OE-29007-60
Bulletin 1963, No. 12

Analysis of Research in the Teaching of Mathematics

1959 and 1960

KENNETH E. BROWN, *Specialist for Mathematics, Office of Education*

JOHN J. KINSELLA, *New York University*

HOWARD FEHR, *Columbia University*

SHELDON MYERS, *Educational Testing Service, Princeton, New Jersey*

FRED WEAVER, *Boston University*

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
ANTHONY J. CELEBREZZE, *Secretary*

Office of Education . . . FRANCIS KEPPEL, *Commissioner*

Foreword

THE TECHNICAL ADVANCEMENT of the space age has increased the need for high-quality scientists, engineers, and technicians. Helping to meet this need for high-quality scientific personnel falls heavily upon the Nation's schools. Research can affect the quality of the product of the schools only to the extent the findings are made known to those responsible for the education of the youth of our Nation.

This study makes available the findings of the research in the teaching of mathematics reported to the U.S. Office of Education during the calendar years 1959 and 1960.

To assist in disseminating the findings of research on the teaching of mathematics, the U.S. Office of Education in cooperation with the National Council of Teachers of Mathematics prepared summaries of research in mathematics education in 1952 (Circular No. 377) and in 1954 (Circular No. 377–II). As a result of the suggestions from readers of the research summaries, these organizations cooperated further by including an analysis as well as a summary of the research for the two periods 1955–56 and 1957–58. The current study is a continuation of this cooperative effort. It is hoped that this summary analysis of research in mathematics education for the calendar years 1959 and 1960 will be helpful to both research workers and classroom teachers in improving mathematics instruction.

Appreciation is expressed to the deans of graduate schools and to research workers in mathematics education for readily supplying the data on which the study is based. The Office of Education is grateful to the Research Committee of the National Council of Teachers of Mathematics for its cooperation in preparing the report.

J. DAN HULL, *Director,*
Instructional Programs Branch

ERIC R. BABER,
Assistant Commissioner,
Division of Elementary and Secondary Education

Contents

ANALYSIS OF RESEARCH IN THE TEACHING OF MATHEMATICS

Introduction

TO SECURE the data for this study the U.S. Office of Education, with the aid of the Research Committee of the National Council of Teachers of Mathematics, sent a questionnaire to 454 colleges that offered graduate work in mathematics education, or whose staffs or students had made previous contributions in that area.

Data were received from 247 colleges or research workers. In many cases the questionnaire was not only completely filled out, but an abstract of the reported study was attached. In other cases, the questionnaire was returned with the notation that no such research had been done, but a copy of the published report was desired.

Of the 247 colleges that returned the questionnaire, 46 reported research in the teaching of mathematics. The committee carefully studied the 137 reported research studies and selected 105 of them for inclusion in this analysis. The selected studies consisted of 40 doctoral dissertations, 49 master's theses, and 16 nondegree studies. A summary of each is included in the appendix.

If the studies were classified by major emphasis, methods would rank first. However, in such a classification there would be considerable duplication because many studies were concerned with both method and content.

Other studies were primarily concerned with evaluation, yet included a consideration of method or content. Studies of international mathematics education were based on the study of content. Although the major themes of many studies seemed to emphasize such aspects as methods, content, teacher education, evaluation, survey, psychology of learning mathematics, or the history of certain topics or techniques, a discrete classification by such categories was not possible.

Therefore, instead of attempting to classify the research on the basis of the major emphasis of each study, this study is organized according to pertinent questions in mathematics education. For the convenience of the reader, these questions and analyses are grouped under three headings: Research in the Teaching of Elementary School Mathematics, Research in the Teaching of High School Mathematics, and Research in the Teaching of College Mathematics. It will be observed that there is considerable overlapping even in these broad categories.

The research concerned with the elementary level contained 31 studies; the high school level, 45; and the college level, 29. The names and numbers in parentheses in the following analysis denote the investigator and the number of his study as summarized in the appendix.

Research in the Teaching of Elementary School Mathematics

RESEARCH IN THE TEACHING of elementary school mathematics during 1959–60 dealt chiefly with problem solving, grouping for instruction, enrichment for more capable learners, multisensory aids, alternative methods for teaching certain topics, and various status studies. Other areas of interest received isolated scattered attention, as seen in the questions and answers which follow.

What factors seem to be related to success in problem solving?

Factorial studies of the problems-solving ability of fifth-grade boys (Sr. Emm—30) and fifth-grade girls(McTaggert—66) revealed two primary factors common for both boys and girls—a verbal-cognitive factor and an arithmetic factor—with a third primary factor differing for boys (a spatial factor) and girls (an approach-to-problem-solving factor). Another investigator found that among fourth-grade pupils intelligence was not a major factor in relation to problem-solving ability, and that comprehensive reading skill was more highly related to problem-solving ability than was word concept skill (Sanderlin—81). One investigator developed a specific problem-solving program for sixth-grade pupils and found it to be no more or less effective than the procedures suggested by the authors of a basic textbook series (Faulk—34). A cooperative "action research" study sought to determine ways to improve pupils' problem-solving ability (Sisters of Mercy—85).

How helpful is the grouping of children for instruction?

One investigator found no significant difference in achievement among second-grade pupils when two types of grouping for instruction were compared: intraclass grouping and whole-class instruction (Pressler—76). On the basis of informal observation, another investigator suggested that two or three groups were most desirable at the fourth-grade level. (Luetge—57). In a different kind of investigation involving seventh-grade pupils, no significant difference in the emergence of creative intellectual behavior in mathematics was found between pupils working in groups and those working as individuals (Spraker—89).

What enrichment activities are worthy of use?

Historical number stories were suggested for use in the intermediate grades (Kreitz—52). Another investigator compiled a list of suitable activities and materials for use at the second-grade level (Anderson—3).

What multisensory aids are suggested as helpful?

A compilation of multisensory aids for use in the intermediate grades was prepared by one investigator (Drisdale—27). Another investigator found that the use of prearranged multisensory materials in the teaching of measurement units at the fifth- and sixth-grade levels produced no significant advantage in relation to quantitative understanding, computational skill, and attitude toward school subjects (Mott—68).

What do analyses of textbooks reveal?

One investigator found that in connection with the program for teaching basic addition and subtraction facts in the first and second grades, the State-approved textbooks differed among themselves as to scope, organization, and presentation of facts included (Wade—99). Another investigator found that for texts for grades 3 to 6 published between 1920 and 1960, many changes during this 40-year period were in harmony with research findings relative to the teaching of problem solving and computational skills, but that numerous recommendations stemming from research had not been utilized in the development of textbook materials (Singer—84). One investigator developed criteria and procedures for textbook evaluation (Story—92). In a somewhat different vein, an analysis of the first-grade texts and professional writings of five "arithmetic specialists" revealed that each holds similar ideas regarding the nature of first-grade arithmetic, but there is a great difference in content and method (Sr. Ryan—79).

What factors are related to the understanding of basic mathematical principles?

Based on students in grades 8 to 12 and in a teacher education program, age and student teaching experience were found not to add to the understanding of basic mathematical principles, but the factors of teaching experience, level of academic preparation, and number of semesters of high school mathematics were related positively to the understanding of basic mathematical principles (Stoneking—91). In another investigation, it was suggested that because of psychological factors involved in teaching mathematics in grades K to 8, number cannot be made rigorously logical; mastering the number concept requires that the student develop a sense of structure and an ability to make generalizations (Blacka—10).

What are the effects of different schedules of reinforcement upon the learning of arithmetic?

At the fifth-grade level, it was found that arithmetic materials learned under a schedule of reinforcement are retained longer than similar material under a schedule of nonreinforcement or a schedule of reinforcement which follows nonreinforcement (Davis—24).

What are the relative merits of different methods of estimating quotient figures when dividing by two-figure divisors?

Of the familiar methods of estimation taught at the fifth-grade level, the "two-rule method" appeared to be least advantageous; also pointed to evidence that pupils may not actually use the method they were "taught" (Carter—20).

Do children taught division of fractions by the inversion method retain more, or less skill than those taught by the common denominator method?

No significant difference in retention was found for pupils tested at the end of grade 6 and again at the beginning of grade 7 (Stephens—90 and Dutton—29).

Is the "ratio method" or the "conventional method" of teaching percent to be preferred?

At the seventh-grade level there appeared to be no difference between methods in developing ability to interpret statements about percent, but the ratio method resulted in greater and more permanent skill; however, neither method was judged successful with pupils of low mental ability (McMahon—65).

What are the current attitudes toward arithmetic on the part of children and teachers?

At the third-, fourth-, and sixth-grade levels it was found that a very large proportion of both boys and girls liked arithmetic and felt it is useful (at all three levels, girls liked arithmetic better than boys); also, the majority of teachers sampled definitely enjoyed teaching arithmetic (Stright—93).

How do high and low arithmetic achievers among underage and normal-age children compare in personal and social adjustments?

At the second-grade level it was found that high arithmetic achievement was associated with high ratings on the personality instrument, but that differences between normal-age and underage pupils and between boys and girls tended to be only chance differences (Anderson—51).

What relationship exists between understanding various systems of numeration and understanding our conventional decimal system?

At the seventh-grade level a statistically significant correlation of 0.67 was found between test scores dealing with nondecimal numeration systems and those dealing with our conventional decimal system (Albanese—1).

The following status and related studies were reported and are listed here only by topic investigated:

1. A comparison of the teaching of arithmetic in the elementary schools of the United States and New Zealand (Duncan—28).
2. A survey of arithmetic teaching practices in Tennessee, grades 1 to 8 (Johnston—45).
3. A diagnostic study of the understandings of concepts in mathematics by 33 fifth-grade pupils (Bruce—15).
4. A study of the major causes of arithmetic difficulties among 35 seventh-grade pupils (Lindsey—54).
5. Identification of individual differences in arithmetic abilities among three fourth-grade classes (Wallace—100).
6. A study of children's learning to write the 10 basic numerals (Downs—26).

Research in the Teaching of High School Mathematics

MANY OF THE FACETS and points of view of the new curriculums for the high school which have developed in the last few years are being tested experimentally and evaluated. Studies reflecting current interest in high-ability students are also in evidence. These and other studies are briefly reviewed in connection with 10 major questions which follow.

What do studies on the evaluation of new curriculums show?

