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A STUDY OF THE EFFECTIVENESS OF A MODIFIED LIBERAL ARTS MATHEMATICS COURSE IN THE MATHEMATICAL PREPARATION OF PROSPECTIVE ELEMENTARY TEACHERS

by

Sister Francetta Coughlin

A dissertation submitted in partial fulfillment
of the requirements for the degree of
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ABSTRACT

A STUDY OF THE EFFECTIVENESS OF A MODIFIED LIBERAL ARTS MATHEMATICS COURSE IN THE MATHEMATICAL PREPARATION OF PROSPECTIVE ELEMENTARY TEACHERS

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Problem

The purpose of this study was to investigate the effectiveness of a modified liberal arts mathematics course in the mathematical preparation of prospective elementary teachers. Three distinct courses were involved: A_1, a modified required liberal arts mathematics course; A_2, a regular required liberal arts mathematics course; B, a course designed specifically for prospective elementary teachers. The author taught four classes of A_1 and A_2 at Marygrove College in Detroit, Michigan. There were 39 students in A_1 and 74 students in A_2. Course B was taught to 196 students in six sections at Eastern Michigan University.

The effectiveness of these courses was measured on the following criteria: computational skill, understanding of fundamental concepts, and attitudes.

Procedure

The instruments used in this study were the mathematics fundamentals section of the 1957 edition of the California Mathematics Test by Tiegs and Clark, an Attitude Opinionnaire designed by Aiken and Dreger in 1957, and a Basic Concepts Test designed by James Howard Northey. The main statistical tools used were covariance analyses and a chi square test. The covariates used were SAT-quantitative scores, pre-computation scores, and pre-attitude scores. Covariance analyses

were carried out on A_1-B, A_2-B, and A_1-A_2. An investigation of the performance of the groups on the items of the basic concepts test was also carried out.

Results

(1) With post-computation as the dependent variable there were no significant differences between the adjusted means of any of the pairs of groups. (2) With basic concepts as the dependent variable, B and A_1 did significantly better than A_2. There was no significant difference between adjusted means of A_1 and B. (3) With post-attitude as the dependent variable, B did significantly better than either A_1 or A_2 while there was no significant difference between the adjusted means of A_1 and A_2.

Conclusions

The results of this study led the investigator to conclude the following:

(1) The modified liberal arts course was just as effective as the course designed specifically for prospective elementary teachers, judged by the students' mastery of fundamental mathematical concepts.

(2) Both the modified liberal arts course and the course designed specifically for prospective elementary teachers were significantly more effective than the regular liberal arts course in producing a mastery of fundamental mathematical concepts.

(3) All three courses were equally effective, judged on the basis of the computational skill of the students.

(4) The course designed specifically for prospective elementary teachers was significantly more effective in producing favorable attitudes toward mathematics than either of the other courses.

(5) The results of the study of the response to the items of the Basic Concepts Test showed that the students in the modified liberal arts course actually performed better than the students in either A_2 or B.

The first two conclusions indicate that it is not necessary for liberal arts colleges to introduce new courses provided they are willing to adapt existing courses.

Students in A_1 and A_2 were initially well matched on all variables. The fact that A_1 performed considerably better than A_2 on the Basic Concepts Test indicates that concepts which are to be mastered must be taught explicitly as well as implicitly. Therefore, liberal arts mathematics courses must be modified if they are to satisfy the needs of prospective elementary teachers.

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CHAPTER I

INTRODUCTION AND RESEARCH DESIGN

The tremendous 20th century expansion in the field of mathematics itself as well as new developments in the uses of mathematics is responsible, at least in part, for the searching scrutiny to which school mathematics programs have been subjected during the last fifteen or twenty years. Both the effectiveness of instruction and the appropriateness of course content have been objects of intense study by mathematicians, educators, and psychologists. As a result of this re-evaluation of school mathematics many changes have been made in content and method in mathematics programs. At the elementary school level, for example, new topics have been introduced, often from geometry and elementary number theory, and old topics such as numbers and numerals have been treated in greater depth. These changes are directed toward the development of greater mathematical understanding and power.

In order that the proposed improvements in mathematics education be implemented, it is essential that more and better prepared teachers be provided. These teachers must be mathematically competent, able to recognize suitable materials and techniques, and capable of teaching mathematics effectively. It is important, also, that they have positive attitudes toward the mathematics they teach. This vital

need for adequately prepared mathematics teachers is responsible for an increased concern with teacher education programs.

Though there is no agreement as to what constitutes the most effective preparation for prospective elementary teachers, some recommendations have been made. In 1948 the National Commission on Teacher Education and Professional Standards proposed that a course in general mathematics in college be required of all teachers (184). In 1959 the Commission on Mathematics of the College Entrance Examination Board recommended that three years of secondary mathematics comparable to that outlined in their report be required of all prospective elementary teachers (57). In 1960 the Committee on the Undergraduate Program in Mathematics (CUPM) of the Mathematics Association of America recommended at least two years of college preparatory mathematics, consisting of a year of algebra and a year of geometry, as a prerequisite for the college training of elementary school teachers. For their college training, the following courses were advised:

A. A two-course sequence devoted to the structure of the real number system and its subsystems;

B. A course devoted to the basic concepts of algebra;

C. A course in informal geometry (163).

Although the mathematics required in the pre-service preparation of elementary teachers has increased since 1960, there is still considerable evidence that the mathematical training of these prospective teachers is far below the minimum standards set by the CUPM.

Teacher training programs are a vital part of many diverse institutions; the large university, the teacher training school, and

the liberal arts college. This study concerns itself with teacher preparation in mathematics in the liberal arts college.

Because of the demands of general education requirements and because of the "liberal" rather than professional emphasis, liberal arts colleges find it especially difficult to implement recommendations such as those of the CUPM. Though these schools may have a mathematics course required of all freshmen, they often do not have a mathematics course designed for prospective elementary teachers. Even when they do have such a course it is unlikely that it will follow the recommendations of the CUPM. In a study made in 1965, John J. Fisher examined the types of courses required in pre-service training of prospective elementary teachers in 78 schools. Forty-two of 128 courses listed were of the foundations, appreciation, liberal arts type of course; 58 followed the CUPM recommendations (87).

Is it possible for liberal arts colleges, by modifying the regular required liberal arts mathematics course to provide for the mathematical preparation of elementary teachers? Research is needed on the problem of finding ways in which general education courses can be modified so that liberal arts colleges can provide adequate professional preparation for elementary teachers without neglecting the aims of liberal education.

The PROBLEM

The primary purpose of this study was to investigate the effectiveness of a modified liberal arts mathematics course in the mathematical preparation of prospective elementary teachers. A secondary aim was to measure the effectiveness of a regular liberal arts mathematics course, judged on the basis of the needs of elementary

teachers. It was hoped that the results of this investigation would provide a basis for making recommendations for improving the mathematics preparation of prospective elementary teachers in liberal arts colleges.

Three courses, differing in content, were involved in this investigation. One course, labeled A_1, was a modified form of a liberal arts mathematics course required of all freshmen at Marygrove College in Detroit, Michigan. The students in A_1 were those who expressed an interest in elementary education after they had registered for the required course. There were 39 students in A_1. A second course, labeled A_2, was the regular liberal arts mathematics course, entitled "An Analysis of Mathematical Thinking," required of all freshmen at this college. There were 74 students in A_2. The third course, labeled B, was a course designed specifically for prospective elementary teachers. This course followed the CUPM recommendations. The 196 students in B were prospective elementary teachers at Eastern Michigan University in Ypsilanti, Michigan. Because A_1 and A_2 were comprised entirely of girls while B contained some male students, it was deemed necessary to investigate the influence of sex differences on the results of the analyses. Therefore, B was partitioned into two subsets. B' was the subset of B consisting of the female students.

The effectiveness of these three courses was measured on the basis of the following criteria:

1. Skill in performing fundamental computations
2. Understanding of fundamental mathematical concepts
3. Attitudes toward mathematics

Objectives

The specific objectives of this study were to determine:

1. Which course, A_1 or B, was more effective
   (a) In enabling prospective elementary teachers to develop computational skill?
   (b) In enabling prospective elementary teachers to master fundamental mathematical concepts?
   (c) In fostering more positive attitudes toward mathematics?
2. Which course, A_2 or B, was more effective
   (a) In producing a mastery of computational skills?
   (b) In producing a mastery of fundatmental mathematical concepts?
   (c) In fostering more favorable attitudes toward mathematics?
3. Which course, A_1 or A_2, was more effective
   (a) In producing a mastery of computational skills?
   (b) In producing a mastery of fundamental mathematical concepts?
   (c) In fostering more favorable attitudes toward mathematics?

Significance of the Study

This problem is educationally significant for three reasons:

1. Evidence which indicates feasible ways for the liberal arts college to provide a better mathematics program for prospective elementary teachers is of value to the individual mathematics department as well as to mathematics education itself.

2. Any insight related to valid ways of retaining the general education course without neglecting professional education is of value to a liberal arts college engaged in teacher training.

3. There is some evidence that positive attitudes toward mathematics correlate with the acquiring of mathematical understanding. Any evidence as to what type of course fosters positive attitudes is valuable to mathematics educators.

RESEARCH DESIGN

Procedure

The instructor at Marygrove College taught four classes of approximately 30 students each during the school year 1967-1968. Each class met four times a week for 75 minutes each day for 10½ weeks. Since A_1 and A_2 were liberal arts courses the emphasis was placed on mathematics as a way of knowing rather than on specific mathematical content to be mastered. This is not to say that content was not important. For three of the four days each week students in A_1 and A_2 were not separated. The course content for A_1 and A_2 was the same for both groups on these three days. It consisted of a brief introduction to mathematics as a way of knowing, material on logic, and selected topics from Mathematics: The Man-Made Universe[1] by Stein.

During the fourth class each week, courses A_1 and A_2 differed from each other. The content for A_1 during this fourth class period consisted of topics which were included in course B and recommended for elementary teachers. The material was selected from Theory of Arithmetic by Peterson and Hashisaki and was not included in the regular liberal arts course.

The content for A_2 during this fourth class period each week consisted of additional topics from the text by Stein as well as a

[1]Sherman K. Stein, Mathematics: The Man-Made Universe (San Francisco and London: W. H. Freeman and Company, 1963).

more extensive treatment of some of the topics which A_2 had in common with A_1.

Six sections of course B were taught by James Northey at Eastern Michigan University in Ypsilanti, Michigan during the spring semester of 1966. The content for this course consisted of material selected from Theory of Arithmetic by Peterson and Hashisaki.

A detailed outline of the course content for A_1 and A_2 is contained in the Appendices.

Data and Instrumentation

The following data were collected for each of the students in A_1 and A_2. The abbreviations given here will be used throughout the following pages.

1. SHSM - number of semesters of high school mathematics completed
2. GPA - high school grade point average
3. SATQ - Scholastic Aptitude Test - Quantitative Score
4. SATV - Scholastic Aptitude Test - Verbal Score
5. PrecompS - Pre-computation score
6. PreattS - Pre-attitude score
7. PostcompS - Post-computation score
8. PostattS - Post-attitude score
9. BCTS - Basic Concepts Test score
10. RICT - Response to Items of Basic Concepts Test

SHSM, GPA, SATQ, and SATV were obtained from high school records for the two groups A_1 and A_2 but not for B. Items 1-9 above were obtained for the students in B from tables in the dissertation of James Howard Northey (190). Item 10 and the sex of each student

were obtained from Dr. Northey himself. Since Dr. Northey had used the School and College Aptitude Test (SCAT) scores in his study, these scores were converted to SAT scores by means of a conversion table constructed by the Guidance and Testing Office of Eastern Michigan University These data are tabulated in the Appendices for A_1 and A_2.

Computation Test

The computational skills test used in this study was the mathematics fundamentals section of the 1957 edition of the California Mathematics Test by E. W. Tiegs and W. W. Clark. Form W was given at the beginning of each term and Form X was administered at the end of the term, just prior to the final examination for the course.

Basic Concepts Test

The Basic Concepts Test used was designed and analyzed by James Howard Northey for use in his study. It contains 50 multiple-choice questions which test the material he covered in his course from Theory of Arithmetic. In his judgment and that of other experts, a mastery of this material is essential to the adequate preparation of prospective elementary teachers. A copy of this test is contained in the Appendices.

Attitude Opinionnaire

The attitude opinionnaire used in this study was designed by L. R. Aiken and R. M. Dreger in 1957 and revised in 1963. It contains 20 items, some positive and some negative, which express attitudes toward mathematics. The five responses range from "strongly agree" to "strongly disagree." The scores for an item range from 5 to 1 making 100 the maximum score and 20 the minimum score. A copy of this opinionnaire is contained in the Appendices.

Statistical Procedures

Means and standard deviations were computed for A_1, A_2, B, and B' on each pre- and post-variable. Correlation coefficients between all pairs of variables were computed for each group in order to aid in determining the covariates. The main analysis tools were the analysis of covariance with multiple covariates and a chi square test. The covariance analyses were one-way with one or two covariates. The covariates used were SATQ, PrecompS, PreattS, and the multiple covariates, SATQ-PrecompS. The dependent variables were PostcompS, PostattS, and BCTS.

In order to compare the performance of A_1 with B, A_2 with B, and A_1 with A_2 on the 50 items of the Basic Concepts Test a chi-square analysis was computed. For a two by two table this chi-square test is equivalent to a test of the significance of the differences in proportions or percentages correct on each item. It was hoped that this table would enable the investigator to identify content on which one group did consistently better than the other.

CHAPTER II

RELATED LITERATURE

This chapter is divided into three sections. The first section contains a review of the literature on teacher education in liberal arts colleges. The second section contains a survey of the literature on the mathematical preparation of prospective elementary teachers. In the third section the literature concerned with studies of the mathematical understanding and attitudes of prospective elementary teachers is reviewed.

TEACHER EDUCATION IN LIBERAL ARTS COLLEGES

There is little argument about the importance of a liberal arts background for prospective elementary teachers, but there is a long history of argument related to the responsibility of the liberal arts college to provide a teacher education program as well as the means for insuring the adequacy of such a program once it has been provided.

The literature contains much evidence of the controversy over the place of teacher education in a liberal arts college. This controversy has its roots in the quarrel which has long existed between academic and education professors. In fact, Perel and Vairo claim,

> It is indeed one of the tragedies of American higher education that liberal arts and teacher education faculties have not been able to

> communicate, or at least have a tolerant understanding of each others' goals (198: 470).

Conant says that while certain campuses may be free from actual hostility between academicians and educationists, there has always been a wide gap between these two groups of professors in most institutions. He describes this quarrel as a "power struggle" and claims that it has not been fought on the grounds of factual evidence or theoretical speculation (58). Robb refers to the "rancorous old feud between teachers' colleges and liberal arts colleges" (223).

Academic professors contend that the courses offered by their colleagues in education are worthless and they resent the fact that education professors claim to be the only ones who know what good teaching is. More recently, state certification requirements have intensified this hostility on the part of the academic professors. These academicians hold that the educationists have a built-in clientele because of these requirements (58).

According to Hill, the liberalists consider their courses to be of professional benefit but not vice-versa. These scholars consider education courses to be merely "how-to," rule-book gimmicks which consume as much as one-third of the undergraduate's time (121). On the other hand, Henderson says that the educationists contend that the prospective teacher does not get what is advertised in liberal arts courses. They claim that the needs of the research scholar dominate the curriculum design and that these needs are poles away from those of the school teacher (117). According to Brender, those who espouse the liberal arts curriculum hold that professional schools place undue emphasis on pedagogical techniques while slighting the

content of the subject the student is preparing to teach. Some of these devotees of the arts even contend that the quality of teaching in content areas is inferior in professional schools. The defenders of the view that teacher training is best accomplished in normal schools and schools of education hold that mastery of method and technique is at least as important as mastery of content (25).

These diverse points of view have resulted in a rift between liberal arts and education sufficiently serious to alienate the department of education from other departments on many college campuses. For many years, according to L. J. Stiles, prospective teachers have suffered from the effects of this conflict. Colleges ignored the need for liberally educated elementary teachers, and graduates of liberal arts schools "fell" into secondary teaching with little professional orientation and little attention paid to their role in the classroom. Normal schools and teachers' colleges were set up as separate institutions and prospective teachers were often denied the right to study under scholars in the liberal arts. This abdication on the part of liberal arts schools of any control over teacher education has been responsible for an under-emphasis on the subject matter fields in the training of teachers and for a lessening of respect for teaching in general (247).

Despite these opposing views on the place of teacher education in liberal arts colleges and despite the fact that one almost never reads about the role of the department of education in a liberal arts catalog, statistics show that the vast majority of arts colleges do provide teacher education programs (270). Paul Reinert says that one gets the impression that liberal arts colleges get into the

business of "training teachers" because it attracts students but that they do it rather reluctantly and shamefacedly (213). However reluctant they may be, the fact remains that student demand has forced liberal arts colleges to add teacher education programs to their offerings as an essential condition of survival.

This existential fact has forced liberal arts colleges to begin to examine ways in which liberal education can be adapted to produce effective elementary and secondary teachers (213). The editor of Liberal Education rejoices that this dialog is getting under way, even though haltingly. He claims, however, that before it can become a "love feast," questions must be raised. He proposes, for a start, the following,

> How can we design a liberal arts program for teachers which will be an intensive and exciting intellectual experience? (289:479)

Though much more research is needed in order to answer this question satisfactorily, the literature contains evidence that some studies have been conducted and recommendations made.

Among these one finds attempts to decrease the autonomy of the education department. The education faculty at Adelphi College concluded that since each department is affected by the total college, it is imperative that the education faculty take an active part in everything which concerns the development of the college (2). For many years Marylhurst College in Oregon, 40% of whose 650 students are in education, had a normal school which was completely separate from the liberal arts junior college even though both were on the same campus. Even after a four-year program was introduced at the college, faculty and students considered the teacher education

curriculum one for the less able students and prospective teachers were not granted a liberal arts degree. Finally, in 1962, the preparation of teachers became the function of the entire faculty of the liberal arts college and prospective teachers were admitted to the liberal arts program (155).

