores than those who indicated that they disliked arithmetic. This difference between standard deviations was significant at the 1 per cent level. The next greatest difference between standard deviations was not statistically significant. In this case, the t-ratio was 1.71. In order for the next greatest difference between standard deviations to have been significant, the t-ratio with 178 degrees of freedom would have had to be at least 1.97. It follows that the differences between the remaining standard deviations were not significant.

As a summary of these findings with respect to attitude towards arithmetic, it can be stated that when the mean standard scores of the freshmen were compared to ninth-grade norms, some variation in performance was noted. The students who indicated that they liked arithmetic or felt indifferent towards arithmetic had an average performance in these three areas of arithmetic that either reached or surpassed the median performance of ninth-grade pupils. In problem solving and computation, the students who indicated that they disliked arithmetic exhibited an average performance that fell below the typical ninth-grade performance. The remaining average performances were similar to the typical ninth-grade performance.

It was found that those who liked or felt indifferent towards arithmetic exhibited greater competence in these three areas of arithmetic than those who disliked arithmetic. There were no statistically significant differences between average performances for the freshmen who liked and felt indifferent towards arithmetic.

Except in the computational phase of arithmetic, there was a tendency for the freshmen who liked arithmetic to show the widest spread of scores. On the problem solving test, the statistically significant wider spread of scores for those who liked and disliked arithmetic favored the freshmen who liked arithmetic. However, in quantitative understanding and computation, the differences among the standard deviations were not statistically significant.

Comparison for Those Who Expressed a Need for a Refresher Course in Arithmetic and for Those Who Expressed No Need. Presented in Table 10 are the findings for the 129 freshmen who expressed a need for a refresher course in arithmetic and the 81 freshmen who said that they did not need a refresher course in arithmetic.

A study of the findings of Table 10 shows that only in quantitative understanding did the average performance of a freshmen group considerably exceed a ninth-grade median score of 50. In this instance, the mean standard score of the freshmen who did not express a need for a refresher course in arithmetic was 54.52. This group of freshmen surpassed the median performance of ninth-grade pupils by four-tenths of a standard deviation. The remaining mean standard scores approximated ninth-grade median performance.

An inspection of this table showed that on the quantitative understanding test, problem solving test, and basic computation test, the freshmen who did not feel the need for a refresher course in arithmetic exhibited

TABLE 10

COMPARISON FOR THOSE WHO EXPRESSED A NEED FOR A REFRESHER COURSE IN ARITHMETIC AND THOSE WHO DID NOT EXPRESS SUCH A NEED

	Test 4		Test 5		Test 6	
	(1)	(2)	(1)	(2)	(1)	(2)
N	129	81	129	81	129	81
Mean	51.56	54.52	51.07	51.99	48.93	50.92
S. D.	7.50	10.05	8.52	8.79	9.15	9.18

Significance of Difference between Means

	Difference between Means	S. E. of Difference	t-ratio
Expressed no need - expressed need (Test 4)	2.96	1.30	2.27*
Expressed no need - expressed need (Test 5)	.92	1.24	.74
Expressed no need - expressed need (Test 6)	2.00	1.31	1.53

*Beyond .05 level of significance

(1) Freshmen who expressed a need for a refresher course in arithmetic.

(2) Freshmen who expressed no need for a refresher course in arithmetic.

the higher mean standard scores. However, only on the quantitative understanding test was the difference between average performances statistically significant. This difference between the standard scores for those who felt the need for a refresher course in arithmetic and for the freshmen who felt no such need was statistically significant at the 5 per cent level. That is, only in the arithmetical area of quantitative understanding was the difference between average performances statistically significant, and in this case, the higher average performance favored the freshmen who did not feel the need for a refresher course in arithmetic.

An inspection of Table 10 shows that on the test of quantitative understanding, the standard deviation for the students who expressed a need for a refresher course in arithmetic was 7.50, while the standard deviation for those who expressed no need was very large (10.05). In problem solving, the standard deviation for those who expressed a need for a refresher course was 8.52, and for those who expressed no need the standard deviation was 8.79. In computation, the standard deviation was 9.15 for those who expressed a need for a refresher course and 9.18 for those who expressed no need. While the standard deviations show that the freshmen exhibited considerable difference in performance on each of the three tests, the greatest difference was shown in quantitative understanding for the group who did not express a need for a refresher course in arithmetic.

Further inspection of Table 10 showed that in each of these three areas of arithmetic, the freshmen who did feel the need for a refresher course in arithmetic had the wider spread of scores in the test distributions. When the reliability of difference between standard deviations was determined for the greatest differences, it was found that only on the quantitative understanding test was the difference between the spreads of scores statistically significant. This difference was statistically significant at the 5 per cent level. In other words, even though the freshmen who did not express the need for a refresher course in arithmetic had the wider spread of scores in the test distributions, only in the quantitative understanding area of arithmetic was the difference statistically significant.

In summary, the ninth-grade median performance was approximated by the average performances of both the students who did not express a need for a refresher course in arithmetic and the students who did express such a need.

These findings show that there seemed to be little relationship between the expressed needs of the freshmen and their competence in these three areas of arithmetic. In the problem solving and computational areas of arithmetic, there was no significant difference in competence between the freshmen who expressed a need to take a refresher course in arithmetic and the freshmen who expressed no such need. However, in the quantitative understanding phase of arithmetic, greater competence was exhibited by the freshmen who did not feel the need to take a refresher course in arithmetic.

Even though there was a tendency for the wider spread of scores in the test distributions to be in favor of the freshmen who did not feel a need to take a refresher course in arithmetic, only on the quantitative understanding test was this difference statistically significant.

Preferences of Freshmen in Three Areas of Arithmetic. Table 11 shows the percentage of students who expressed certain preferences (or the opposite) for each of the three areas of arithmetic under consideration. An inspection of Table 11 shows that seven-tenths (70 per cent) of this freshmen group liked problem solving least, while a little less than one-tenth (9 per cent) of the freshmen liked basic computation least. Approximately one-fifth (21 per cent) of this freshmen group liked number meaning least. In other words, seven times as many of the freshmen liked computation as liked problem

TABLE 11

PERCENTAGE OF LIKES AND DISLIKES FOR EACH OF THESE AREAS OF ARITHMETIC

	N	Percentage of Total
Liked problem solving least	131	70%
Liked number meaning least	40	21%
Liked computation least	16	9%
Liked problem solving best	19	10%
Liked number meaning best	10	5%
Liked computation best	158	85%

solving, while twice as many liked number meaning as liked problem solving.

Further examination of the table shows that a little over five-sixths (85 per cent) of the freshmen liked computation best, while only one-tenth (10 per cent) liked problem solving best. Only a small fractional part (1/20) of this freshmen group indicated that they liked number meaning best.

If "liked least" is given a rating of 1, and "liked best" a rating of 3, 2 would represent a neutral rating. In terms of such a rating, approximately three-fourths (74 per cent) of this freshmen group gave number meaning a neutral rating. This may indicate that a large proportion of the freshmen did not understand what was meant by "number meaning," and as a result they did not rate it either high or low on preferences.

These facts are quite interesting when related to the results presented in Table 2. Table 2 showed the status of the total freshmen group in three areas of arithmetic. Table 2 showed that these freshmen exhibited poorest competence in basic computation, yet Table 11 shows that over five-sixths (85 per cent) of this freshmen group declared that they liked computation best. Seven-tenths of the freshmen indicated that they liked problem solving least, yet their competence in this area of arithmetic was superior to their competence in computation. Almost three-fourths (74 per cent) of the freshmen gave quantitative understanding a neutral rating, yet their competence in this area of arithmetic was equal to their competence in problem solving and superior to their competence in computation. However, Table 9 (which presented the results in the three areas of arithmetic for the freshmen who liked, felt indifferent towards, and disliked arithmetic) showed that in each of the three areas of arithmetic, the freshmen who indicated a liking for arithmetic exhibited a higher average performance than the freshmen who indicated a dislike for arithmetic. That is, Table 9 shows that the freshmen who liked arithmetic exhibited greater competence in arithmetic than those who disliked it. However, a comparison of Tables 2 and 11 shows that the freshmen exhibited lowest competence in the computational phase of arithmetic, yet liked this phase most. The freshmen liked problem solving least, yet they showed relatively superior performance in this phase of arithmetic.

At first thought, one might consider these several findings contradictory to one another. However, when the student filled in the questionnaire, he became obligated to indicate which phase he liked least and which phase he liked best. Thus, a freshman who liked arithmetic was still faced with the choice of rating one area as "liked least." Similarly, the student who did not like arithmetic in general still had to rate one phase as "liked best." Therefore, whether a student exhibited superior, average, or poor competence in arithmetic or whether he liked, felt indifferent towards, or disliked arithmetic, he was requested to rank these three areas of arithmetic in order of preference.

In summary, a significant proportion of the freshmen preferred computation to problem solving. Through inference, it can be stated that a majority of the students indirectly ranked number meaning in between computation and problem solving.

Interrelationships Among Data on Different Socio-Psychological Factors. The arithmetic performance of the freshmen in relation to each socio-psychological characteristic considered in this investigation has been discussed separately. A thorough study, however, of comparisons among the items on the data sheets revealed certain consistencies. These noted consistencies are as follows: (1) generally, the students who attended small elementary schools came from rural communities and the students who attended average sized and large elementary schools came from urban centers; (2) generally, the freshmen who liked arithmetic were also the same students who took general mathematics, algebra, and geometry in high school; (3) the freshmen who indicated that they were superior and above average students in high school tended to like arithmetic; (4) the freshmen who indicated that they were average students in high school tended to dislike arithmetic; (5) a majority of the students who did not express a need for a refresher course in arithmetic indicated that they were superior and above average students in high school; and (6) the freshmen who indicated that they were superior and above average students in high school tended to take general mathematics, algebra, and geometry in high school.

Chapter Summary

The author has presented in this chapter the data of his study. The findings were presented under two main headings: (1) the findings which showed the status in three areas of arithmetic for a group of Alabama freshmen elementary education majors and a comparison of their performance in these three areas of arithmetic, and (2) the findings which showed the relationship of certain socio-psychological characteristics to competence in arithmetic.

A summary of the findings of the first part of this chapter shows that in the three areas of arithmetic under consideration, the average performance of the students approximated the typical performance of ninth-grade pupils.

A study of the distribution tables showed that in quantitative understanding the distribution of scores approximated a normal distribution, while in problem solving and computation there was a slight tendency for the scores to gather at the lower end of the distributions.

When consideration was given to cumulative percentages, it was found that the smallest percentage of scores at or below the ninth-grade median occurred in the quantitative understanding phase of arithmetic, while the largest percentage of scores at or below the ninth-grade median occurred in the computational phase of arithmetic.

In each of these three areas of arithmetic, over 50 per cent of the students reached or exceeded the median performances of the seventh, eighth, and ninth-grade pupils. A larger percentage of the students dropped below the seventh, eighth, and ninth-grade medians in the computational phase of arithmetic than in the other two phases. The lowest percentage of the students who dropped below the seventh, eighth, and ninth-grade medians did so in the quantitative understanding phase of arithmetic.

It was found that the students varied considerably in their performance on each phase of arithmetic (quantitative understanding, problem solving, and computation). In the quantitative understanding and problem solving phases, some of the freshmen exhibited performances that equaled the top performances of the seventh, eighth, and ninth-grade pupils. In computation some of the students exhibited performances that equaled the lowest performance of these junior high school pupils.

When comparing the performance of the freshmen in these three areas of arithmetic, it was found that the students exhibited greater competence on the quantitative understanding and problem solving tests than they did on the computation test. In other words, the students showed greater ability in perceiving quantitative relationships and in solving word problems than in computation. This group of freshmen showed about the same facility for solving word problems as they did in perceiving quantitative relationships.

This group of freshmen elementary education majors did not exhibit significant differences in spreads of scores among the test distributions.

When the performances of students in these three areas of arithmetic were related to certain socio-psychological characteristics, it was found that in some instances a relationship did exist between these characteristics and competence in arithmetic. When the arithmetical status of the freshmen were considered in terms of ninth-grade norms, it was found that their status in arithmetic approximated the median performance of ninth-grade pupils. The main exception to this general finding was found when the standings of the freshmen were considered in the light of their indicated scholastic rating. In this case, the students who indicated that they were "A" students in high school exhibited average performances that were above a ninth-grade median score of 50. The average performances of the students who indicated that they were "B" students were similar to the ninth-grade median, and the students who indicated that they were "C" students did not reach the median performance of ninth-grade pupils.

A study of the test data showed that the freshmen students who came from urban centers exhibited greater competence in the quantitative understanding phase of arithmetic than did the freshmen students from rural communities. However, there were no significant differences in average performances in the problem solving and computational phases of arithmetic. On no test was there a significant difference in spread of scores between the freshmen who came from rural and urban communities.

When the average performances for the freshmen were considered in terms of size of high school attended, it was found that no apparent relationship existed between the size of the high school and the average performance of the freshmen. Also, for each of the possible comparisons among the freshmen who graduated from high schools of different sizes, there were no significant differences among the spread of scores in the test distributions.

When the average performances of the freshmen were considered in relation to the size of the elementary school attended, it was found that only a slight relationship existed between the size of the elementary school and the average performance of the freshmen. In the computational and quantitative understanding phases of arithmetic, the freshmen who attended elementary schools of average size exhibited greater competence than the freshmen who attended small elementary schools. In the quantitative understanding phase of arithmetic, the freshmen who attended large elementary schools exhibited greater competence than the freshmen who attended small elementary schools. Generally, there were no significant differences among the spreads of scores in the test distributions.

Generally, the freshmen who took general mathematics, algebra, and geometry in high school showed higher competence in the three areas of arithmetic than the freshmen who had taken other patterns (including varying amounts) of high school mathematics. There appeared to be little difference among the spreads of scores in the test distributions.

When a comparison was made between the average performances of the freshmen and their indicated scholastic rating, it was found that the freshmen who indicated that they were above average and superior students in high school exhibited greater competence in the three areas of arithmetic than the freshmen who indicated that they were average students in high school. There were no significant differences among the spreads of scores in the test distributions in any of the possible comparisons.

The freshmen who reported employment which included the use of arithmetic showed greater competence in the computational and problem solving phases of arithmetic than the freshmen who did not report such employment. Only on the problem solving test was the difference in spread of scores statistically significant.

The freshmen who indicated that they liked or felt indifferent towards arithmetic exhibited greater competence in the three areas of arithmetic than those who expressed a dislike for arithmetic.