A large-scale study (Payette—72) showed that students exposed to conventional mathematics have neither a pronounced nor a consistent advantage over students exposed to School Mathematics Study Group mathematics with respect to the learning of traditional mathematical skills. Students exposed to SMSG instruction acquire pronounced and consistent extensions of developed mathematical ability beyond that developed by students exposed to conventional mathematics instruction. There is positive evidence to suggest that students at all academic ability levels as measured by School and College Ability Test can learn considerable segments of School Mathematics Study Group materials.

In another study (Malan—59) students studying a modern ninth-grade program achieved significantly higher on the Lankton Algebra Test than students studying traditional materials.

In a third study (Hamilton—39) students in contemporary sections of algebra I were found to have more enthusiasm than students in traditional sections with no loss of achievement on traditional materials.

What are the comparative merits of different pedagogical techniques in teaching mathematics?

The inductive method of teaching was compared with the deductive method in ninth-grade general mathematics (Thompson—95). Although the before and after tests used were too dissimilar for significant comparison, it was observed that weekly recitations and weekly test performances were better during the semester when the inductive method was used.

The spiral or functional method of teaching was compared with the traditional method in ninth-grade general mathematics classes and algebra classes (Woodbury—103). General mathematics achievement is greater for the spiral method, while algebra achievement is greater for the traditional method. Positive responses toward mathematics was greater in both algebra and general mathematics classes when taught by the traditional method.

The experimental method of teaching computations with signed numbers in which pupils were enabled to formulate their own rules was compared with the traditional method of teaching with a standard textbook (Zahnke—104). Comparisons of matched groups indicated no significant difference, but the students in the experimental classes were more enthusiastic about their homework.

A method of teaching the three cases of percentage in which emphasis was placed on an understanding of the three types and their interrelationships was compared with the usual textbook method (Tredway—97). The experimental method provided significantly better learning and superior retention for pupils of average intelligence. It was found that 20 days was adequate time for teaching percentage when the experimental method was used.

The effectiveness of a team of two teachers and a secretary teaching large algebra classes of 107, 192, and 192 students was compared with that of a single teacher with algebra classes averaging 34 students (Engstrom—32). The top and bottom 20 percent in the large groups achieved as much, if not more, than the equivalent groups in the small classes, more individual help was given in the large classes, superior and poor students received more special instruction in the large classes, discipline was better in the larger groups, and there was more competition among top students in the larger classes.

The effects of a remedial program on the mathematical disabilities of junior high students was studied (Cahoon—17). Significant gains warranted the recommendation of a remedial instruction program, but this should be longer than 10 weeks.

What are the psychological factors in learning mathematics?

Mental age was found to be a stronger factor than algebra aptitude or grade level in influencing the learning of the concepts and fundamental skills in handling signed numbers (Zelechoski—105).

Eighth- and ninth-grade students with high mathematical aptitude were paired in order to compare their capacity to achieve in a traditional algebra course (Cornum—22). It was found that the eighth-grade students had as much capacity as the ninth-grade students in learning algebra.

A study comparing boys and girls (Dirr—25) found that boys and girls are equal in algebraic and geometric vocabulary, while the boys are superior in geometric computation and the girls in algebraic computation.

Another study compared boys' and girls' factor patterns through an investigation of the domain of an elementary algebra test. A comparison of the factor patterns in this study indicates that boys and girls, even when equally matched for achievement in algebra, use their abilities in different ways in algebraic computation. Boys tend to solve algebraic problems through a recognition of broad relationships among content areas; girls tend to keep content areas relatively separate and to see detailed relationships among the elements of a given area.

What are the results of studies of high-ability students in mathematics?

The relation of personality factors to success in mathematics was investigated (Kochnower—51). The mathematically inclined male emerged as a sensitive, insecure, introspective individual who tends to avoid group activities. He clings to his own convictions, refusing to subordinate them to common group standards. In the female, there was no evidence relating personality to achievement in mathematics.

The reasons for success and failure in mathematics of high-ability students was investigated (Mamary—61). The successful students had regular study hours, studied without radio or TV, had chores to do at home, found mathematics useful, had parents who were good in mathematics, did not expect better grades in other courses, had elementary school teachers who enjoyed arithmetic, and did not get behind in their work. Unsuccessful students felt they would have done better in a slower moving group and thought their teachers taught only to a top few. Successful students did not try to relate mathematics to everything, thought that insight into mathematics was an important reason for success, that to be successful one should not memorize it, and that one had to work hard to succeed.

What are the results of attempts to include new topics in the mathematics curriculum?

A unit on inequalities was developed and taught to a high school geometry class (Anderson—4). The students strengthened their ability to work with equalities and were more able to make generalizations not limited to equalities. The concept of inequalities was successfully introduced in a high school class.

A 6-week course incorporating aspects of linear program with traditional ninth-grade algebra was taught and evaluated (Cotter—

23). The group displayed interest and enthusiasm. Almost every student was able to contribute to the applications. Questions about proof, postulates, and theorems arose naturally. Most of the group finished the final test problem.

A unit on probability and statistics for high school seniors was prepared and taught, and the relationship between certain factors and achievement in the unit was analyzed (McKinley—64). The students showed a significant gain in achievement during the study, that of the college preparatory students being the greatest.

A unit on dimensional analysis was developed and taught to an experimental high school class (Saar—80). Tests before and after the unit showed that high school students in mathematics and physics have slight knowledge of dimensional analysis but that elementary aspects of the topic can be taught with understanding at their level.

A 4-week unit on quadratic functions was constructed, taught, and evaluated in a ninth-grade algebra class (Paige—70). The experimental class was matched with a control group on the basis of mathematical achievement. Statistically significant differences in favor of the experimental class were obtained. Tabulated observed reactions favored the experimental group on a number of points.

What are the attitudes of mathematics teachers toward the inclusion of certain advanced topics in the mathematics curriculum?

Teachers were favorable to the inclusion of analytic geometry, calculus and statistics, but their attitudes did not show a high relationship with such factors as feelings of competency, credits in mathematics, experience, and size of school (Spillane—88).

What topics are suitable for enrichment of the mathematics curriculum?

Fourteen major understandings associated with probable inference and 26 major understandings associated with necessary inference were developed (Smith—87) with specific suggestions for inclusion in arithmetic, algebra, geometry, and trigonometry.

Episodes in the development of *pi* can be developed into a number of worthwhile and interesting units for junior and senior high school students (Schaffner—82).

Materials in non-Euclidean geometry, projective geometry, and topology were prepared as a set of 30 enrichment lessons, presented informally and the effectiveness of the presentation evaluated (Smart—86). The papers on these topics written by the 44 students in the study showed a mastery on the average of 28 of the 37 major points upon which they were graded.

Such topics as geometrical transformations, geometry of circles, items related to the Pythagorean theorem, homothetic figures, and trisection problems were used by one researcher (Hanson—41).

What are the findings of certain surveys of secondary mathematics education in the United States?

One survey (Baker—8) showed that there were special mathematics programs for superior seventh- and eighth-grade pupils in 17.6 percent of Michigan junior high schools. In the seventh grade, one-third were enrichment, one-third were acceleration, and one-third were both enrichment and acceleration. More teachers than pupils regarded the subject matter of the special courses as more difficult.

The status of the mathematics program for above-average students in 56 New Jersey junior high schools in the spring of 1960 was surveyed (Maccia—58). Of the nine schools having over 1,000 students, all had either acceleration or enrichment programs. All 11 schools with neither acceleration nor enrichment had fewer than 1,000 pupils. A total of 12 schools had only acceleration, 19 had only enrichment, while 14 had both.

Trends in secondary school mathematics in New Jersey were surveyed by a seminar at Trenton State College (Hansdoerffer—40). Of 200 schools contacted, 58 responded, all of which indicated that they were offering contemporary mathematics to their students.

The trends in secondary school mathematics education from 1955 to 1960 were studied (Kelley—48). The trends revealed a broader sense of mathematical values and more stress on mathematics as such and less on consumer mathematics. There has not been the fundamental change in mathematics that publicity about the major curricular reports seem to indicate. The 12th-grade courses presented considerable divergence.

The status of mathematics teachers in Kansas high schools was investigated (Clark—21). One-half of the teachers have a student load of fewer than 40 students, while 1 in 7 instructs more than 120 mathematics students per day. Almost one-third failed to meet the new State certification requirement of 18 hours of mathematics.

What are the findings of certain surveys of secondary mathematics education abroad?

The status and innovations in the mathematics program of the Soviet secondary school was the object of the studies of two investigators (Vogeli—98 and Bolser—12). Syllabuses, textbooks, problem books, and graduation examinations were analyzed in detail. Three trends were largely responsible for changes from 1952 to 1959: (1)

675708 O—63——3

Polytechnism or stress on applications, (2) a trend toward lightening the pupils' academic load, (3) desire to modernize or raise the scientific level of their secondary mathematics program.

An extremely detailed and authentic picture of mathematics education in the Soviet Union was presented in the Bolser (12) study. Many sources were studied ranging from Library of Congress materials to interviews with Soviet educators and officials. Besides the curriculum, the study describes the training and status of mathematics teachers.

How well do tests predict?

An experiment in the prediction of success in ninth-grade algebra and general mathematics indicated that five predictor variables have significant predictive value for algebra but not for general mathematics. A regression equation was developed to help teachers and counselors predict success in algebra (Carboneau—18).

The validity of the Orleans Algebra Prognosis Test was investigated (Anderson—5). The criterion being predicted was success on the State objective test in algebra. The validity coefficient was found to be as high or higher than can usually be expected for a prognosis test.

The comparative value of three geometry prognosis tests and an arithmetic achievement test in predicting success in plane geometry was studied (Hohman—42). The Lee Test seemed to be the best predictor, but statistical tests of the significance of the differences did not confirm this. However, at the 10 percent level of confidence the Lee Test was a better predictor than the California Mathematics Test.

A pilot study was made to determine the efficiency of the Iowa Tests of Educational Development in predicting mathematics grades of 12th-grade boys. The highest correlation was with algebra and next with intermediate algebra, both at the .01 level of confidence. The correlation with geometry was not significant.

Research in the Teaching of College Mathematics

THE MAJOR EMPHASES in studies on the college level were on the content of the curriculum, methods of teaching, and the preparation of teachers. Also, the historical method of research was an essential tool in several investigations. The questions below, supplemented by some comments, reflect the major issues considered in these studies.

What should be the nature of the freshman mathematics course for liberal arts students?