Other studies have led to suggestions for the revision of curriculum. While elementary teachers are expected to teach mathematics, general science, social studies, and language arts, few colleges provide appropriate courses in these areas. In mathematics, for example, one must ask whether the usual freshman and sophomore courses, with their enrollment dominated by science and engineering majors, are appropriate for prospective elementary teachers (198). According to Perel and Vairo, in addition to giving prospective teachers a liberal education, there must be some discussion of the best way to instruct them in the subjects they will be expected to teach (198).

William Cartwright believes that liberal arts colleges must make teacher education one of their specific purposes. He claims that not every program in a given area is appropriate for the prospective teacher and that, therefore, the colleges must provide a program of specialization. According to him, the freedom of arts schools is an asset in the achieving of this goal (47).

Thomas Carter recognizes that divergent mathematical needs cannot dictate the content of a liberal arts mathematics course but, he says, neither should the course be a limitation on the career needs of the student (46). A study conducted by E. Leverett of 140 colleges, almost all of them liberal arts, showed that only 29% of them had any specific requirement in mathematics (153). Ulmer quotes

a study of 91 colleges reporting a general education program. Only 46 of them required any mathematics. He concluded that research is needed to design suitable curricula for small colleges (267).

Marion Clark wonders what one can hope to achieve while there is no agreement on either objectives or content. She says that as a result of a survey made by Kenneth E. Brown, he suggests that the way in which content is presented may be more important than the way in which topics are selected. After an analysis of the content of several liberal arts courses she reported that in 13 colleges with courses for the non-specialist, 9 different texts were used. She points out that the absence of a single suitable text indicates the disagreement as to what constitutes appropriate content (53).

A. L. Nelson conducted a study of selected church-related liberal arts colleges. He proposed to evaluate the effectiveness of general education curricula for elementary and secondary teachers. He reported that instructors favored de-emphasizing a vocational orientation in the general education courses. On the other hand, according to Nelson, the students favored a plan in which general education courses could be utilized to meet vocational needs (186).

In summary, the controversy over the place of teacher education in a liberal arts college is one of long standing and the approach of such colleges to the provision of adequate teacher training programs is often one of reluctant acquiescence to legal requirements for certification (117). Nevertheless, it is a fact that the majority of such colleges do offer teacher preparation programs. It is also a fact, according to Cartwright, that 32% of the teachers in the country come from liberal arts colleges (47). Therefore, teacher education is

an essential function of the liberal arts college and the question of how to design a program for teachers which will achieve both liberal and professional objectives is a vital one. Research which will help insure that this function be carried out effectively is not only useful but necessary. This study investigated one facet of this larger problem. It attempted to measure the effectiveness of a required liberal arts mathematics course adapted for prospective elementary teachers.

MATHEMATICAL PREPARATION OF ELEMENTARY TEACHERS

The previous section contains a review of the literature related to the responsibility of the liberal arts college to provide adequate teacher education programs. Since the present study was concerned specifically with the mathematical preparation of elementary teachers in such colleges, the next section contains a review of the literature related to the mathematical preparation of prospective elementary teachers. First, literature dealing with certification requirements and the preparation of these future teachers is summarized. Then the literature which contains recommendations for improving these preparation programs and the extent to which some of these recommendations have been implemented is reviewed.

Until recently mathematics was one of the most neglected areas in the preparation of elementary teachers. Much evidence of this neglect is available. A study made by Layton in 1950 of 85 institutions which prepare teachers showed that only one-fourth of them required mathematics for entrance. Mathematics requirements were far below those of other content areas studied (150). In a second study of the requirements of 48 states, Layton found that not

more than 11 states required any mathematics for certification and none of these required more than five hours (148). Layton conducted still another study of 150 colleges in order to survey the mathematical requirements of colleges which have a general education program. He stated several conclusions concerning the 91 colleges which had such a program:

(1) 74 of the 91 required that the education candidate enroll in the general education program.

(2) 46 of the 91 required some mathematics in this program.

(3) General mathematics was the most frequently required and most highly recommended course for this program.

(4) 1.97 semester hours was the mean mathematical requirement (149).

In 1952 a study of 62 institutions showed that 22 of them required no mathematics for prospective teachers. The researcher, Joseph Stepanowich, concluded that his study supported the claim that many institutions are not preparing teachers adequately (245).

Two studies made by Grossnickle attest to the inadequacy of the mathematical preparation of prospective teachers. In 1951 he reported that one out of 62 departments of education that he sampled required a course in background mathematics and 12 required a course in the teaching of arithmetic (102). The results of a study which Grossnickle made 5 years later showed that 41% of 209 institutions sampled required some mathematics in the program for elementary teachers. This was more apt to be a requirement in teachers' colleges than in departments of education in liberal arts colleges or in schools of education in universities (274).

Wilbur Waggoner quotes a publication of the Educational Testing Service, "Problems of Mathematical Education."

> In the majority of cases an individual with ambition to teach in an elementary school can matriculate without showing any high school mathematics on his record. He can graduate without studying college mathematics (272:84).

Though this situation has been remedied to some extent, as late as 1958 the University of Maryland required no mathematics of its prospective elementary teachers (93).

In the 1960 yearbook of the National Council of Teachers of Mathematics, Ruddell, Dutton, and Rechzeh propose that because of the great demand for good mathematical background for elementary teachers, one might expect to find institutions of higher learning offering courses to fulfill this need. But according to them this is not the case. They write that, "Research studies show alarming inadequacies in background courses in arithmetic for prospective teachers" (225: 297).

Less than 3 years ago a poll of 25 leaders in mathematics education showed that the improvement of pre-service mathematics training for elementary teachers is one of the most essential factors for improving mathematics programs in the schools (165). John J. Fisher claims that in 1965 the mathematics preparation of elementary teachers in the United States was still far below the minimum standards set by the Committee on the Undergraduate Program in Mathematics (88).

The fact that for many years the mathematical preparation of elementary teachers was grossly inadequate is true in spite of strong and frequent recommendations for remedying the situation. In 1947 in

its Guidance Report, the Commission on Postwar Plans of the National Council of Teachers of Mathematics, recommended that requirements for elementary teachers include two courses in mathematics subject matter and one good methods course (104). In 1948, after noting the lack of agreement as to what constitutes the most effective training for prospective teachers, the National Commission on Teacher Education and Professional Standards proposed that a course in general mathematics at the college level be required of all teachers (183). In 1951 Newsom recommended a minimum requirement of three hours in mathematics and a course in the teaching of arithmetic (189).

In 1956 after he conducted a study of his own and examined the results of other studies, J. F. Weaver concluded that the level of understanding of arithmetic teachers was sufficiently low to demand immediate corrective measures. He recommended that a mathematics course designed to meet the needs of these future teachers be required of them. He insisted that the content of such a course be mathematics appropriate to the needs of these teachers and that the emphasis be placed on understanding (274). In the 25th Yearbook of the National Council of Teachers of Mathematics, published in 1960, Ruddell, Dutton, and Reckzeh insist that a

> . . . careful preparation of prospective teachers in mathematics subject matter is an essential prerequisite to an improved program in arithmetic in the elementary schools (225:297).

They recommended a minimum of six hours in mathematics for elementary teachers (225).

In its Report of 1959 the Commission on Mathematics of the College Entrance Examination Board (CEEB) insisted that all mathematical

instruction rests on the foundation laid in the elementary school. Because of this, the Commission felt obliged to comment on the preparation of elementary teachers. They recommended that at least three years of secondary mathematics be required of all prospective elementary teachers. This minimum requirement might be required for admission by colleges or it could be taught as part of the college curriculum. The Commission further recommended that additional work in college mathematics was highly desirable (57).

Because of its deep concern with the preparation of prospective teachers the Committee on the Undergraduate Program in Mathematics established its Panel on Teacher Training. In December of 1960 the original recommendations of the Panel were published in the American Mathematical Monthly. A month later CUPM published a reprint of this article, called Recommendations for the Training of Teachers of Mathematics. Here are the Panel's recommendations for Level I:

> As a prerequisite for the college training of elementary school teachers, we recommend at least two years of college preparatory mathematics, consisting of a year of algebra and a year of geometry, or the same material in integrated courses. It must also be assured that these teachers are competent in the basic techniques of arithmetic. The exact length of the training program will depend on the strength of their preparation. For their college training, we recommend the equivalent of the following courses:
>
> (A) A two-course sequence devoted to the structure of the real number system and its subsystems.
>
> (B) A course devoted to the basic concepts of algebra.
>
> (C) A course in informal geometry (163:3).

Though the recommendations of the Committee on the Undergraduate Program in Mathematics have, on occasion, been called "absurd and unrealistic" (208), they have been strongly endorsed by large groups

of elementary teachers (109) as well as by officials responsible for elementary teacher training (88). Gail S. Young believes that not only are they "not revolutionary" but simply the barest minimum necessary for teaching in the elementary school (296).

In spite of enthusiastic verbal endorsement, however, colleges and universities are implementing these recommendations more slowly than one would wish. In 1962-63 the Central Office of the Committee on the Undergraduate Program in Mathematics conducted a study of the requirements and offerings in mathematics provided in elementary teacher training programs in 906 colleges and universities. Of the 906 schools sampled, 762 submitted usable responses. The findings are summarized below:

Of the 762 colleges and universities

22.4% require no mathematics of elementary teachers

68.9% require 4 or fewer hours

55.6% offer no courses specifically designed for elementary teachers

In many colleges, elementary algebra or elementary trigonometry were the only courses available to these students (109).

In 1966 the Committee on the Undergraduate Program in Mathematics made another study of the preparation of elementary teachers and compared this second survey with that made in 1962. This time the Committee on the Undergraduate Program in Mathematics canvassed 911 colleges and received usable responses from 887. The findings of this survey are as follows:

Colleges requiring no mathematics of prospective teachers dropped from 22.4% to 8.1%.

50.1% require 5 or more semester hours as compared with 31.8% in 1962 (163).

The Committee on the Undergraduate Program in Mathematics commented that there was progress in the area of Level I courses but the progress was slow and there was some backsliding. The Commission added that the findings justify encouragement but not complacency (163).

In 1966, Fisher also surveyed the extent of implementation of the Committee on the Undergraduate Program in Mathematics recommendations. He analyzed the usable material returned by 78 of the 117 colleges he sampled randomly. The findings of this study are below:

> In 1960 more than one-half of the institutions required no mathematics for elementary teachers.
>
> In 1965 one-sixth of the institutions required no mathematics of elementary teachers.
>
> Of the 128 mathematics courses offered in these institutions, 58 were of the Committee on the Undergraduate Program in Mathematics type and 48 of the liberal, appreciation, foundations type. The rest were traditional college courses.

Fisher concluded that though the mathematical preparation of elementary teachers was still deficient in 1965, there was evidence of progress since 1960. The increase took place primarily in courses in the structure of the real number system; little attention was paid to algebra and geometry for elementary teachers. He reports that there is little evidence of the kind of positive action which he believes is called for (88).

The dire inadequacy of the mathematical preparation of prospective elementary teachers and the wide gap which exists between recommendations for improving preparation and the implementation of these recommendations point to the need for investigating ways of incorporating some of these proposals into teacher preparation programs. This study proposed to evaluate the effectiveness of one such attempt.

STUDIES OF UNDERSTANDINGS AND ATTITUDES OF PROSPECTIVE ELEMENTARY TEACHERS

In the previous section the literature dealing with the mathematical preparation of elementary teachers, the recommendations for improving this preparation, and the implementation of these recommendations was reviewed. This section deals with studies of understanding of mathematical concepts and attitudes toward mathematics of prospective elementary teachers.

In an attempt to measure the growth and mastery of basic mathematical understandings possessed by teachers' college freshmen, seniors, and in-service teachers, Glennon administered a test of understandings basic to grades 1 through 6 to 476 persons. He found that freshmen understood 44% of the mathematics tested while seniors understood only 43% of the same material (96). Another attempt to measure teachers' understandings, attitudes, and need for improvement was conducted in 1959 by John Bean under the sponsorship of the Utah Education Research Council. The instrument used to measure understandings was Glennon's Test of Basic Mathematical Understandings. The teachers' scores on the 80-item test ranged from 18-78. The mean score was 52.46. The study indicated that as teachers gain experience there is a small increase in their understanding of arithmetic. The author concluded that there was a need for a basic course in arithmetic and methods (15).

James Northey conducted a study of a single pre-service mathematics course for 196 elementary teachers at Eastern University. He found that success in the course, as he outlined it, was directly related to the amount of high school algebra studied. He concluded also that, when prospective elementary teachers compete among themselves,

students with less than a year of high school algebra and geometry can do about as well as those who have had a year of each, in a course which stresses the number systems and not geometry (190). He learned that while students understand many basic concepts, they often cling to traditional methods and mechanical procedures when attempting to explain them. For example, they tend to explain the partial product in multiplication, the placement of quotient figures in long division, and the placement of decimal points in a purely mechanical fashion. He found also that attitudes improve as understanding increases and that one course was sufficient to bring about much progress in understanding (80). Dutton also states that evaluation of teacher understandings of arithmetical concepts is related to pupil understanding of these concepts (77).

Forty-one beginning teachers from six suburban Philadelphia school districts were studied by Ruth Melson. These 1963 graduates from 17 colleges and universities in 7 states were tested on 33 items from the arithmetic content of grades 1 through 6. The median score was 12. The author concluded that most teachers are not adequately prepared to teach arithmetic (167). Frank Smith administered Ruth Melson's test, pre and post, to 80 education majors. Only 8% scored above 75% on the pre-test while 45% scored above 75% after a one-semester course. He concluded that there was no reason to say that those who completed the mathematics course displayed a lack of mastery of the content (240).

Melvin Withnell conducted a study of 2,513 students to investigate the relative effectiveness, as measured by understanding of concepts from arithmetic, algebra, and geometry, of three different

requirements for prospective elementary teachers. Groups 1, 2, and 3 were required to take 3, 6, and 9 hours, respectively, of course work in mathematics for prospective teachers. The test items were classified as basic or related. Satisfactory preparation was defined to be a correct response to at least 75% of the 24 basic items on the test. He found that the average achievement for the three groups was less than 60%. He concluded that, judged by his criterion, colleges are not satisfactorily preparing prospective elementary teachers in mathematics (284).

It would seem that students who do well in school might be expected to express satisfaction when they are questioned about their school experiences. But, although objective measurement of attitudes toward elementary school subjects is noticeably lacking (79), there do exist some studies which show, quite consistently, that the correlation between attitudes toward and achievement in mathematics is low (69, 129, 161).

In a study 292 sixth graders responded to two questionnaires which assessed attitudes. These questionnaires were a revision of Jackson and Getzel's questionnaire and The Michigan Student Questionnaire. Intelligence Quotient, achievement test scores, and course grades were obtained. The author found very low correlation between attitudes and achievement and no difference between the sexes (130). A study by O'Donnell showed a low correlation between arithmetic achievement and measured attitudes (192). Aiken and Dreger reported that the hypothesis of a significant contribution of mathematical attitudes to the prediction of achievement is borne out for females but not for males (3). From her study of achievement and attitudes

of sixth graders, Ann Hungerman concluded that there is a relationship between attitudes and achievement but not a strong one (125).

Wesley Lyda conducted a study to investigate the role of attitude in arithmetic achievement. He administered the Dutton Arithmetic Attitude Scale, the Stanford Arithmetic Achievement Test, and the Otis Quick Scoring Mental Ability Test to one section of fourth graders at the Peach County Training School, Fort Valley, Georgia. The mean Intelligence Quotient was 92 and the Intelligence Quotient range was 73-124. After 21 instructional periods of 40 minutes each, the three tests were repeated. He concluded:

> (1) That attitudes do change when the methods used in teaching arithmetic are meaningful;
>
> (2) That significant gains in arithmetic achievement are associated with the use of meaningful teaching methods and attitude changes (157).

In addition to showing quite consistently that the correlation between attitudes and achievement is not significant, attitude studies point out the importance of attitudes for students preparing to teach arithmetic. A study of prospective teachers made by Dutton revealed that while students develop feelings toward arithmetic in all grades, the most crucial time is in grades 3 through 6 and junior high school. Dutton also found that the main reasons for unfavorable attitudes on the part of students are lack of understanding and inadequacy on the part of teachers (79). Because he suspected that attitudes are important in learning experiences, Dutton conducted a study of the attitudes of 211 students enrolled in 3 elementary-curriculum methods courses at the University of California. He asked the students to put into writing the most important favorable and unfavorable attitudes they had toward mathematics. He reports that the

first significant discernible factor in the data was the tremendous outpouring of unfavorable attitudes toward arithmetic. Seventy-four per cent of all responses were unfavorable. The most frequently mentioned reasons were lack of understanding, boring drill, poor teaching, pages of word problems, and fear of making mistakes. Dutton reports that the students' statements were so emotionally charged that they would influence the learning of methods for teaching arithmetic for a large part of the class (76).

A comparison of Dutton's results with those of a study of prospective teachers made 10 years later by Frank Smith revealed that while the attitudes of the second group were more favorable than those of Dutton's group, still too many prospective teachers had negative attitudes toward arithmetic (241). In 1956 the Educational Testing Service (ETS) carried out a study to analyze the reasons why so many students who do not avoid mathematics entirely either fail or barely make the grade. The answer the study provided was brief--poor teaching. ETS then assumed that poor teaching is due, in large part, to inadequate background (31).

Most of the studies reported here show that many prospective elementary teachers are deficient in the understanding of fundamental mathematical concepts and that many of these teachers respond unfavorably toward mathematics. It is evident that improvement in both understanding and attitude is needed. The present study is an attempt to help bring about some improvement in these two areas. It is concerned with evaluating the effectiveness, as measured by attitudes, computational skill, and basic understandings, of a required liberal arts course adapted for prospective elementary teachers.

SUMMARY

In summarizing the literature concerned with teacher preparation programs in liberal arts colleges, one is forced to admit that liberal arts and education people have contended against each other for many years. Nevertheless, because of student pressure, it is a fact that most liberal arts colleges do offer teacher education programs. But, because of the bias of these colleges, their education programs are often professionally inadequate. It is necessary, therefore, that research be carried out directed toward finding ways of adapting liberal arts programs in order to provide adequately for prospective elementary teachers.

The literature concerned with the mathematical preparation of elementary teachers contains evidence that, until recently, state certification requirements and college or university requirements seriously neglected mathematics. This neglect existed despite the fact that those interested in the improvement of mathematics teaching consistently submitted strong recommendations concerned with the mathematics needed to prepare elementary teachers adequately. Though some progress toward the implementation of the recommendations has been made, there is still much to be desired. Research which will help colleges and universities remedy this unfortunate situation is needed.