There was little relationship between the expressed needs of the freshmen and their competence in arithmetic. Only on the test of quantitative relationships was there a significant difference between average performances, and in this case the freshmen who did not express a need to take a refresher course in arithmetic had the higher average performance. When a comparison was made between the standard deviations, it was found that only on the test of quantitative relationships was this difference statistically significant. In this instance, the freshmen who did not express a need for a refresher course in arithmetic exhibited the wider spread of scores.

It was found that a significant proportion of the freshmen preferred computation to problem solving, while through inference, a majority of the freshmen indirectly gave number meaning a neutral rating.

The findings presented in the present chapter will form the basis for interpretations, conclusions, and implications discussed in the following chapter. Suggestions for additional research will also be included in the final chapter.

CHAPTER V

GENERAL SUMMARY, CONCLUSIONS, AND IMPLICATIONS

A brief summary of the study, qualifications regarding interpretations, general interpretations and conclusions, interpretations and conclusions concerning arithmetic abilities of freshmen in three areas of arithmetic, interpretations and conclusions concerning relationship of certain socio-psychological factors to performance in arithmetic, implications of the study, and need for further research are presented in this final chapter.

Summary of Study

In Chapter I the purpose of the study was presented along with a justification for research of this type. This investigation had a two-fold purpose: (1) to determine the status in three areas of arithmetic of a group of Alabama freshmen majoring in elementary education and to compare their performance in the three areas of arithmetic under consideration, and (2) to study the arithmetic performance of this group of freshmen elementary education majors in relation to the following socio-psychological characteristics: (a) environmental background (rural and urban); (b) size of high school attended; (c) size of elementary school attended; (d) nature of background in high school mathematics; (e) high school academic rating; (f) employment which included the functional use of arithmetic and no such employment; (g) expressed attitudes toward arithmetic; and (h) expression of a need or no need for a refresher course in arithmetic.

A review of the literature pertinent to the two basic purposes of this study was presented in Chapter II. The studies reviewed there were discussed under five main headings: the status of college freshmen in the subject field of arithmetic; comparison of the performance of individuals in several phases of arithmetic; competence of individuals in arithmetic in relation to socio-psychological factors; the training of teachers of arithmetic; and some theories of how children learn arithmetic.

The method, techniques, and procedures used in the study were presented in Chapter III. This included a discussion of the initial planning, the conduct of a pilot study, the method employed in the main investigation, the tests used, and the treatment of the data.

The findings were presented and discussed in Chapter IV. The data of the investigation were presented under two main headings: (1) arithmetic abilities of Alabama freshmen in three areas of arithmetic, and (2) relationship of selected socio-psychological characteristics to performance in arithmetic.

Qualifications Regarding Interpretations

As a basis for interpretation of the findings, it is desirable that certain limitations be recognized.

First, all comparisons were made as group comparisons and as such should not be confused with individual comparisons. The status of the freshmen in three areas of arithmetic and a comparison of their performance in the quantitative understanding, problem solving, and computational phases of arithmetic were considered as group status and group comparisons. Also, the relationship of arithmetical performance to certain socio-psychological factors was considered in terms of group performance.

Secondly, the investigation was done with a group of white college freshmen majoring in elementary education in Alabama state supported institutions. Since the study population consists of 90 per cent of all white Alabama freshmen majoring in elementary education, the results obtained and the conclusions drawn from the test data of this freshmen group should represent a fair sample of white elementary education majors in the state of Alabama. The reported findings should be interpreted as applying to this particular group.

Thirdly, the findings of this investigation are stated in terms of seventh, eighth, and ninth-grade norms. The index of the student's ability in arithmetic was considered in terms of these junior high school norms. The measuring instrument used in this study is one of the first of its kind in that the authors of the test attempted to measure the ability of the individual to perceive quantitative relationships. It is quite possible that if the test series used in this study had been standardized on an adult level, the arithmetical status of the freshmen and a comparison of their performance in quantitative understanding, problem solving, and computation might have been different. The writer is aware of possible weaknesses in any measuring instrument and is cognizant of its effects upon the conclusions to be presented in this chapter.

General Interpretations and Conclusions

A study of the test data shows several general trends which seem to be characteristic of this population. From an over-all view of the findings it is possible to make the following general conclusions:

1. The findings seem to suggest that regardless of the type of comparisons made the average performance of

the freshmen in quantitative understanding, problem solving, and computation is similar to typical ninth-grade performance.

The only exception to this general conclusion occurs when the performances of the freshmen are considered in terms of high school scholastic rating. It appears that the students who indicate that they were superior students in high school exceed the median performance of ninth-grade pupils in the three areas of arithmetic under consideration.

2. The findings suggest that regardless of the comparisons made and the factors considered there appears to be little difference among spreads of scores in the test distributions.

This is true with respect to all groupings on socio-psychological factors except in the following cases: (1) in computation, the students who attended average sized elementary schools had a statistically significant wider spread of scores than those who attended small elementary schools; (2) in quantitative understanding, the freshmen who took general mathematics, algebra, and geometry (Category 4) in high school had a statistically significant wider spread of scores than those who took only general mathematics in high school (Category 1); (3) in problem solving, the freshmen who reported employment which included the functional use of arithmetic had a statistically significant wider spread of scores than those who did not report such employment; (4) in problem solving, the students who expressed a liking for arithmetic had a statistically significant wider spread of scores than those who expressed a dislike for arithmetic; and (5) in quantitative understanding, the freshmen who did not express a need for a refresher course in arithmetic had a statistically significant wider spread of scores than those who expressed a need for a refresher course in arithmetic.

3. The findings of this study seem to suggest that in the light of all the factors considered and comparisons made, there appear to be relatively few statistically significant differences among either average performances or standard deviations.

4. The findings of this study seem to show that in the light of all the socio-psychological factors considered and other comparisons made, the freshmen appear to encounter most difficulty with computation.

The investigation does not present evidence to suggest any clear explanation for these four over-all conclusions.

Interpretations and Conclusions Concerning Arithmetic Abilities of Freshmen in Three Areas of Arithmetic

The discussion of the findings under this first main heading will be divided into two parts: (1) status of freshmen in three areas of arithmetic, and (2) relationship of certain socio-psychological characteristics to performance in arithmetic.

Status of Freshmen Group in Three Areas of Arithmetic. An examination of other studies in which arithmetic tests were administered to college freshmen has revealed the fact that the performance of these freshmen as a group was similar to average eighth-grade performance in computational skill. The few studies that were found which dealt with the ability of the students to solve word problems showed that upon entrance to college freshmen as a group had about eighth-grade ability. The one earlier investigation that had as its purpose the determination of arithmetical understandings on seven levels of growth and development showed that teachers college freshmen lacked ability in perceiving quantitative relationships. In contrast, study of the findings of this investigation showed that in quantitative understanding and problem solving, the students exhibited slightly higher average performances than the median performance of ninth-grade pupils. In the computational phase of arithmetic the average performance of the freshmen was a little below the median performance of ninth-graders. Generally, in the three areas of arithmetic under consideration, the average performance of this freshmen group was similar to typical ninth-grade performance. If previous research has found that entering college freshmen as a group were much like eighth-graders, then it appears that Alabama freshmen majoring in elementary education have exhibited somewhat higher performance in arithmetic than groups of entering freshmen tested in the past.

However, certain limitations must be placed on such an interpretation. First, one must take into consideration differences between measuring instruments used in the past and the instrument used in this investigation. Secondly, one must take into consideration the differences that probably exist between the test norms of the measuring instruments used in earlier studies and the test norms of the measuring instrument used in this study. In other words, the differences that exist between the measuring instrument used in the present investigation and the measuring instruments used in previous studies might account for the slightly higher arithmetical competence exhibited by the freshmen tested in this study.

The question might be asked, have all the students tested in this study performed satisfactorily in quantitative understanding, problem solving, and computation? It was found that on each of the three tests, the students exhibited wide but perhaps normal differences in individual performance. When the status of the freshmen was considered in terms of ninth-grade norms, it was found that almost as many of the students dropped below the ninth-grade median as those who reached or exceeded this median. In other words, almost half of the study population did not reach average ninth-grade performance. Further investigation of the findings shows that in terms of eighth-grade norms about 33 per cent of the freshmen did not reach average eighth-grade performance, while in terms of seventh-grade norms, approximately 23 per cent of the freshmen were below the seventh-grade median. It is safe to assume that these students who did not reach seventh, eighth, or ninth-grade median performances exhibited performances that were not satisfactory. In other words, a significant proportion of this tested freshmen group did not show adequate competence in these three areas of arithmetic.

It can probably be assumed that the group of students tested in this study represented a more select group than the total group of ninth-grade pupils on whose performance ninth-grade norms were based, that is, select in terms of higher scholastic rating and in terms of higher mental ability. Although the writer does not know how the study population performed in arithmetic when they were ninth-graders, it is reasonable to assume that their ability in arithmetic was superior to the arithmetic ability of the total ninth-grade group. In fact, it is possible that their present status in arithmetic indicates a loss since they were in the ninth grade. Also, it must be remembered that this group of freshmen have become more mature, that as a group they have had some additional mathematics since their ninth-grade experiences, and that they have had more time and opportunities to use arithmetic in functional situations. In the light of these facts and the fact that many authors of previous investigations concluded that eighth-grade performance in arithmetic was not satisfactory for entering freshmen, can the performance of the students that did not reach average ninth-grade performance be labeled as satisfactory competence in arithmetic for students who will eventually become teachers of arithmetic? The writer thinks not.

Conclusion: It appears that in quantitative understanding, problem solving, and computation the performance of many freshmen majors in elementary education is not as high as it should be.

Comparison of Performance in Three Areas of Arithmetic. Further study of the findings showed that the study group exhibited about the same competence in quantitative understanding and problem solving, with lower competence in computation. If it can be assumed that this group of freshmen were taught arithmetic with most of the emphasis on computation, with less time being devoted to the solving of word problems, and probably little or no attention being given to the quantitative understanding phase of arithmetic, an assumption that seems safe when one considers the typical class in arithmetic, how was this tested group of freshmen able to have average performances in quantitative understanding and problem solving which were superior to their performance in computation? Perhaps the answer rests on the factors of greater maturity, additional experience in more advanced mathematics, and increased opportunities to use arithmetic in practical life situations.

Since this group of freshmen last studied arithmetic as a subject in itself, they have experienced the advantages derived from becoming more mature. They also have experienced, in varying amounts, advanced work in high school mathematics and have had numerous opportunities to use arithmetic in life situations. The writer feels that of these several factors perhaps the factor of increased maturity has had the greatest effect on the ability of this group of freshmen to exhibit greater proficiency in perceiving quantitative relationships and in solving word problems than they could have shown as ninth-graders. It is also reasonable to assume that perhaps this freshmen group were not as proficient in computation as they were as ninth graders. It must be remembered that four to five years have elapsed since this study population last experienced formal training in arithmetic, training which probably emphasized drill in computation. As a result, it is possible that as a group these students have lost some of their speed and accuracy in computing. This explanation may account for the fact that the study population exhibited greater competence in quantitative understanding and problem solving than in computation.

The question might be asked, did not these students compute in the advanced mathematics courses they took in high school? The answer is a qualified yes. The students computed in general mathematics, algebra, and geometry, but in courses of this type emphasis was probably not placed on speed and accuracy in computation. To a considerable extent formal training in arithmetic has considered computation as an end in itself, therefore, the emphasis on speed and accuracy. In courses of advanced mathematics, computing has been used as a means to an end, consequently computation probably has not received as much special and separate attention. With these considerations in mind, it becomes easier for one to understand why this group of freshmen exhibited greater competence in perceiving number relationships and in the solving of word problems than they did in computation.

Conclusion: *It seems that in terms of junior high school standards for this particular measuring instrument, Alabama freshmen majors in elementary education do better in quantitative understanding and problem solving than they do in computation.*

Interpretations and Conclusions Concerning the Relationship of Selected Socio-Psychological Factors to Performance in Arithmetic

The discussion of the findings in this section will deal with the relation of the arithmetic competence of the freshmen to a series of socio-psychological characteristics.

Comparison of Performance for Freshmen from Rural and Urban Communities. When the attempt was made to see if any relationship existed between competence in arithmetic and the community background (rural and urban) of the students, it was found that the freshmen who came from urban centers exhibited greater competence in quantitative understanding than did the freshmen who came from rural areas. This would seem to suggest that the freshmen who came from urban centers may have experienced the higher quality instruction and may have had the use of superior instructional materials. These findings may, on the other hand, suggest that the environmental background of the students who came from urban centers was such that these students had more opportunity to see number relationships and to utilize these basic concepts in everyday life situations, while the environmental background of the students who came from rural areas did not afford equivalent opportunities for growth and development in number relationships. However, the point is made by the writer that the present study presents no evidence in support of either of the above suggestions.

It was found that generally in the problem solving and computational phases of arithmetic, the freshmen who came from urban centers performed no better than the freshmen who came from rural areas. These findings suggest that the teaching of how to solve word problems may have been as poor or as good in rural communities as in urban centers.

The findings show that there was no relationship between the environmental background (rural or urban) of the two groups of freshmen and their ability in computation. In other words, whether the students came from rural communities or from urban centers, both groups exhibited about the same proficiency in computation. Because the chances are good that computation was taught to both groups of students (rural and urban students) as somewhat mechanical manipulation of number symbols, perhaps the relationship between quality of teaching and the conducting of drill exercises in computation was such that a significant difference in computational competence between students from rural and urban communities should not be expected.

A study of the findings showed that the average performances of both the students who came from urban centers and those who came from rural communities were similar to the performance of ninth-grade pupils in problem solving and computation, except that in quantitative understanding, the students from urban centers tended to surpass the typical performance of ninth-grade pupils.

Conclusions: 1. The findings seem to suggest that the difference in environmental backgrounds (rural and urban) generally has little relation to performance in the problem solving and computational phases of arithmetic.

2. The only point at which a relationship seems to exist is in quantitative understanding in which case urban students appear to be superior to rural students.