For junior college freshmen one investigator (Besserman—9) recommended a type of remedial course for students poorly prepared in mathematics and, for others, a cultural course emphasizing the nature of mathematics and its role in our civilization. A study dealing with remedial mathematics in Kansas (Fisher—35) indicated that a freshman course in "elementary and intermediate algebra" was indefensible.

Another investigator (Milligan—67), guided by criteria for content selection and sequence, found that it was possible to devise a modern mathematics course for freshmen without rejecting all of traditional mathematics.

When an integrated course in college algebra, trigonometry, and analytic geometry was compared with the teaching of these separately over a period of three quarters during the freshman year, it was found (Popejoy—75) that there was no difference in the learning of the first two subjects, but a significant advantage in the learning of analytic geometry when taught as part of the integrated course.

To what extent is there an emphasis on modern mathematics in the junior colleges?

In Illinois it was discovered (Litwiller—55) that only brief mention of modern mathematics was made in junior college courses. The lack of attention to such mathematics was apparently due to certain gaps in the preparation of the teachers.

What mathematics is needed for applications?

One study (Wood—102) showed that mathematical analysis, matrix theory, probability and statistics, and numerical analysis were needed in applications to industry. Very little use was found for various kinds of geometry.

Is it possible to use more physics in teaching mathematics?

One research study (Grant—37) showed how many physics formulas could be selected and used in teaching mathematics topics as far as the calculus.

Should the concept of sets be used in teaching a first course in probability?

The method of teaching probability via sets (Maletsky—60) did not have a statistically significant advantage over a traditional method and one other procedure, when the solving of problems in statistics and success in statistical inference were used as criteria.

Do student-constructed assignments have a desirable effect on learning?

Students who constructed, worked, and checked assignments in a freshman mathematics course surpassed another group taught traditionally (Sister Rose Marian—62), by a statistically significant amount, in the solving of algebraic problems, critical thinking, and mastery of algebraic content.

Is there an advantage in teaching solid analytic geometry by means of vectors?

Although there was a constant margin in favor of the vector method over the traditional procedure (Pettofrezzo—73), the difference was not statistically significant.

What are the results of using television in the teaching of mathematics?

A questionnaire evaluation of a course in the teaching of arithmetic, involving 16 weekly telecasts as well as other activities, revealed (Jenni—44) that the respondents were motivated more by the new medium than by the usual classroom procedure. It seemed unlikely, however, that the telecasts alone could have produced the understandings attained.

Another study (Lancaster and Erskine—53) seemed to reveal that large class instruction surpassed both television and small class methods in the learning of analytic geometry. However, the difference between the first two methods was indecisive in the case of the calculus.

What should be the content and organization of a freshman mathematics course for engineers?

The conclusion in one study (Horton—43) was that the course should be organized around the function concept, with certain basic analytical concepts providing the problem-solving structure.

What do students beginning a course in the teaching of arithmetic know about arithmetic?

In a study of 158 prospective elementary school teachers in Illinois, one investigator (Fulkerson—36) found that performance was poorest on verbal problems and percentage. The students with more high school units of mathematical preparation did better on the test than those with fewer.

Can prospective elementary school teachers come to understand arithmetic through a short preservice course?

Two studies (Dutton—29 and Pitts—74) produced encouraging results. Many concepts are understood. In the second study over 80 percent of the responses to items on the comprehension of the structure of the number system were correct. However, the ability to apply structural properties varied greatly, especially in the case of the inverse. Dislike for arithmetic, expressed by one-third of the students in the first study, centered around fear of word problems and a repugnance toward drill.

Which concepts and processes of mathematics are needed in the preparation of elementary school teachers?

In the opinion of elementary school teachers and experts in mathematics education, concepts needed are from arithmetic, consumer mathematics, business application, certain geometric concepts, and graphs, supplemented by selected concepts and processes from modern mathematics (Carpenter—19).

What is the present preparation of prospective elementary school teachers in arithmetic in this country?

A nationwide survey (Erst—33) revealed that the majority of elementary school teachers are not adequately prepared in the content of mathematics or in methods of teaching mathematics. Content courses for these future teachers are offered in only one-fourth of the liberal arts colleges; such a course is usually college algebra, or geometry, or trigonometry.

Seventy-seven percent of the liberal arts colleges required neither courses in content nor methods of teaching mathematics. Teachers colleges, as a whole, gave better preparation.

What have been the trends in the education of senior high school mathematics teachers?

One investigator (Schumaker—83) discovered that from 1920 to 1958 the median minimum requirement for teaching majors rose from

24 to 27 semester hours of mathematics, and from 21 to 24 semester hours in education courses. Over the years the mathematics courses showing the greatest gain in popularity were college geometry, mathematics of finance, and elementary statistics. In general, the requirements were influenced most by the nature of the secondary school curriculum, very little by national committee reports.

How serious is the shortage of college teachers of mathematics?

Reports on 144 positions available in 1957–58 showed that 25 percent of those employed failed to meet the minimum degree requirements for the position. Of 79 positions requiring a Ph. D. degree, only 50 were filled by individuals holding the degree (Keller—47 and Smith—87).

The same investigators also evaluated a special master's degree program designed to use retired armed services personnel for helping to meet shortages in the teaching of college mathematics. Of 2,562 positions listed for 1959–61, 1,153, or 45 percent, would be available to these retired men.

Did Saccheri's publications have any influence on the later development of non-Euclidean geometry?

Although most historians had discounted the influence of Saccheri's works, such as *Euclides Ab Omni Naevo Vindicatus*, one study (Allegri—2) provided considerable evidence to the contrary.

What contributions did Hilbert make to the evolution of mathematics?

Hilbert, early concerned with the method of models, noncontradiction, and independence in an axiom system, later worked on a simultaneous development of logic and mathematics leading to the science of metamathematics (Kenner—49).

What has been the impact of the development of tests of statistical hypotheses on the teaching of statistics in the United States?

The work of Bayes on inverse probability in 1763 was followed much later by R. A. Fisher's work involving the making of probability statements about certain parameters of sampling distributions. In modern times, after Neyman's and Pearson's contributions to "best tests" of hypotheses, mathematical abstractions have developed to such a point that those interested in applying the tests have had great difficulties. In the United States there has been a shift of emphasis from descriptive statistics to statistical inference (Taylor—94).

What can be done to stimulate undergraduate students in mathematics to show initiative and do creative work?

One investigator (May—63) found honor work, including honor problems, colloquia, student-faculty collaboration, and publication of results, very helpful. It seemed, however, that honor work should be a supplement to regular courses, and that enrichment, rather than acceleration, was most effective.

How can success in college freshman mathematics be predicted?

One investigation (Grehl—38) showed that neither the Q-score of the American Council on Education nor a mathematics proficiency test proved their value in predicting the individual's success in freshman mathematics. However, the Q-score did just about as well as the proficiency test.

Summary

Elementary School Level

THE TASK of the teacher of arithmetic is to develop not only the student's computational ability but also his ability to solve problems. In harmony with such objectives, several researchers tried to determine the factors that are related to success in problem solving. Most teachers will agree with the finding that comprehensive reading ability is related to problem-solving ability; however, it is doubtful if they will agree that intelligence is not a major factor. A profitable area for investigation may be indicated by the studies that hint that boys differ from girls in the way they approach problem solving.

The grouping of children was the theme of several research studies; however, no significant results were reported. The answer to "Is grouping of children desirable?" may depend on the teacher, objectives of the grouping, and the children. Perhaps a more important question for the teacher is "When and how can grouping be helpful?"

This same type of question about multisensory aids might be investigated rather than a statistical study about children taught with aids and children taught without aids.

Research was concerned with the "best" method of teaching a particular skill or concept. This type of research is not yielding great returns. Perhaps there is not a best method for all teachers or all pupils. Successful teachers seem to use many different methods, and there is evidence the pupil may not *use* the method he is taught.

In several of the experimental programs in arithmetic, nondecimal systems of numeration are studied. One research study sought to find relationships between understanding various systems of numeration and understanding our decimal system. Perhaps this area needs further exploration to answer the question, "Under what circumstances and for what pupil is the study of the other systems of numeration profitable?"

High School Level

Nearly half of the studies done at the high school level grew out of the ferment in the mathematics curriculum of the past 7 or 8 years.

Some of these involved tryouts of new units of content. Others were concerned about the possibility of teaching some of the traditional subjects earlier. In other studies the learning of mathematics by students in some of the new programs was compared with the learning of students in traditional programs.

Other investigations dealt with the influence of attitudes on the learning of mathematics, the effectiveness of special programs for the gifted, basic differences between boys and girls in learning algebra and geometry, what difference small or large classes make, and the contrasts between the Russian program and ours. Predicting success in algebra and geometry, comparing methods of teaching the same topic or subject, and a historical study of plane geometry textbooks were other subjects of research.

Briefly stated, new units can be taught effectively without harming the learning of the old units. For students at the same level of ability algebra can be learned just as well in the eighth grade as in the ninth. Students can gain a fairly good grasp of what is meant by geometric proof as early as the seventh grade. It seems highly probable that even when the teacher variable and the "halo effect" are controlled, students taught under the SMSG program in grades 7 through 12 do almost as well with traditional materials and distinctly better in content extending beyond the conventional.

In addition to the content of the curriculum, there were several studies emphasizing the attitudes and typical behavioral patterns of those who were successful, and those who were unsuccessful in learning mathematics. Some of these findings may be useful in identifying high-ability students and in counseling them. One university has, for several years, been concentrating on acquiring information about sex differences in learning elementary and secondary school mathematics through extensive use of factor analysis applied to large numbers of students. This cooperative type of research is likely, in the long run, to yield a larger harvest than scattered, unorganized research involving small numbers of students. An important sex difference among high achievers also turned up in a study done at a different university. It appeared that high-achieving girls are less likely to be labeled "brains" than are many of the high-achieving boys.

Some studies seemed to confirm the results of earlier studies. Thus, teaching percentage in one package as a relation among three variables gave better results than teaching it by the "three cases." Students in large classes, at the upper and lower levels of ability did as well, if not better, than comparable sets in smaller classes. Of course, limits have to be put on the meaning of "large" and "small." Finally,

675708 O—63——4

attempts to predict achievement on a criterion by multiple correlation and regression added nothing of significance to what was already known from past studies.

College Level

What were the distinctive features of research in college-level problems of mathematics education during 1959–60? What was new? What seemed significant? Which studies provided further support for conclusions tentatively established by earlier research? Which research method seemed to be most frequently used?