Most of the studies in the literature related to mathematical understandings and attitudes on the part of prospective elementary teachers support the following:

> Many prospective elementary teachers do not possess an adequate understanding of fundamental mathematical concepts.

Many prospective elementary teachers respond unfavorably toward mathematics.

The correlation between attitudes and achievement in mathematics is low.

Attempts to design courses which will increase the understanding of basic mathematical concepts and improve attitudes on the part of prospective elementary teachers are needed.

CHAPTER III

ANALYSIS OF DATA

This chapter is concerned primarily with the presentation and analysis of data. In the introductory section of the chapter fundamental data for each of the pre- and post-variables for the four groups, A_1, A_2, B, and B', are tabulated. The second section contains the results of the analyses of covariance for the criterion measures related to achievement, that is, PostcompS and BCTS, for A_1-B, A_2-B, A_1-A_2, A_1-B' and A_2-B'. The third section contains the results of the analyses of covariance for the criterion measure PostattS for each of the five pairs of groups. The fourth section contains a comparison of the five pairs of groups based on their performance on the items of the Basic Concepts Test.

INTRODUCTION

First, tables of the means and standard deviations for each of the pre- and post-variables were constructed for A_1, A_2, B, and B'. These data are contained in Table 1. Next, tables of the pair-wise correlations between all pre- and post-variables were constructed for A_1, A_2, B, and B'. These are reported in Tables 2, 3, 4, and 5. An examination of the tables of correlations reveals that the measure PreattS correlates most highly with the criterion measure PostattS, and that SATQ and PrecompS correlate, in general, most highly with the other two criterion measures, PostcompS and BCTS. The correlations

Table 1

MEANS, STANDARD DEVIATIONS, AND HIGHEST POSSIBLE SCORES ON THE PRE- AND POST-VARIABLES FOR A_1, A_2, B, AND B'

Measure		A_1	A_2	B	B'	Highest Possible Score
SHSM	Mean	6.91	7.0	5.27	5.28	9
	S.D.	1.19	1.29	1.68	1.67	
SATQ	Mean	537.11	545.56	456.29	456.55	800
	S.D.	66.18	81.98	77.44	81.43	
SATV	Mean	527.05	546.06	451.76	454.40	800
	S.D.	84.43	94.37	77.26	77.74	
PreattS	Mean	68.51	67.86	62.77	63.01	100
	S.D.	18.37	19.71	20.48	20.72	
PrecompS	Mean	71.62	71.90	65.35	65.29	80
	S.D.	5.59	6.57	10.05	10.28	
GPA	Mean	2.02	2.14	2.99	2.91	1.0
	S.D.	1.04	0.96	1.08	1.04	
PostattS	Mean	66.42	65.86	65.66	65.97	100
	S.D.	19.36	17.81	19.71	19.96	
PostcompS	Mean	72.68	73.60	68.26	68.34	80
	S.D.	5.15	6.11	9.34	9.48	
BCTS	Mean	36.8	33.06	33.43	33.55	50
	S.D.	5.86	6.91	8.14	8.03	

between SATV and the post-measures were low just as they were in Dr. Northey's study. The correlations involving GPA were not high and many of them were negative. The fact that the students came from such a variety of high schools might indicate that this measure is less standardized and objective and, therefore, less reliable than the other measures. It is interesting to note that the correlations involving SHSM were low for A_1 and A_2 but fairly high for B and B'.

Table 2

CORRELATION TABLE FOR INITIAL AND FINAL VARIABLES FOR A_1

	SHSM	SATQ	SATV	PreattS	PrecompS	GPA	PostattS	PostcompS	BCTS
SHSM	1.000								
SATQ	-.078	1.000							
SATV	-.285	.439	1.000						
PreattS	.635	.249	-.189	1.000					
PrecompS	.069	.174	-.065	.286	1.000				
GPA	.049	.335	-.311	-.186	-.204	1.000			
PostattS	.399	.313	.008	.744	.438	-.430	1.000		
PostcompS	.214	.122	.018	.392	.438	-.178	.326	1.000	
BCTS	.186	.252	.325	.301	.315	-.364	.555	.400	1.000

Table 3

CORRELATION TABLE FOR INITIAL AND FINAL VARIABLES FOR A_2

	SHSM	SATQ	SATV	PreattS	PrecompS	GPA	PostattS	PostcompS	BCTS
SHSM	1.000								
SATQ	.025	1.000							
SATV	-.164	.557	1.000						
PreattS	.393	.228	-.195	1.000					
PrecompS	.170	.497	.241	.250	1.000				
GPA	-.077	-.245	-.140	-.152	-.529	1.000			
PostattS	.388	.270	-.079	.760	.322	-.057	1.000		
PostcompS	.173	.265	-.035	.329	.617	-.328	.324	1.000	
BCTS	.292	.380	.210	.367	.537	-.442	.496	.477	1.000

Table 4

CORRELATION TABLE FOR INITIAL AND FINAL VARIABLES FOR B

	SHSM	SATQ	SATV	PreattS	PrecompS	GPA	PostattS	PostcompS	BCTS
SHSM	1.000								
SATQ	.556	1.000							
SATV	.074	.398	1.000						
PreattS	.653	.513	-.041	1.000					
PrecompS	.601	.611	.245	.516	1.000				
GPA	-.198	.377	-.269	-.238	-.415	1.000			
PostattS	.600	.532	.032	.856	.482	-.227	1.000		
PostcompS	.514	.599	.226	.426	.801	-.384	.426	1.000	
BCTS	.494	.615	.268	.450	.586	-.450	.541	.589	1.000

Table 5

CORRELATION TABLE FOR INITIAL AND FINAL VARIABLES FOR B'

	SHSM	SATQ	SATV	PreattS	PrecompS	GPA	PostattS	PostcompS	BCTS
SHSM	1.000								
SATQ	.549	1.000							
SATV	.075	.430	1.000						
PreattS	.658	.501	-.046	1.000					
PrecompS	.604	.068	.261	.518	1.000				
GPA	-.215	-.378	-.289	-.227	-.451	1.000			
PostattS	.611	.521	.023	.863	.492	-.210	1.000		
PostcompS	.518	.592	.242	.421	.809	-.391	.427	1.000	
BCTS	.518	.618	.320	.459	.598	-.468	.541	.586	1.000

On the other hand, the mean scores for SHSM were 6.91 and 7.0 for A_1 and A_2, respectively, while those for B and B' were 5.27 and 5.28. This may indicate that the number of students in A_1 and A_2 who took more high school mathematics than their ability would warrant was greater than in B or B'.

After a careful examination of these correlations it was decided to use PreattS, SATQ, and PrecompS as covariates in the analyses which will be discussed in the following pages.

ACHIEVEMENT

For each pair of groups, A_1-B, A_2-B, A_1-A_2, A_1-B', and A_2-B', and for each of the criterion measures, PostcompS and BCTS, three one-way analyses of covariance were computed. The covariates used in these three analyses were SATQ, PrecompS, and SATQ-PrecompS. The means and standard deviations of these covariates for each of the groups are tabulated in Table 6. The results of the covariance analyses will be given for each pair of groups separately. Throughout this section the only dependent variables considered will be PostcompS and BCTS.

Table 6

MEANS AND STANDARD DEVIATIONS OF THE COVARIATES, SATQ AND PrecompS, FOR A_1, A_2, B, AND B'

Covariate	Measures	A_1	A_2	B	B'
SATQ	Mean	537.11	545.56	456.29	456.55
	S.D.	66.18	81.98	77.44	81.43
PrecompS	Mean	71.62	71.90	65.35	65.29
	S.D.	5.59	6.57	10.05	10.28

The results of the covariance analyses for A_1-B are summarized in Table 7 while the complete covariance table is given in Table 8.

Table 7

MEANS, ADJUSTED MEANS, AND F RATIOS FOR PostcompS AND BCTS WITH COVARIATES SATQ, PrecompS, and SATQ-PrecompS for A_1-B

Criterion Measure	Covariate	Mean		Adjusted Mean		F Ratio
		A_1	B	A_1	B	
PostcompS	SATQ	72.6857	68.2602	68.4423	69.0179	.1553
	PrecompS	72.4615	68.2602	68.8095	68.9868	.0320
	SATQ-PrecompS	72.6857	68.2602	68.1300	69.0737	.7830
BCTS	SATQ	36.8000	33.4387	32.7767	34.1572	1.2104
	PrecompS	36.6666	33.4387	34.3171	33.9062	.1237
	SATQ-PrecompS	36.8000	33.4387	32.6397	34.1816	1.7124

Though all but one of the differences in adjusted means favored B over A_1, none of the differences in these means on either of the criterion measures was significant at the 5% level of significance. This indicates that, using computational skill and mastery of basic concepts as criteria, there is no conclusive evidence that a course designed specifically for prospective elementary teachers is more effective than a modified liberal arts course.

The results of the covariance analyses for A_2-B are summarized in Table 9 and given in detail in Table 10. All three analyses using SATQ, PrecompS, and SATQ-PrecompS as covariates and BCTS as the dependent variable resulted in adjusted means which differed significantly in favor of B over A_2 with $P \leq .01$. These results indicate that a course designed specifically for elementary teachers is more effective, judged by students' understanding of basic concepts, than a liberal arts course without any modification. No such conclusion can be stated if PostcompS is used as the criterion.

Table 8

ANALYSES OF COVARIANCE FOR A_1-B FOR CRITERION MEASURES PostcompS and BCTS WITH COVARIATES SATQ, PrecompS, AND SATQ-PrecompS

Criterion	Covariate	Source of Variation	DF	Adjusted Sum of Squares	Mean Square	F Ratio*
PostcompS	SATQ	Between Groups	1	8.6261	8.6261	.1553
		Within Groups	228	12660.7400	55.5295	
		Total	229	12669.3662		
	PrecompS	Between Groups	1	.9686	.9686	.0320
		Within Groups	232	7010.5634	30.2179	
		Total	233	7011.5320		
	SATQ-PrecompS	Between Groups	1	23.1717	23.1717	.7830
		Within Groups	227	6717.3093	29.5916	
		Total	228	6740.4811		
BCTS	SATQ	Between Groups	1	49.6139	49.6139	1.2104
		Within Groups	228	9345.2324	40.9878	
		Total	229	9394.8464		
	PrecompS	Between Groups	1	5.1984	5.1984	.1237
		Within Groups	232	9745.8673	42.0080	
		Total	233	9751.0657		
	SATQ-PrecompS	Between Groups	1	61.8657	61.8657	1.7124
		Within Groups	227	8200.8948	36.1272	
		Total	228	8262.7605		

*$F_{.95}(1,\infty) = 3.84$ $F_{.99}(1,\infty) = 6.64$

Table 9

MEANS, ADJUSTED MEANS, AND F RATIOS FOR PostcompS AND BCTS WITH COVARIATES SATQ, PrecompS, AND SATQ-PrecompS FOR A_2-B

Criterion Measure	Covariate	Mean		Adjusted Mean		F Ratio
		A_2	B	A_2	B	
PostcompS	SATQ	73.6081	68.2602	69.9748	69.6319	.0940
	PrecompS	73.6081	68.2602	70.1770	69.5556	.6399
	SATQ-PrecompS	73.6081	68.2602	69.6901	69.7394	.0036
BCTS	SATQ	33.0675	33.4387	29.5526	34.7658	27.4908
	PrecompS	33.0675	33.4387	30.7515	34.3132	15.0339
	SATQ-PrecompS	33.0675	33.4387	29.4137	34.8182	34.1727

The results of the covariance analyses for A_1-A_2 are summarized in Table 11 and given in complete form in Table 12. In this case, with BCTS as the dependent variable, the three analyses using SATQ, PrecompS, and SATQ-PrecompS as covariates resulted in differences in adjusted means favoring A_1 over A_2. These differences were significant with $P \leq .01$. The three analyses with PostcompS as the dependent variable gave differences in adjusted means which favored A_2 but not significantly. These results support the hypothesis that, using a mastery of basic concepts as the criterion, a liberal arts course in which some specific attention is given to the understanding of fundamental mathematical ideas needed by elementary teachers is more effective than the liberal arts course. Again, this conclusion is not warranted if PostcompS is used as the criterion.

The next analyses, those between A_1-B' and A_2-B' were carried out in an attempt to discover whether sex differences played an important part in determining the results obtained in the analyses just discussed. The results of these two analyses are summarized in

Table 10

ANALYSES OF COVARIANCE FOR A_2-B FOR CRITERION MEASURES PostcompS AND BCTS WITH COVARIATES SATQ, PrecompS, AND SATQ-PrecompS

Criterion	Covariate	Source of Variation	DF	Adjusted Sum of Squares	Mean Square	F Ratio*
PostcompS	SATQ	Between Groups	1	5.0591	5.0591	.0940
		Within Groups	267	14356.9489	53.7713	
		Total	268	14362.0080		
	PrecompS	Between Groups	1	18.8423	18.8423	.6399
		Within Groups	267	7862.0032	29.4457	
		Total	268	7880.8455		
	SATQ-PrecompS	Between Groups	1	0.1044	0.1044	.0036
		Within Groups	266	7700.0002	28.9473	
		Total	267	7700.1046		
BCTS	SATQ	Between Groups	1	1169.1474	1169.1474	27.4908
		Within Groups	267	11355.1568	42.5286	
		Total	268	12524.3043		
	PrecompS	Between Groups	1	619.0523	619.0523	15.0339
		Within Groups	267	10994.2742	41.1770	
		Total	268	11613.3266		
	SATQ-PrecompS	Between Groups	1	1255.2908	1255.2908	34.1727
		Within Groups	266	9771.1690	36.7337	
		Total	267	11026.4598		

*$F_{.95}(1, \infty) = 3.84$ $F_{.99}(1, \infty) = 6.64$

Table 11

MEANS, ADJUSTED MEANS, AND F RATIOS FOR PostcompS AND BCTS WITH COVARIATES SATQ, PrecompS, AND SATQ-PrecompS for A_1-A_2

Criterion Measure	Covariate	Mean		Adjusted Mean		F Ratio
		A_1	A_2	A_1	A_2	
PostcompS	SATQ	72.6857	73.6081	72.7601	73.5729	.4709
	PrecompS	72.4615	73.6081	72.6567	73.5052	.7994
	SATQ-PrecompS	72.6857	73.6081	72.7559	73.5748	.6896
BCTS	SATQ	36.8000	33.0675	36.9712	32.9865	9.7403
	PrecompS	36.6666	33.0675	36.8508	32.9704	11.2099
	SATQ-PrecompS	36.8000	33.0675	36.9680	32.9880	11.3892

Tables 13 and 14 and given completely in Tables 15 and 16. The conclusions of these analyses are identical with those of A_1-B and A_2-B respectively. That is, in the analyses of A_1-B' none of the differences in adjusted means were significant with $P \leq .05$. In the case of A_2-B' all three of the analyses using BCTS as the dependent variable resulted in adjusted means which differed significantly. Each analysis favored B' over A_2, $P \leq .01$. The three analyses using PostcompS as the dependent variable resulted in adjusted means which did not differ significantly, $P \leq .05$.

These results show that the analyses using groups from which the male students had been removed resulted in conclusions identical with those obtained using groups including the male students. Therefore, there is no reason to believe that sex difference was an important factor in determining the results discussed in the previous paragraphs. These results are consistent with those of Jackson and Lahaderne who found no difference between the sexes in their study of the correlation between achievement and attitudes (130).