Comparison of Performance for Students Who Graduated from High Schools Differing in Size. It was found that there was no difference in the average performance of the freshmen whether they attended high schools which were large, average, or small in size. In other words, there appeared to be no relationship between the size of the high school attended and the average performance of the freshmen on any of the tests. One might suppose that the small high schools were located in rural areas and that most of the average sized and large high schools were located in urban centers. However, the typical organization of school systems in rural areas in Alabama holds to the cluster concept. That is, in any one rural locality, a consolidated high school may be found. This high school obtains most of its students from smaller elementary schools and junior high schools located in areas too thinly populated to support a high school. Consequently, most of the consolidated high schools located in rural areas are large enough to maintain an adequate instructional program. It follows that a student who attended a rural high school had as good an opportunity to experience an adequate instructional program as a student who attended either a large or an average sized city high school. Thus, whether a student attended a smaller high school located in a rural area or a large high school located in the heart of an urban center, his chance for receiving adequate instruction in both small and large high schools was good. Perhaps this is one reason why no differences were found in arithmetical performance among the students who attended high schools of different sizes.

No doubt most of the competence developed by the student in arithmetic was developed during his elementary and junior high school experiences, and the period of time spent in high school did not particularly tend to alter his competence in arithmetic. If it can be assumed that the competence of the student in arithmetic was primarily acquired in the elementary and junior high schools, it is quite possible that the number of students who received poor, average, and good background work in arithmetic and who were good, average and poor students in arithmetic were so evenly distributed in the high schools of different sizes that there was no relationship between the size of the high school and the competence exhibited by the students in these three areas of arithmetic.

These several factors may account for the lack of difference in arithmetical competence exhibited by the freshmen who attended high schools of different sizes.

Conclusion: These findings seem to suggest that the size of the high school attended has no relation to the arithmetic abilities of college freshmen.

Comparison of Performance for Freshmen Who Attended Elementary Schools Differing in Size. The findings for this particular comparison show that the freshmen who attended large and average size elementary schools exhibited greater competence in quantitative understanding than those who attended small elementary schools. It was also found that the students who attended average sized elementary schools had a significantly higher average performance in computation than those who attended small elementary schools. In none of the other possible comparisons were differences among average performances significant.

A majority of the students who attended small elementary schools came from rural communities and a majority of the students who attended average sized and large elementary schools came from urban centers. It was pointed out earlier that the students who came from urban centers exhibited greater competence in quantitative understanding than those who came from rural communities. This fact may contribute to the consistency in results as noted in the quantitative understanding phase of arithmetic. This would seem to suggest that the freshmen who attended large and average sized elementary schools may have experienced the higher quality instruction and may have had the use of superior instructional materials. This might be one reason why the students who attended large and average sized elementary schools exhibited greater competence in quantitative understanding than those who attended small elementary schools. Another reason for this higher performance of the students who attended large and average sized elementary schools might be explained by the difference in environmental background. As has already been pointed out in the rural and urban discussion, students from urban centers perhaps have experienced an environmental background that has afforded them one type of opportunity to see number relationships and to utilize these basic concepts in every day life situations, while students from rural communities have experienced opportunities of another kind, perhaps these opportunities not affording rural students the same type of chance for growth and development.

Higher quality instruction and superior instructional materials probably have been responsible for the fact that students who attended average sized elementary schools exhibited greater competence in computation than those who attended small elementary schools.

In problem solving, there were no significant differences among average performances for the groups of students who attended large, averaged sized, and small elementary schools. This suggests that problem solving was taught as poorly or as well in small elementary schools as in large and averaged sized elementary schools.

Conclusions: 1. These findings seem to suggest that, in general, size of elementary schools attended has little relation to the arithmetic abilities of the college freshmen.

2. One point at which a relationship seems to exist is in quantitative understanding, in which case students who attended large and average sized elementary schools appear to be superior to students who attended small elementary schools.

3. A second point at which a relationship seems to exist is in computation, in which case students who attended average sized elementary schools appear to be superior to students who attended small elementary schools.

Comparison of Performance for Students Who Had Different Backgrounds in High School Mathematics. The freshmen who took general mathematics, algebra, and geometry in high school exhibited greater competence in the three areas of arithmetic under consideration than the freshman who took only general mathematics or general mathematics and algebra in high school. However, there was no significant difference in competence between the freshmen who took general mathematics, algebra, and geometry in high school and the freshmen who took general mathematics and commercial mathematics in high school. There are several possible reasons for this latter finding. The number of freshmen who took general mathematics and commercial mathematics was small (17). The difference between the mean standard scores would have to be extremely large for the difference to have been statistically significant. That is, the size of the sample was so small that little significance can be given to the results obtained.

Except for a comparison with the freshmen who had general and commercial mathematics in high school, the freshmen who had general mathematics, algebra, and geometry exhibited greater competence in these three areas of arithmetic than either the freshmen who had only general mathematics or general mathematics and algebra in high school. It appears that the freshmen who had the greatest number of courses in mathematics exhibited the greater competence in the three areas of arithmetic. It cannot be assumed, however, that mere number of courses taken in mathematics would be solely responsible for this greater competence in arithmetic. Perhaps the nature of these three courses and their combination of one to the other played some part in the superior competence in arithmetic exhibited by this particular group of freshmen. Another important factor to consider is that perhaps only the more capable students took general mathematics, algebra, and geometry in high school. A significant proportion of the students who indicated that they were "A" and "B" students in high school tended to take general mathematics, algebra, and geometry in high school. This may indicate that the differences found for students with different patterns of high school mathematics may actually have been differences as noted with students' general scholastic ability.

The factor of interest is probably closely associated with the above findings. The test results showed that the freshmen who liked arithmetic performed better than the freshmen who disliked arithmetic. A significant proportion of the freshmen who liked arithmetic also took general mathematics, algebra, and geometry in high school.

The relationship between the greatest number of courses taken in high school mathematics and the competence exhibited by the freshmen in arithmetic was a positive one. However, it can not be concluded that the number of courses alone affected the performance of the freshmen in arithmetic. As was pointed out, each of the factors of student capability, scholastic rating, interest, and the nature of the combination of the mathematics courses taken probably had its influence on the competence of the student in arithmetic.

Conclusions: 1. These findings seem to suggest that there is no difference between the arithmetic competence of the students who had a mathematics background of general mathematics, algebra, and geometry and the arithmetic competence of those who had a mathematics background of general mathematics and commercial mathematics; between the arithmetic competence of the students who had a mathematics background of general mathematics and commercial mathematics and the arithmetic competence of those who had a background of either general mathematics and algebra or general mathematics; and between the arithmetic competence of the students who had a mathematics background of general mathematics and algebra and the arithmetic competence of those who had a background of only general mathematics.

2. A relationship does seem to exist in quantitative understanding, problem solving, and computation in that students who had a high school mathematics

background of general mathematics, algebra, and geometry appear to be superior to students who had either a combination of general mathematics and algebra or only general mathematics.

Comparison of Performance for Freshmen Who Indicated That They Were Superior, Good, and Average Students in High School. As has been previously reported, a relationship existed between competence in arithmetic and the self estimated scholastic rating of the student. It was found that for each of the three areas of arithmetic under consideration, the freshmen who indicated that they were "A" students in high school exhibited the highest performance, the freshmen who indicated that they were "B" students the next highest performance, and the students who indicated that they were "C" students in high school the lowest performance. A majority of the freshmen who indicated that they were above average and superior students in high school tended to like arithmetic, while a majority of the students who indicated that they were average students tended to dislike arithmetic. Therefore, it is reasonable to assume that not only was high school scholarship closely related to an underlying ability but the psychological factor of interest appeared to be related to arithmetical performance.

Conclusion: 1. The findings suggest that a relationship exists between quantitative understanding, problem solving, and computational ability and the self estimated scholastic rating of the freshmen in that those who indicate that they were superior and above average students in high school appear to be superior to those who indicate that they were average students in high school.

Comparison of Performance for Freshmen Who Reported Employment Which Included the Functional Use of Arithmetic and for Those Who did not Report Such Employment. It was found that on the problem solving and computation tests, the freshmen who reported having been employed at work which included the use of arithmetic exhibited greater competence than the freshmen who reported no such employment. On the quantitative understanding test the difference between average performances was not statistically significant. A large majority of the freshmen who reported employment had worked as cashiers and sales clerks in a variety of stores. Apparently the phases of arithmetic used in these functional situations included ability to compute and solve practical problems. If this assumption is valid, the indication is that the freshmen who worked had a greater opportunity to use these two phases of arithmetic in practical situations. Certainly, the greater the number of opportunities an individual has had to use a skill and ability he has acquired, the more proficient in the particular skill and ability he should become.

Conclusions: 1. The findings suggest that a relationship exists between both computation and problem solving ability and work experience which includes the functional use of arithmetic in that the students who report employment which included the use of arithmetic appear to be superior to students who do not report such employment.

2. There appears to be no relationship between the factor of employment and performance in quantitative understanding.

Comparison of Performance of Freshmen in Relation to Their Expressed Attitude Towards Arithmetic. A study of the findings which dealt with comparisons of competence among the freshmen groups who liked, felt indifferent towards, and disliked arithmetic showed that in general the students who liked or felt indifferent towards arithmetic exhibited greater competence in these three areas of arithmetic than those who disliked arithmetic. However, it must be noted that the number of freshmen who felt indifferent toward arithmetic was comparatively small (27). Therefore little statistical significance can be given to the average performance of such a small group. It is interesting to note, however, that out of 212 freshmen who expressed their feelings toward arithmetic, only 27 held a neutral attitude towards arithmetic. In other words, 87 per cent of the total group of tested freshmen either expressed a favorable or unfavorable attitude towards arithmetic.

These findings indicate that the factor of expressed attitude does bear a relation to the arithmetical competence exhibited by the tested freshmen groups. That is, when an individual likes and does well or does well and likes a particular learning activity, the chances are probably good that the individual will show increased proficiency in the particular activity.

Conclusions: 1. The findings seem to suggest that some relationship exists between the factor of expressed attitudes toward arithmetic and arithmetic ability of the freshmen in that the students who like arithmetic seem to be superior to the students who dislike arithmetic.

2. It appears that the difference between a favorable and an indifferent attitude toward arithmetic has little relation to arithmetic abilities of the freshmen.

Comparison of the Ability of Those Who Expressed a Need for a Refresher Course in Arithmetic and Those Who Expressed No Need. It was found that there was little relationship between the expressed needs of the freshmen and their competence in the problem solving and computational phases of arithmetic. That is, in computation and problem solving, the differences in performances were not statistically significant for the students who expressed a need for a refresher course in arithmetic and for those who expressed no such need.

In quantitative understanding, however, the students who did not express a need for a refresher course in arithmetic exhibited a statistically significant higher average performance.

The author does not make the assumption that all the students who expressed a need for a refresher course in arithmetic actually needed such a course, or that all the students who did not express a need for a refresher course in arithmetic did not actually need such a course. The differences in individual performances show that some of the freshmen who expressed a need for a refresher course in arithmetic had scores that fell at the top of the test distributions. Certainly, these students do not need a refresher course in arithmetic. Also, some of the students who did not express a need for a refresher course in arithmetic had scores that fell at the lower end of the test distributions. It is possible that these students do need a refresher course in arithmetic. Therefore, it seems that some of the students were not able to accurately determine their needs.

It is desirable to point out that this group expressed their felt needs prior to taking the series of three tests in arithmetic. Therefore, it is difficult to determine what the freshmen considered arithmetic to be. Some members of the group may have considered arithmetic in terms of computation, while other members of the group may have considered arithmetic in terms of problem solving or a combination of problem solving and computation. It is doubtful if any of the freshmen considered arithmetic in terms of number relationships, principles and basic concepts. It is possible that many of the students who did not express a need for a refresher course considered arithmetic in terms of computation, and if so, probably thought that they were not in need of further work in this area of arithmetic. For those who considered arithmetic in terms of problem solving or at least in part as problem solving may have felt a need for a refresher course in arithmetic.

It is assumed by the writer that many students feel more secure in their ability to compute than in their ability to solve word problems. If this assumption is valid, then many of the students felt a lack of confidence and security in their ability to solve word problems and as a result expressed a need for a refresher course in arithmetic, while those who considered arithmetic as computation and felt more secure in this phase of arithmetic (even though such a feeling of security might be false) felt no need for a refresher course in arithmetic.

A majority of the freshmen who did not express a need for a refresher course in arithmetic had indicated that they were above average students in high school. This fact may in part explain the higher competence in quantitative understanding for the freshmen who did not express a need for a refresher course in arithmetic.

Conclusions: 1. These findings seem to suggest that the factor of expressed needs (expressing of a need or no need for a refresher course in arithmetic) has no relation to the performance of the freshmen in problem solving and computation.

2. The point at which a relationship seems to exist is in quantitative understanding in which case the students who do not express a need for a refresher course in arithmetic appear to be superior to those who express a need for a refresher course in arithmetic.

<u>Preferences of Freshmen in Three Areas of Arithmetic</u>. When the freshmen were asked to rate each of these three areas of arithmetic in terms of which they liked least and liked best, it was found that over five-sixths (85 per cent) of this freshmen group liked computation best, that seven-tenths (70 per cent) of this freshmen group liked problem solving least, and that almost three-fourths (74 per cent) of the students (by inference) gave quantitative understanding a neutral rating. That almost three-fourths of the students gave quantitative understanding a neutral rating might indicate that they were not familiar with this area of arithmetic or that they did not recognize this area of arithmetic by the term quantitative understanding. Consequently, this group of students could not like best or least something they knew nothing about. As a result they may have given quantitative understanding a neutral rating.

Perhaps the basic reason that over five-sixths of the students liked computation best and that seven-tenths liked problem solving least is the possibility that most of the emphasis these students experienced in learning arithmetic was placed on computation, and as a result they felt more secure in their ability to compute. Perhaps the students did not feel nearly so secure in their ability to solve word problems and consequently they tended to like least the phase in which they lacked a feeling of security.

When consideration is given to the facts that the freshmen who liked arithmetic exhibited greater competence in arithmetic than the freshmen who disliked arithmetic, that the freshmen showed least competence in computation yet indicated that they liked computation best, and that they liked problem solving least yet exhibited a higher average performance in problem solving than they did in computation, one might at first consider these findings in direct opposition to one another. However, when the freshmen were asked to indicate the phases of arithmetic they liked best and liked least, they were given a choice to indicate in one manner or the other the way they felt about each of the three areas of arithmetic. In other words, whether a student exhibited superior, average, or poor competence in arithmetic or whether he liked, felt indifferent towards, or disliked arithmetic, he was requested to rank these three areas of arithmetic in order of preference. With this consideration in mind it is possible to see that little conflict exists between the findings of the freshmen who indicated whether they liked, felt indifferent towards, and disliked arithmetic and the findings of the freshmen who indicated which of the three areas of arithmetic they liked least or liked best.