Although it is often difficult to separate clearly studies concerned with what to teach from those dealing with how to teach, at least five studies were essentially "content" studies. Four of these investigations treated the problem of what to teach in freshman mathematics courses. The findings did not seem to reveal any new ideas on this subject. They did, however, confirm what has been done in the past. The fifth study, concerned with what should be the mathematical preparation of prospective elementary teachers, likewise produced no startling revelations. A comparison of the findings of this study with the recent recommendations of the Mathematical Association of America indicates how much needs to be done.

Two curriculum studies have a bearing on the emphasis on "modern mathematics" in precollege and college courses of study. Despite the work of the College Entrance Examination Board, the University of Illinois Committee on School Mathematics, the School Mathematics Study Group, and Committee on the Undergraduate Program in Mathematics, junior college teachers of mathematics in one State hardly mentioned modern mathematics in their classes. It is important to know whether this ignoring of modern mathematics is a general practice in college courses.

Another survey of the uses of mathematics in industry seemed to imply that there is still no great demand for the "new mathematics" in this field.

For our technological world some thinkers and experimenters have been calling for the coordinated teaching of mathematics and physics. One dissertation showed how topics from physics might be incorporated into the mathematics program as far as the calculus.

Other investigations involved both content and methods of teaching. The results of teaching probability via sets, and solid analytical geometry by means of vectors, were just as good as those obtained by traditional methods. If it had been possible to conduct the experiments longer, the new approaches might have been significantly better.

Two studies were concerned with the use of television. It seems obvious that television cannot be used alone for effective results. The increased cost per segment of instruction was not reported. Apparently, we still do not know at what point, in terms of number of students, television "pays off."

For a long time teachers have wondered whether courses in "integrated mathematics" are any better than compartmentalized teaching of separate subjects. In a program involving college algebra, trigonometry, and analytic geometry, the integrated course results were just as good as the compartmentalized ones in college algebra and trigonometry, and much better than a separate course in analytic geometry. These findings occurred even when no attempt was made to find out whether one group of students or the other would be more successful in solving problems involving the coordinated use of the three subjects.

The mathematics education of elementary school teachers received considerable attention in 1959–60. Previous studies had suggested that these teachers might never come to understand elementary mathematics. Two studies on their ability to comprehend the concepts and structure of arithmetic gave very optimistic results. Perhaps the SMSG program for the elementary school is feasible.

On the other hand, another extensive survey made it quite clear that liberal arts colleges need to reconsider the adequacy of their programs for preparing future teachers of mathematics in the elementary school.

The conclusion by Schumaker that mathematical requirements in the preparation of teachers of senior high school mathematics have been influenced by the new mathematics programs of the secondary school is certainly true. It is further confirmed by the report of the Mathematical Association of America in the publication of high school mathematics. All one needs to do is to read the report of the association on what the preparation of high school teachers of mathematics should be.

It is interesting to note that, of three historical studies, two were concerned with men who influenced the development of modern geometry and one with the evolution of modern statistics. It is encouraging to see some movement away from exclusive dependence on controlled groups and sophisticated statistics in educational research.

On the other hand, a considerable number of studies during this period made extensive use of polls of expert opinion, responses to questionnaires, and derivation of criteria from an analysis of the literature. Too often the result is a mirrorlike one in which the findings are a reflection of the status quo. Frequently the reports received indicate that the results obtained are not reliable because of the careless use of techniques.

Recommendations for Future Research

THIS PART of the report is written with a great deal of humility and with the knowledge that it is much easier to point out weaknesses in research than it is to conduct research without weaknesses. For many of the researchers it was their first introduction to research in mathematics education; others were under economic pressure to complete a degree; therefore, perfection is not expected. However, the reported research in 1959–60 represents considerable time out of the lives of many people and the expenditure of money which could be used for other purposes. The writers would be remiss not to point out some vital weaknesses that are readily apparent. The neophyte should either make a small contribution to the solution of a significant problem, or he should gain experience in techniques and research design that reflect the best research practice. Even a casual inspection of the studies shows that few of the researchers experienced either of these values.

To improve mathematics education research, leaders in the field must become more critical of both the design and the findings of the studies. It would seem advisable to make an earnest nationwide effort to upgrade research in mathematics education. The present summary of research shows that many persons have attacked small problems of minor importance. Statistical treatment in many cases was not appropriate for the raw data. Some of the studies were mere compilation of teaching materials which were never published. Such research makes little, if any, improvement in the teaching of mathematics. In fact, participation in such activities does not prepare the neophyte for membership on a team project in mathematics education such as those being financed by the Federal Government or national foundations.

The research in mathematics education from the first collection in 1952 to the present collection in 1960 reflect three important needs:

First, crucial problems need to be identified. National leaders in the field need to identify important problems that may be successfully solved as part of the requirements for a degree. These problems may be identified by State groups, national committees, or higher education conferences. In any case they must be identified to give direction to the research.

Second, teams of research workers are needed in attacking many of the problems. The day has passed when the efforts of a single researcher makes an impact on mathematics education. The research of the beginners must be coordinated and cooperative when possible, as in a project carried on by the Catholic University of America. Several of their students have tried to determine factors or patterns in learning mathematics that exist among girls but not among boys.

Third, the results of the research should be clearly and adequately reported. It is difficult for research findings to be implemented unless the following criteria are met:

1. The problem and subproblems should be *clearly* stated.
2. The number and characteristics of the subjects of the experiment should be provided.
3. The duration of the experiment should be stated.
4. The procedure of the experiment or study should be clearly described.
5. The method of sampling should be specified.
6. The evaluation instruments should be identified.
7. The findings should be separated from the researcher's conclusions and recommendations.

In addition to the accurate reporting of research, the reports must receive wide distribution. Perhaps a national organization such as the National Council of Teachers of Mathematics could stimulate better research by giving wide publicity to the better studies. Unpublished research has little impact on classroom practice.

The many students and faculty who are working in mathematics education will increase their impact if (a) crucial problems are attacked, (b) coordinated efforts are used to solve them, and (c) research findings, clearly and adequately reported, receive wide distribution.

Unanswered Questions in the Teaching of Mathematics

THE QUESTIONNAIRE used in this study asked the researcher to list one or two important questions still unanswered. In general, these questions were related to the researcher's study; however, these questions or problems vary widely both as to significance and as to type. Each of the following questions was asked or implied by at least one researcher, and some of the questions were the concern of several.

1. To what extent do courses in methods of teaching arithmetic contribute to the improvement of instruction in the subject?
2. When is the discovery method more effective than the telling method in the teaching of arithmetic?
3. Which type of inservice programs seem most effective for improving the teaching of mathematics?
4. What is the best combination of concrete and abstract mathematics in an undergraduate mathematics curriculum?
5. What are the best ways to stimulate mathematical creativity among undergraduates and graduate major in mathematics?
6. What is the effect of the SMSG junior high school program on the student's later learning of mathematics?
7. What are the best ways to measure the ability to reason?
8. What are the effects of audiovisual methods on the learning of high school algebra?
9. How effective is a vector method in teaching trigonometry or plane geometery?
10. Does the teaching of the calculus before analytic geometry make the latter more meaningful?
11. How effective are teacher-education curriculums in meeting the needs of the mathematics teachers in the field?
12. Can pupils learn more easily and retain longer certain ideas and topics in mathematics if they work creatively without a textbook?
13. To what extent does acceleration influence a student's future interest and work in mathematics?
14. To what extent do concrete or manipulative materials contribute to the learning of arithmetic?
15. Should less capable students study the same mathematics as other students at a slower pace, or be exposed to a different program of mathematics?

16. In what ways do certain attitudes toward mathematics influence the learning of mathematics? To what extent can certain of these attitudes be strengthened or weakened? How?
17. Can eighth-grade students having high mathematical aptitude succeed as well in a modern ninth-grade course as they can in a traditional one?
18. Do students studying contemporary mathematics in high school do better in the examinations of the College Entrance Examination Board than those who study traditional mathematics?
19. What kind of rigorous development of algebra, trigonometry, and analytic geometry, analogous to that of plane geometry, would be most effective in the secondary school?
20. What should be the grade placement of topics from probability and statistics in elementary and secondary schools?
21. To what extent does membership in a mathematics club influence interest and achievement at the secondary school level?
22. What is the lowest mental age at which the concept of directed numbers, and the operations on them, should be taught?
23. To what extent have the mathematics programs of American colleges been revised to include more of "modern mathematics"?
24. What are appropriate materials and exercises for teaching mathematical proof at the ninth-grade level through algebra?
25. Are integrated mathematics courses at the 10th- or 11th-grade level more effective than separate courses in plane geometry, advanced algebra, and trigonometry?
26. To what extent should social applications of arithmetic be taught at the seventh- and eighth-grade levels?
27. What modern mathematics should be included in the education of prospective elementary school teachers?
28. What specific concepts in modern mathematics should be taught the slow pupil in the secondary school?
29. What difference in pupil achievement does the teacher's knowledge of arithmetic really make?
30. What provisions can one make for gifted students when enrollments do not allow for homogeneous sectioning of classes?
31. What mathematics should we require of all high school pupils?
32. What are the characteristics of teachers who motivate students to pursue the study of mathematics?
33. What new demands in mathematics is industry placing upon its employees?
34. Is mathematical aptitude a single identity or a pattern of aptitudes?
35. To what extent and how may programed material in mathematics be used?
36. How should television be used to make mathematics instruction most effective?

Appendix: Summary of Research Studies

1. ALBANESE, DOROTHY THERESA. The Relationship Between the Average Test Scores on a Unit Using Various Systems of Numeration and Average Test Scores on Units Using the Traditional Numeration Earned by 113 Seventh-Grade Pupils. (1960, Montclair State College, Upper Montclair, N.J.)

Problem.—To investigate the relationship between the average test scores on an original unit using various systems of numeration and average test scores on units using traditional base-ten numeration.

Procedure.—A 2-week unit on nondecimal systems of numeration was developed. Five seventh-grade classes (113 pupils) were tested on (a) their knowledge of and ability to work with nondecimal systems of numeration following use of the experimental unit, and (b) their knowledge of and ability to work with the conventional decimal system of numeration during the course of relevant instruction spread out over a 7-month period.