Table 12

ANALYSES OF COVARIANCE FOR A_1-A_2 FOR CRITERION MEASURES PostcompS AND BCTS WITH COVARIATES SATQ, PrecompS, AND SATQ-PrecompS

Criterion	Covariate	Source of Variation	DF	Adjusted Sum of Squares	Mean Square	F Ratio*
PostcompS	SATQ	Between Groups	1	15.6556	15.6556	.4709
		Within Groups	106	3523.6373	33.2418	
		Total	107	3539.2930		
	PrecompS	Between Groups	1	18.3530	18.3530	.7994
		Within Groups	110	2525.3296	22.9575	
		Total	111	2543.6826		
	SATQ-PrecompS	Between Groups	1	15.8923	15.8923	.6896
		Within Groups	105	2419.5801	23.0436	
		Total	106	2435.4724		
BCTS	SATQ	Between Groups	1	376.2740	376.2740	9.7403
		Within Groups	106	4094.8107	38.6302	
		Total	107	4471.0847		
	PrecompS	Between Groups	1	383.8965	383.8965	11.2099
		Within Groups	110	3767.0607	34.2460	
		Total	111	4150.9572		
	SATQ-PrecompS	Between Groups	1	375.3984	375.3984	11.3892
		Within Groups	105	3460.8876	32.9608	
		Total	106	3836.2861		

*$F_{.95}(1,60) = 4.0$ $F_{.99}(1,60) = 7.08$

Table 13

MEANS, ADJUSTED MEANS, AND F RATIOS FOR PostcompS AND BCTS WITH COVARIATES SATQ, PrecompS, AND SATQ-PrecompS FOR A_1-B'

Criterion Measure	Covariate	Mean		Adjusted Mean		F Ratio
		A_1	B'	A_1	B'	
PostcompS	SATQ	72.6857	68.3483	68.6399	69.1438	.1132
	PrecompS	72.4615	68.3483	68.8338	69.1431	.0967
	SATQ-PrecompS	72.6857	68.3483	68.2483	69.2208	.8202
BCTS	SATQ	36.8000	33.5561	32.9804	34.3072	1.1323
	PrecompS	36.6666	33.5561	34.3658	34.0603	.0702
	SATQ-PrecompS	36.8000	33.5561	32.8090	34.3409	1.7351

Table 14

MEANS, ADJUSTED MEANS, AND F RATIOS FOR PostcompS AND BCTS WITH COVARIATES SATQ, PrecompS, AND SATQ-PrecompS FOR A_2-B'

Criterion Measure	Covariate	Mean		Adjusted Mean		F Ratio
		A_2	B'	A_2	B'	
PostcompS	SATQ	73.6081	68.3483	70.1847	69.7715	.1298
	PrecompS	73.6081	68.3483	70.2404	69.7483	.3939
	SATQ-PrecompS	73.6081	68.3483	69.8350	69.9168	.0097
BCTS	SATQ	33.0675	33.5561	29.7640	34.9295	26.9105
	PrecompS	33.0675	33.5561	30.8178	34.4914	16.1520
	SATQ-PrecompS	33.0675	33.5561	29.5931	35.0005	34.5355

Table 15

ANALYSES OF COVARIANCE FOR A_1-B' FOR CRITERION MEASURES PostcompS AND BCTS WITH COVARIATES SATQ, PrecompS, AND SATQ-PrecompS

Criterion	Covariate	Source of Variation	DF	Adjusted Sum of Squares	Mean Square	F Ratio*
PostcompS	SATQ	Between Groups	1	6.4943	6.4943	.1132
		Within Groups	210	12039.2958	57.3399	
		Total	211	12045.7901		
	PrecompS	Between Groups	1	2.8909	2.8909	.0967
		Within Groups	214	6393.4608	29.8759	
		Total	215	6396.3518		
	SATQ-PrecompS	Between Groups	1	24.1672	24.1672	.8202
		Within Groups	209	6157.5216	29.4618	
		Total	210	6181.6888		
BCTS	SATQ	Between Groups	1	45.0240	45.0240	1.1323
		Within Groups	210	8350.1538	39.7626	
		Total	211	8395.1778		
	PrecompS	Between Groups	1	2.8195	2.8195	.0702
		Within Groups	214	8594.3463	40.1604	
		Total	215	8597.1659		
	SATQ-PrecompS	Between Groups	1	59.9670	59.9670	1.7351
		Within Groups	209	7222.8715	34.5591	
		Total	210	7282.8386		

*$F_{.95}(1,\infty) = 3.84$ $F_{.99}(1,\infty) = 6.64$

Table 16

ANALYSES OF COVARIANCE FOR A_2-B' FOR CRITERION MEASURES PostcompS AND BCTS WITH COVARIATES SATQ, PrecompS, AND SATQ-PrecompS

Criterion	Covariate	Source of Variation	DF	Adjusted Sum of Squares	Mean Square	F Ratio*
PostcompS	SATQ	Between Groups	1	7.1478	7.1478	.1298
		Within Groups	249	13705.9331	55.0439	
		Total	250	13713.0810		
	PrecompS	Between Groups	1	11.4623	11.4623	.3939
		Within Groups	249	7244.8707	29.0958	
		Total	250	7256.3330		
	SATQ-PrecompS	Between Groups	1	0.2799	0.2799	.0097
		Within Groups	248	7127.3524	28.7393	
		Total	249	7127.6323		
BCTS	SATQ	Between Groups	1	1117.1071	1117.1071	26.9105
		Within Groups	249	10336.4480	41.5118	
		Total	250	11453.5551		
	PrecompS	Between Groups	1	638.7795	638.7795	16.1520
		Within Groups	249	9847.4095	39.5478	
		Total	250	10486.1890		
	SATQ-PrecompS	Between Groups	1	1221.9545	1221.9545	34.5355
		Within Groups	248	8774.8549	35.3824	
		Total	249	9996.8095		

*$F_{.95}(1,\infty) = 3.84$ $F_{.99}(1,\infty) = 6.64$

The results of the analyses which have been discussed in this section can be summarized as follows:

Using BCTS as the criterion, there were significant differences between the adjusted means of A_2-B, A_1-A_2, and A_2-B'. These differences favored B over A_2, B' over A_2, and A_1 over A_2, all with $P \leq .01$.

Using BCTS as the criterion, there were no significant differences between the adjusted means of A_1-B or A_1-B'.

Using PostcompS as the criterion, there were no significant differences between the adjusted means of A_1-B, A_2-B, A_1-A_2, A_1-B', or A_2-B'.

These results seem to support Cartwright's contention, discussed in the previous chapter, that liberal arts colleges cannot assume that every course in an area is appropriate for prospective elementary teachers (47).

ATTITUDE

The results of the covariance analyses using PreattS as the covariate and PostattS as the dependent variable are summarized for

Table 17

MEAN AND STANDARD DEVIATION FOR THE COVARIATE, PreattS, for A_1, A_2, B, and B'

		A_1	A_2	B	B'
PreattS	Mean	68.51	67.86	62.77	63.01
	S.D.	18.37	19.71	20.48	20.72

each pair of groups in Table 18. The mean and standard deviation of the covariate are given in Table 17. The complete covariance table

Table 18

MEANS, ADJUSTED MEANS, AND F RATIOS FOR CRITERION MEASURE, PostattS, WITH COVARIATE, PreattS, for A_1-B, A_2-B, A_1-A_2, A_1-B', AND A_2-B'

Criterion Measure	Covariate	Mean		Adjusted Mean		F Ratio
PostattS	PreattS	A_1 66.6410	B 65.6632	A_1 62.3924	B 66.5086	4.8618
		A_2 65.8648	B 65.6632	A_2 62.9474	B 66.7647	6.7978
		A_1 66.6410	A_2 65.8648	A_1 66.1159	A_2 66.1415	.0001
		A_1 66.6410	B' 65.9719	A_1 62.5989	B' 66.8575	5.1577
		A_2 65.8648	B' 65.9719	A_2 63.1519	B' 67.0997	7.1083

is reported in Table 19. All but one of the differences in adjusted means were significant. They favored B over A_1 and B' over A_1 with $P \leq .05$. The differences also favored B over A_2 and B' over A_2 with $P \leq .01$. In the analysis of A_1-A_2 the difference in adjusted means was not significant.

It is clear from these results that the mean attitude of students in a course designed specifically for prospective elementary teachers is more favorable toward mathematics than the mean attitude of those in a liberal arts course, modified or otherwise. It is

Table 19

ANALYSES OF COVARIANCE FOR CRITERION MEASURE PostattS WITH COVARIATE PreattS FOR A_1-B, A_2-B, A_1-A_2, A_1-B', AND A_2-B'

Sample	Source of Variation	DF	Adjusted Sum of Squares	Mean Square	F Ratio*
A_1-B	Between Groups	1	543.9214	543.9214	4.8618
	Within Groups	232	25955.0014	111.8750	
	Total	233	26498.9228		
A_2-B	Between Groups	1	772.9961	772.9961	6.7978
	Within Groups	267	30361.2433	113.7125	
	Total	268	31134.2394		
A_1-A_2	Between Groups	1	.0167	.0167	.0001
	Within Groups	110	15662.4509	142.3859	
	Total	111	15662.4676		
A_1-B'	Between Groups	1	572.8456	572.8456	5.1577
	Within Groups	214	23767.9304	111.0650	
	Total	215	24340.7760		
A_2-B'	Between Groups	1	805.1785	805.1785	7.1083
	Within Groups	249	28204.9220	113.2727	
	Total	250	29010.1005		

*$F_{.95}(1,\infty) = 3.84$ $F_{.99}(1,\infty) = 6.64$

clear, too, that there is no reason to say that a modified liberal arts course is any more effective in producing favorable attitudes toward mathematics than a regular liberal arts course.

Table 18 shows that the PostattS mean for A_1 was higher than that of any of the other three groups. Nevertheless, after the covariance adjustment was carried out, both B and B' had adjusted means which were significantly higher than those of A_1. In addition to the fact that the mean of the covariate, PreattS, was higher for A_1 than it was for any of the other groups, Table 1 reveals another factor which helps to account for this significant difference in adjusted means. Table 1 shows that the mean attitudes of both A_1 and A_2 were less favorable at the end of the course than they were at the beginning while the attitudes of both B and B' improved during the course. This observation challenged the investigator to look for an explanation even though attitudes generally have a tendency to become less favorable as a course progresses (190). Though it is difficult to account for attitudes it is a fact that many of the students in A_1 and A_2 felt no need for the course they were required to take. They recognized that fulfilling this requirement deprived them of an elective of their choice. Perhaps this factor accounted, in part, for their less favorable attitudes.

SUMMARY

Table 20 contains a summary of the results which have been discussed in the last two sections of this chapter. Significance levels are given in the table. With PostcompS as the criterion measure there were no significant differences between the adjusted means of any of the pairs of groups for any of the three covariates. With

Table 20

SUMMARY OF RESULTS OF COVARIANCE ANALYSES FOR CRITERION MEASURES PostcompS, BCTS, AND PostattS WITH COVARIATES SATQ, PrecompS, SATQ-PrecompS, AND PreattS

Criterion Measure	Covariate	A_1-B	A_2-B	A_1-A_2	A_1-B'	A_2-B'
PostcompS	SATQ	n.s.	n.s.	n.s.	n.s.	n.s.
	PrecompS	n.s.	n.s.	n.s.	n.s.	n.s.
	SATQ-PrecompS	n.s.	n.s.	n.s.	n.s.	n.s.
BCTS	SATQ	n.s.	B > A_2**	A_1 > A_2**	n.s.	B' > A_2**
	Precomps	n.s.	B > A_2**	A_1 > A_2**	n.s.	B' > A_2**
	SATQ-PrecompS	n.s.	B > A_2**	A_1 > A_2**	n.s.	B' > A_2**
PostattS	PreattS	B > A_1*	B > A_2**	n.s.	B' > A_1*	B' > A_2**

*P ≤ .05
**P ≤ .01

BCTS as the criterion measure, B, A_1, and B' did significantly better than A_2 regardless of which of the three covariates was used. With PostattS as the criterion measure, B and B' did significantly better than either A_1 or A_2 while there was no significant difference between the adjusted means of A_1 and A_2.

INVESTIGATION OF DIFFERENCES IN GROUP PERFORMANCE ON BASIC CONCEPTS TEST

The Basic Concepts Test was one of the three criterion measures used throughout this study. It was designed by Dr. Northey who item analyzed the test before he used it for his study. It was examined critically by two experts in the field of mathematics education and, in their judgment, it tested fundamental mathematical concepts the understanding of which is essential for prospective elementary teachers.

For the purposes of this study, therefore, an attempt was made to compare the performance on each item of the test of A_1-B, A_2-B, and A_1-A_2. For each group, the per cent responding correctly to an item was computed for each item. For each pair of groups, the differences between these per cents were computed for each of the 50 items of the test. The items were then ranked according to these differences and the significance levels indicated. These results are reported in Tables 21, 22, and 23.

An examination of Table 21 shows that, of the 19 items on which A_1 and B differ significantly, 15 favor A_1. It shows also that A_1 did better than B on 35 of the 50 test items. It is interesting to compare these results with those of the covariance analyses between A_1 and B with BCTS as the criterion measure. Those results showed no significant differences between the adjusted means of A_1 and B. This apparent contradiction in results is accounted for by the adjustment made for the covariates in the covariance analyses. Though there was no completely consistent pattern, there was a tendency for A_1 to do better than B on items dealing with numbers and number systems. These items dealt with such topics as the following: recognition of number systems; recognition of properties of number systems, for example, the existence of an inverse element; operations within number systems; properties of numbers such as primeness; and solutions of inequalities. The four questions on which B did significantly better than A_1 dealt with the following: least common multiple; expanded notation in base 4; decimals; and the symmetric property of a relation.

In the analysis involving A_2 and B, reported in Table 22, of the 18 items on which they differ significantly, 9 favor A_2 and 9

Table 21

RANK ORDER OF ITEMS OF BASIC CONCEPTS TEST BASED ON DIFFERENCES BETWEEN A_1 AND B IN PERCENTAGES CORRECT ON EACH ITEM

Rank	% Correct for A_1	% Correct for B	Difference	Significance Level	Item Number
1	82.05	40.30	41.75	.01	30
2	97.43	64.79	32.64	.01	36
3	38.46	8.67	29.79	.01	48
4	87.17	59.18	27.99	.01	5
5	79.48	53.06	26.42	.01	11
6	43.58	69.89	-26.31	.01	25
7	89.74	63.77	25.97	.01	49
8	66.66	92.34	-25.68	.01	44
9	56.41	80.10	-23.69	.01	2
10	71.79	51.53	20.26	.05	1
11	89.74	69.89	19.85	.05	9
12	87.17	67.34	19.83	.05	6
13	58.97	40.30	18.67	.05	14
14	58.97	40.81	18.16	.05	17
15	53.84	71.42	-17.58	.05	13
16	46.15	62.24	-16.09	n.s.	15
17	94.87	80.10	14.77	.05	23
18	92.30	78.06	14.24	.05	32
19	92.30	78.06	14.24	.05	29
20	92.30	78.57	13.73	.05	20
21	71.79	58.67	13.12	n.s.	34
22	84.61	71.93	12.68	n.s.	41
23	58.97	71.42	-12.45	n.s.	37
24	94.87	83.16	11.71	n.s.	33
25	48.71	60.20	-11.49	n.s.	21
26	35.89	25.00	10.89	n.s.	10
27	97.43	87.24	10.19	n.s.	38
28	69.23	59.18	10.05	n.s.	43
29	94.87	85.71	9.16	n.s.	19

Table 21 (Con't.)

Rank	% Correct for A_1	% Correct for B	Difference	Significance Level	Item Number
30	89.74	80.61	9.13	n.s.	46
31	61.53	52.55	8.98	n.s.	4
32	94.87	86.22	8.65	n.s.	24
33	56.41	47.95	8.46	n.s.	8
34	61.53	69.38	-7.85	n.s.	3
35	76.92	70.91	6.01	n.s.	50
36	46.15	40.30	5.85	n.s.	7
37	51.28	55.61	-4.46	n.s.	35
38	74.35	69.89	4.33	n.s.	27
39	43.58	47.44	-3.86	n.s.	12
40	66.66	70.40	-3.74	n.s.	42
41	74.35	78.06	-3.71	n.s.	16
42	97.43	93.87	3.56	n.s.	39
43	84.61	81.12	3.49	n.s.	18
44	71.79	68.36	3.43	n.s.	26
45	92.30	95.40	-3.10	n.s.	28
46	92.30	89.28	3.02	n.s.	45
47	64.10	61.73	2.37	n.s.	22
48	74.35	75.51	-1.16	n.s.	40
49	79.48	78.57	.91	n.s.	31
50	76.92	77.55	- .63	n.s.	47

Table 22

RANK ORDER OF ITEMS OF BASIC CONCEPTS TEST BASED ON DIFFERENCES BETWEEN A_2 AND B IN PERCENTAGES CORRECT ON EACH ITEM

Rank	% Correct for A_2	% Correct for B	Difference	Significance Level	Item Number
1	9.45	71.42	-61.97	.01	13
2	68.91	40.30	28.61	.01	30
3	33.78	62.24	-28.46	.01	15
4	90.54	63.77	26.77	.01	49
5	66.21	92.34	-26.13	.01	44
6	58.10	80.10	-22.00	.01	2
7	43.24	61.73	-18.49	.01	22
8	31.08	47.44	-16.36	.05	12
9	56.75	40.81	15.94	.05	17
10	68.91	53.06	15.85	.05	11
11	45.94	60.20	-14.26	.05	21
12	54.05	40.30	13.75	.05	7
13	64.86	78.57	-13.71	.05	31
14	21.62	8.67	12.95	.01	48
15	82.43	69.89	12.54	.05	9
16	59.45	47.95	11.50	n.s.	8
17	82.43	93.87	-11.44	.01	39
18	94.59	83.16	11.43	.05	33
19	89.18	78.06	11.12	.05	32
20	75.67	64.79	10.88	n.s.	36
21	59.45	69.38	-9.93	n.s.	3
22	79.72	69.89	9.83	n.s.	27
23	87.83	78.06	9.77	n.s.	29
24	68.91	59.18	9.73	n.s.	5
25	62.16	71.42	-9.26	n.s.	37
26	83.78	89.28	-5.50	n.s.	45
27	56.75	51.53	5.22	n.s.	1
28	77.02	71.93	5.09	n.s.	41
29	64.86	69.89	-5.03	n.s.	25

Table 22 (Con't.)

Rank	% Correct for A_2	% Correct for B	Difference	Significance Level	Item Number
30	90.54	85.71	4.83	n.s.	19
31	54.05	58.67	-4.62	n.s.	34
32	75.67	80.10	-4.43	n.s.	23
33	44.59	40.30	4.29	n.s.	14
34	56.75	52.55	4.20	n.s.	4
35	82.43	78.57	3.86	n.s.	20
36	82.43	86.22	-3.79	n.s.	24
37	83.78	87.24	-3.46	n.s.	38
38	21.62	25.00	-3.38	n.s.	10
39	62.16	59.18	2.98	n.s.	43
40	70.27	67.34	2.93	n.s.	6
41	75.67	78.06	-2.39	n.s.	16
42	78.37	80.61	-2.24	n.s.	46
43	75.67	77.55	-1.88	n.s.	47
44	94.59	95.40	- .81	n.s.	28
45	67.56	68.36	- .80	n.s.	26
46	70.27	70.91	- .64	n.s.	50
47	55.40	55.61	- .21	n.s.	35
48	75.67	75.51	.16	n.s.	40
49	70.27	70.40	- .13	n.s.	42
50	81.08	81.12	- .04	n.s.	18

Table 23

RANK ORDER OF ITEMS OF BASIC CONCEPTS TEST BASED ON DIFFERENCES BETWEEN A_1 and A_2 IN PERCENTAGES CORRECT ON EACH ITEM

Rank	% Correct for A_1	% Correct for A_2	Difference	Significance Level	Item Number
1	53.84	9.45	44.39	.001	13
2	97.43	75.67	21.76	.01	36
3	43.58	64.86	-21.28	.05	25
4	64.10	43.24	20.86	.05	22
5	94.87	75.67	19.20	.05	23
6	87.17	68.91	18.26	.05	5
7	71.79	54.05	17.74	n.s.	34
8	87.17	70.27	16.90	.05	6
9	38.46	21.62	16.84	n.s.	48
10	71.79	56.75	15.04	n.s.	1
11	97.43	82.43	15.00	.05	39
12	79.48	64.86	14.62	n.s.	31
13	58.97	44.59	14.38	n.s.	14
14	35.89	21.62	14.27	n.s.	10
15	97.43	83.78	13.65	.05	38
16	82.05	68.91	13.14	n.s.	30
17	43.58	31.08	12.50	n.s.	12
18	94.87	82.43	12.44	n.s.	24
19	46.15	33.78	12.37	n.s.	15
20	89.74	78.37	11.37	n.s.	46
21	79.48	68.91	10.57	n.s.	11
22	92.30	82.43	9.87	n.s.	20
23	92.30	83.78	8.52	n.s.	45
24	46.15	54.05	-7.90	n.s.	7
25	84.61	77.02	7.59	n.s.	41
26	89.74	82.43	7.31	n.s.	9
27	69.23	62.16	7.07	n.s.	43
28	76.92	70.27	6.65	n.s.	50
29	74.35	79.72	-5.37	n.s.	27

Table 23 (Con't.)