In light of the fact that there is a tendency for individuals to do well in the activities they like, it is possible that these students experienced earlier "success" in computation and that this "success" may have been false. In light of this assumption, whether they liked computation best or least would have little effect on their present proficiency in computation. Even though this group of students gave quantitative understanding a neutral rating and indicated that they liked problem solving least, the factors of greater maturity, experience in higher mathematics, and an increase in opportunities to use arithmetic in practical life situations have enabled the freshmen to show greater ability in solving word problems and in perceiving number relationships while still holding to their earlier idea that "problem solving is hard."

Conclusion: 1. These findings seem to suggest that a significant proportion of the students preferred computation to problem solving, while a majority of the students indirectly ranked quantitative understanding in between computation and problem solving.

Implications of Study

The implications and pertinent discussions related to this investigation are presented as follows:

1. The findings of this study showed that many Alabama college freshmen who plan to enter the field of elementary education are deficient in quantitative understanding, problem solving, and computation. In the light of these factors it would seem advisable that teacher training institutions assume the responsibility for correcting the arithmetical deficiencies of these beginning students. Even though the teacher training institutions are not directly responsible for the particular arithmetical status of the entering freshmen, the fact that students are accepted by an institution of higher learning obligates the particular institution to remedy the deficiencies found.

2. On each of the three tests administered to the group of freshmen, it was found that they exhibited wide but normal differences in individual performance. When the status of the students was considered in terms of ninth-grade norms, it was found that a little over 50 per cent had reached or exceeded median ninth-grade performance in each of these three areas of arithmetic, while almost one-half of the students dropped below this level. Such findings indicate that not all of the freshmen are in need of remedial work in arithmetic. However, the students who dropped below the median performance of ninth-grade pupils in the three areas of arithmetic under

consideration should receive some special help in arithmetic. In the light of these findings, it is suggested that remedial work in arithmetic be offered by teacher training institutions. In other words, the students who did not reach the average performance of ninth-graders should be required to take remedial work in arithmetic. Also, any of the students who approximated ninth-grade median performance should be allowed to take the remedial work, although for this group it would be a matter of voluntary choice.

3. Since a significant proportion of the students did not exhibit satisfactory performance in each of these three areas of arithmetic, it is necessary that the content of the remedial course should include work in perceiving quantitative relationships, solving of word problems, and computation.

4. If a professional course in the teaching of arithmetic is to be effective and accomplish its objectives, it would seem to be necessary that many of the students have a solid foundation in arithmetic prior to taking course work in how to teach arithmetic. Certainly, the teacher of the professional course in arithmetic would be able to devote more time to methods and to the problems future teachers of arithmetic will face if the

students entered such a course with an adequate arithmetical background.

5. It has been stated that if the teacher training institution accepts freshmen who are deficient in arithmetic, then it becomes the responsibility of the institution to correct these deficiencies. However, the findings of this study are of equal significance to persons engaged in education at the elementary school and junior high school level. If a significant proportion of a more select group of students show deficiencies in arithmetic, then it becomes the responsibility of the teachers and administrators of our public schools to evaluate their programs in arithmetic. It becomes the responsibility of school superintendents and principals to initiate in-service-training for teachers of arithmetic. In such an in-service-training program emphasis should be placed on the arithmetical understandings and knowledge of teachers of arithmetic as well as on teaching methods. The teacher cannot teach for arithmetical understandings if he does not fully understand the concepts inherent in our number system, nor can the teacher adequately teach these concepts and principles if he does not understand the psychology of learning.

6. At the high school level, it would seem to be desirable that the status of all students in arithmetic

be determined, and that special remedial work be given to the students who exhibit deficiencies in any of the several aspects of arithmetic. It is just as important that the high school graduates who do not go on to college have a working knowledge and understanding of arithmetic as those who plan to continue their education. The point is that school administrators should carefully evaluate their programs in arithmetic and as a result of such evaluations adjust the curriculum and improve the quality of teaching to the place that high school graduates will be able to exhibit satisfactory competence in arithmetic.

7. It will be remembered that the attempt was made to determine whether or not relationships existed between the competence in arithmetic exhibited by the students and certain socio-psychological characteristics. In several instances there appeared to be some relation between performance in arithmetic and some of the socio-psychological characteristics under consideration. It was found that students who came from urban centers and who attended large and average sized elementary schools tended to exhibit greater competence in quantitative understanding than those who came from rural communities and who attended small elementary schools. The suggestion can be made from these findings that those who teach in rural

areas and who teach in small elementary schools should see to it that the experiential background in arithmetic for children from rural communities includes number relationships and understandings. Also, effort should be made by the principals and teachers of small elementary schools to provide the children with the type of instructional materials that would emphasize the quantitative understanding phase of arithmetic.

8. The findings showed that students who indicated that they were superior and good students in high school exhibited greater competence in arithmetic than those who indicated that they were average students in high school. This finding indicates that students differ in ability and that average classrooms are made up of students who differ in ability. In other words, the teacher of arithmetic should be cognizant of this fact and as a result the arithmetic program should be flexible enough so that the individual needs of the children in arithmetic can be taken care of. The children who are more capable can be carried along at a more rapid rate and the level of difficulty they reach in arithmetic can be higher than the less capable students. The less capable students should be carried along as fast as they comprehend and understand the several phases of arithmetic. Also, less capable students should not be

required to reach the level of difficulty in arithmetic attained by the more capable students. By taking care of individual differences, all the children should be able to understand the concepts and basic understandings of arithmetic; the only difference would be in the level of difficulty reached by any particular student.

9. The findings showed that in problem solving and computation, the students who reported work which included the functional use of arithmetic exhibited greater competence in these two phases of arithmetic than the students who reported no such employment. From this finding the writer suggests that the teacher of arithmetic make use of every opportunity for the students to use arithmetic in practical life situations. That is, the teacher should encourage the children to make practical use of the arithmetic they learn in life situations both in and outside the school. Such use of arithmetic should supplement and help to fix for retention the arithmetic learned in the classroom.

10. The findings of this study showed that the students who expressed a liking for arithmetic had a higher average performance in arithmetic than those who expressed a dislike for arithmetic. This finding implies that the teacher should do all within her power to create an active interest in arithmetic on the part of the

children. When a student becomes interested in what is being taught and fosters a genuine liking for a particular subject or does well in a particular subject and develops a liking for it, it is imperative that the teacher present arithmetic in such a way that the interest of the students will be developed and maintained at a high level. When such a situation occurs, students of all capabilities will increase their ability in arithmetic.

The findings of this investigation are not only of significance to persons engaged in the training of teachers of arithmetic but are equally significant to school administrators, principals, and teachers of arithmetic at the elementary school level.

Need For Further Research

This study is one of the first to determine the status of freshmen elementary education majors in quantitative understanding, problem solving, and computation and to compare their performance in each of these three areas of arithmetic. Also, this investigation is one of the first to compare the arithmetical competence of a group of freshmen majoring in elementary education in relation to certain socio-psychological characteristics. Even though the study population included almost nine-tenths of the Alabama college freshmen majoring in elementary education, the size of the sample is relatively small. Consequently, there is a need for similar studies of this type. Certainly, the findings of a series of studies of similar nature would acquire more significance than the findings of only one study.

It is desirable that the competence of freshmen in arithmetic be considered in the light of other socio-psychological factors. The socio-psychological characteristics considered in this study are only a few of the many that could be considered, e.g., mental ability, attitude towards teachers, home environment, sex, participation in extra-curricular activities, and learning handicaps experienced.

There is a definite need for research that would determine the arithmetical status of college students majoring in elementary education at the freshmen, sophomore, junior, and senior class levels. Research of this type would determine the effectiveness of the entire arithmetic program of the teacher training institution on the competence of the student in arithmetic at four successive levels of growth and development. The findings from such research would be of invaluable aid in determining the nature of a desired arithmetic program. Research of this type should consider varied phases of arithmetic, e.g., quantitative understanding, problem solving, and computation.

As was found from a review of the literature, there is a lack of measuring instruments to determine the ability of the students to perceive quantitative relationships. It is desirable that additional reliable and valid instruments to measure the arithmetical understandings of individuals be developed. The more reliable and valid the test, the greater are the opportunities to learn more about the ability of an individual to understand the concepts and principles inherent in our number system.

Research should be conducted that would determine the status of teachers-in-service in each of the three areas of arithmetic under consideration. Research of this type would indicate not only the effectiveness of teacher training programs in the subject field of arithmetic, but it would determine to a degree the quality of instruction in arithmetic the pupils at the elementary school level are receiving.

Longitudinal studies should be conducted, that is, studies that would have as their basic purpose the determination of arithmetic abilities of the same group of students at several levels of growth and development. It would seem to be highly desirable to determine the arithmetical status of the same group of students at the elementary, junior high, and senior high school levels.

The determination of the status in these three areas of arithmetic of the same students at several levels of growth and development would provide school administrators with invaluable information as to the quality of instruction the children are receiving, the strong and weak points of the arithmetic part of the curriculum, and the need for in-service-training for teachers of arithmetic.

Finally, much could be gained in the way of new data from research that would determine the phases of arithmetic that are being stressed at the elementary school level. It would be highly desirable to determine the degree of emphasis that is being placed on the several phases of arithmetic and to determine which of these phases of arithmetic is emphasized most (or least) in the elementary school.

APPENDICES

APPENDIX A

TESTS USED IN THE INVESTIGATION

FUNCTIONAL EVALUATION IN MATHEMATICS

William A. Brownell, Editor

Number Right

Test 4—Quantitative Understanding

by

BEN. A. SUELTZ

Upper Level — Grades 7, 8, and 9 — Form A

NAME .... Boy .... Girl .... Grade ....

Teacher .... Date .... Year .... Month .... Day

School .... Born .... Year .... Month .... Day

City .... State .... Age .... Years .... Months .... Days

To the Student:

With the tests in this booklet you can show how well you understand and use the principles of mathematics. Each of the questions is followed by four answers. Think what the question means and use your best judgment in choosing the correct answer.

If you have trouble with a question, go on to the next ones and come back to it after you have answered all the others. Work as rapidly as you can without making errors. If you are not quite sure of the right answer for a question, choose the answer you THINK is best. If you are not at all sure of the right answer for a question, leave its answer space blank. Read and think, but do not guess.

EDUCATIONAL TEST BUREAU
EDUCATIONAL PUBLISHERS, Inc.

Philadelphia, 3433 Walnut St. — Minneapolis, 720 Washington Ave. S. E — Nashville, 3106 Pierce Ave.

Test 4 — Quantitative Understanding

DIRECTIONS

1. Read a question and the four answers below it.

2. Without using your pencil to work out the problem, choose the answer you think is right an write its letter on the dotted line at the side of the page.

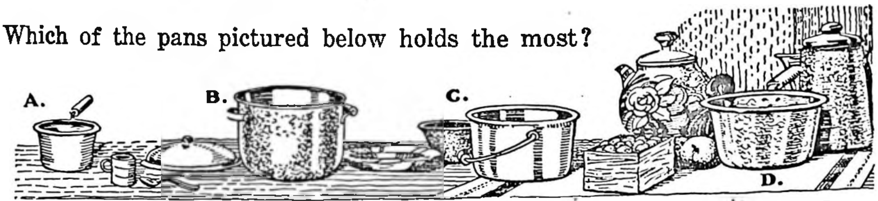
3. Look at the example questions below and see how the answers are marked.

EXAMPLE QUESTIONS

1. How many minutes are there in an hour?

A 10 minutes **B** 30 minutes **C** 60 minutes **D** 100 minutes 1...C...

2. Which of the pans pictured below holds the most? 2...B...



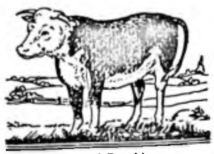
1 PINT 2 QUARTS 3 PINTS 1½ QUARTS

1. Mr. Stevens said that he had "ten hundred pounds" of coal on his light truck. How many pounds was that?

A 100 **B** 10,000 **C** 1000 **D** 110 1.......

2. At the county fair, a $100 prize was given to the person who most accurately estimated the weight of a fat steer. Which number below is closest to the correct weight of 1412 pounds?

A 1250 **B** 1450 **C** 1310 **D** 1385



1412 lbs.

2.......

3. The KOOLAIR COMPANY advertised on the radio that it had installed over a quarter o a million air-conditioning plants. Which number below equals a quarter of a million?

A 1,400,000 **B** 250,000 **C** $\frac{1}{4}$,000,000,000 **D** 25,000 3.......

4. A builders' magazine states that a new apartment house is needed each year for every 1000 people in the country. How many thousands are there in our population of 150,000,000?

A 150,000 B 150 C 15,000 D 15,000,000 4..........

5. George read that "gasoline consumption was 12.8 billion gallons." Which number below is equal to 12.8 billion?

A 12,000,000.8 B 12.8,000,000 C 12,800,000,000 D 12.8 5..........

6. In the canning plant the foreman must turn the steam off after 1 hour and 25 minutes of cooking. If he begins timing at the time shown by the clock at the right, when should he turn off the steam?

A 11:15 B 11:45 C 11:25 D 12:15 6..........

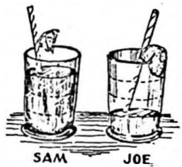
7. At one time the population of the United States was estimated at 136,538,700. How should this number be rounded to the nearest hundred thousand?

A 136,500,000 B 137,000,000 C 1365 D 500,000 7..........

8. Which one of the fractions below does not express the same ratio or value as "five out of every ten"?

A $\frac{4}{8}$ B $\frac{19}{39}$ C $\frac{50}{100}$ D $\frac{2\frac{1}{2}}{5}$ 8..........

9. Sam's glass is three-fourths full of lemonade. Joe's glass is only one-fourth full. Joe's lemonade is what fractional part of Sam's lemonade?



A $\frac{1}{3}$ B $\frac{1}{4}$ C $\frac{1}{2}$ D $\frac{3}{4}$ 9..........

10. A ball team has won 6 of the 10 gar ... the next two games, what fraction of its games will it then]

A $\frac{4}{5}$ B $\frac{1}{2}$ C $\frac{3}{8}$ D $\frac{2}{3}$ 10..........

11. Mrs. Kelly weighed 150 pounds b ... sickness she weighed only 120 pounds. What fractional part o ... she was sick?

A $\frac{1}{3}$ B $\frac{1}{4}$ C $\frac{1}{5}$ D $\frac{4}{5}$ 11..........

Go on to Page 4

12. The Canadian gallon contains 4 Canadian quarts. The U.S. gallon contains 4 U.S. quarts. The Canadian gallon equals 5 U.S. quarts. The U.S. quart is what fractional part of the Canadian quart?