Major Findings and Conclusions.—A statistically significant correlation of 0.67 ± 0.05 was observed between test scores on the experimental unit (nondecimal numeration systems) and average test scores on units pertaining to the conventional decimal system of numeration. The difference between means (expressed as percents of items right) of average scores on the two kinds of tests (nondecimal numeration systems and the decimal system of numeration) was not statistically significant ($CR = 0.79$).

2. ALLEGRI, LINDA. The Mathematical Works of Girolamo Saccheri, S.J. (1667–1733). (Ph. D., 1960, Teachers College, Columbia University, N.Y.)

Major Faculty Adviser.—Howard F. Fehr.

Problem.—To analyze each of Saccheri's mathematical publications; to appraise the influence of his work on the development of non-Euclidean geometry; and to determine the characteristics of the man having a bearing on his contributions to mathematics.

Procedure.—Saccheri's works were read with special attention to his use of a rarely used form of indirect proof, and to his critique of Euclid's treatment of proportions. Book II of *Euclides Ab Omni Naevo Vindicatus* was translated. The mathematical literature of the period from 1733, the date of publication of this major work, to the appearance of the first non-Euclidean geometry in 1829, was studied.

Major Findings and Conclusions.—Repeated mention of Saccheri in the literature from 1733 to 1829 points to the possibility that his influence on non-Euclidean geometry may have been greater than previous historians have indicated. Saccheri emerges as a logician with some ideas about the subject that are quite modern. He certainly had an appreciation of the crucial importance of the parallel postulate in the foundation of geometry.

3. ANDERSON, DORIS W. Arithmetic Enrichment Activities for Second Grade. (Ed.M., 1961, University of Texas, Austin.)

Major Faculty Adviser.—Frances Flournoy.

Problem.—To collect and prepare enrichment materials related to the arithmetic concepts and skills taught in the second grade.

Procedure.—Survey of professional literature, published and unpublished, and resource materials. Compilation of suitable activities and materials, listed according to use.

Major Findings and Conclusions.—Judged appropriate enrichment activities and experiences to be helpful in creating a wholesome classroom atmosphere, in promoting a meaningful use of numbers, in providing for individual differences, in developing desirable personality traits, and in creating an appreciative attitude toward mathematics. Expressed the need for a careful study of specific contributions of arithmetic enrichment to arithmetic development among children in the primary grades.

4. ANDERSON, EDWIN LEROY. A Proposed Curriculum Change Based on a Study of Algebraic Inequalities. (M.Ed., 1959, University of Washington, Seattle.)

Major Faculty Adviser.—Sylvia Vopni.

Problem.—To develop procedures and methods of presentation for the teaching of inequalities in conjunction with the teaching of equalities in high school algebra.

Procedure.—A unit on inequalities was taught to a high school geometry class consisting of pupils with above average ability. The time allotted for the presentation was 10 teaching days. The lecture method was utilized, and the pupils were responsible for taking notes on the lecture. Homework assignments were mimeographed. Short daily quizzes were given, and a final test on the unit was administered on the tenth teaching day. The unit was organized to develop techniques of solving inequalities, algebraically and graphically, and to develop basic concepts of equations, inequalities, and literal number symbols. In order to accomplish this, the unit began with definitions, followed by simple illustrations and applications. Basic axioms were then developed for further use. Elementary graphing, the solution of linear, quadratic and higher degree inequalities were the next topics. The unit continued with work on combinations of equalities and inequalities and concluded with a brief presentation of inequalities as limits in elementary graphing.

Major Findings and Conclusions.—(1) Students strengthened their ability to work with equalities; (2) the concept of inequalities was introduced successfully in a high school class; (3) pupils became more able to make generalizations not limited to equalities.

5. ANDERSON, ETHEL. An Investigation of the Validity of the Orleans Algebra Prognosis Test in Predicting Success in Algebra in Williamsville Junior High School. (M.A., 1959, Niagara University, Niagara Falls, N.Y.)

Major Faculty Adviser.—James V. Deegan.

Problem.—To determine how well the Orleans Algebra Prognosis Test predicts success in ninth-grade algbera as measured by the State objective test in algebra.

Procedure.—Scores on the Orleans Algebra Prognosis Test and the end-of-year State algebra test were obtained for students in Williamsville Junior High School over a 4-year period. Other data, such as type of community, marking procedures, instructional procedures, and selection of students for algebra was obtained. Percentile norms and McCall t-scores were computed and an expectancy table prepared.

Major Findings and Conclusions.—The validity coefficient for the Orleans Algebra Prognosis Test was found to be as high or higher than can usually be expected in correlating a prognosis test with a criterion of success. These results may not apply if another criterion of success in algebra than the State test were used.

6. ANDERSON, GEORGE A. Student Preference Survey of Four Major Subjects. (1960. Millersville State College, Millersville, Pa.)

Problem.—To compare student preference for four major subjects (mathematics, English, geography and history) in the eleventh grade with their previous rating of these during their study of them in the eighth grade.

Procedure.—The same questionnaire used in 1956 was administered again 3 years later. The respondents also indicated the reasons for their choices. The number of replies was 354. In the 1956 study 534 students had been involved.

Major Findings and Conclusions.—Mathematics was the best liked subject both in the eighth and eleventh grades. In the eleventh grade the boys placed mathematics first and English last; the ratings of the girls were the reverse of these. Liking for the subject itself, rather than for the teacher, was the dominant reason given for the preference. Dislike of the subject, not of the teacher, was the reason for the lowest ranking of a subject.

7. ANDERSON, NORMA JEAN. Personal and Social Adjustment of High and Low Arithmetic Achievers Among Underage and Normal-age Second-Grade Pupils. (M.Ed., 1960, University of Texas, Austin.)

Major Faculty Adviser.—M. Vere DeVault.

Problem.—To determine the relative social and personal adjustment of high and low achievers in arithmetic at the second-grade level and to determine whether these factors of adjustment were related differently among underage children and normal-age children.

Procedure.—Starting with an original population of 694 pupils in 24 classes, 64 pupils were randomly selected from 8 stratified groups. The Metropolitan Achievement Test and the California Test of Mental Maturity were used. An analysis of variance design was used in the statistical treatment of the data.

Major Findings and Conclusions.—High arithmetic achievement was associated with high rating on the personality instrument in many of the 16 categories. Differences between normal-age and underage pupils and between boys and girls tended to be only chance differences.

8. BAKER, RUSSELL RAY. Program Provisions in Michigan Junior High Schools for Superior Students. (Ed. D., 1960, University of Michigan, Ann Arbor.)

Major Faculty Adviser.—Joseph N. Payne.

Problem.—To identify the various special mathematics programs for superior seventh- and eighth-grade pupils in all public junior high schools in Michigan. To study the opinions of principals, teachers, and students in eight selected schools regarding the effectiveness of the programs. To determine the achievement level attained by students in the selected schools by the end of the eighth grade.

Procedure.—A questionnaire was sent to principals of all junior high schools in Michigan. A special opinionnaire on the effectiveness of programs was designed and administered to principals, teachers, and students in eight selected schools.

Major Findings and Conclusions.—(1) There were special programs in 17.6 percent of Michigan junior high schools. (2) Of the seventh-grade population, 25.6 percent were in schools with special programs: of eighth-grade population, 30.5 percent were in schools with programs available. (3) In the seventh grade, one-third of the special programs were enrichment, one-third were acceleration, and one-third were enrichment and acceleration. (4) Over 90 percent of the special programs had been organized in the last 4 years. (5) A significantly larger percent of teachers than pupils regarded the subject matter of the special courses as difficult. (6) The attitudes of students toward acceleration into a full year of algebra were more favorable at the .05 level of confidence than of students for one-half year of algebra.

9. BESSERMAN, ALBERT G. A proposed Outline for a Mathematics Course in General Education at the Junior College Level. (M.S., 1960, Illinois State University, Normal.)

Major Faculty Adviser.—T. E. Rine.

Problem.—To determine the content for a course in mathematics for general education at the junior college level.

Procedure.—A review of current literature was made to determine the objectives and possible topics of the course. A validated checklist, including the topics, was sent to junior college mathematics instructors and administrators, as well as mathematics department heads of selected 4-year colleges. The responses to the checklist were analyzed.

Major Findings and Conclusions.—The literature, as well as 96 percent of the replies from 96 percent of the administrators, supported the need for such a course for both the terminal and preparatory students. It appeared that two courses would be most desirable. One would be a noncredit course for students with a poor mathematical background, including such topics as a review of arithmetic, ratio, proportion, variation, mensuration, and problems of the consumer. The other course would be a cultural type emphasizing an understanding of the nature of mathematics and its role in our civilization.

10. BLACKA, ALLAN WELLS. The Initiation and Growth of the Number Concept in Preparation for Algebra—Grades K to 8. (M.A., 1960, Ohio State University, Columbus.)

Major Faculty Adviser.—Harold P. Fawcett.

Problem.—To develop suggestions for initiating and promoting in grades K to 8 a continuous growth of the number concept in order to insure an adequate preparation for algebra.

Procedure.—Survey of literature, leading to the development of a suggested curricular sequence.

Major Findings and Conclusions.—Mathematics must be derived, in grades K to 8, from the physical entities which it counts, measures, and describes. Number systems should be built from the counting numbers. All numbers may be presented as natural and needed outgrowths of the counting numbers. Because of the psychological factors involved in teaching mathematics in grades K to 8, arithmetic should not be made rigorously logical. However, mastering the number concept requires that the student develop a sense of structure and an ability to make generalizations.

11. BLUMEL, RICHARD EMERSON. A study of Teaching Secondary School Mathematics. (M.A., 1960, Montana State University, Missoula.)

Major Faculty Adviser.—Vernon Sletten.

Problem.—To gather and analyze data regarding the teaching of mathematics in the secondary schools of Alberta, Canada.

Procedure.—A three-part questionnaire was sent to a sampling of 170 secondary schools in Alberta, Canada, all of which were accredited. A total of 153 questionnaires were returned.

Major Findings and Conclusions.—Two out of 3 reporting schools were staffed by 6 or fewer teachers. One teacher in 5 had taken four or more university courses in mathematics. One out of 3 had no mathematics beyond high school. Nine out of 10 schools gave 140 or more minutes per week to mathematics; 6 schools had a special class for the gifted. Thirteen out of 15 schools reported having a motion picture projector and a duplicator. One school in 30 had a special room for mathematics.

12. BOLSER, FRANK C. Education in the Field of Mathematics in the U.S.S.R. (Ed. D., 1959, University of Florida, Gainesville.)