Rank	% Correct for A_1	% Correct for A_2	Difference	Significance Level	Item Number
30	61.53	56.75	4.78	n.s.	4
31	92.30	87.83	4.47	n.s.	29
32	94.87	90.54	4.33	n.s.	19
33	71.79	67.56	4.23	n.s.	26
34	51.28	55.40	-4.12	n.s.	35
35	66.66	70.27	-3.61	n.s.	42
36	84.61	81.08	3.53	n.s.	18
37	58.97	62.16	-3.19	n.s.	37
38	92.30	89.18	3.12	n.s.	32
39	56.41	59.45	-3.04	n.s.	8
40	48.71	45.94	2.77	n.s.	21
41	58.97	56.75	2.22	n.s.	17
42	61.53	59.45	2.08	n.s.	3
43	56.41	58.10	-1.69	n.s.	2
44	74.35	75.67	-1.32	n.s.	16
45	74.35	75.67	-1.32	n.s.	40
46	92.30	94.59	-1.29	n.s.	28
47	76.92	75.67	1.25	n.s.	47
48	89.74	90.54	- .80	n.s.	49
49	66.66	66.21	.45	n.s.	44
50	94.87	94.59	.28	n.s.	33

favor B. B did better than A_2 on 27 of the 50 test items. There does not seem to be any one type of content on which one group did consistently better than the other.

In the analysis involving A_1 and A_2, reported in Table 23, A_1 did better than A_2 on 38 of the 50 test items. This difference was significant, however, on only 9 items all but one of which favored A_1 and most of which dealt with problems concerning number systems.

It is clear that A_1 performed considerably better than both B and A_2 while A_2 and B performed about the same on the items of the Basic Concepts Test. These observations together with the fact that A_1 and A_2 were well matched groups initially led the investigator to conclude that the modified liberal arts course is more effective than the regular liberal arts course, judged on the basis of the needs of elementary teachers.

Conclusions and recommendations based on these analyses will be found in the next chapter.

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

This chapter contains a brief review of the problem followed by findings and conclusions based on the analysis of data presented in Chapter III. Suggestions for further research in this area complete the chapter and dissertation.

RESTATEMENT OF THE PROBLEM

The purpose of this study was to investigate the effectiveness of a modified liberal arts mathematics course in the mathematical preparation of prospective elementary teachers. It was designed to provide a basis for making recommendations for improving the mathematics preparation of prospective elementary teachers in liberal arts colleges.

Three courses, differing in content, were involved in this investigation. One course, labeled A_1, was a modified form of a liberal arts course required of all freshmen at Marygrove College in Detroit, Michigan. A second course, labeled A_2, was the regular liberal arts mathematics course required of all freshmen at this college. The third course, labeled B, was a course designed specifically for prospective elementary teachers. This course followed

the CUPM recommendations. B' was the subset of B consisting of the female students.

The course content for A_1 and A_2 was the same for three of the four classes each week. During the fourth class each week, courses A_1 and A_2 differed from each other. For this fourth class the content for A_1 consisted of topics recommended for elementary teachers; A_2 was given a more extensive treatment of topics from the liberal arts course. The course content for B consisted of material selected from Theory of Arithmetic by Peterson and Hashisaki.

The effectiveness of these three courses was compared on the basis of the following criteria:

1. Skill in performing fundamental computations.
2. Understanding of fundamental mathematical concepts.
3. Attitudes toward mathematics.

In the following section the questions which were investigated are stated as null hypotheses. They are then rejected or not rejected according to the evidence cited.

FINDINGS AND CONCLUSIONS

Hypotheses 1-3

There is no significant difference between the adjusted mean scores of A_1 and B with respect to:

1. Computational skill.
2. Mastery of fundamental mathematical concepts.
3. Attitudes toward mathematics.

Findings--All but one of the covariance analyses carried out showed B achieving slightly higher than A_1 on computational

skills and fundamental mathematical concepts. None of the differences in adjusted means, however, was significant. The analysis concerned with attitudes favored B significantly over A_1 with $P \leq .05$.

Conclusion 1--On the basis of the findings cited above, there was no reason to reject Hypothesis 1.

Conclusion 2--There was no evidence to warrant rejecting Hypothesis 2.

Conclusion 3--Hypothesis 3 was rejected with $P \leq .05$.

Hypotheses 4-6

There is no significant difference between the adjusted means of A_2 and B with respect to:

4. Computational skill.
5. Mastery of fundamental mathematical concepts.
6. Attitudes toward mathematics.

Findings--On the test of computational skill there was no significant difference between the adjusted means of these two groups. On the other hand, all of the analyses concerned with fundamental concepts and attitudes toward mathematics favored B over A_2 with $P \leq .01$.

Conclusion 4--Hypothesis 4 could not be rejected on the basis of these results.

Conclusion 5--Supported by the evidence of the superiority of B over A_2 in mastery of fundamental mathematical concepts after the covariance adjustment was carried out, Hypothesis 5 was rejected with $P \leq .01$.

Conclusion 6--Hypothesis 6 was rejected with $P \leq .01$.

Hypotheses 7-9

There is no significant difference between the adjusted means of A_1 and A_2 with respect to:

7. Computational skill.
8. Mastery of fundamental mathematical concepts.
9. Attitudes toward mathematics.

Findings--The results of the analyses showed no significant difference between these groups in computational skill. On the test of basic concepts, however, all three covariance analyses showed A_1 significantly higher than A_2 with $P \leq .01$. The analysis involving the attitude scale showed no significant difference between the adjusted mean attitudes of A_1 and A_2.

Conclusion 7--There was no reason to reject Hypothesis 7.

Conclusion 8--The evidence cited above indicated that Hypothesis 8 should be rejected at the 1 per cent level of significance.

Conclusion 9--The results of the analysis did not support the rejection of Hypothesis 9.

In an attempt to determine the influence of sex differences on the results given above, the investigator carried out covariance analyses on A_1-B' and A_2-B'. Since the conclusions from these analyses were identical with those of A_1-B and A_2-B, respectively, the author concluded that difference in sex was not an important factor in determining the outcome of the analyses.

Summary

The results or this study led the investigator to conclude the following:

1) The modified liberal arts course was just as effective as the course designed specifically for prospective elementary teachers, judged by the students' mastery of fundamental mathematical concepts, adjusting for covariates.

2) Both the modified liberal arts course and the course designed specifically for prospective elementary teachers were significantly more effective than the regular liberal arts course in producing a mastery of fundamental mathematical concepts.

3) All three courses were equally effective, judged on the basis of the computational skill of the students.

4) The course designed specifically for prospective elementary teachers was significantly more effective in producing favorable attitudes toward mathematics than either of the other courses.

5) The results of the study of the response to the items of the Basic Concepts Test showed that the students in the modified liberal arts course actually performed better than the students in either A_2 or B, without adjusting for covariates.

If one considers the mathematics content essential for prospective elementary teachers, the first two conclusions indicate that it is not necessary for liberal arts colleges to introduce new courses provided they are willing to adapt existing courses.

Students in the modified and the regular liberal arts courses, that is, in A_1 and A_2, were initially well matched on

all variables, primarily because they were in the same school. The fact that A_1 performed considerably better than A_2 on the Basic Concepts Test clearly indicates that concepts which are to be mastered must be taught explicitly as well as implicitly. Therefore, liberal arts mathematics courses must be modified if they are to satisfy the needs of prospective elementary teachers.

SUGGESTIONS FOR FURTHER RESEARCH

The problem of providing an adequate preparation for prospective elementary teachers is a difficult one in any case. In liberal arts colleges it is particularly difficult. Research directed toward finding ways of providing for professional needs without neglecting the liberal aims of the college is needed.

The results of this study indicate areas in which this kind of research might be carried out.

First, such questions as the following need to be answered:

What constitutes adequate mathematical preparation for prospective elementary teachers?

Is one who can compute, understands fundamental concepts, and has favorable attitudes toward mathematics adequately prepared?

Is a certain mathematical creativity necessary in order for a prospective elementary teacher to be adequately prepared?

How can this creative ability be taught and measured?

Studies to determine criteria for measuring adequate preparation for prospective elementary teachers are needed.

Second, a follow-up study of the prospective teachers who actually taught would help to establish a basis on which to judge the effectiveness of courses for prospective elementary teachers.

Third, an investigation of alternate ways of modifying liberal arts courses might well contribute much to the solution of the problem of teacher education in liberal arts colleges. Such things as content, time allotment, independent study, and individualized instruction should be considered.

APPENDICES

APPENDIX A

COURSE CONTENT

Course Content and Approximate Time Schedule for A_1 and A_2

The material in the first column was common to both A_1 and A_2 while the content in the second column was taught only to A_1, and that in the third column only to A_2.

A_1 and A_2	Approx. No. of Days	A_1	Approx. No. of Days	A_2	Approx. No. of Days
Introduction	3	Sets	1	Probability (Unit)	1
Logic	3	Relations	1	Probability	1
Evenness and Oddness (Ch. 1)	2	Relations	1	Probability	1
The Primes (Ch. 3)	3	Numeration Systems	1	Representation of Numbers (Ch. 14)	1
Fundamental Theorem of Arithmetic (Ch. 4)	3	Whole Numbers	1	Rationals and Irrationals (Ch. 5)	1
Congruence (Ch. 10)	3	Whole Numbers	1	Topology	1
Strange Algebras (Ch. 11)	2	Integers	1	Problems	1
Types of Numbers (Ch. 15)	2	Rational Numbers	2	Vectors (Unit)	2
Infinite Sets (Ch. 16)	1	Real Numbers	1	Problems	1
A General View (Ch. 17)	1				

The chapter numbers refer to Mathematics--The Man Made Universe by Stein.

Outline of Course Content Common to A_1 and A_2

This material was taken from Mathematics--The Man Made Universe by Sherman K. Stein.

Mathematics as a Way of Knowing

Logic
- Quantifiers
- Sentences
- Truth Tables and Tautologies
- Inference
- Logic and Sets

Even and Odd Arrangements

Primes and Composites
- The "Divides" Relation
- How Many Primes?
- Gaps Between Primes
- Lagado Primes

The Fundamental Theorem of Arithmetic
- "Special" Numbers
- GCD and LCM
- Euclidean Algorithm
- Fundamental Theorem

Congruence
- Meaning
- Relation to Ideas Considered Earlier
- Operations with Congruences
- Solving Congruences

Strange Algebras
- Finite Arithmetics
- Groups

The Representation of Numbers
- Decimal System
- Binary System

Infinite Sets
- Contrast of Finite with Infinite
- One-to-One Correspondence Between Infinite Sets

Outline of Course Content for A_1

This material was taken from Theory of Arithmetic by Peterson and Hashisaki.[1]

Sets
- Notation
- Subsets
- Operations

Relations
- Properties
- One-to-One Correspondence
- Equivalence Relations
- Cardinal Number of a Set

Numeration Systems
- Exponents
- Bases
- Computation in Bases Other Than 10

Whole Numbers
- Operations and Their Properties
- Properties of Zero and One

Integers
- Operations and Their Properties
- Cancellation Laws
- Order Relations
- Clock Arithmetic

Rational Numbers
- Operations and Their Properties
- Order Relations

Real Numbers
- Repeating Decimals
- Non-repeating Decimals

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[1] John A. Peterson and Joseph Hashasaki, Theory of Arithmetic (New York: Wiley, 1967).

APPENDIX B

TEST OF BASIC CONCEPTS OF ELEMENTARY MATHEMATICS

Do Not Turn This Page Until the Examiner Tells You To Do So

TEST OF BASIC CONCEPTS OF ELEMENTARY MATHEMATICS

General Directions

There are 50 questions in this test. Each of the questions is followed by five suggested answers labeled A through E. You are to: (1) choose the answer you think is best, (2) locate on your answer sheet the row of spaces having the same number as the questions you are answering, (3) blacken the answer space beneath the letter of the answer you have chosen. Some questions are harder than others so do those which are the easiest first and come back to the remaining ones. Your score will be the total number correct. Any questions left unanswered will be considered incorrect.

Do Not Turn This Page Until the Examiner Tells You To Do So

Basic Concepts of Elementary Mathematics

1. The value of $\frac{2^5 \cdot 2^0}{2^{-2}}$ is:

   A. 2^3
   B. 1
   C. 2^8
   D. 2^7
   E. 2^4

2. $3(4^4) + 2(4^2) + 1(4^0)$ names the same number as which of the following?

   A. 321_4
   B. 3021_4
   C. 32_4
   D. 30201_4
   E. 3201_4

3. The numeral 1010_2 represents the same number as the decimal:

   A. 10
   B. 10.10
   C. 0.1010
   D. 1,010
   E. 20

4. If A is the set $\{\{a,b,c\}, \{d,e\}, \{f\}\}$ which of the following is a subset of A?

   A. $\{a,b,d\}$
   B. $\{d,f\}$
   C. $\{\{d,e\}, \{f\}\}$
   D. $\{d,e\}$
   E. none of these

5. If A is the set $\{1,2,b\}$ then A is equivalent to the set:

   A. $\{x,y,z\}$
   B. $\{1,2,b,5\}$
   C. $\emptyset$
   D. $\{3\}$
   E. none of these

6. In what base are the numerals written if 2 x 2 = 10?

   A. base four
   B. base three
   C. base two
   D. base eight
   E. base five

7. How many of the following numbers are odd? 3_5, 4_{10}, 36_7, 11_9, 12_3

A. one
B. four
C. two
D. three
E. five

8. 6120_9 is how many times 612_9?

A. twelve
B. ten
C. nine
D. five
E. four

9. Four of the following numerals are names for the same number. Which one names a different number?

A. 0.025
B. 2.5%
C. 1/40
D. 25/100
E. 25 thousandths

10. The most important common property of the sets $\{a,2,=\}$ and $\{0,1,2\}$ is suggested by:

A. 2
B. $\{,,\}$
C. 6
D. 3
E. None of these

11. What is the sum of 6_8 and 3_8?

A. 11_8
B. 18_8
C. 10_8
D. 9_8
E. 110_8

12. If set A is $\{1,2,5,9\}$ and set B is $\{3,7\}$ then the cardinality of $A \cap B$ is:

A. 1
B. 0
C. $\aleph_0$
D. $\emptyset$
E. 6

13. If x is related to y implies y is related to x, then the relation under discussion has what property?

A. reflexive
B. transitive
C. successive
D. commutative
E. none of these

14. $A \cap B \supseteq A$ is:

A. always true
B. sometimes true
C. never true
D. meaningless
E. none of these

15. If $f_1 = \{(3,2), (5,8), (2,1)\}$ and $f_2 = \{(4,7), (6,2)\}$ then $f_1 \cup f_2^{-1}$ is:

A. the less than relation
B. a function
C. a relation
D. the greater than relation
E. none of these

16. The number 8.2×10^{-4} is:

A. .82
B. 82000
C. .0082
D. 820
E. .00082

17. The set of natural numbers contains:

A. an additive identity
B. an additive inverse for each number
C. a multiplicative identity
D. a multiplicative inverse for each number
E. none of these

18. The set of integers satisfying both $x \geq -3$ and $x + 2 < 4$ is:

A. $\{-2, -1, 0, 1\}$
B. $\{-3, -2, -1, 0, 1\}$
C. $\{-2, -1, 0\}$
D. $\{-3, -2, -1, 0\}$
E. $\{-2, -1\}$

19. The set of whole numbers satisfying both $3 + n > 5$ and $2 + n < 6$ is:

A. $\{0, 1, 2, 3\}$
B. $\{3\}$
C. $\{3, 4, 5, \ldots\}$
D. $\{3, 4\}$
E. $\{0, 1, 2, 3, \ldots\}$

20. If $^{-}8 + 4$ is written in each blank below which inequality will be true?

(a) _____ $< {}^{-}8 + {}^{-}8$
(b) _____ $> 1 + 2$
(c) _____ $< 0 + 5$
(d) _____ $> 7 + {}^{-}2$
(e) _____ > 0

A. a
B. b
C. c
D. d
E. e

21. If A is the set $\{n \mid -3 < n < 12, n \text{ is an integer}\}$ then the least upper bound of A is:

A. 12
B. 11
C. -2
D. -3
E. 13

22. The Division Algorithm states: If (a,b) is an ordered pair of whole numbers, $b \neq 0$, it is always possible to find whole numbers q and r with $0 \leq r < b$ such that $a = q \cdot b + r$. For the ordered pair (978, 37) which of the following pairs are correct for q and r?