A $\frac{3}{4}$ B $\frac{4}{5}$ C $\frac{5}{4}$ D $\frac{4}{4}$

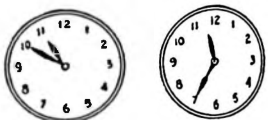
12.........

13. Below are shown the numbers of cases of mumps in four different classes in a school. In which class does the largest fraction of the pupils have mumps?

A 6 cases out of 24 pupils B 11 cases out of 44 pupils
C 10 cases out of 39 pupils D 7 cases out of 30 pupils 13.........

14. If you begin work at the time shown on clock 1, and stop at the time shown on clock 2, how long have you worked?

A 45 min. B 40 min. C 7 min. D 17 min.



1 2

14.........

15. We often speak of the first three months of the calendar year as the "first quarter," the next three months as the "second quarter," and so on. By this system, in an ordinary year (not a leap year) which quarter of the year is shortest?

A fourth quarter B third quarter C second quarter D first quarter 15.........

16. On the calendar at the right, July fourth falls on Friday. On what day of the week must the month of July begin when the fourth falls on Sunday?

A Friday B Thursday C Wednesday D Sunday

JULY

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

16.........

17. Mr. Porter bought 6.6 gallons of gasoline to fill the tank in his car. Which number below does not show this amount?

A $6\frac{6}{100}$ B $\frac{66}{10}$ C $6\frac{3}{5}$ D $6\frac{8}{10}$ 17.........

18. George wants a steel pin 0.785 inches in diameter. Which pin-diameter given below is nearest the correct size?

A 0.875 in. B 0.790 in. C 0.788 in. D 0.778 in.

18.........

19. Which one of the four wires whose diameters are given below is <u>thinnest</u>?

A 0.150 in. B 0.075 in. C 0.100 in. D 0.025 in. 19..........

20. The copyright date as printed on a movie film is given at the right. What date is this?

MCMLII

A 2112 B 1952 C 1492 D there is no such date 20..........

21. Which one of the following Roman Numerals is correctly written?

A LCIX B MIXV C CDIV D MCMXLX 21..........

22. Some cloth is 55% wool. What per cent <u>is not</u> wool?

A 55% B you can't tell the per cent C 95% D 45% 22..........

23. What per cent of a dozen eggs is left in the carton shown at the right?

A 9% B 75% C 3% D $66\frac{2}{3}$ % 23..........

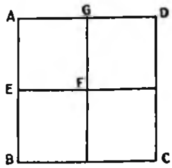
24. A spraying mixture is made by mixing <u>4 pounds</u> of sulphur in each <u>100 gallons</u> of water. What per cent of the mixture is sulphur?

A You can't tell exactly B 4% C $\frac{1}{4}$ % D 400% 24..........

25. Sally bought 4 yards of cloth. It will shrink not more than one-half per cent. Which one of the following best shows the shrinkage or how to find it?

A $\frac{1}{2}$ in. B $\frac{1}{2}$ yd. C $\frac{1}{2}$ of 4 yd. D $\frac{1}{2}$ of 1% of 4 yd. 25..........

26. The square ABCD is one inch along each side. How long is the <u>perimeter</u> of the little square AEFG?



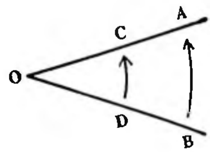
A 2 in. B 1 in. C $\frac{1}{2}$ in. D $\frac{1}{4}$ in. 26..........

27. How large is the area of the little square AEFG in the figure above?

A 1 in. B $\frac{1}{2}$ sq. in. C $\frac{1}{4}$ sq. in. D 1 sq. in. 27..........

Go on to Page 6

28. The angle COD at the right has 35 degrees. How large is the angle AOB?

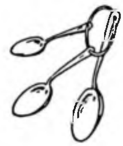


A 70° B 35° C 50° D you can't tell without measuring 28........

29. Which one of the following statements can never be true of a rectangle?

A It has equal opposite sides B It has two parallel sides
C It has a 60° angle D It has a 90° angle 29........

30. Three measuring spoons that have the same shape but different sizes suggest what geometric idea?

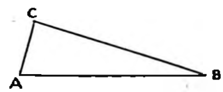


A similarity B congruence C equality D parallelism 30........

31. Ann is supposed to read half of Chapter 12. It begins at the top of page 152 and ends at the bottom of page 167. How far should she read?

A to the middle of page 159 B to the bottom of page 159
C to the middle of page 160 D to the bottom of page 160 31........

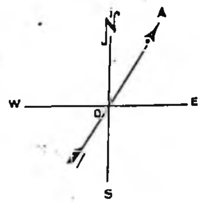
32. In the triangle ABC, angle A = 78° and angle B = 18°. How large is angle C?



A It can't be found from the information given B 122° C 96° D 84° 32........

33. In the triangle above, which is the longest side?
A AB B AC C BC D you can't tell from the information given 33........

34. When Mr. Long was hunting, he went into the woods in the direction 30° east of north. This is shown by the line OA and the angle NOA. What direction must he travel to return along the same route when he comes out of the woods?



A 30° E. of N. B 60° W. of S. C 30° E. of S. D 30° W. of S. 34........

35. Which one of the following is the lowest temperature?

A 0° B —10° C 7.5° D —5.5° 35............

36. Which one of the following is a correct way of writing the value of four and a half cents?

A $.04\frac{1}{2}$¢ B $0.4\frac{1}{2}$¢ C \$.045 D \$.45 36............

37. Which of the following is equal to one and one-half yards?

A $3\frac{1}{2}$ ft. B 4.5 ft. C 4.6 ft. D 4 ft. 5 in. 37............

38. In which of the figures below is there a straight line perpendicular to another straight line?

38............

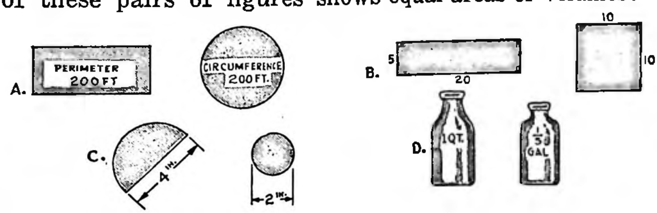
39. The newspaper reported that Homeville (population 3024) has gained 100% in population in the last 10 years. According to this statement, which one of the following is true?

A Homeville now has twice as many people as 10 years ago
B Homeville has exactly as many people now as it had 10 years ago
C The number gained is less than the number it had 10 years ago 39............
D Homeville now has 100 more people than 10 years ago

40. The tax in the village of Geneva is \$3.60 per hundred dollars. Which rate below equals the tax rate in Geneva?

A .36 mills per \$1 B 36% C 3.6 mills per \$1 D 3.6% 40............

41. Which one of these pairs of figures shows equal areas or volumes?

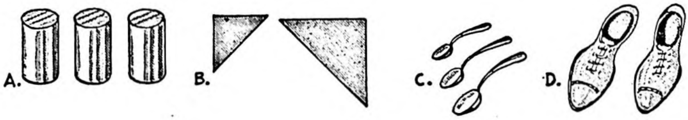


41............

42. Four lines — A, B, C, and D — enclose a rectangle. If the same four lines enclose a parallelogram, which one of the following statements comparing the rectangle and the parallelogram <u>is not true</u>?

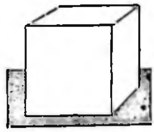
A The areas of both figures are unequal B Both perimeters are equal C The sums of the angles in both figures are equal D The altitudes of both figures are equal 42............

43. In which one of the following sets of figures are the objects congruent?



43........

44. The illustration at the right represents a cube that contains one cubic foot. Which one of the following statements is true about a "foot-cube?"



44........

A Its volume is the same as that of a sphere with a diameter of one foot
B Each of its surfaces is a square foot
C It contains 144 cubic inches
D It has 8 edges, each one foot long

45. Which one of the following exercises would have a negative number for an answer?

A $\begin{array}{r}(-8)\\ \underline{\times(-2)}\end{array}$ B $\begin{array}{r}(-2)\\ \underline{-(-3)}\end{array}$ C $\begin{array}{r}(-8)\\ \underline{+(-2)}\end{array}$ D $(-8) \div (-2)$ 45........

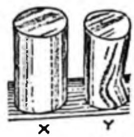
46. Which of the following can not be done to both sides of an equation without destroying the equality?

A Add the same number to both sides B Multiply both sides by π 46........
C Take the square root of both sides D Divide one side by 2, providing the other side is multiplied by 2

47. Which one of the following is true or correct?

A $\frac{-2^2}{2} = -2$ B $\frac{X}{2} + \frac{X}{2} = \frac{2X}{4}$ C $\frac{-X}{Y} = \frac{X}{-Y}$ D $\sqrt{4^2} = 8$ 47........

48. Two tin cans, X and Y, were made the same size, but can Y has been deeply dented on one side. Which one of the following statements is true if the metal in can Y was only bent and not stretched.



A Can Y holds as much sand as can X B Can Y has as much metal as can X
C The distance around the top rim of Y is larger than the corresponding distance on X
D The dotted line on Y is longer than the dotted line on X 48........

49. The formula for the roots of the quadratic equation $ax^2 + bx + c = 0$ is given at the right. Which one of the following statements cannot be true?

$$X = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

A When $b^2 - 4ac = 0$, the roots are equal to $\frac{-b}{2a}$
B When $b^2 - 4ac$ is less than zero, both roots are imaginary 49........
C When "a" is zero, there is no quadratic equation
D It is the 2a in the denominator that creates two roots

50. Which one of the following equations is correct or true for all values of X and not for some special value only?

A $X - 2 = 2 - X$ B $\frac{X}{1} = \frac{1}{X}$ 50........
C $X^2 - 4 = (X + 2)\ (X - 2)$ D $(X - 1)^2 = X^2 + 1$

  End of Test. Look over your work. *No. Right* ....

FUNCTIONAL EVALUATION IN MATHEMATICS

William A. Brownell, Editor

Number Right [ ]

Test 5 — Problem Solving

by

BEN. A. SUELTZ

Upper Level | Grades 7, 8, and 9 | Form A

NAME .... Boy .... Girl .... Grade ....

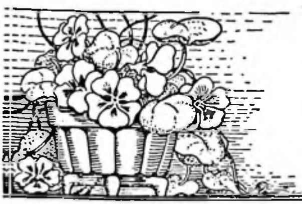
Teacher .... Date .... Year .... Month .... Day

School .... Born .... Year .... Month .... Day

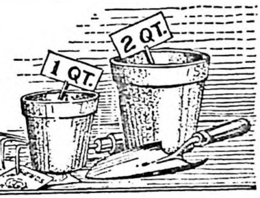
City .... State .... Age .... Years .... Months .... Days

DIRECTIONS — Read each problem carefully and be sure to do just what it asks. Show your work in the work space and write your answer on the dotted line at the side of the page. The sample problems show you how to do this.

SAMPLE PROBLEMS



The pupils in one room changed the soil for the plants in their room. They had two sizes of flower pots. The large pots each held 2 quarts of soil and the small pots each held 1 quart of soil.

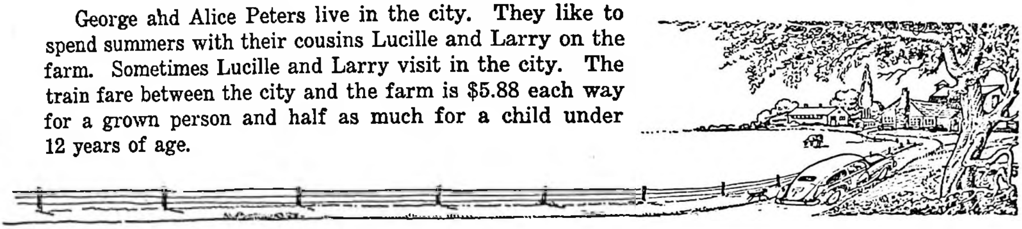


	Space for Work	Answers
A. How many quarts of soil were needed for 7 of the large-size pots?	7 × 2 = 14	A. ....14.... qt.
B. For new soil for the plants 1 quart of sand was used for each 2 quarts of soil from the garden. How much sand was used with a bushel (32 quarts) of soil from the garden?	32 ÷ 2 = 16	B. ....16.... qt.

EDUCATIONAL TEST BUREAU
EDUCATIONAL PUBLISHERS, Inc.
Philadelphia 3433 Walnut St. | Minneapolis 720 Washington Ave. S. E | Nashville 2106 Pierce Ave.

VACATION ON THE FARM

George and Alice Peters live in the city. They like to spend summers with their cousins Lucille and Larry on the farm. Sometimes Lucille and Larry visit in the city. The train fare between the city and the farm is $5.88 each way for a grown person and half as much for a child under 12 years of age.



	Space for Work	Answers
1. Alice is 11 years old. How much is the train fare for her from the city to the farm?		1. $........
2. Mr. and Mrs. Peters and George use full-fare tickets. How much do these tickets cost for the trip to the farm for the 3 people?		2. $........
3. One summer Mr. Peters took the children in his car. When they started, the speedometer read 49,826 miles. When they arrived, it read 50,031 miles. How far did they drive?		3. .... mi
4. They started at 8:30 in the morning and arrived at 10 minutes after 3 in the afternoon. How much time was used in traveling?		4. ......hr. ......min
5. When Mr. Peters had driven 250 miles, he had used 13 gallons of gas. To the nearest whole mile, how many miles was this per gallon?		5. .... mi
6. For spending money, George received 75¢ per week and Alice 50¢ per week. What was the total for six weeks for both children?		6. $........
7. The children rode Larry's pony. It could run a mile in 5 minutes. How many miles per hour is this?		7. .... m.p.h
8. Alice helped her cousin make curtains. Each curtain was 60 inches long and 6 extra inches per curtain were used in making hems. How many yards of material were needed for six curtains?		8. .... yd
9. On the farm, the children got up at 6:45 in the morning. When did they go to sleep if they had $9\frac{1}{2}$ hours of sleep?		9. ....
10. They served fried chicken to a group of friends on Sunday. Three chickens each weighing $3\frac{1}{2}$ pounds were used. How many people did these serve if $\frac{3}{4}$ of a pound was allowed for each person?		10. ....

Go on to Page 3

CHICKENS ON THE FARM

The farm has a few cattle and raises some grain for feed, but it specializes in raising chickens and selling eggs. Eggs that are fresh, clean, and large bring the best prices. Alice and George learned to sort and grade the eggs.