Major Faculty Adviser.—Kenneth P. Kidd.

Problem.—To present a detailed and authentic picture of mathematics education in the Soviet Union.

Procedure.—The first major source of information for this study was the available literature in Russian and English on mathematics education in the Soviet Union—such materials in the Library of Congress as books containing Soviet educational decrees, educational journals, periodicals, statistical compendiums, and handbooks. Bulletins and pamphlets on the subject by the Department of Health, Education, and Welfare were included. Soviet secondary mathematics textbooks were examined. Interviews were obtained with Soviet educators and officials. Studies compiled by specialists, educators, and students who had visited the U.S.S.R. were analyzed.

Major Findings and Conclusions.—The Soviet educational philosophy, policy, and organization of the past 25 years was reviewed. Against this background, the mathematics currricula for the primary-secondary grades was analyzed in considerable detail. Next the general and special patterns of mathematics teacher education in the pedagogical schools, pedagogical institutes, and the universities were described. A pedagogical institute student specializing in the teaching of mathematics in grades 5 through 10 spends nearly as much time in the study of mathematics as a future professional mathematician pursuing university training for advanced work. Finally such related topics as teacher environment, social position of the mathematics teacher, working conditions, classroom situation, teaching load, salary, tenure, and pension are discussed in some detail.

13. BOYD, JAMES BRIDGES. The Role of the Administrator With Respect to Mathematics Education in a Comprehensive High School. (Ed.D., 1960, Teachers College, Columbia University, N.Y.)

Major Faculty Adviser.—Howard F. Fehr.

Problem.—To study the role of the administrator with respect to mathematics education in Montclair High School, Montclair, N.J.

Procedure.—First part: Factual information about the local educational situation is presented, including inferences from local records and school and citizen committee reports. Second part: General administrative policies, procedures, and attitudes that seem to promise better mathematics education are discussed. Third part: Conclusions are presented which are based on the application of sound policies, procedures, and attitudes to mathematics education in Montclair High School.

Major Findings and Conclusions.—Administrators must continuously evaluate the educational program and plan for improvement. In any evaluation of the mathematics program the objectives of the teaching of mathematics need to be carefully considered. The administrator should provide for early identification of the talented. All pupils should be guided into programs that will suit their needs. The administrator should guarantee that classes are assigned teachers on the bases of ability and interest, not on the basis of seniority. The rolé of the mathematics department chairman in supervising and improving instruction needs to be enlarged. The administrator should use group processes in helping teachers to develop a good professional library, develop and use mathematics resources in the student library, organize mathematics programs for the college and noncollege preparatory student, develop an advanced placement program.

14. BRADSHAW, LUCY SORECIA. The Solving of Verbal Problems in First-Year Algebra. (M.A., 1960, Agricultural and Technical College of North Carolina, Greensboro.)

Major Faculty Adviser.—F. A. Williams.

Problem.—To study and improve the teaching of verbal problems in first-year algebra.

Procedure.—The related literature in books, journals, and theses was examined. Exercises and historical information was used to show the value of the study.

Major Findings and Conclusions.—Reading is one of the difficulties encountered by students in solving verbal problems. Algebra teachers must assist students with their reading problems by studying the reading weaknesses of each student.

15. BRUCE, MARIE NELSON. A Diagnostic Study of Understandings of Concepts in Mathematics by Fifth-Grade Pupils. (M.S., 1959, Tennessee Agricultural and Industrial State University, Chattanooga.)

Major Faculty Adviser.—(None indicated).

Problem.—To diagnose understandings of concepts in mathematics by fifth-grade pupils in the West Main Street School, Chattanooga, Tenn.

Procedure.—In the fall the following tests were administered to 33 fifth-grade pupils: California Arithmetic Test, Stanford Reading Test and Stanford Arithmetic Test, and Lorge-Thorndike Intelligence Tests. Instruction during the school year was planned and given for the purpose of eliminating weaknesses shown by performance on the California Arithmetic Test. The California and Stanford tests were readministered at the end of the school year.

Major Findings and Conclusions.—Based on the fall tests, the median IQ was 75; the median grade equivalent in arithmetic, 3.5; and the median grade equivalent in reading, 3.4; also, the correlation between IQ and arithmetic achievement was 0.46, and the correlation between reading and arithmetic achievement was 0.49. The median grade equivalent in arithmetic on end-of-year tests was 4.7. Concluded that pupils taught by the meanings method make higher achievements.

16. BUDDEKE, SISTER RITA, S.N.D. Differential Factorial Patterns of Boys and Girls in Algebraic Computation. (Ph. D., 1960, Catholic University of America, Washington, D.C.)

Major Faculty Adviser.—Rt. Rev. Msgr. Francis J. Houlahan.

Problem.—To compare boys' and girls' factor patterns through an investigation of the domain of an elementary algebra test.

Procedure.—The Algebra Test, Form S, of the Affiliation Testing Program of the Catholic University of America was administered to about 4,000 average boys and girls in 100 high schools. The answer sheets of an equal number of boys and girls were carefully matched with respect to total score, school, and teacher. Coefficients of the tetrachoric correlation among all items answered correctly by 20 to 80 percent of both boys and girls were calculated and fitted into separate correlation matrices. Thurstone's Centroid Method of Factor Analysis was then applied to each of the matrices.

Major Findings and Conclusions.—The boys' primary factors were identified as follows: (1) A high level of achievement factor, (2) manipulation of fractions in the solution of equations, (3) flexibility in abstract quantitative reasoning, (4) rigidity in application of algebraic formulas, (5) facility in geometric interpretation of algebraic data.

The girls' primary factors were identified as follows: (1) Rigidity in the application of rules to specific problems, (2) arithmetic achievement, (3) flexibility in interpretation of algebraic and geometric data, (4) facility in manipulating signed numbers, (5) facility in multiplication, division, and algebraic factoring.

A comparison of the factor patterns in this study indicates that boys and girls, even when equally matched for achievement in algebra, use their abilities in different ways in algebraic computation. The study has indicated that boys tend to solve algebraic problems through a recognition of broad relationships among content areas; girls tend to keep content areas relatively separate and to see detailed relationships among the elements of a given area.

17. CAHOON, REX A. A Study of Mathematics Disabilities of the Junior High School Students in the Taber School District and the Effects of a Remedial Instruction Program. (M.Ed., 1959, Brigham Young University, Provo, Utah.)

Major Faculty Adviser.—J. C. Moffitt.

Problem.—To study the mathematics disabilities among junior high school students and the effects of a remedial instruction program conducted with an experimental control group.

Procedure.—The California Arithmetic Test, Junior High Level, Form W, was given in January 1959 to 594 junior high school students. An experimental group received remedial instruction of one-half per week for 10 weeks in April, May, and June 1959. Form X of the California Arithmetic Test was administered to the 83 students in the experimental and control groups subjected to the t-ratio test of significance.

Major Findings and Conclusions.—Outside factors may have influenced test results, but enough significant gains were made in the experimental group to warrant the recommendation of a remedial instruction program.

18. CARBONEAU, ROBERT D. An Evaluation of an Experiment in the Prediction of Success in Ninth-Grade Algebra and General Mathematics in Everett Junior High School. (M.Ed., 1959, University of Washington, Seattle.)

Major Faculty Adviser.—August Dvorak.

Problem.—To discover the most reliable use of available data for predicting success in algebra and general mathematics in the ninth grade.

Procedure.—The criterion of success in algebra and general mathematics was the first semester grades of 418 algebra students and 177 general mathematics students. Data for five predictor variables were used: The Orleans Algebra Prognostic Test, teacher's estimated algebra grade, the eighth-year arithmetic grade, Iowa Test of Educational Development, and the California Mental Maturity Test. Correlation matrices were computed on the IBM 650 by means of a program devised by Dvorak and Wright. Next, these data were applied to the Horst iterative predictor selection process programed by Lunneborg.

Major Findings and Conclusions.—All predictors had some predictive value but the results for general mathematics were not as significant as those for algebra. The highest multiple correlation (.671) was obtained when the California Test of Mental Maturity was omitted from the battery of variables for predicting algebra grades. The multiple correlations developed were:

General Mathematics, all predictors	.508
General Mathematics, four predictors	.509
Algebra, all predictors	.670
Algebra, four predictors	.671

The data were not of significant predictive value when applied to general mathematics grades. A regression equation was developed for use by teachers and counselors in the junior high schools of Everett, Wash., to help in predicting success in algebra.

19. CARPENTER, RAYMOND. Identifying Concepts and Processes in Mathematics Needed for the Adequate Preparation of Elementary Teachers. (Ed. D., 1959, Oklahoma State University, Stillwater.)

Major Faculty Adviser.—James Zant.

Problem.—To identify the concepts and processes of mathematics needed by elementary school teachers.

Procedure.—The concepts and processes were obtained from an analysis of elementary school arithmetic textbooks, followed by the results of a questionnaire sent to selected groups of elementary school teachers and to experts in mathematics education. A total of 334 mathematical concepts and 70 processes were checked for importance by 245 teachers and 21 experts.

Major Findings and Conclusions.—About 69 percent of the concepts were deemed "essential" and 20 percent "desirable." Rated as "essential" were concepts of order; synthesis, including addition and subtraction: comparison; measures; the number system; concepts pertaining to verbal problems; and some geometric terms. The "desirable" concepts were analysis, including subtraction and division; the family budget; business and graphs. Practically all of the operations were considered "essential." It was recommended that the "essential" concepts and processes be strongly emphasized in the training of teachers and that the "desirable" ones be included. These should be supplemented with new and modern concepts and processes.

20. CARTER, MARY KATHERINE. A Comparative Study of Two Methods of Estimating Quotients When Learning To Divide by Two-Figure Divisors. (Ed. D., 1959, Boston University, Boston, Mass.)

Major Faculty Adviser.—J. Fred Weaver.

Problem.—To compare the relative merits of two methods of estimating quotient figures when dividing by two-figure divisors: the one-rule and two-rule methods; and to study the effects of first learning the one-rule method and then introducing the two-rule method as an alternative.

Procedure.—Data derived from 544 fifth-grade pupils divided into three groups: (a) those taught only the one-rule method of estimation; (b) those taught the two-rule method; and (c) those first taught the one-rule method for all kinds of examples, then taught the two-rule method as an alternative. Pre- and end-testing with criterion instrument at beginning and end of 12-week instructional period; also after lapse of 6 weeks and of 18 weeks. Factors of IQ, MA, and skill in division with 1-figure divisors were controlled statistically.