A. $q = 20, r = 238$
B. $q = 6, r = 16$
C. $q = 30, r = 68$
D. $q = 26, r = 16$
E. $q = 26, r = 6$

23. The solution of $-3x = 9$ is a(n):

A. natural number
B. whole number
C. integer
D. irrational number
E. none of these

24. The greatest common divisor of 24, 36, and 90 is:

A. 6
B. 18
C. 3
D. 12
E. 2

25. The least common multiple of 360 and 84 is:

A. 2520
B. 5040
C. 420
D. 10080
E. 12

26. 0/-4 is:

A. meaningless
B. 0
C. 4
D. any number
E. none of these

27. -4/0 is:

A. meaningless
B. 0
C. 4
D. -4
E. none of these

28. The additive inverse of (-3 + 5) is:

A. $3 + \bar{}5$
B. $\underline{3} + 5_$
C. $\bar{}3 + \bar{}5$
D. $\underline{2}$
E. $\bar{}8$

29. Which the the numbers 99, 2025, 91, 462, 47 is prime?

A. 99
B. 2025
C. 91
D. 462
E. 47

30. If m and n are any two integers then $|m + n|$ is _____ $|m| + |n|$:

A. $\leq$
B. $<$
C. $\geq$
D. $>$
E. $=$

31. $(a + b)\ 1 + (a + b)c = (a + b)\ (1 + C)$ because of the:

A. multiplicative identity
B. commutative law of addition
C. associative low of multiplication
D. distributive law
E. additive identity

32. If m is a negative integer then ^{-}m is:

A. a positive integer
B. a negative integer
C. the multiplicative inverse of m
D. zero
E. m

33. Select the number which is not rational:

A. -7
B. $1/3$
C. $\sqrt{9}$
D. 1.313131
E. $\sqrt{3}$

34. A set of numbers which has a multiplicative inverse for each number except zero is:

A. the set of natural numbers
B. the set of integers
C. the set of even natural numbers
D. the set of whole numbers
E. the set of rational numbers

35. The greatest of the numbers 7/19, 5/14, 13/31, 1/10 and 2/5 is:

A. 1/10
B. 13/31
C. 5/14
D. 7/19
E. 2/5

36. Which of the following is true?

(a) if $1/3 - r = 3/4$ then $r = 5/12$
(b) $(8/2 - 3/2) - 1/2 = 8/2 - (3/2 - 1/2)$
(c) $3/4 - 1/3 = 1/3 - 3/4$
(d) $4/5 - 0/5 = 0/5$
(e) $1/3 - 5/4 = -11/12$

A. a
B. b
C. c
D. d
E. e

37. There is a 1 to 1 correspondence between the set of _____ numbers and the points of a straight line:

A. natural
B. rational
C. irrational
D. integers
E. real

38. Which of the following is not true?

(a) $5/3 \div 1/2 = 10/3$
(b) $3 \div 3/5 \div 5 = 1$
(c) $5/3 \div 3 = \frac{5 \cdot 1}{3 \cdot 3}$
(d) $3/2 \div (9/4 \div 7/6) = (3/2 \div 9/4) \div 7/6$
(e) if $r = 2/3 \div 1/4$ then $r = 8/3$

A. a
B. b
C. c
D. d
E. e

39. Which of the following is not true?

(a) $2/3 = 4/6 = 8/12 = 10/15 = 14/21$
(b) $2/3 + 5/7 = 28/21$
(c) $2/3 + 1/4 = 11/12$
(d) $5/24 + 7/18 = 43/72$
(e) $1/3 + 0/3 = 1/3$

A. a
B. b
C. c
D. d
E. e

40. The solution of $3/2\ x = 5$ is a:

A. natural number
B. whole number
C. real number
D. integer
E. irrational number

41. An infinite non-repeating decimal is a(n):

A. rational number
B. integer
C. irrational number
D. whole number
E. natural number

42. Any solution of $x^2 - 2 = 0$ is a(n):

A. natural number
B. whole number
C. integer
D. real number
E. rational number

43. The equation $mx = q$ where m and q are real numbers and $m \neq 0$ can always be solved in the:

A. natural numbers
B. integers
C. real numbers
D. rational numbers
E. whole numbers

44. A decimal fraction is one that is equivalent to a fraction whose denominator is:

A. less than its numerator
B. greater than its numerator
C. an integral power of 10
D. any natural number
E. none of these

45. In order for a rational number in lowest terms to be written as a terminating decimal its denominator can include only _____:

A. powers of 2
B. powers of 2 and/or powers of 5
C. powers of 5
D. powers of 3 or 5
E. powers of 3 or 7

46. The $\sqrt{-4}$ is:

A. 4
B. 2
C. -2
D. 16
E. none of these

47. The additive inverse of 3/2 is:

A. 2/3
B. -3/2
C. 3/2
D. 0
E. -2/3

48. The cardinality of the set of real numbers is:

A. $\aleph_0$
B. some finite number
C. $< \aleph_0$
D. $> \aleph_0$
E. none of these

49. The number named by .499. . . is _____ the number named by .500:

A. .001 less than
B. .1 less than
C. .001 times
D. .001 more than
E. the same as

50. What is the hundredths digit in the answer to 36.8 times .74?

A. 2
B. 4
C. 5
D. 7
E. 3

APPENDIX C

ATTITUDE SCALE: OPINIONNAIRE

OPPINIONNAIRE

by L. R. Aiken, Jr., and R. M. Dreger

DIRECTIONS: Please write your name in the upper right hand corner. Each of the statements on this opinionnaire expresses a feeling which a particular person has toward mathematics. You are to express on a five-point scale, the extent of agreement between the feeling expressed in each statement and your own personal feeling. The five points are: Strongly disagree (SD), Disagree (D), Undecided (U), Agree (A), Strongly agree (SA). You are to encircle the letter which best indicates how closely you agree or disagree with the feeling expressed to each statement as it concerns you.

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

13.	I approach math with a feeling of hesitation --hesitation resulting from a fear of not being able to do math.	SD	D	U	A	SA
14.	I really like mathematics.	SD	D	U	A	SA
15.	Mathematics is a course in school which I have always liked and enjoyed studying.	SD	D	U	A	SA
16.	I don't like mathematics. It makes me nervous to even think about having to do a math problem.	SD	D	U	A	SA
17.	I have never liked math, and it is my most dreaded subject.	SD	D	U	A	SA
18.	I love mathematics. I am happier in a math class than in any other class.	SD	D	U	A	SA
19.	I feel at ease in mathematics, and I like it very much.	SD	D	U	A	SA
20.	I feel a definite positive reaction to mathematics; it's enjoyable.	SD	D	U	A	SA

APPENDIX D

RAW DATA FOR A_1 AND A_2

SHSM, SATQ, SATV, PreattS, PrecompS, GPA, PostattS, PostcompS, AND BCTS FOR STUDENTS IN A_1 AND A_2

Class	Student Number	SHSM	SATQ	SATV	PreattS	PrecompS	GPA*	PostattS	PostcompS	BCTS
A_1	1	8	440	416	62	67	1	61	68	24
	2	8			62	70	2	53	78	38
	3	8	468	532	71	62	2	68	71	43
	4	8	482	444	78	74	3	83	71	40
	5	4	569	631	33	72	1	42	70	35
	6	8			93	77	4	87	76	41
	7	6	450	389	69	74	3	54	73	33
	8	8	496	423	92	74	1	84	79	37
	9	8	533	470	89	73	1	74	76	41
	10	8	478	580	86	69	3	76	73	40
	11	8	431	457	52	76	2	51	79	43
	12	6	478	464	89	75	2	72	79	34
	13	6			48	64	2	48	64	22
	14	8	609	419	81	69	5	53	71	30
	15	8	561	470	74	75	1	82	80	47
	16	6	589	423	97	78	1	94	78	36
	17	8	582	641	80	72	1	48	72	37
	18	8	515	552	88	70	3	97	75	40
	19	7			89	65	4	86	64	41
	20	8	661	686	100	79	1	100	80	43

*GPA: 1 = 3.6-4.0; 2 = 3.1-3.5; 3 = 2.6-3.0; 4 = 2.1-2.5; 5 = 1.6-2.0

Class	Student Number	SHSM	SATQ	SATV	PreattS	PrecompS	GPA*	PostattS	PostcompS	BCTS
A_1	21	8	701	511	100	74	1	100	66	44
	22	6	672	592	70	64	1	79	71	39
	23	8	530	491	66	70	3	60	63	25
	24	6	505	514	68	75	2	73	70	38
	25	6	478	511	48	77	3	73	74	37
	26	8	496	498	69	68	4	46	76	33
	27	8	533	587	70	72	1	81	74	44
	28	6	539	573	59	69	2	67	72	41
	29	6	624	546	51	80	2	72	68	46
	30	6	543	450	48	74	2	56	65	25
	31	6	571	607	42	72	2	43	67	31
	32	8	598	593	83	76	1	82	80	39
	33	6	468	600	43	66	3	45	76	37
	34	6	515	457	43	69	4	13	71	30
	35	5	564	695	48	74	1	67	78	41
	36	8	524	505	79	77	2	75	76	34
	37	5	598	709	58	86	2	50	71	35
	38	6	487	498	66	73	2	65	77	36
	39	6	511	513	46	50	2	39	64	30
A_2	40	6	515	498	77	73	2	71	75	35
	41	8	496	450	72	72	2	62	72	37

*GPA: 1 = 3.6-4.0; 2 = 3.1-3.5; 3 = 2.6-3.0; 4 = 2.1-2.5; 5 = 1.6-2.0

Class	Student Number	SHSM	SATQ	SATV	PreattS	PrecompS	GPA*	PostattS	PostcompS	BCTS
A_2	42	8	533	608	37	57	4	50	60	38
	43	6	524	496	90	51	5	77	58	28
	44	8	500	627	72	74	2	73	78	35
	45	9			81	66	2	79	75	37
	46	8	410	559	73	55	2	60	59	22
	47	4	635	721	48	76	1	53	80	40
	48	8	502	526	63	78	3	72	80	32
	49	6	533	539	91	76	4	92	76	28
	50	8	571	457	81	66	4	74	72	31
	51	4	543	539	88	78	1	74	79	42
	52	8	500	613	42	76	2	31	74	35
	53	8	543	689	53	75	1	66	66	35
	54	6	555	605	42	75	2	52	78	37
	55	6	527	559	66	69	1	54	73	39
	56	8	698	655	82	80	1	77	80	44
	57	8	571	546	74	78	2	55	77	37
	58	8	571	546	85	79	1	80	77	42
	59	6	533	573	51	64	3	41	70	28
	60	8	626	486	91	78	1	60	79	37
	61	6	589	511	70	72	2	56	75	24
	62	8	505	464	93	77	1	71	78	40
	63	8	654	668	94	78	1	94	76	45

*GPA: 1 = 3.6-4.0; 2 = 3.1-3.5; 3 = 2.6-3.0; 4 = 2.1-2.5; 5 = 1.6-2.0

Class	Student Number	SHSM	SATQ	SATV	PreattS	PrecompS	GPA*	PostattS	PostcompS	BCTS
A_2	64	8	543	436	90	72	3	95	70	38
	65	8	711	621	89	80	3	95	69	38
	66	8	543	730	92	77	2	94	73	39
	67	8	672	493	96	79	1	96	79	35
	68	8	543	450	96	80	1	92	80	39
	69	8	668	716	64	75	3	67	76	35
	70	8	502	430	95	58	4	86	77	32
	71	8	563	610	98	75	2	76	80	40
	72	8	505	484	75	69	4	67	80	31
	73	8	533	546	45	72	2	41	78	37
	74	9	626	623	94	74	1	61	76	30
	75	8	573	580	88	74	3	96	75	29
	76	6	608	648	39	74	1	46	76	41
	77	8	617	498	78	77	2	76	78	34
	78	9	671	512	78	79	1	86	77	37
	79	7	501	364	81	54	2	59	69	18
	80	8	530	491	77	73	3	73	77	37
	81	8	515	546	50	70	3	67	75	34
	82	6	530	599	53	70	3	69	72	34
	83	8	505	634	74	73	2	76	71	28
	84	6	478	491	46	67	1	49	75	38
	85	6	589	580	59	69	2	68	72	37

*GPA: 1 = 3.6-4.0; 2 = 3.1-3.5; 3 = 2.6-3.0; 4 = 2.1-2.5; 5 = 1.6-2.0

Class	Student Number	SHSM	SATQ	SATV	PreattS	PrecompS	GPA*	PostattS	PostcompS	BCTS
A_2	86	6	524	580	40	57	3	54	66	25
	87	6	440	436	57	71	2	69	75	29
	88	8	533	518	39	73	3	79	73	30
	89	2	546	552	63	71	3	58	72	21
	90	6	598	559	84	73	2	66	78	36
	91	6	608	744	55	74	2	58	75	41
	92	6	515	559	42	73	3	69	71	32
	93	8	643	506	98	77	2	100	78	43
	94	6	487	532	80	71	2	70	76	37
	95	6	552	525	60	77	1	75	77	37
	96	6	518	491	34	68	2	43	67	16
	97	8	664	409	78	80	1	78	78	42
	98	8	546	498	55	75	2	40	74	22
	99	6	478	614	34	70	3	37	71	22
	100	8	459	525	64	66	2	62	78	27
	101	6	478	525	43	64	2	41	73	28
	102	6	510	560	64	68	3	64	73	26
	103	6	487	566	46	67	2	52	71	22
	104	8	614	599	84	77	1	83	77	42
	105	6	680	719	55	74	1	76	67	42
	106	8	530	573	82	79	1	74	76	35
	107	6	440	539	51	63	2	35	42	21

*GPA: 1 = 3.6-4.0; 2 = 3.1-3.5; 3 = 2.6-3.0; 4 = 2.1-2.5; 5 = 1.6-2.0

Class	Student Number	SHSM	SATQ	SATV	PreattS	PrecompS	GPA*	PostattS	PostcompS	BCTS
A_2	108	6	524	580	55	67	3	34	73	23
	109	6	536	473	72	70	3	72	72	29
	110	6	505	566	31	72	3	23	66	23
	111	6	626	593	95	79	1	71	79	33
	112	6	539	513	42	77	2	47	78	30
	113	6	521	427	46	74	3	35	69	23

*GPA: 1 = 3.6-4.0; 2 = 3.1-3.5; 3 = 2.6-3.0; 4 = 2.1-2.5; 5 = 1.6-2.0

LIST OF REFERENCES

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1. Abrego, M. B. Children's attitudes toward arithmetic. Arithmetic Teacher, 13:206-208, 1966.

2. Adelphi College. Teacher education in a liberal arts setting. A report of the faculty of the Department of Education. Educational Leadership, IX:352-358, March, 1952.

3. Aiken, Lewis R., Jr., and Dreger, Ralph M. The effect of attitudes on performance in mathematics. Journal of Educational Psychology, 52:19-24, February, 1961.

4. Alberty, Elsie J. Mathematics in general education. Mathematics Teacher, LIX:426-431, May, 1966.

5. Allen, E. A. Professional training of teachers: A review of research. Educational Research, 5:200-215, June, 1963.

6. Allen, James E., Jr. Liberal education for adults in a changing society. School and Society, 94:454-458, December 19, 1966.

7. Allendoerfer, C. B. Mathematics for liberal arts students. American Mathematical Monthly, LIV:573-578, December, 1947.

8. _____. An analysis of certification requirements for teachers of mathematics. Bureau of Publications, George Peabody College, Nashville, Tennessee, 1949.

9. Andrews, L. O., and Palmer, R. R. The education of the elementary school teacher. The Education of Teachers: New Perspectives. Official Report of the Second Bowling Green Conference. Washington, D. C.: National Commission on Teacher Education and Professional Standards, N.E.A., 1958, pp. 322-329.

10. Andree, Richard V. College textbooks. American Mathematical Monthly, LXVI:323-348, April, 1950.

11. Ayre, H. Glenn. Can a single course in mathematics or the sciences fill the dual objectives of general education and training of future specialists? School Science and Mathematics, LIII:107-113, February, 1953.

12. Baird, G., Schutz, H. A., Andrews, E. D., and Booth, G. W. How to implement a modern mathematics program: Interviews. School Management, 7:55-60, October, 1963.

13. Bassham, Harrell, Murphy, Michael, and Murphy, Katherine. Attitude and achievement in arithmetic. Arithmetic Teacher, 11: 66-72, February, 1964.

14. Bassham, Harrell. Teacher understanding and pupil efficiency in mathematics--a study of relationship. Arithmetic Teacher, IX:383-387, November, 1962.

15. Bean, John E. The arithmetical understandings of elementary school teachers. Unpublished doctoral dissertation, Stanford University, 1958.

16. _____. Arithmetical understanding of elementary school teachers. Elementary School Journal, LIX:447-450, May, 1959.

17. Bedrosian, A., and Pincus, A. L. Teaching teachers. Improving College and University Teaching (9), 3:117-121, Summer, 1961.

18. Begle, E. G. Study of mathematical abilities; National longitudinal study of mathematical abilities. Arithmetic Teacher, 9:388-389, November, 1962.

19. Bellack, A. A. What knowledge is of most worth? High School Journal, 48:318-332, February, 1965.

20. Bezuszka, S. J. New trends in mathematics. Catholic School Journal, 60:48-52, September, 1960.

21. Bishop, J. F. Profile: the woman in liberal arts. Journal of College Placement, 25:37+, April, 1965.

22. Boardman, G. C. Taking a new look at subject matter. Wisconsin Journal of Education, 93:9-10, March, 1961.

23. Boyd, Elizabeth N. The cultural course in mathematics for college students. Mathematics Teacher, XLVII:479-481, November, 1954.

24. Breazier, Eldon E. A fifth year program for professional preparation. School and Community, LII:16, April, 1966.

25. Brender, Myron. A possible resolution of the current teacher training controversy. Association of American Colleges Bulletin, XLIV, October, 1958, pp. 449-453.

26. Breslich, E. R. Importance of mathematics in general education. Mathematics Teacher, 59:464-469, May, 1965; 44:1-6; January, 1951.

27. Broudy, Harry S. The role of the liberal arts in professional study. Journal of General Education, XVIII:50-67, April, 1966.

28. Brown, Bancroft H. Offerings for freshmen. American Mathematical Monthly, LXVIII:285-287, March, 1961.

29. Brown, Edward D. Arithmetical understandings and attitudes toward arithmetic of experienced and inexperienced teachers. Unpublished doctoral dissertation, University of Nebraska, 1961.

30. _____. Arithmetical understandings and attitudes toward arithmetic of experienced and inexperienced teachers. Dissertation Abstracts, XXII:775, July-September, 1961.

31. Brown, Francis R. Arithmetic---Friend or foe? Arithmetic Teacher, IV:1-9, January, 1957.

32. Brown, John A. and Mayor, John R. Academic and professional training of teachers of mathematics. Review of Educational Research, XXXI:296-304, June, 1961.

33. Brown, Kenneth E. The content of a course in general mathematics--Teachers' opinions. Mathematics Teacher, XLIII:25-30, January, 1950.

34. _____. General Mathematics in American Colleges. Bureau of Publications, Teachers College, Columbia University, 1943.

35. Brown, Kenneth E., and Abell, T. L. Analysis of research in the teaching of mathematics. U. S. Department of Health, Education and Welfare, Office of Education, Washington, D. C.: Superintendent of Documents, Government Printing Office, (No. 28, 1965).

36. _____. Research in the teaching of elementary school mathematics. Arithmetic Teacher, 12:547-549, November, 1965.

37. _____. Trends in mathematics offerings and enrollments. Mathematics Teacher, 59:652-655, November, 1966.