Questions	Space for Work	Answers

11. Medium-sized eggs usually sell for 80% as much as large eggs. When large eggs are 55¢ per dozen, for how much should medium-sized eggs sell?

11. ....¢

12. Large eggs weigh 28 ounces per dozen and extra-large eggs weigh 32 ounces per dozen. The large eggs weigh what per cent as much as the extra-large eggs?

12. ....%

13. At the right is a chart showing the percentage of content of some chicken feed. What per cent of the content of this feed is not accounted for on the chart?

Feed Content	
Protein	20%
Fat	4%
Fiber	8%

13. ....%

14. Larry and George brought home a load of feed that weighed 2250 pounds. How much did this feed cost at $2.80 per hundred pounds?

14. $........................

15. In preparing feed for laying hens, Larry had to put in $\frac{1}{2}$ of 1% salt. How many pounds of salt did he use in mixing 1500 pounds of feed?

15. .... lb.

16. Mrs. Peters pays 54¢ per dozen for eggs for which the farmer gets 45¢ per dozen. Her cost is what per cent more than the price the farmer gets?

16. ....%

17. To build another chicken house, Larry's father borrowed $1600. If he paid it back in four months, how much was the interest? The interest rate was 4% per year.

17. $........................

18. In a new breed of chicken, 60% of the weight is edible. In a 5-pound chicken of this breed, how much is *inedible?*

18. .... lb.

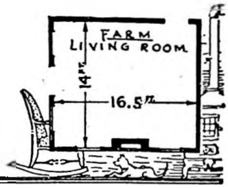
19. To produce one pound of chicken, 4 pounds of feed are needed. Feed costs $3\frac{1}{2}$ cents per pound. If the chicken sells for 35¢ per pound, what per cent of the selling price is spent on feed?

19. ....%

Go on to Page 4.

THE CITY AND THE FARM

In the city George and Alice spend much of their spare time reading. On the farm, they helped with the work. George helped his cousin with the outdoor work and Lucille helped in the house. It was a large pleasant house.



	Space for Work	Answers
20. Two living room floors are sketched above. Which is larger, and how many more square feet of space does it contain? (If they are both the same in size, write <u>same</u>.)		20. .... sq. ft
21. The perimeter of the city living room is how many feet more than the perimeter of the farm living room, or are both the same?		21. .... ft
22. In the city, people cook with gas. They pay $12\frac{1}{2}$ cents per 100 cubic feet of gas. How much is the bill for a month when 1700 cubic feet are used?		22. $ ....
23. The farm uses electricity for cooking, washing, and other machinery. The rate is \$5 for all electricity up to 100 kilowatts, and $3\frac{1}{2}$ cents per kilowatt for any extra beyond the first 100. How much is the bill when 238 kilowatts are used?		23. $ ....
24. The round water tank on the farm is 6 feet in diameter and 2 feet, 4 inches deep. How many cubic feet of water will it hold? ($V = \pi r^2 h$)		24. .... cu. ft
25. One day the boys made a rectangular yard for chickens. They used 120 yards of fence to enclose it. If the chicken yard was two times as long as wide, how long was it?		25. .... yd
26. If Alice lives "10 minutes by bus" from her school and the bus averages 10 miles per hour, how many miles is it to the school?		26. .... mi
27. For his science class, George recorded the following low temperatures one week: $-2°$, $-8°$, $0°$, $+7°$, $-1°$, $+6°$, $+10°$. What was the average of these temperatures?		27. ....

End of Test. Look over your work.

No. Right.........

FUNCTIONAL EVALUATION IN MATHEMATICS

William A. Brownell, Editor

Number Right

Test 6—Basic Computations

by

BEN. A. SUELTZ

Upper Level Grades 7, 8, and 9 Form A

NAME .... Boy .... Girl .... Grade ....

Teacher .... Date ....
Year Month Day

School .... Born ....
Year Month Day

City .... State .... Age ....
Years Months Days

AU

e.

Phil
3433

Nashville
2106 Pierce Ave.

TEST 6—Computations

DIRECTIONS

This is a test of computations in arithmetic. Do as many of the examples as you can. Work carefully at your usual rate of speed. Your score will be the total number that you have done correctly.

Write each answer under the example and again in the proper answer space at the side of the page. The samples at the right show where you should write your answers.

There is room to work on the test paper. Show all of your work for every example you do.

Subtract —

A feet

$4\frac{3}{4}$
$1\frac{1}{4}$
~~$3\frac{2}{4}$~~ $3\frac{1}{2}$

B

Find 15% of $372

$372
.15
1860
372
$ 55.80

Notice that in Sample A the answer was reduced to $3\frac{1}{2}$ ft. All final answers should be given in reduced form.

Answers

A $3\frac{1}{2}$ ft.

B $ 55.80

Add +	Subtract —	Multiply ×	Divide ÷
1 pounds	2 acres	3 tons	4 yards
3595 3290 2075 3960 4455	270,850 69,785	74,690 409	yd. 28) 825 yd.

Answers

1 .... lb.

2 .... A.

3 .... T.

4 .... yd.

ADD +

5 feet

$3\frac{1}{4}$
$4\frac{1}{3}$
3

6 inches

$20\frac{7}{8}$
$21\frac{11}{16}$
$18\frac{3}{4}$

SUBTRACT —

7 barrels

$12\frac{7}{8}$
$10\frac{1}{4}$

8 hours

$40\frac{1}{2}$
$9\frac{3}{4}$

5 .... ft.

6 .... in.

7 .... bbl.

8 .... hr.

MULTIPLY ×

9 ounces

$5 \times 7\frac{1}{2} =$

10 feet

$3\frac{1}{7} \times 12\frac{1}{4} =$

DIVIDE ÷

11 yards

$16\frac{2}{3} \div 6 =$

12 inches

$12\frac{1}{2} \div 2\frac{3}{16} =$

9 .... oz.

10 .... ft.

11 .... yd.

12 .... in.

Go on to Page 3

13
Arrange in a column, then Add

$22.22 + $2.10 + $76.95 = $.........

14
Arrange in a column, then Subtract

$259 — $49.95 = $..........

MULTIPLY ×

15 feet

200
.025

16 inches

74.6
3.14

Divide ÷

17

.06) $36

18 (ans. to 1 dec. place)

3.14) 96.5 in.

Add +

19

12 lb. 9 oz.
4 lb. 6 oz.
7 lb. 8 oz.

(Reduce answer)

Subtract —

20

100 gal. — 60 gal. 3 qt.

= ......gal. ......qt.

Multiply ×

21

$\frac{3}{4}$ of 2 hr. 40 min.

= ......hr. ......min.

Fill in the blank spaces in the chart below.

	Fraction	Decimal	Per Cent	
	$\frac{1}{4}$	.25	25%	
22	$\frac{2}{5}$			23
24		.077		25

Find PERCENTAGE

26
44% of $75 = $ ....

27
150% of $10.50 = $ ....

Find RATE PER CENT

28
16 in. = ...% of 24 in.

29
$42 = ...% of $540

Answers

13 $ ....

14 $ ....

15 .... ft.

16 .... in.

17 $ ....

18 .... in.

19 ....lb. ....oz.

20 ...... gal. ...... qt.

21 ......hr. ......min.

22 ....

23 .... %

24 ....

25 .... %

26 $ ....

27 $ ....

28 .... %

29 .... %

Go on to Page 4

Find the WHOLE AMOUNT

30 $\$3 = 1\%$ of \$........

31 12% of \$........ $= \$366$

Find INTEREST

32 $\$330 \times \frac{4}{100} \times \frac{60}{360} = \$$____

SOLVE FOR X

33 $5X = 34$

X =

34 $6X - 40 = 2X + 44$

X =

35 $\frac{X}{8} = 4\frac{1}{2}$

X =

36 $\frac{2}{3}X + 10 = X - 5$

X =

ADD +

37

(-4)
$(+7)$
(-8)

38

$(+10)$
(-25)
(-44)
$(+11)$

SUBTRACT −

39

$(+27)$
(-15)

40

(-200)
$(-\ 65)$

MULTIPLY ×

41

(-48)
$(+\ 2)$

Divide ÷

42 $(-275) \div (-2) =$

SOLVE FOR THE LETTER INDICATED

43 $S^2 = 100$

S =

44 $I = PRT$

P =

45 When $r = 14$, $\pi = 22/7$ and $A = \pi r^2$

A =

46 When $b = 8$, $b' = 9$, $h = 5$, and $A = \frac{1}{2}(b + b')\ h$

A =

Answers

30 \$ ....

31 \$ ....

32 \$ ....

33 X = ...

34 X = ...

35 X = ...

36 X = ...

37 ....

38 ....

39 ....

40 ....

41 ....

42 ....

43 S = ...

44 P = ...

45 A = ...

46 A = ...

 End of Test. Look over your work. *No. Right* ......

APPENDIX B

DATA SHEET USED IN PILOT STUDY

Please answer briefly the following questions.

Name?____

What is your home address?________________________

Is your home in a rural or an urban area?_____________

What is the name and address of the school in which you teach?_______________________________________

Is the school located in a rural or an urban area?_______

What is your sex?_______________ (Male - Female)

Was the high school you attended in a rural or an urban area?____

What were the basic courses in mathematics which you took in college?_____________________________________

____

What were the basic courses in mathematics which you took in high school?__________________________________

____

Do you consider your background in mathematics good, fair, or poor?_______________

What grade do you teach?__________________

How many years have you taught arithmetic?______________

How many years have you taught high school mathematics?

____

What mathematics did you teach?________________________

Did you enjoy arithmetic when you were in the elementary school?______________

Did you enjoy mathematics when you were in high school?

____

Do you enjoy teaching mathematics or arithmetic?

____

APPENDIX C

BASIC DATA SHEETS USED IN STUDY

Please fill in the following blanks with care and thoughtful consideration.

1. Name________________________________ Sex______
   last first middle M or F

2. Present address________________________________
   st.,no.,or dormitory city or town state

3. Home address________________________________
   st.,no., or P.O. Box city or town state

4. Place a check mark on the blank following the statement which best describes your home location.

   Rural --Population 2500 or less. An area pertaining to the country as distinguished from a city or large town. ______

   Urban --Population 2500 or over. An area pertaining to the city or large town as distinguished from the country. ______

   Rurban--Population 2500 or over. A metropolitan or residential district which is in close proximity to a city or large town. ______

5. Underline the enrollment figure which comes nearest the enrollment of your senior class in high school.

   not more than 50 students not more than 150 students

   not more than 300 students over 300 students

6. Underline the word which comes nearest describing the size of the elementary school which you attended. If you attended more than one elementary school, consider the size of the elementary school which you last attended.

   small (200 students or less)

   large (800 students or less)

   average (400 students or less)

7. Look at the following list of subjects or courses in mathematics. Underline the courses which you had in high school.

(a) general mathematics (b) algebra (1st year)

(c) algebra (2nd year) (d) plane geometry

(e) solid geometry (f) trigonometry

(g) commercial mathematics (h) others______________

8. List the courses in mathematics which you are now taking.

(a) ______________________ (c) ____________________

(b) ______________________ (d) ____________________

9. Please place a check mark on the blank preceding the statement which corresponds closest to your standing.

_____ "A" student in high school

_____ "B" student in high school

_____ "C" student in high school

_____ "D" student in high school

10. When you had arithmetic in the elementary school you most probably did work in computation (addition, subtraction, multiplication, and division of whole numbers and fractions), problem solving (solving of word problems in arithmetic), and number meaning (understanding of basic concepts and principles in arithmetic). Of the three phases in arithmetic (computation, problem solving, and number meaning) write in the blanks provided the phase which you liked least and the phase which you liked best.

(a) Liked least_________________________.

(b) Liked best__________________________.

11. You may have had odd jobs in the summer time or in the afternoons which included the use of arithmetic (e.g., cashier in a grocery or drug store, temporary office work which included the use of simple arithmetic etc.). If so, indicate by writing on the blanks

provided a brief description of the job you held. Describe just the portion of the job which included the use of arithmetic.

(a) ____

(b) ____

(c) ____

12. Place a check mark on one of the following blanks. When you were in the elementary school, did you --

(a) like arithmetic very much? _____

(b) like arithmetic (moderately)? _____

(c) feel indifferent (neutral) towards arithmetic? _____

(d) dislike arithmetic? _____

(e) intensely dislike arithmetic? _____

13. Do you feel the need to take a refresher course in arithmetic (a course involving basic number work, problem solving, and basic computations) during your stay in college? If so, indicate by placing a check mark on the blank which follows the word yes. If not, indicate by placing a check mark on the blank which follows the word no.

Yes_____ No_____

14. Do you recall any particular factor which may have been a handicap to you in learning arithmetic while in the elementary school? If so, list the handicap(s) in the blanks provided.

____

____

15. Please indicate your present preference in education by placing a check mark on one of the blanks preceding the following statements.

(a) _____ It is my present desire to major in elementary education.

(b) _____ It is my present desire to major in secondary education.

APPENDIX D

DISTRIBUTIONS OF TEST SCORES

The following headings will be used to identify the distribution tables: Test 4, Quantitative Understanding; Test 5, Problem Solving; and Test 6, Basic Computation.