Major Findings and Conclusions.—Whether measured at the end of instruction or after a lapse of time, students taught only the one-rule method were more accurate than those taught the two-rule method; those taught first the one-rule method and then introduced to the two-rule method were more accurate than those taught just the two-rule method, but were neither more nor less accurate than those taught just the one-rule method. In terms of speed of performance, those taught the two-rule method were slower than either of the other groups when measured at the close of instruction, but these differences do not exist after a lapse of time. No factor such as IQ, MA, or prerequisite skill with division was highly correlated with speed and accuracy of work with two-place divisors. It may be inferred from information collected that pupils do not always use the method they are taught for estimating quotient digits when dividing by two-place divisors.

21. CLARK, JOHN R. A survey of the Status of Mathematics Teachers in Kansas Public Secondary Schools 1958–59. (M.S., 1959, University of Kansas, Lawrence, Kans.)

Major Faculty Adviser.—Gilbert Ulmer.

Problem.—To investigate the status of mathematics teachers in Kansas high schools.

Procedure.—The data were compiled from the organization reports filed by each high school principal with the State department of education.

Major Findings and Conclusions.—Almost one-third of Kansas mathematics teachers failed to meet the new State certification requirement of 18 hours of mathematics. Slightly less than one-third were teaching mathematics only. One teacher in 7 serves as principal or superintendent and 1 in 9 as a coach or assistant coach. One-half of the mathematics teachers have a student load in mathematics of fewer than 40 students, while 1 in 7 instructs more than 120 mathematics students per day. Nearly three-fourths of the mathematics teachers are men, the majority of whom have taught fewer than 10 years. The women generally have more years of experience but receive lower salaries. On all points studied, the status of teachers in larger schools was superior to those in smaller schools.

22. CORNUM, ALGER R. Comparison of Achievement in Beginning Algebra of Paired Eighth- and Ninth-Grade Students with High Mathematical Aptitudes. (M.Ed., 1960, Brigham Young University, Provo, Utah.)

Major Faculty Adviser.—Sterling Callahan.

Problem.—To determine whether eighth-grade students who had a high mathematical aptitude were capable of reaching an achievement level in beginning algebra as high as ninth-grade students who had a high mathematical aptitude.

Procedure.—Twenty-four boys and 12 girls in the eighth grade were compared with 24 boys and 12 girls in the ninth grade. The pupils were selected and paired on the bases of previous achievement in mathematics, algebra aptitude test scores and standard intelligence scores. The Seattle Algebra Test was given in January and Form Y of the Cooperative Algebra Test was given in the fourth week in May 1960. The t-ratio analysis was used to determine significance of differences.

Major Findings and Conclusions.—The eighth-grade group was capable of reaching an achievement level in beginning algebra as high as the ninth-grade group. The algebra course in this study was a traditional course.

23. COTTER, VERNON EARL. Linear programing in High School Mathematics. (M.A., 1959, Iowa State Teachers College, Cedar Falls.)

Major Faculty Adviser.—H. C. Trimble.

Problem.—(1) To extract from the complex topic of linear programing suitable subject matter to be integrated with ninth-grade algebra, (2) To prepare and teach a 6-week course of study incorporating both linear programing and traditional subject matter, (3) To evaluate results.

Procedure.—A set of 30 lesson outlines was constructed starting with a review of the language of sets and graphs of inequalities and ending with simple industrial applications. Evaluation was done by means of a single linear programing problem to be worked by students in a 55-minute period.

Major Findings and Conclusions.—The group displayed more than usual interest and enthusiasm. Almost every student was able to contribute to the applications. Most difficulty was encountered in writing problems in algebraic language. Questions about proof, postulates, and theorems arose naturally. Most of the group finished the final test problem. In a group of 24 students, scores ranged from 8 to a total possible score of 37 with a median of 25.

24. DAVIS, BETTY. The Effect of Reinforcement in Teaching Arithmetic on the Performance of Fifth-Grade Students. (Ed.D., 1960, Pennsylvania State University, University Park.)

Major Faculty Adviser.—H. M. Davison.

Problem.—To investigate the effects of different schedules of reinforcement upon the learning of arithmetic in the fifth grade.

Procedure.—Three groups of fifth-grade pupils worked at separate times under two different schedules of reinforcement and one schedule of nonreinforcement. The study was divided into three 3-week periods, with a specific reinforcement schedule in effect during each 3-week period and a test administered at the end of each period. Also, a retention test was administered 3 months after the end of the 9-week experimental period.

Major Findings and Conclusions.—At the fifth-grade level, the learning behavior pattern acquired during a period of nonreinforcement extended over a longer period of time than the learning behavior acquired during a similar period of reinforcement. Arithmetic material learned under a fixed-ratio reinforcement schedule was retained longer than material learned under a fixed-interval schedule or under a schedule when no reinforcement was given. Retention tests supported the fact that arithmetic materials learned under a schedule of reinforcement are retained longer than similar material under a schedule of nonreinforcement or a schedule of reinforcement which follows nonreinforcement.

25. DIRR, SISTER PIERRE MARIE, C.S.J. A Comparative Statistical Study of a Selected Number of Catholic Junior-Year Boys and Girls in Their Abilities in Mathematical Vocabulary as Contrasted with Mathematical Computations. (M.A., 1959, Catholic University of America, Washington, D.C.)

Major Faculty Adviser.—Rt. Rev. Msgr. Francis J. Houlahan.

Problem.—To construct appropriate tests and compare junior-year boys and girls in algebraic and geometric vocabulary and in algebraic and geometric computation.

Procedure.—Tests were constructed and administered to 366 junior-year students in eight Catholic coeducational high schools in New Jersey and West Virginia. The statistical work included calculations of the means, standard error of the means, differences between means, standard errors of the differences, and the critical ratio.

Major Findings and Conclusions.—Boys and girls are equal in algebraic and geometric vocabulary. The boys are superior in geometric computation and the girls in algebraic computation.

26. DOWNS, DOROTHY. A Study of Children's Learning To Write the Ten Basic Numerals. (Ed.M., 1960, University of Texas, Austin.)

Major Faculty Adviser.—Frances Flournoy.

Problem.—To study first-grade children's success and difficulties in learning to write the numerals from 1 to 10, and to study the accuracy with which children at all grade levels write these numerals when using them in computation.

Procedure.—Development and implementation of a program for teaching the writing of the numerals 1 to 10 to 31 first-grade children, with tests administered at three different times during the school year; analysis of one set of arithmetic test papers from all grades, one through six, in the Pleasant Hill School.

Major Findings and Conclusions.—The results of the three tests of writing the numerals failed to show any improvement during the course of the first grade. The analysis of the arithmetic test papers from all grades showed an overall decrease in errors made in writing the numerals in grades two through six. Concluded that specific attention to writing numerals must be started in grade one and continued throughout the elementary grades.

27. DRISDALE, RUBY BEATRICE CAIRO. A Survey of Certain Instructional Materials for the Development of Concepts and Skills in Arithmetic for Intermediate Grades. (Ed.M., 1960, University of Texas, Austin.)

Major Faculty Adviser.—Frances Flournoy.

Problem.—To survey, describe, and give sources of instructional materials which may be used in developing concepts and skills in arithmetic in the intermediate grades.

Procedure.—Survey of literature, and of teacher-made and commercial materials, including films and filmstrips, leading to a descriptive listing of materials, including uses.

Major Findings and Conclusions.—Recommendations were made in relation to teachers, administrators, and manufacturers of motion picture films and filmstrips.

28. DUNCAN, ERNEST ROWLAND. Arithmetic in the United States and New Zealand. (Ed.D., 1960, Teachers College, Columbia University, New York.)

Major Faculty Adviser.—Howard F. Fehr.

Problem.—To compare the teaching of arithmetic in the elementary schools of the United States and New Zealand in relation to topics taught, teaching methods used, learning concepts formed, and the philosophy underlying the teaching of the subject.

Procedure.—Survey of relevant literature, including arithmetic textbooks and related materials used in both countries; also, administration of arithmetic achievement tests to 200 12-year-olds in Teaneck, N.J., and New Plymouth, New Zealand.

Major Findings and Conclusions.—The teaching of arithmetic is affected by the cultural, social, and technological differences in the two countries being compared. In both countries the basic philosophy of teaching arithmetic is consistently maintained throughout the various phases of the subject. The philosophy stresses both the social and the mathematical aims of arithmetic; the New Zealand philosophy places more stress on its values as a tool subject. The American approach emphasizes meaning and discovery as basic principles in teaching; the New Zealand approach places more emphasis on drill methods. American methods are consistent with the field theories of learning; New Zealand methods rely more on a modified connectionism. The New Zealand program is seriously handicapped by the use of the English monetary system and this was reflected in the achievement tests. The tests also disclosed that meaningful teaching can secure better results for older children than methods based on drill.

29. DUTTON, WILBUR. University Students Comprehension of Mathematical Concepts. (1960, University of California, Los Angeles.)

Problem.—To measure student changes in understanding arithmetical concepts before and after completing a lower division course for elementary school teachers.

Procedure.—At the beginning and end of the semester, 55 students enrolled in a lower division mathematics course for prospective elementary teachers at the University of California, Los Angeles, were given the University of California Arithmetic Comprehension Test for sixth-grade students. No attempt was made by the professors in the two classes involved to gear their instruction to the content of the test.

Major Findings and Conclusions.—Many concepts are understood. These students clung to the traditional methods when attempting to explain partial products in multiplication, placement of quotient figures in long division, and in placing the decimal point. Denominate numerals were not well understood. Specific dislike of arithmetic, expressed by one-third of the students, centered around fear of word problems and dislike of drill. The gain in content background and understanding during the course was significant.

A systematic approach to eradicate student misunderstanding of the concepts should be provided on an individual basis.

30. EMM, SISTER M. ELOISE. A Factorial Study of the Problem Solving Ability of Fifth-Grade Boys. (Ph. D., 1958, Catholic University of America, Washington, D.C.)

Major Faculty Adviser.—Rt. Rev. Msgr. Francis J. Houlahan.

Problem.—To investigate the factor pattern of arithmetic performance of beginning fifth-grade boys, and to compare it with the factor patterns of fifth-grade girls and sixth-grade boys.