38. Bruner, Jerome S. Liberal education for all youth. Science Teacher, XXXII:19-21, November, 1965.

39. _____. On learning mathematics. Mathematics Teacher, 53: 610-619, December, 1960.

40. Burns, Paul C. and Dessart, Donald J. A summary of investigations relating to mathematics in elementary education: 1964. School Science and Mathematics, LXV:779-790, December, 1965.

41. Butterweck, Joseph S. The role of the liberal arts college in teacher education. Association of American Colleges Bulletin, XLIII, December, 1951, 602-608.

42. Callow, W. G. Why not a survey course in mathematics? Mathematics Teacher, 59:662-664, November, 1966.

43. Cameron, E. A. Some observations on undergraduate mathematics in American colleges and universities. American Mathematical Monthly, LX:151-155, March, 1953.

44. _____. Careers in mathematics: Conference board of the mathematical sciences. Mathematics Teacher, 53:340-343, May, 1960.

45. Carroll, Emma C. A study of the mathematical understanding possessed by undergraduate students majoring in elementary education. Dissertation Abstracts, XXII:494-495, August, 1961.

46. Carter, Thomas M. The preparation of teachers in a liberal arts college. School and Society, 93:242-244, April 17, 1965.

47. Cartwright, William H. The liberal arts college and the preparation of teachers. Journal of Teacher Education, 18:104-108, April, 1967.

48. Celine, Sister Mary. Excellence in the liberal education of a teacher. National Catholic Educational Association Bulletin, 57:173-177, August, 1960.

49. _____. A Half Century of Science and Mathematics Teaching. Oak Park, Ill.: Central Association of Science and Mathematics Teachers, Inc., 1950.

50. _____. Changing curricula in teacher education programs. Teachers College Journal, 32:7-9, October, 1960.

51. Christensen, G. J. Attitude, not subject matter. College and University, 39:5-12, Fall, 1963.

52. Clapp, Jane. College Textbooks. New York: The Scarecrow Press, 1960.

53. Clark, Marion Elmo. A critical analysis of the objectives and content of mathematics for liberal education at the college level. Dissertation Abstracts, V. 23, May, 1963, p. 4255.

54. Coleman, D. S., et al. Liberalizing the professional curriculum. Journal of Teacher Education, 11:41-44, March, 1960.

55. _____. College mathematics for general education, A selected bibliography. California Committee for the Study of Education, Subcommittee on the Content and Sequence of Mathematics from the 9th through the 14th Grades. (Mimeographed material, 1956).

56. _____. College mathematics for non-science students. American Mathematical Monthly, LXIII:639-642, November, 1956.

57. College Entrance Examination Board. Program for College Preparatory Mathematics. A Report of the Commission on Mathematics, New York, 1959.

58. Conant, James Bryant. The Education of American Teachers. New York: McGraw-Hill, 1963.

59. Corcoran, M. and Giab, E. G. Appraising attitudes in the learning of mathematics. The National Council of Teachers of Mathematics Yearbook, Evaluating Mathematics, 26:105-122.

60. Cornish, Norman Kester. The issue of college mathematics in general education. Dissertation Abstracts, 26:3777, January, 1966.

61. Cornish, Robert Lee. A study of the State University of Iowa undergraduate elementary teacher education program and its graduates. Dissertation Abstracts, 23:2805, February, 1963.

62. Creswell, J. L. An analysis of the relationships of selected factors to mathematics and arithmetic competency of prospective elementary teachers in Georgia. Dissertation Abstracts, 24:2374, December, 1963.

63. _____. Competence in arithmetic of prospective Georgia elementary teachers. Arithmetic Teacher, 11:248-250, April, 1964.

64. Cristantiello, P. D. Attitude toward mathematics and the predictive validity of a measure of quantitative aptitude. Journal of Educational Research, 55:184-186, December, 1961.

65. Curtis, E. L. A study of the mathematical backgrounds of students who are preparing to be elementary teachers and who are enrolled in certain colleges in Minnesota. Dissertation Abstracts, XVI: 2391, December, 1956.

66. Davis, R. B. A Modern Mathematics Program as It Pertains to the Interrelationship of Mathematical Content, Teaching Methods, and Classroom Atmosphere. Syracuse University and Webster College, 1:67, 1963.

67. Deans, Edwina. Pre-service and in-service education in mathematics. Arithmetic Teacher, XII:315-316, May, 1965.

68. Deutsch, O.S.F., Sister M. Bernardin. A developmental study of the philosophy of teacher preparation according to the National Commission on Teacher Education and Professional Standards. Dissertation Abstracts, 25:3419, December, 1964.

69. Diedrich, R. Teacher perceptions as related to teacher-student similarity and student satisfaction with school. Unpublished Doctoral Dissertation. University of Chicago, 1966.

70. Dixon, Lyle J. Mathematics and general education. Mathematics Teacher, XLVIII:204-208, April, 1955.

71. Dodes, I. A. Some comments on general mathematics. Mathematics Teacher, 60:246-251, March, 1967.

72. Douglas, Richard M. Science and the humanities. Science Teacher, XXXII:16-20, May, 1965.

73. Dressel, Paul L. What should be the content of the liberal arts curriculum? Current Issues in Higher Education, 1960, 62-66.

74. Dressel, P., Mayhew, L., and McGrath, E. The Liberal Arts as Viewed by Faculty Members in Professional Schools. New York: Teachers College, Columbia University, 1959.

75. Dutton, Wilbur H. Attitude change of prospective elementary teachers toward arithmetic. Arithmetic Teacher, IX:418-424, December, 1962.

76. _____. Attitudes of prospective teachers toward arithmetic. Elementary School Journal, LII:84-90, October, 1951.

77. _____. Evaluating Pupils' Understanding of Arithmetic. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1964.

78. _____. Individualizing instruction in elementary school mathematics for prospective teachers. Arithmetic Teacher, XIII:178-264, March, 1966.

79. _____. Measuring attitudes toward arithmetic. Elementary School Journal, LV:24-31, September, 1954.

80. _____. University students' comprehension of mathematical concepts. Arithmetic Teacher, VIII:60-64, February, 1961.

81. Dutton, Wilbur H., and Cheney, Augustine P. Pre-service and in-service education of elementary school teachers in arithmetic. Arithmetic Teacher, 11:192-198, March, 1964.

82. Dyer, H. S., Kalin, Rober and Lord, F. M. Problems in Mathematics Education. Princeton, N.J.: ETS, 1956, pp. 12-17.

83. Fawcett, H. P. Guidelines in mathematics education. Mathematics Teacher, 53:418-423, October, 1960.

84. Fedon, Peter. The role of attitude in learning arithmetic. Arithmetic Teacher, V:304-310, December, 1958.

85. Fehr, H. F. Mathematics education: Some new thinking. Teachers College Record, 62:456-464, March, 1961.

86. Ferguson, W. E. Current reforms in the mathematics curricula: A passing phase or progress? Mathematics Teacher, 57:143-148, March, 1964.

87. Fisher, John J. Extent of implementation of CUPM Level I recommendations. Arithmetic Teacher, 14:194-197, March, 1967.

88. _____. A survey to determine the extent of implementation of CUPM recommendations. Dissertation Abstracts, 28:1324A, October, 1967.

89. Flanders, Ned A. Teacher influence, pupil attitudes, and achievements. Co-Operative Research Monograph, No. 12. Washington: Government Printing Office, 1965.

90. Foerster, Norman. The Future of the Liberal College. New York: D. Appleton-Century Company, 1938.

91. Fulkerson, E. How well do 158 prospective elementary teachers know arithmetic? Arithmetic Teacher, VII:141-146-158, March, 1960.

92. Garstens, Helen L. Mathematics and elementary education majors. Arithmetic Teacher, XI:540-542, December, 1964.

93. _____. University of Maryland mathematics course for elementary education majors. National Commission on Teacher Education and Professional Standards:Official Report, 1963:146-152.

94. Gee, Burton Cleon. Attitudes toward mathematics and basic mathematical understanding of prospective elementary school teachers at Brigham Young University. Dissertation Abstracts, 26:6528, May, 1966.

95. Gentry, I. What knowledge is of most worth in mathematics? High School Journal, 48:351-355, February, 1965.

96. Glennon, Vincent J. A study in needed redirection in preparation of teachers of arithmetic. Mathematics Teacher, XLII:389-396, December, 1949.

97. Glodson, M. R., and Graham, E. K. Dialogue for a spring evening between the deans of liberal arts and education of Boston University with a monologue postscript by each. Journal of Teacher Education, 10:267-279, September, 1959.

98. Goodlad, J. I. Professional curriculum of teachers. Journal of Teacher Education, 11:454-459, December, 1960.

99. Graff, Patrick J. Self-estimate of ability to teach arithmetic. Arithmetic Teacher, X:479-480, December, 1963.

100. Griswold, Alfred W. Liberal Education and the Democratic Ideal. New Haven: Yale University Press, 1962, p. 206.

101. Grossnickle, Foster E. Growth in mathematical ability among prospective teachers of arithmetic. Arithmetic Teacher, IX:278-279, May, 1962.

102. _____. The training of teachers of arithmetic. The Teaching of Arithmetic, Fiftieth Yearbook of the National Society for the Study of Education, Part II (Chicago: University of Chicago Press, 1951), 203-231.

103. _____. The Use of Visual Aids in the Teaching of Arithmetic. Brooklyn: Rambler Press, 1950, p. 58.

104. Guidance report of the Commission on Post-War Plans. Mathematics Teacher, XL:315-339, November, 1947.

105. Guidelines for Science and Mathematics in the Preparation Program of Elementary School Teachers. (NASDTEC-AAAS), 1963.

106. Haggard, J. D. College mathematics for the general student. Dissertation Abstracts, XI: p. 570, 1951.

107. Hangartner, Carl A., S. J. Teacher education--A concern of the total college? Liberal Education, LLI:434-441, December, 1966.

108. Hannon, H. New look at content and its placement in elementary mathematics. School Science and Mathematics, 59:614-623, November, 1959.

109. Hardgrove, Clarence E., and Jacobson, Bernard. CUPM Report on the training of the teachers of elementary school mathematics. Arithmetic Teacher, 11:89-93, February, 1964.

110. Harlan, E. Liberal arts are the teacher's profession. New York State Education, 47:184, December, 1959.

111. Harper, E. Harold. Elementary teachers' knowledge of basic arithmetic concepts and symbols. Arithmetic Teacher, XI:543-546, December, 1964.

112. Harrington, Lester Garth. Attitude towards mathematics and the relationship between such attitude and grade obtained in a freshman mathematics course. Dissertation Abstracts, 20:4717, November 12, 1961.

113. Harvard Committee. General Education in a Free Society. Cambridge: Harvard University Press, 1945.

114. Hauer, C. E., Jr. Nature and purpose of liberal arts education: A point of view. Liberal Education, 49:204-217, May, 1963.

115. Hayes, R. B. Improving teacher education in a liberal arts college. National Committee on Teacher Education and Professional Standards; Official Report, 1963, 431-439.

116. Heisey, Daniel Joseph. A characterization of provers and non-provers in an axiomatic geometry course for elementary education majors: A discriminate analysis. Dissertation Abstracts, 27:413, August, 1966.

117. Henderson, Algo D. The liberal arts college and teacher education. Association of American Colleges Bulletin, XLI, October, 1955, 405-415.

118. Hengst, Herbert. Conant's latest: Naive, timid, or the answer? Michigan Education Journal, 41:38-39, November, 1963.

119. Herman, J. J. What problems are involved in implementing the new curricular programs? Arithmetic Teacher, 12:575-577, November, 1965.

120. Hiebert, Vern D. Preparing elementary teachers in mathematics. Educational Leadership, XIX:383-385, March, 1962.

121. Hill, W. F. Liberalizing a teacher education program: How one professional educator sees it. National Commission on Teacher Education and Professional Standards: Official Report 1963: 419-431.

122. Hilton, P. Continuing work of the Cambridge Conference on School Mathematics (CCSM). Arithmetic Teacher, 13:145-149, February, 1966.

123. Holton, B. Motivation and general mathematics students. Mathematics Teacher, 57:20-25, January, 1964.

124. Huettig, Alice, and Newell, John M. Attitudes toward introduction of modern mathematics program by teachers with large and small number of years' experience. Arithmetic Teacher, XIII:125-130, February, 1966.

125. Hungerman, A. D. Achievement and attitude of sixth-grade pupils in conventional and contemporary mathematics programs. Arithmetic Teacher, 14:30-39, January, 1967.

126. _____. A study of the achievement and attitude of sixth-grade pupils in conventional and contemporary mathematics programs. Dissertation Abstracts, 27:414, August, 1966.

127. Hutchins, Robert Maynard. The Higher Learning in America. New Haven: Yale University Press, 1936.

128. Hutchinson, C. A. (Ed.) Mathematics instruction for purposes of general education. American Mathematical Monthly, XLVIII: 189-197, March, 1941.

129. Jackson, P. W., and Getzels, J. W. Psychological health and classroom functioning: A study of dissatisfaction with school among adolescents. Journal of Educational Psychology, 50:295-300, December, 1959.

130. Jackson, Philip W., and Lahaderne, Henriette M. Scholastic success and attitude toward school in a population of sixth graders, Journal of Educational Psychology, 58:15-18, February, 1967.

131. Jensen, O. V. The development and standardization of a test of understandings of the real number system. Dissertation Abstracts, 28:988A, September, 1967.

132. Jones, P. S. New curriculum patterns for mathematics teachers. American Association of College Teachers of Education Yearbook, Foundations for Excellence, 1962, 90-93.

133. _____. Content in the teaching of mathematics. Virginia Journal of Education, 53:15-21, May, 1960.

134. _____. Recent research in mathematics: Implications for teacher education. American Mathematical Monthly, 67:589-590, June-July, 1960.

135. Kac, Mark. Can liberal arts colleges abandon science? Liberal Education, 52:41-49, March, 1966.

136. Kearney, E. W. Are general education, liberal education the same? Definitions related to educational philosophy. Chicago School Journal, 45:270-276, March, 1964.

137. Kennedy, Gail (Ed.) Education at Amherst. New York: Harper and Brothers, 1955.

138. Kenney, Russell A. Mathematical understanding of elementary school teachers. Arithmetic Teacher, 12:431-442, October, 1965.

139. Kinsella, J. J. Preparation in mathematics of mathematics teachers. Mathematics Teacher, 53:27-32, January, 1960.

140. Kipps, C. Arithmetic in college? Junior College Journal, 37:38-40, December, 1966.

141. Kline, Morris. Freshman mathematics as an integral part of western culture. American Mathematical Monthly, 61:295-306, May, 1954.

142. _____. Mathematics for Liberal Arts. Reading, Mass.: Wesley Publishing Company, 1967. 577 pp.

143. _____. The liberal educational values of mathematics, science, and technology for youth. NEA Addresses and Proceedings, 103:50-67, 1965.

144. Lafferty, William Andrew. The selection of subject matter in mathematics for general education. Unpublished doctoral dissertation, Teachers College, Columbia University, New York, 1956.

145. LaGrone, H. F. Toward a new curriculum for professional teacher development. Liberal Education, 51:70-76, March, 1965.

146. Lajewiski, Sister Mary Fermina, C.S.S.F. An experimental study to determine the effectiveness of one type of course in college mathematics for the non-major. Dissertation Abstracts, 27:4476B, October, 1967.

147. Lampela, Roland Mitchell. An investigation of the relationship between teacher understanding and change in pupil understanding of selected concepts in elementary school mathematics. Dissertation Abstracts, 27:1548, December, 1966.

148. Layton, W. I. The certification of teachers of mathematics. Mathematics Teacher, 42:377-380, December, 1949.

149. _____. Mathematics in general education. Mathematics Teacher, 50:493-497, November, 1957.

150. _____. Mathematical training prescribed by teachers' colleges in the preparation of elementary teachers. Mathematics Teacher, 44:551-556, December, 1951.

151. Leonhardt, Earl Albert. An analysis of selected factors in relation to high and low achievement in mathematics. Dissertation Abstracts, 23:3689, April, 1963.

152. Leonhardy, Adele. The mathematics used in the humanities, social sciences, and natural science areas in a program of general education on the college level. Dissertation Abstracts, 10: 72; No. 3, 1950.

153. Leverett, E. Basic requirements in college curricula. School and Society, 89:186-187, April 8, 1961.

154. Liggitt, W. A. Evaluation of general education in elementary teacher preparation. Journal of Educational Research, 57: 156-159, November, 1963.

155. Lois, Sister Mary. Evolution of a liberal arts program for elementary school teachers. National Commission on Teacher Education and Professional Standards: Official Report, 1963: 120-128.

156. Lonsdale, B. J. Teacher education programs for the preparation of elementary school teachers. California Journal of Elementary Education, 29:226-240, May, 1961.

157. Lyda, Wesley J., and Morse, E. C. Attitudes, teaching methods, and arithmetic achievement. Arithmetic Teacher, 10:136-138, March, 1963.

158. McGrath, Earl J. Liberal Education in the Professions. New York: Teachers College, Columbia University, 1959, 63 pp.

159. _____. The liberal element in professional education. Association of American Colleges Bulletin, XLIII:102-120, March, 1957.

160. McIvers, William Daniel. An analysis of professional educational periodical literature relating to the objectives of American liberal arts education, 1920 to 1950. Dissertation Abstracts, 25:2335, October, 1964.

161. Malpass, L. F. Some relationships between students' perceptions of school and their achievement. Journal of Educational Psychology, 44:475-482, 1953.

162. Marks, John L. The uneven progress of the revolution in elementary school mathematics. Arithmetic Teacher, 10:474-478, December, 1963.

163. Mathematical Association of America. Forty-One Conferences on the Training of Teachers of Elementary School Mathematics: A Summary. A report prepared by the Committee on the Undergraduate Program in Mathematics, Berkeley, California, No. 15, 1966.

164. May, J. R., et al. An implication for teacher education of recent research in mathematics education. Journal of Teacher Education, 483-489, December, 1965.

165. Mayor, J. R. Issues and directions. Arithmetic Teacher, 13:349-354, May, 1966.

166. Meder, Albert E., Jr. Sets, sinners, and salvation. Mathematics Teacher, 59:358-363, April, 1966.

167. Melson, Ruth. How well are colleges preparing teachers for modern mathematics? Arithmetic Teacher, 12:51-53, January, 1965.