DISTRIBUTION OF TEST SCORES FOR THE TOTAL GROUP OF FRESHMEN IN THREE AREAS OF ARITHMETIC

Test 4

	f
73-75	5
70-72	4
67-69	4
64-66	5
61-63	22
58-60	22
55-57	20
52-54	34
49-51	24
46-48	26
43-45	22
40-42	7
37-39	10
34-36	3
31-33	4
N =	212

Test 5

	f
72-74	3
69-71	7
66-68	7
63-65	10
60-62	11
57-59	19
54-56	18
51-53	28
48-50	20
45-47	49
42-44	23
39-41	8
36-38	6
33-35	1
30-32	2
N =	212

Test 6

	f
73-75	1
70-72	2
67-69	4
64-66	9
61-63	17
58-60	16
55-57	12
52-54	25
49-51	21
46-48	32
43-45	18
40-42	22
37-39	21
34-36	7
31-33	5
N =	212

DISTRIBUTION OF TEST SCORES FOR RURAL AND URBAN STUDENTS

Freshmen from Rural Areas

Test 4

	f
73-75	3
70-72	2
67-69	3
64-66	1
61-63	8
58-60	4
55-57	8
52-54	19
49-51	10
46-48	16
43-45	14
40-42	5
37-39	5
34-36	2
31-33	3
N =	103

Test 5

	f
72-74	1
69-71	5
66-68	1
63-65	5
60-62	3
57-59	12
54-56	8
51-53	13
48-50	8
45-47	23
42-44	13
39-41	4
36-38	4
33-35	1
30-32	2
N =	103

Test 6

	f
71-73	1
68-70	2
65-67	3
62-64	4
59-61	6
56-58	9
53-55	8
50-52	11
47-49	8
44-46	13
41-43	19
38-40	8
35-37	4
32-34	6
29-31	1
N =	103

Freshmen from Urban Centers

Test 4

	f
71-73	1
68-70	3
65-67	2
62-64	9
59-61	15
56-58	16
53-55	15
50-52	13
47-49	14
44-46	11
41-43	3
38-40	3
35-37	2
32-34	2
N =	109

Test 5

	f
72-74	2
69-71	1
66-68	6
63-65	5
60-62	8
57-59	6
54-56	10
51-53	15
48-50	12
45-47	26
42-44	11
39-41	4
36-38	2
33-35	0
30-32	1
N =	109

Test 6

	f
68-70	4
65-67	3
62-64	11
59-61	4
56-58	11
53-55	9
50-52	12
47-49	20
44-46	7
41-43	12
38-40	8
35-37	6
32-34	2
N =	109

DISTRIBUTION OF TEST SCORES FOR THE FRESHMEN WHOSE GRADUATING CLASSES DIFFERED IN SIZE

Graduating Classes with not More Than 50 Students

Test 4

	f
73-75	2
70-72	1
67-69	2
64-66	4
61-63	8
58-60	7
55-57	8
52-54	18
49-51	10
46-48	10
43-45	10
40-42	3
37-39	5
34-36	1
31-33	4
N =	93

Test 5

	f
72-74	1
69-71	3
66-68	2
63-65	5
60-62	4
57-59	11
54-56	8
51-53	9
48-50	9
45-47	20
42-44	14
39-41	1
36-38	3
33-35	1
30-32	2
N =	93

Test 6

	f
73-75	1
70-72	1
67-69	2
64-66	
61-63	8
58-60	7
55-57	6
52-54	13
49-51	12
46-48	11
43-45	7
40-42	11
37-39	7
34-36	6
31-33	1
N =	93

Graduating Classes That Ranged from 50 to 150 Students in Number

Test 4

	f
73-75	2
70-72	2
67-69	2
64-66	1
61-63	5
58-60	6
55-57	11
52-54	7
49-51	11
46-48	10
43-45	8
40-42	4
37-39	4
34-36	2
N =	75

Test 5

	f
73-75	2
70-72	2
67-69	3
64-66	
61-63	4
58-60	2
55-57	9
52-54	7
49-51	14
46-48	11
43-45	9
40-42	2
37-39	9
34-36	
31-33	1
N =	75

Test 6

	f
68-70	2
65-67	3
62-64	6
59-61	3
56-58	6
53-55	4
50-52	7
47-49	13
44-46	6
41-43	11
38-40	8
35-37	3
32-34	3
N =	75

Graduating Classes That Were Over 150 Students in Number

Test 4

	f
71-73	1
68-70	1
64-66	
61-63	9
58-60	7
55-57	3
52-54	9
49-51	2
46-48	6
43-45	4
40-42	
37-39	2
N =	44

Test 5

	f
69-71	1
66-68	3
63-65	2
60-62	6
57-59	3
54-56	4
51-53	6
48-50	3
45-47	11
42-44	4
39-41	1
N =	44

Test 6

	f
68-70	1
65-67	3
62-64	3
59-61	3
56-58	6
53-55	3
50-52	4
47-49	7
44-46	3
41-43	6
38-40	2
35-37	1
32-34	2
N =	44

DISTRIBUTION OF TEST SCORES FOR FRESHMEN WHO ATTENDED ELEMENTARY SCHOOLS OF DIFFERENT SIZES

Elementary Schools Small in Size (200 Students or Less)

Test 4

	f
73-75	1
70-72	
67-69	2
64-66	1
61-63	3
58-60	2
55-57	7
52-54	12
49-51	8
46-48	9
43-45	13
40-42	2
37-39	4
34-36	2
31-33	2
N =	68

Test 5

	f
72-74	1
69-71	2
66-68	1
63-65	3
60-62	3
57-59	8
54-56	4
51-53	9
48-50	7
45-47	16
42-44	8
39-41	2
36-38	1
33-35	1
30-32	2
N =	68

Test 6

	f
67-69	1
64-66	1
61-63	5
58-60	6
55-57	2
52-54	7
49-51	11
46-48	7
43-45	4
40-42	9
37-39	7
34-36	5
31-33	3
N =	68

Elementary Schools Average in Size (200 to 400 Students)

Test 4

	f
73-75	4
70-72	1
67-69	1
64-66	4
61-63	10
58-60	12
55-57	10
52-54	14
49-51	11
46-48	12
43-45	8
40-42	4
37-39	3
34-36	1
31-33	2
N =	97

Test 5

	f
73-75	1
70-72	3
67-69	8
64-66	1
61-63	8
58-60	3
55-57	15
52-54	8
49-51	13
46-48	13
43-45	11
40-42	6
37-39	7
N =	97

Test 6

	f
71-73	1
68-70	5
65-67	3
62-64	8
59-61	3
56-58	10
53-55	11
50-52	6
47-49	13
44-46	15
41-43	8
38-40	7
35-37	5
32-34	2
N =	97

Elementary Schools Large in Size (400 to 800 Students)

Test 4

	f
69-71	4
66-68	
63-65	4
60-62	5
57-59	10
54-56	4
51-53	5
48-50	9
45-47	1
42-44	2
39-41	4
N =	48

Test 5

	f
73-75	1
70-72	
67-69	
64-66	
61-63	6
58-60	2
55-57	6
52-54	5
49-51	6
46-48	7
43-45	10
40-42	1
37-39	4
N =	48

Test 6

	f
64-66	4
61-63	4
58-60	4
55-57	3
52-54	6
49-51	5
46-48	7
43-45	4
40-42	7
37-39	3
34-36	1
N =	48

DISTRIBUTION OF TEST SCORES FOR FRESHMEN WHO HAD DIFFERENT AMOUNTS OF MATHEMATICS IN HIGH SCHOOL

Distribution of Test Scores for Those Who Took General Mathematics

Test 4

	f
69-71	1
66-68	
63-65	
60-62	
57-59	1
54-56	3
51-53	6
48-50	12
45-47	2
42-44	9
39-41	5
N =	39

Test 5

	f
66-68	1
63-65	1
60-62	3
57-59	5
54-56	2
51-53	3
48-50	5
45-47	7
42-44	6
39-41	4
36-38	
33-35	
30-32	2
N =	39

Test 6

	f
63-65	1
60-62	3
57-59	
54-56	2
51-53	3
48-50	4
45-47	5
42-44	4
39-41	6
36-38	5
33-35	4
30-32	2
N =	39

Distribution of Test Scores for Those Who Took General Mathematics and Algebra

Test 4

	f
61-63	1
58-60	7
55-57	4
52-54	8
49-51	7
46-48	8
43-45	6
40-42	
37-39	5
34-36	2
31-33	3
N =	51

Test 5

	f
70-72	2
67-69	2
64-66	
61-63	2
58-60	1
55-57	7
52-54	4
49-51	8
46-48	7
43-45	11
40-42	3
37-39	3
34-36	1
N =	51

Test 6

	f
67-69	1
64-66	1
61-63	1
58-60	3
55-57	5
52-54	7
50-51	2
47-49	3
44-46	7
41-43	10
38-40	5
35-37	3
32-34	3
N =	51

Distribution of Test Scores for Those Who Took General Mathematics and Commercial Mathematics

Test 4

	f
61-63	2
58-60	3
55-57	3
52-54	3
49-51	
46-48	3
43-45	1
40-42	
37-39	1
34-36	1
N =	17

Test 5

	f
67-69	1
64-66	
61-63	2
58-60	
55-57	4
52-54	2
49-51	4
46-48	1
43-45	1
40-42	1
37-39	1
N =	17

Test 6

	f
66-68	1
63-65	1
60-62	
57-59	
54-56	2
51-53	3
48-50	2
45-47	3
42-44	2
39-41	3
N =	17

Distribution of Test Scores for Those Who Took General Mathematics, Algebra, and Geometry

Test 4

	f
73-75	5
70-72	3
67-69	4
64-66	5
61-63	18
58-60	13
55-57	10
52-54	16
49-51	10
46-48	8
43-45	5
40-42	3
37-39	2
34-36	
31-33	1
N =	103

Test 5

	f
73-75	3
70-72	3
67-69	6
64-66	2
61-63	10
58-60	6
55-57	13
52-54	10
49-51	11
46-48	19
43-45	11
40-42	5
37-39	4
N =	103

Test 6

	f
71-73	1
68-70	4
65-67	7
62-64	8
59-61	7
56-58	16
53-55	8
50-52	9
47-49	18
44-46	6
41-43	11
38-40	3
35-37	3
32-34	2
N =	103

DISTRIBUTION OF TEST SCORES FOR THE FRESHMEN WHO INDICATED THAT THEY WERE SUPERIOR (A), GOOD (B), AND AVERAGE (C) STUDENTS IN HIGH SCHOOL

Distribution of Test Scores for the Freshmen Who Indicated That They Were Superior (A) Students in High School

Test 4

	f
73-75	3
70-72	1
67-69	2
64-66	2
61-63	9
58-60	4
55-57	3
52-54	10
49-51	
46-48	3
43-45	1
N =	38

Test 5

	f
70-72	3
67-69	4
64-66	2
61-63	7
58-60	3
55-57	4
52-54	6
49-51	
46-48	3
43-45	5
40-42	
37-39	1
N =	38

Test 6

	f
72-74	1
69-71	1
66-68	3
63-65	1
60-62	7
57-59	3
54-56	5
51-53	3
48-50	3
45-47	7
42-44	1
39-41	3
N =	38

Distribution of Test Scores for the Freshmen Who Indicated That They Were Good (B) Students in High School

Test 4

	f
73-75	1
70-72	3
67-69	2
64-66	3
61-63	12
58-60	11
55-57	11
52-54	21
49-51	16
46-48	15
43-45	13
40-42	4
37-39	6
34-36	3
31-33	1
N =	122

Test 5

	f
73-75	3
70-72	1
67-69	5
64-66	1
61-63	11
58-60	3
55-57	16
52-54	9
49-51	21
46-48	19
43-45	18
40-42	9
37-39	5
34-36	
31-33	1
N =	122

Test 6

	f
70-72	1
67-69	3
64-66	5
61-63	10
58-60	7
55-57	8
52-54	15
49-51	16
46-48	19
43-45	10
40-42	10
37-39	10
34-36	5
31-33	3
N =	122

Distribution of Test Scores for the Freshmen Who Indicated That They Were Average (C) Students in High School

Test 4

	f
73-75	1
70-72	
67-69	
64-66	
61-63	2
58-60	6
55-57	6
52-54	3
49-51	8
46-48	8
43-45	8
40-42	3
37-39	4
34-36	
31-33	3
N =	52

Test 5

	f
69-71	1
66-68	
63-65	
60-62	
57-59	6
54-56	5
51-53	5
48-50	7
45-47	13
42-44	5
39-41	4
36-38	4
33-35	1
30-32	1
N =	52

Test 6

	f
65-67	1
62-64	2
59-61	1
56-58	4
53-55	2
50-52	3
47-49	7
44-46	5
41-43	14
38-40	4
35-37	6
32-34	3
N =	52

DISTRIBUTION OF TEST SCORES FOR THE FRESHMEN WHO REPORTED EMPLOYMENT WHICH INCLUDED THE USE OF ARITHMETIC AND FOR THOSE WHO DID NOT REPORT SUCH EMPLOYMENT

Distribution of Test Scores for Those Who Reported Employment Which Included the Use of Arithmetic

Test 4

	f
73-75	3
70-72	2
67-69	2
64-66	2
61-63	14
58-60	11
55-57	11
52-54	17
49-51	11
46-48	13
43-45	9
40-42	4
37-39	6
34-36	2
31-33	1
N =	108

Test 5

	f
73-75	3
70-72	4
67-69	7
64-66	
61-63	15
58-60	3
55-57	14
52-54	12
49-51	14
46-48	13
43-45	13
40-42	5
37-39	4
34-36	
31-33	1
N =	108

Test 6

	f
73-75	1
70-72	2
67-69	4
64-66	6
61-63	10
58-60	4
55-57	8
52-54	12
49-51	9
46-48	20
43-45	10
40-42	6
37-39	8
34-36	6
31-33	2
N =	108

Distribution of Test Scores for Those Who Reported no Employment

Test 4

	f
73-75	2
70-72	2
67-69	2
64-66	3
61-63	8
58-60	11
55-57	9
52-54	17
49-51	13
46-48	13
43-45	13
40-42	2
37-39	4
34-36	1
31-33	3
N =	103

Test 5

	f
69-71	1
66-68	2
63-65	3
60-62	3
57-59	13
54-56	7
51-53	11
48-50	11
45-50	28
42-44	13
39-41	5
36-38	4
33-35	1
30-32	1
N =	103

Test 6

	f
64-66	3
61-63	6
58-60	12
55-57	4
52-54	13
49-51	12
46-48	12
43-45	8
40-42	16
37-39	12
34-36	1
31-33	4
N =	103

DISTRIBUTION OF TEST SCORES FOR FRESHMEN WHO LIKED, FELT INDIFFERENT TOWARDS, AND DISLIKED ARITHMETIC

Distribution of Test Scores for Freshmen Who Liked Arithmetic

Test 4

	f
73-75	5
70-72	4
67-69	2
64-66	2
61-64	14
58-60	12
55-57	11
52-54	17
49-51	12
46-48	16
43-45	11
40-42	5
37-39	5
34-36	1
N =	117

Test 5

	f
73-75	3
70-72	4
67-69	7
64-66	3
61-63	14
58-60	6
55-57	20
52-54	7
49-51	16
46-48	17
43-45	11
40-42	7
37-39	2
N =	117

Test 6

	f
71-73	1
68-70	4
65-67	7
62-64	11
59-61	7
56-58	8
53-55	14
50-52	13
47-49	18
44-46	11
41-43	12
38-40	6
35-37	4
32-34	1
N =	117

Distribution of Test Scores for Freshmen Who Felt Indifferent Towards Arithmetic

Test 4

	f
68-70	1
65-67	2
62-64	2
59-61	5
56-58	2
53-55	5
50-52	2
47-49	2
44-46	3
41-43	1
38-30	1
35-37	1
N =	27

Test 5

	f
67-69	3
64-66	
61-63	2
58-60	1
55-57	2
52-54	5
49-51	2
46-48	2
43-45	7
40-43	1
37-39	2
N =	27

Test 6

	f
67-69	1
64-66	1
61-63	2
58-60	5
55-57	1
52-54	2
49-51	4
46-48	3
43-45	2
40-42	2
37-39	
34-36	4
N =	27

Distribution of Test Scores for Freshmen Who Disliked Arithmetic

Test 4

	f
70-72	1
67-69	
64-66	1
61-63	3
58-60	8
55-57	5
52-54	13
49-51	10
46-48	6
43-45	7
40-42	2
37-39	2
34-36	1
31-33	3
N =	62

Test 5

	f
63-65	1
60-62	1
57-59	1
54-56	7
51-53	8
48-50	9
45-47	14
42-44	9
39-41	6
36-38	4
33-35	1
30-32	1
N =	62

Test 6

	f
62-63	1
59-61	1
56-58	4
53-55	5
50-52	5
47-49	8
44-46	8
41-43	13
38-40	9
35-37	4
32-34	4
N =	62

DISTRIBUTION OF TEST SCORES FOR FRESHMEN WHO DID NOT EXPRESS NEED FOR A REFRESHER COURSE IN ARITHMETIC AND FOR THOSE WHO EXPRESSED A NEED

Distribution of Test Scores for Those Who did not Express Need for a Refresher Course in Arithmetic

Test 4

	f
73-75	5
70-72	4
67-69	3
64-66	1
61-63	11
58-60	8
55-57	4
52-54	13
49-51	7
46-48	8
43-45	7
40-42	4
37-39	6
N =	81

Test 5

	f
73-75	1
70-72	3
67-69	3
64-66	1
61-63	7
58-60	4
55-57	12
52-54	7
49-51	12
46-48	9
43-45	11
40-42	6
37-39	5
N =	81

Test 6

	f
70-72	2
67-69	1
64-66	4
61-63	7
58-60	8
55-57	8
52-54	10
49-51	5
46-48	10
43-45	8
40-42	9
37-39	6
34-36	2
31-33	1
N =	81

Distribution of Test Scores for Those Who Expressed a Need for a Refresher Course in Arithmetic

Test 4

	f
67-69	1
64-66	4
61-63	11
58-60	14
55-57	17
52-54	21
49-51	16
46-48	18
43-45	15
40-42	3
37-39	4
34-36	3
31-33	2
N =	129

Test 5

	f
72-74	2
69-71	2
66-68	6
63-65	7
60-62	6
57-59	9
54-56	10
51-53	17
48-50	12
45-47	36
42-44	11
39-41	6
36-38	3
33-35	
30-32	2
N =	129

Test 6

	f
73-75	1
70-72	
67-69	3
64-66	5
61-63	10
58-60	8
55-57	3
52-54	16
49-51	16
46-48	22
43-45	10
40-42	12
37-39	14
34-36	5
31-33	4
N =	129

BIBLIOGRAPHY

Books:

Bond, E. A., Professional Treatment of the Subject Matter of Arithmetic for Teacher-Training Institutions. Contributions to Education, No. 525. Bureau of Publications, Teachers College, Columbia University, New York, 1934.

Brueckner, L. J., and Grossnickle, F. E., How to Make Arithmetic Meaningful. John C. Winston Co., Philadelphia, 1947.

Robinson, Arthur E., The Professional Education of Elementary Teachers in the Field of Arithmetic. Contributions to Education, No. 672. Bureau of Publications, Teachers College, Columbia University, New York, 1936.

Spitzer, Herbert F., The Teaching of Arithmetic. Houghton Mifflin Co., Boston, 1948.

Thorndike, Edward L., The Psychology of Arithmetic. Macmillan Co., New York, 1922.

Touton, F. C., Karl, K., and Terry, E. J., Studies of Secondary School Graduates in Their Mastery of Certain Fundamental Processes. University of Southern California Studies, Second Series, No. 1, University of Southern California, Los Angeles, California, 1927.

Yearbooks:

Arithmetic in General Education. Sixteenth Yearbook of the National Council of Teachers of Mathematics. Bureau of Publications, Teachers College, Columbia University, New York, 1941.

Brownell, W. A., "Psychological Considerations in the Learning and the Teaching of Arithmetic." Teaching of Arithmetic. Tenth Yearbook of the National Council of Teachers of Mathematics, pp. 1-31. Bureau of Publications, Teachers College, Columbia University, New York, 1935.

Buckingham, B. R., "The Training of Teachers in Arithmetic." Report of the Society's Committee on Arithmetic. Twenty-ninth Yearbook of the National Society for the Study of Education, Part I, Chapter VI. University of Chicago Press, Chicago, 1930.

Curriculum Problems in Teaching Mathematics. Second Yearbook of the National Council of Teachers of Mathematics. Bureau of Publications, Teachers College, Columbia University, New York, 1927.

Grossnickle, F. E., "Training of Teachers of Arithmetic." The Teaching of Arithmetic. Fiftieth Yearbook of the National Society for the Study of Education, Part II, pp. 203-231. The University of Chicago Press, Chicago, 1951.

Judd, R. D., and Morton, R. L., "Current Practices in Teacher-Training Courses in Arithmetic." Teaching of Arithmetic. Tenth Yearbook of the National Council of Teachers of Mathematics, pp. 157-172. Bureau of Publications, Teachers College, Columbia University, New York, 1935.

Newsom, C. V., "Mathematical Background Needed by Teachers of Arithmetic." The Teaching of Arithmetic. Fiftieth Yearbook of the National Society for the Study of Education, Part II, pp. 232-250. The University of Chicago Press, Chicago, 1951.

Articles:

Arnold, H. J., "Computational Weaknesses of College Freshmen," American Association Collegiate Registrars Journal, XX (April, 1945), 367-382.

Bloom, B. S., and Broder, L. J., "Problem Solving Processes of College Students," Mathematics Teacher, XLIV (April, 1951), 250-252.

Bond, E. A., "Recent Changes in Point of View Relating to the Teaching of Arithmetic," Mathematics Teacher, XXX (April, 1937), 175-179.

Bowman, H. L., "A Technique for Determining the Relationship Between Reported Preference and Performance," Journal of Applied Psychology, XVI (August, 1932), 288-297.

Braverman, B., "Does a Year's Exposure to Algebra Improve a Pupil's Ability in Arithmetic?" Mathematics Teacher, XXXII (November, 1939), 301-312.

Brownell, W. A., "The Place of Meaning in the Teaching of Arithmetic," Elementary School Journal, XLVII (January, 1947), 256-265.

Brownell, W. A., "Trends in Primary Arithmetic," Childhood Education, XIII (March, 1937), 419-421.

Brownell, W. A., "When is Arithmetic Meaningful?" Journal of Educational Research, XXXIII (November, 1945), 481-498.

Brueckner, L. J., "Analysis of Difficulties in Decimals," Elementary School Journal, XXIX (September, 1929), 32-41.

Brueckner, L. J., "Functions of Instruction in Arithmetic," National Education Association Journal, XX (October, 1931), 239-241.

Buckingham, B. R., "Arithmetic as a Contribution to a Liberal Education," Elementary School Journal, XXXIX (April, 1939), 577-583.

Carson, T. E., and Wheeler, L. R., "Rehabilitation in Arithmetic with College Freshmen," Peabody Journal of Education, VIII (July, 1930), 24-27.

Christofferson, H. C., "Arithmetic and College Freshmen," Journal of Educational Research, XXI (January, 1930), 78-80.

Christofferson, H. C., "College Freshmen and Problem Solving in Arithmetic," Journal of Educational Research, XXI (January, 1930), 15-20.

Cooke, D. H., and Fields, C. L., "Relation of Arithmetical Ability to Achievement in Algebra and Geometry," Peabody Journal of Education, IX (May, 1932), 355-361.

Davis, R. A., and Road, E. J., "Remembering and Forgetting Arithmetical Abilities," Journal of Educational Psychology, XXXVIII (March, 1947), 216-222.

Dickey, J. W., "Arithmetic and Gestalt Psychology," Elementary School Journal, XXXIX (July, 1938), 46-54.

Drushel, J. A., "A Study of the Amount of Arithmetic at the Command of High School Graduates Who Have Had no Arithmetic in Their High School Course," Elementary School Journal, XVII (September, 1917), 657-661.

Dutton, W. H., "Attitude of Prospective Teachers Toward Arithmetic," Elementary School Journal, LII (October, 1951), 84-90.

Englehart, M. D., "The Relative Contribution of Certain Factors to Individual Differences in Arithmetical Problem Solving Ability," Journal of Experimental Education, I (September, 1932), 19-27.

Foberg, J. A., "Effect of Courses in the Teaching of Arithmetic Upon Arithmetic Skills," Journal of Educational Research, XXI (January, 1930), 74-76.

Glennon, V. J., "Study in Needed Redirection in the Preparation of Teachers of Arithmetic," Mathematics Teacher, XLII (December, 1949), 389-396.

Gortner, R. A., and Rogers, C. F., "Secondary Education, Arithmetic and College Science Students," School and Society, XLV (April, 1937), 545-546.

Guiler, W. S., "Computational Errors Made by Teachers of Arithmetic," Elementary School Journal, XXXIII (September, 1932), 51-58.

Guiler, W. S., "Difficulties Encountered in Percentage by Ninth-Grade Pupils," Elementary School Journal, XLVI (June, 1946), 563-573.

Guiler, W. S., "Difficulties Encountered by Ninth-Grade Pupils in Decimals," Elementary School Journal, XLVI (March, 1946), 384-393.

Guiler, W. S., "Difficulties Encountered in Percentage by College Freshmen," Journal of Educational Research, XL (October, 1946), 81-95.

Guiler, W. S., "Difficulties Encountered by College Freshmen in Fractions," Journal of Educational Research, XXXIX (October, 1945), 102-115.

Guiler, W. S., "Difficulties Encountered by College Freshmen in Decimals," Journal of Educational Research, XL (September, 1946), 1-13.

Guiler, W. S., "Computational Weaknesses of College Freshmen," American Association Collegiate Registrars Journal, XX (April, 1945), 367-382.

Guiler, W. S., and Hoffman, H. B., "Effect of Different Types of Mathematics Courses on Computational Ability," Educational Administration and Supervision, XXXIX (November, 1943), 449-456.

Habel, E. A., "Deficiencies of College Freshmen in Arithmetic: Diagnosis and Remedy," School Science and Mathematics, L (June, 1950), 480-484.

Keller, M. W., and Shreve, D. R., "Abilities of University Students in College Mathematics," School Science and Mathematics, XLII (January, 1942), 38-46.

Kinzer, J. R., and Fawcett, H. P., "Arithmetic Deficiency of College Chemistry Students," Educational Research Bulletin, XXV (May, 1946), 113-114.

Kinzer, J. R., and Kinzer, L. G., "College Chemistry Students Deficient in Arithmetic: Academic Data," Educational Research Bulletin, XXVII (January, 1948), 8-10.

Kinzer, J. R., and Kinzer, L. G., "College Chemistry Students Deficient in Arithmetic," Educational Research Bulletin, XXVIII (March, 1949), 74-76.

Lenore, J., "Difficulties in Solving Problems in Arithmetic," Elementary School Journal, XXXI (November, 1930), 202-215.

Lueck, W. R., "How Much Arithmetic and Algebra do Students of First Year College Physics Really Know?" School Science and Mathematics, XXXII (December, 1932), 998-1005.

Mayor, J. R., "Special Training for Teachers of Arithmetic," School Science and Mathematics, XLIX (October, 1949), 539-548.

Mohr, J. P., "Arithmetic Disabilities of Junior College Students," Education Digest, IX (September, 1943), 56-57.

Orleans, J. S., and Saxe, E., "How Much Commercial Arithmetic do Students in a Collegiate School of Business Know?" Journal of Business Education, XVI (September, 1940), 14-22.

Shuler, Caroline E., "The Professional Treatment of Freshmen Mathematics in Teachers Colleges," School Science and Mathematics, XXXVII (April, 1937), 464-472.

Stevens, B. A., "Problem Solving in Arithmetic," Journal of Educational Research, XXV (April-May, 1932), 253-260.

Stretch, L. B., "The Value and Limitations of Drill in Arithmetic," Childhood Education, II (June, 1935), 413-416.

Sueltz, B. A., "Recent Trends in Arithmetic," Mathematics Teacher, XXXIII (October, 1940), 270-275.

Sueltz, B., "Arithmetic in Teacher Training," Mathematics Teacher, XXV (February, 1932), 95-108.

Sutherland, John, "A Comparison of Pupils' Arithmetical Ability in the Secondary School with Their Ability at the Time of Their Transfer from Primary Schools," British Journal of Educational Psychology, XXI (April, 1951), 3-8.

Taylor, E. H., "Preparation of Teachers of Arithmetic in Teachers Colleges," Mathematics Teacher, XX (January, 1937), 10-14.

Volney, W. A., "A Study to Determine Whether Beginning Algebra Should be Taught in the Ninth or Tenth Grade," School and Society, XXXIII (October, 1931), 179-180.

Wakeham, G., "College Students can Learn Arithmetic," School and Society, LIII (April, 1941), 509.

Williams, Lewis W., "The Mathematics Needed in Freshmen Chemistry," School Science and Mathematics, XXI (October, 1921), 654-665.

Wilson, G. M., and Kite, M. B., "Arithmetic Deficiencies," Journal of Higher Education, XIV (March, 1943), 321-322.

Wolfe, J., "Mathematical Skills of College Freshmen in Topics Prerequisite to Trigonometry," Mathematics Teacher, XXXIV (October, 1941), 164-170.

Yorke, G. C., "Preparation Needed by Teachers of Arithmetic," Education, LXIX (February, 1949), 373-375.

Monographs:

Glennon, V. J., Testing Meanings in Arithmetic. Supplementary Educational Monographs, No. 70. Chicago: University of Chicago Press, 1949.

Wren, F. L., The Professional Preparation of Teachers of Arithmetic. Supplementary Educational Monographs, No. 66. Chicago: University of Chicago Press, 1948.

Dissertation:

Glennon, Vincent J., "A Study of the Growth and Mastery of Certain Basic Mathematical Understandings on Seven Educational Levels." Unpublished Doctor's Dissertation. Cambridge, Massachusetts: Graduate School of Education, Harvard University, 1948.