168. Millar, M. Some roles of subject matter in curriculum inquiry. School Review, 68:329-345, No. 3, Autumn, 1960.

169. Miller, B. R. New developments in the teaching of mathematics. National Association of Secondary School Principals Bulletin, 44:87-88, April, 1960.

170. Milligan, Merle Wallace. An inquiry into the selection of subject matter content for college freshman mathematics. Unpublished doctoral dissertation, Oklahoma State University, Stillwater, 1961.

171. _____. An inquiry into the selection of subject matter content for college freshman mathematics. Dissertation Abstracts, 1961.

172. Mires, Katherine C. The need for and nature of one type of course in mathematics for general education at the college level. Unpublished doctoral dissertation, The University of Oklahoma, 1956.

173. Montague, Harriet F. A course on the significance of mathematics. American Mathematical Monthly, 48:681-684, December, 1941.

174. Montague, H. F., and Henry, P. M. Case for a general education course in mathematics. Journal of General Education, 13:97-112, July, 1961.

175. Moody, William B. Teacher competence: What to evaluate and how. Arithmetic Teacher, 13:30-31, January, 1966.

176. Morgan, George W. Liberal education: An assessment of afflictions and suggestions for reform. Liberal Education, 47:376-395, October, 1961.

177. Morton, R. L. Mathematics in the training of arithmetic teachers. Mathematics Teacher, 32:106-110, March, 1939.

178. Moruyama, M. General education: A realistic perspective. College and University, 40:145-152, Winter, 1965.

179. Mueller, Francis J. Arithmetic preparation for elementary teachers. Education, 79:299-302, January, 1959.

180. Nafziger, Mary K. A study of selected arithmetic understandings of undergraduate students in the elementary teacher preparation programs at Goshen College. Dissertation Abstracts, 22:2709, February, 1962.

181. National Council of Teachers of Mathematics. Emerging Practices in Mathematics Education, Twenty-Second Yearbook. Washington, D. C.: N.C.T.M., 1954, 434 pp.

182. _____. Guidance report of the Commission on Post-War Plans. Mathematics Teacher, XL: 315-339, November, 1947.

183. _____. Twenty-Fifth Yearbook, Instruction in Arithmetic. 1960.

184. National Education Association, National Commission on Teacher Education and Professional Standards. The Education of Teachers: Curriculum Programs. Official Report of the Kansas Conference, Washington, D. C.: The Commission, 1959, 453 pp.

185. National Institute of Adult Education. Liberal Education in a Technical Age. London: Max Parrish, 1955, 128 pp.

186. Nelson, Albert Leroy. A study of the general education curricula for teachers offered by selected liberal arts colleges in Kansas. Dissertation Abstracts, V. 26, p. 3111, December, 1965.

187. Ness, Frederic W. Conant on teacher education: Some implications for the liberal arts college. Liberal Education, VL, March, 1964, 402-414.

188. Nelson, L. D., and Worth, W. H. Mathematical competence of prospective elementary teachers in Canada and in the United States. Arithmetic Teacher, 8:147-151, April, 1961.

189. Newsom, C. V. Mathematical background needed by teachers. The Teaching of Arithmetic, Fiftieth Yearbook of the National Society for the Study of Education, Part II. Chicago: University of Chicago Press, 1951, 232-250.

190. Northey, James Howard. The lecture and discussion use of class time in a pre-service mathematics class for elementary teachers. Unpublished doctoral dissertation, The University of Michigan, 1967.

191. Northrop, E. P. Mathematics in a liberal education. American Mathematical Monthly, 52:132-137, March, 1945.

192. O'Donnell, J. R. Levels of arithmetic achievement: Attitudes toward arithmetic, and problem solving behavior shown by prospective elementary teachers. Dissertation Abstracts, 19:1300, December, 1958.

193. Ore, Aystein. Mathematics for students of the humanities. American Mathematical Monthly, 51:453-458, October, 1944.

194. Orleans, Jacob S., and Wandt, Edwin. The understanding of arithmetic possessed by teachers. Elementary School Journal, 53: 501-507, May, 1953.

195. Paige, D. General mathematics: The future as the past? School Science and Mathematics, 64:195-201, March, 1964.

196. Papham, W. James, and Greenberg, Suzanne W. Teacher education: A decade of criticism. Phi Delta Kappan, 40:118-120, December, 1958.

197. Peak, P. Programs for teacher preparation in mathematics and science. School Science and Mathematics, 64:579-584, October, 1964.

198. Perel, W. M., and Vairo, Philip D. Needed: Dialogue between professors of education and academicians. Liberal Education, 52: 470-478, December, 1966.

199. Perkins, James A. Liberal learning and the learning community. Liberal Education, 53:5-15, March, 1967.

200. Peskin, Anne Stern. Teacher understanding and attitude and student achievement and attitude in seventh grade mathematics. Dissertation Abstracts, 26:3983, January, 1966.

201. Phillips, Clarence. A combined content-methods course for elementary mathematics teachers. Arithmetic Teacher, 7:138-140, March, 1960.

202. _____. Background and mathematical achievement of elementary education students in arithmetic for teachers. School Science and Mathematics, 53:48-52, January, 1953.

203. The Place of Mathematics in Secondary Education, Fifteenth Yearbook of the National Council of Teachers of Mathematics. New York: Bureau of Publications, Teachers College, Columbia University, 1940.

204. Poffenburger, T. N., and Norton, D. A. Factors determining attitudes toward arithmetic and mathematics. Arithmetic Teacher, 3:113-116, 1956.

205. _____. Factors in formation of attitudes towards mathematics. Journal of Educational Research, 52:171, 1959.

206. Postl, A. Course in contemporary developments in the sciences and mathematics. Science Education, 43:407-409, December, 1959.

207. Preparation in mathematics for elementary school teachers. Excerpts from the report of the Mathematical Association of America Committee on the Undergraduate Program in Mathematics. Arithmetic Teacher, 14:198-199, March, 1967.

208. Pruitt, C. M. An unrealistic proposal for grade school teacher preparation in mathematics. Science Education, 48:85-86, February, 1961.

209. Radley, Virginia L. Elementary education and the liberal arts college. Liberal Education, XLVI:463-466, March, 1960.

210. Ray, M. M. The preparation of teachers of elementary school mathematics in Louisiana. Dissertation Abstracts, 28:2127A, December, 1967.

211. Recommendations of the Mathematical Association of America for the training of teachers of mathematics. American Mathematical Monthly, 47:982-991, December, 1960.

212. Reed, H. B., and Shepard, J. P. Elementary teacher preparation within the context of the liberal arts. College and University, 39:25-35, Fall, 1963.

213. Reinert, P. C. The liberal arts and teacher education. Liberal Education, LI, March, 1965.

214. Reisert, John Edward. A study of selected teacher characteristics of elementary teachers with different preparation backgrounds. Dissertation Abstracts, 26:52-71, March, 1966.

215. Reports of Regional Conferences on Improving Mathematics Instruction in Elementary Schools. Sacramento, Calif.: State Department of Education, 1961, 85 pp.

216. Reynard, H. E. Pre-service and in-service education of teachers. Review of Educational Research, 33:369-380, October, 1963.

217. Reys, Robert E. Are elementary school teachers satisfied with their mathematics preparation? Arithmetic Teacher, 14:190-193, March, 1967.

218. _____. A study of the mathematics preparatory program for elementary school teachers of the University of Missouri at Columbia. Dissertation Abstracts, 27:2926A, March, 1967.

219. Rice, Jimmy Marshall. A study of attitudes of elementary teachers toward modern mathematics programs. Dissertation Abstracts, 26:1433, September, 1965.

220. Richardson, Moses. Fundamentals in the teaching of undergraduate mathematics. American Mathematical Monthly, LVIII:182-186, March, 1951.

221. _____. Mathematics and intellectual honesty. American Mathematical Monthly, LIX:73-78, February, 1952.

222. _____. The place of mathematics in a liberal education. National Mathematics Magazine, XIX:349-358, April, 1945.

223. Robb, Felix C. The professional content of teacher education. Liberal Education, LI:37-43, March, 1965.

224. Robinson, W. N. The teacher education programs of selected midwestern liberal arts colleges accredited by N.C.A.T.E. Dissertation Abstracts, 26:215, July, 1965.

225. Ruddell, Arden K., Dutton, Wilbur, and Rickzek, John. Background mathematics for elementary teachers. Instruction in Arithmetic, Twenty-Fifth Yearbook. Washington, D. C.: N.C.T.M. Chapter 13, 1960.

226. The St. John's Program. Annapolis: The St. John's College Press, 1955.

227. Scandura, J. M. Nature of research in mathematics education. High School Journal, 50:227-237, February, 1967.

228. Schaaf, William L. Arithmetic for arithmetic teachers. School Science and Mathematics, LIII:537-543, October, 1953.

229. _____. Required mathematics in a liberal arts college. American Mathematical Monthly, 44:445-453, August-September, 1937.

230. _____. The human significance of mathematics. Mathematics Teacher, 19:472-483, December, 1926.

231. Schaffer, Sidney Charles. A study of the graduates and professional curriculum of the Adelphi New Teacher Education Program at Adelphi College. Dissertation Abstracts, 24:1089, September, 1963.

232. Scheer, W. E. Every student needs mathematics. Business Education World, 44:23, January, 1964.

233. Schirmer, M. A. Evaluation of teacher education programs in selected Catholic liberal arts colleges for women. Catholic Educational Review, 57:236-252, 308-326, 385-402, April-May-September, 1959.

234. Scott, Ralph Lincoln. The relationship between achievement in high school and success in college with reference to science and mathematics. Dissertation Abstracts, 27:639, September, 1966.

235. Seidlin, Joseph. A Critical Study of the Teaching of Elementary College Mathematics. New York: Bureau of Publications, Teachers College, Columbia University, 1931.

236. Shryock, Alfred Jerry. A study of mathematics background courses for elementary school teachers. Dissertation Abstracts, 23: 1562, November, 1962.

237. Shryock, J. Mathematics course for prospective elementary school teachers. Arithmetic Teacher, 10:208-211, April, 1963.

238. Smith, B. O. Joint task: The preparation of a teacher. Journal of Teacher Education, 10:189-198, June, 1959.

239. Smith, D. B. Some observations on mathematics curriculum trends. Mathematics Teacher, 53:85-89, February, 1960.

240. Smith, Frank. How well are colleges preparing teachers for modern mathematics? Arithmetic Teacher, 14:200-202, March, 1967.

241. _____. Prospective teachers' attitudes toward arithmetic. Arithmetic Teacher, 11:474-477, November, 1964.

242. Snader, D. W. New era in mathematics, how can it be brought about? School Life, 42:26-31, April, 1960.

243. _____. Mathematical background for teachers of arithmetic. Arithmetic Teacher, 3:59-65, March, 1956.

244. Sparks, Jack N. Arithmetic understandings needed by elementary school teachers. Arithmetic Teacher, 8:395-403, December, 1961.

245. Stepanowich, Joseph. The mathematical training of prospective elementary school teachers. Arithmetic Teacher, 4:240-248, December, 1957.

246. Stewart, Blair (Ed.). The liberal arts. Journal of Higher Education, 37:170-173, March, 1966.

247. Stiles, L. J. Role of liberal arts colleges in teacher education. Educational Forum, 28:171-177, January, 1964. Summary in Michigan Education Journal, 41:16, February, 1964.

248. _____. Teacher Education in the United States. New York: The Ronald Press Company, 1960, 512 pp.

249. Stone, Marshall H. Fundamental issues in the teaching of elementary school mathematics. Arithmetic Teacher, 6:177-179, October, 1959.

250. _____. Reviews and evaluations. Mathematics Teacher, 58: 353-360, April, 1965.

251. Strain, Lucille B. Prospective elementary school teachers' knowledge of selected subject matter. Dissertation Abstracts, 26: 1502, September, 1965.

252. Sudduth, Martha Cooper. An historical survey of the development of the use of instructional materials for the teaching of arithmetic in the elementary grades as recorded in selected publications. Dissertation Abstracts, 23:3822, April, 1963.

253. Summerer, Kenneth H. College mathematics for the non-science, non-mathematics major. School Science and Mathematics, 56: 39-43, January, 1956.

254. Summers, E. G. Doctoral dissertation research in science and mathematics reported for 1964: Mathematics. School Science and Mathematics, 67:44-50, January, 1967.

255. Summers, E. G., and Hubrig, Billie. Doctoral dissertation research in mathematics reported for 1963. School Science and Mathematics, 65:505-528, June, 1965.

256. Summers, E. G., and Stochle, J. E. Bibliography of doctoral dissertations completed in elementary and secondary mathematics from 1950 to 1960. School Science and Mathematics, 61:431-439, June, 1961.

257. Survey of mathematics programs in institutions granting bachelor and higher degrees. Higher Education, 19:9, January, 1963.

258. Teacher education and liberal arts colleges. School and Society, 92:220, Summer, 1964.

259. Teacher education: Whose responsibility? Summary of group report. Teachers College Journal, 31:43-46, November, 1959.

260. Tead, Ordway and Rivlin, Harry N. Conant report on teacher education. Improving College and University Teaching, 12:57-60, Winter, 1964.

261. Ten Conferences on the Training of Teachers of Elementary School Mathematics. Berkeley Calif.: Committee on the Undergraduate Program in Mathematics, 1965.

262. Thomas, Alan. The Liberal Education--A Re-Examination. The University of British Columbia, No. 4, January, 1958, 6 pp.

263. Thompson, Gerry E. An evaluation of the teacher education program of Union College, Lincoln, Nebraska. Dissertation Abstracts, 26:217, July, 1965.

264. Todd, Robert M. A mathematics course for elementary teachers: Does it improve understanding and attitude? Arithmetic Teacher, 13:198-202, March, 1966.

265. The training of elementary school mathematics teachers. Arithmetic Teacher, 7:421-425, December, 1960.

266. Tyack, David. Small colleges and teacher education. School and Society, 94:326-327, October 15, 1966.

267. Ulmer, Gilbert, and Tillotson, Donald. The teaching of mathematics at the college and university level. Review of Educational Research, 31:314, June, 1961.

268. The University of Chicago, College Announcements 1962-1963. Chicago: The University of Chicago, October, 1961.

269. Van Doren, Mark. Liberal Education. Boston: Beacon Press, 1959, 178 pp.

270. Vogel, A. W. Education and the liberal arts college. Liberal Education, 48:252-259, May, 1962.

271. Wagenshein, M. Teaching of mathematics: A tragedy. Review of Educational Research, 2:155-164, 1961.

272. Waggoner, Wilbur. Improving the mathematical competency of teachers in training. Arithmetic Teacher, 5:84-86, March, 1958.

273. Wahlert, Howard Elmer. Elementary mathematics in arts colleges. Unpublished doctoral dissertation, Columbia University, New York, 1952, p. 530.

274. Weaver, J. Fred. A crucial problem in the preparation of elementary school teachers. Elementary School Journal, 56:255-261, February, 1956.

275. _____. The mathematics education of elementary school teachers: Pre-service and in-service. Arithmetic Teacher, 12:71-75, January, 1965.

276. _____. Research on elementary school mathematics--1962. Arithmetic Teacher, 10:297-300, May, 1963.

277. _____. Research on elementary school mathematics--1963. Arithmetic Teacher, 11:273-275, April, 1964.

278. _____. Research on elementary school mathematics--1964. Arithmetic Teacher, 12:382-387, 577-578, May, November, 1965.

279. Wells, D. Which curriculum direction will our schools take? Michigan Education Journal, 38:246, November, 1960.

280. Whitehouse, William W. Report of Commission on Teacher Education. Association of American Colleges Bulletin, XXXIII:242-249, March, 1947.

281. Wickes, H. E. Pre-service mathematics preparation of elementary teachers: The relative effectiveness of two programs in determining attitudes toward, and achievement in, mathematics. Dissertation Abstracts, 28:2591A, January, 1968.

282. Wiebe, Elias Henry. The nature of elementary teacher education in certain liberal arts colleges and universities in California. Dissertation Abstracts, 21:1474-1475, November 6, 1960.

283. Winthrop, Henry. Specialization and intellectual integration in liberal education. Educational Theory, 17:25-31, January, 1967.

284. Withnell, Melvin Cleo. A comparison of the mathematical understandings of prospective elementary teachers in colleges having different mathematics requirements. Unpublished doctoral dissertation, The University of Michigan, 1967.

285. Wolfe, W. C., Jr. Liberal education vs. professional training. Ohio Schools, 39:12, December, 1961.

286. Woodby, Lauren G. A synthesis and evaluation of subject matter topics in mathematics in general education. Unpublished doctoral dissertation, The University of Michigan, 1952, p. 531.

287. Woody, Thomas. Liberal Education for Free Men. Philadelphia: University of Pennsylvania Press, 1951, 296 pp.

288. Wooton, W. Changing mathematics curriculums and the junior college. Junior College Journal, 30:132-135, November, 1959.

289. Wormald, F. L. Editorial notes. Liberal Education, LII:479-480, December, 1966.

290. Woronoff, Israel. Teacher education programs for liberal arts graduates. Journal of Teacher Education, 9:359-362, December, 1958.

291. Wren, F. L. The professional preparation of teachers of arithmetic. Arithmetic 1948, Supplementary Educational Monograph No. 66, Chicago: University of Chicago Press, October, 1948, pp. 80-90.

292. _____. The merits and content of a freshman mathematics course. School Science and Mathematics, 52:595-603, November, 1952.

293. Wren, H. A., et al. Liberal studies in teacher education and implications for A. A. C. T. E. American Association of College Teachers Educational Yearbook. Action for Improvement of Teacher Education, 18:169-178, 1965.

294. Wynne, J. P. General Education. New York: Bookman Associates, 1952, 251 pp.

295. Yorke, Gertrude C. The preparation needed by teachers of arithmetic. Education, 69:373-375, February, 1949.

296. Young, Gail S. Problems in the training of elementary school teachers. Arithmetic Teacher, 13:380-384, May, 1966.

297. Young, J. W. The organization of college courses in mathematics for freshmen. American Mathematical Monthly, 30:6-14, January, 1923.

298. Zant, J. H. Teaching of mathematics at the college and university level: Modern curriculum in college mathematics. Review of Educational Research, 34:347-353, June, 1964.