Procedure.—Administration of a battery of 21 tests, leading to the Thurstone centroid method of factor analysis applied to the matrix of Pearson correlation coefficients.

Major Findings and Conclusions.—For fifth-grade boys, three primary factors were found to account for the common variance of the 21 tests: a verbal-cognitive factor, an arithmetic factor, and a spatial factor. High intercorrelations were found among the three primary factors, and could be accounted for in terms of one general factor. All primary factors correlated highly with the underlying *g* factor. The three primary factors are structured differently for boys than for girls. Concluded that boys and girls 10 years of age do not use the same pattern of traits in arithmetic problem solving and that, since they do not think in the same way, they should not be taught in the same way.

31. ENGLERT, ROY A. Innovations in Mathematics for the Ninth Grade. (M.S., 1960, Kansas State Teachers College, Emporia.)

Major Faculty Adviser.—John M. Burger.

Problem.—To create and maintain interest in mathematics at the ninth grade.

Procedure.—Materials of special attractiveness to ninth-grade students were compiled, developed, and taught to ninth-grade students.

Major Findings and Conclusions.—When presented in a challenging manner, many topics of ninth-grade mathematics are enjoyed by students.

32. ENGSTROM, ERLAND RICHARD. A Study of Large Group Instruction in First-Year Algebra. (1960, University of Minnesota, Minneapolis.)

Problem.—To study the effectiveness of large group instruction in first-year algebra.

Procedure.—Experiments with large groups in the 1930's and in the 1950's were first analyzed. One group of 68 pupils in two small algebra classes in 1957–58 were taught and compared with a large class of 107 pupils taught in 1957–58 and with two other large classes of 192 pupils taught in 1958–59 by two teachers and a secretary. Achievement scores and final examination scores of the top 20 percent and bottom 20 percent were compared in the small and large classes using an analysis of variance for independent groups (F-ratio test).

Major Findings and Conclusions.—The top and bottom 20 percent in the large groups achieved as much, if not more, than the equivalent groups in the small classes. More individual help was given in the large groups. There was more opportunity in the large classes for superior and poor students to receive special instruction. Discipline was better in the larger groups. There was more competition among top students in the larger classes.

33. ERST, MOTHER ANNA MARIA. Preparation of Elementary School Teachers in Arithmetic. (M.S., 1959, Immaculate Heart College, Los Angeles, Calif.)

Major Faculty Adviser.—Sister Elizabeth Ann.

Problem.—To determine (1) the preparation of elementary school teachers in arithmetic content and teaching methods given by different types of institutions, and (2) what that preparation should be in the opinion of superintendents of school and professors of mathematics.

Procedure.—Courses in mathematics content and methods of teaching arithmetic, required of preservice elementary school teachers, were determined from the catalogues of 93 liberal arts colleges, 63 universities, and 43 teachers colleges. The registrars of 50 large teachers colleges or university schools of education answered a questionnaire on the same subject, as a check on the catalogue information. Fifty superintendents of larger school systems and 50 professors of mathematics in other institutions answered another questionnaire designed to determine what the preparation should be.

Major Findings and Conclusions.—The majority of elementary school teachers was not adequately prepared in mathematics content or methods of teaching. About two-thirds of the teachers colleges required content courses while less than one-fourth of the liberal arts colleges and university schools of education did. The liberal arts offering was usually college algebra, geometry, or trigonometry.

No methods courses were offered in 83 out of the 200 institutions. The average was 1.4 semester hours. A significantly smaller percent of the liberal arts colleges required such courses. Seventy-seven percent of the liberal arts colleges required neither courses in content nor methods.

Eighty-three percent of the heads of mathematics departments wanted the content courses taught by a mathematics professor. Seventy-seven percent of the superintendents and 86 percent of the heads of mathematics departments desired arithmetic content courses for the future teachers. Some work in advanced mathematics was recommended by 34 percent of the superintendents and 40 percent of the department heads.

Poor teaching results were judged to be due to lack of content knowledge by 49 percent of the superintendents, to inadequate methods by 29 percent, and to personal dislike of arithmetic by 23 percent. More than half of the superintendents indicated that methods and content courses, given separately, should be given to all of the prospective teachers.

34. FAULK, CHARLES JOSEPH. The Effect of the Use of a Particular Method on Achievement in Problem Solving in Sixth-Grade Arithmetic. (Ed. D., 1961, Louisiana State University, Baton Rouge, La.)

Major Faculty Adviser.—Thomas R. Landry.

Problem.—Development and evaluation of a specific method of instruction in problem solving at the sixth-grade level.

Procedure.—Experimental pupils used for 18 weeks a program of problem solving developed by the investigator, while paired control pupils used problem-solving procedures suggested by the author of the basic textbook being followed. Progress of both groups was measured by administration of the California Arithmetic Reasoning Test as pretest and posttest.

Major Findings and Conclusions.—Both problem-solving methods were judged effective, with no clear superiority for one over the other.

35. FISHER, RICHARD I. A Survey of Remedial Mathematics at the University of Kansas. (Master's, 1959, University of Kansas, Lawrence.)

Major Faculty Adviser.—Gilbert Ulmer.

Problem.—To evaluate the remedial mathematics program at the University of Kansas.

Procedure.—The high school mathematics backgrounds of all freshmen entering the university in the fall of 1956 and of a sample of 200 students in 1957 freshmen mathematics courses were studied. The records of 358 students in remedial courses in 1952–53 were analyzed in terms of scholastic aptitude, success in later mathematics courses, and persistence in the university. The scholastic aptitude of 64 students in Basic Mathematics (mainly for prospective elementary school teachers) was appraised by means of the A.C.E. Psychological Examination.

Major Findings and Conclusions.—About 40 percent of the 1957 freshmen had fewer than 2½ units of high school mathematics, but 95 percent had at least 2 units. The general scholastic ability of those enrolled in intermediate algebra and basic mathematics was about average, but of those in elementary and intermediate algebra was at the 14th percentile. Analysis of persistence in college, including graduation, led to the conclusion that there was a definite need for a remedial course like intermediate algebra as a preparation for college algebra, but no justification for the course entitled elementary and intermediate algebra.

36. Fulkerson, Elbert. How Well Do 158 Prospective Elementary Teachers Know Arithmetic? (1956, Southern Illinois University, Carbondale.)

Problem.—To determine whether students preparing to take a course in methods of teaching arithmetic were deficient in their knowledge of arithmetic.

Procedure.—A 40-item test appraising prospective teachers' knowledge of arithmetic was prepared and administered at the first meeting of the class. Only the answers were recorded. At the second meeting of the class the students gave this information: Age, name of high school, high school mathematics courses taken, colleges attended, college classification, college mathematics courses studied, and years of teaching experience.

Major Findings and Conclusions.—Performance was poorest on verbal problems. Items involving percentage caused considerable difficulty. As amount of high school and college mathematics taken increased, so did performance. Students with more teaching experience performed better than those with less. It was recommended that prospective elementary school teachers take two years of mathematics in high school and at least one college course devoted to understanding arithmetic.

37. Grant, Morris. Physics Formulas Illustrating Concepts and Processes in Mathematics up to Calculus. (Ed. D., 1960, Teachers College, Columbia University, New York.)

Major Faculty Adviser.—Myron F. Rosskopf.

Problem.—To find meaningful applications of physics for courses in mathematics.

Procedure.—Physics terms used in general science were obtained by textbook analysis. Added to these were the terms needed to define those in the original list. After defining these the investigator examined physics textbooks for the formulas which involved only these terms in the augmented list. These formulas were classified according to the mathematics concepts that they illustrated.

Major Findings and Conclusions.—It was shown how physics formulas could be selected and used in the teaching of various mathematical topics.

38. GREHL, PAUL, F. Relative Predictive Value of A.C.E. Psychological Examination for Freshman Science-Mathematics Students at Niagara University for the Years 1948, 1949 and 1950. (M.A., Niagara University, Niagara Falls, New York.)

Major Faculty Adviser.—James V. Deegan.

Problem.—To compare the value of the A.C.E. Psychological Examination for predicting success in two introductory freshman mathematics courses at Niagara University with that of the university's mathematics proficiency test.

Procedure.—Using the final grades in the two courses as the criterion, the investigator obtained the correlations between the scores on the predictive instruments and the criterion for the 195 freshman science-mathematics students of 1948, 1949 and 1950.

Major Findings and Conclusions.—The Q-score of the A.C.E. correlated highest with the criterion, and the L-score, the lowest. There was no statistically significant difference between the correlation of the Q-score and the proficiency test with the criterion. It was recommended that for economic reasons the proficiency test be dropped, since the A.C.E. test could be used for subjects other than mathematics. All correlations were low. Neither the A.C.E. nor the proficiency test proved their value for predicting the success of individuals.

39. HAMILTON, MARY UNA. An Experiment in the Teaching of Algebra I from the Contemporary Point of View. (M.S., 1960, Kansas State Teachers College, Emporia.)

Major Faculty Adviser.—John M. Burger.

Problem.—To compare the achievement of students in traditional and contemporary sections of algebra I.

Procedure.—Sections of contemporary algebra I were compared with sections of traditional algebra I by means of pretests and posttests.

Major Findings and Conclusions.—There was increased enthusiasm of students in the contemporary sections with no loss of achievement in the contemporary sections on traditional materials.

40. HANSDOERFER, WILLIAM. Trends in Secondary School Mathematics in New Jersey. 1960, written by seminar in mathematics education, Trenton State College, Trenton, N.J.)

Problem.—To prepare a compact booklet summarizing some of the many experimental mathematics programs in New Jersey and a list of New Jersey schools participating.

Procedure.—Questionnaires were mailed to all New Jersey school systems asking them to indicate to what extent they are participating in contemporary mathematics programs or units.

Major Findings and Conclusions.—Slightly over 200 schools were contacted. Fifty-eight responded, all of which indicated that they were participating in one way or another in offering contemporary mathematics to their students.

41. HANSON, RICHARD. Selected Enrichment Materials for High School Courses in Plane Geometry. (M.S., 1960 University of North Dakota, Grand Forks.)

Major Faculty Adviser.—Phillip A. Rognlie.

Problem.—To prepare an expanded treatment of selected enrichment topics for a high school course in plane geometry.

Procedure.—The study makes a careful distinction between "pure recreational mathematics" and legitimate enrichment material. A brief survey is made of enrichment materials now included in standard plane geometry textbooks. The main part of the study is devoted to such topics as: Geometrical Transformations (reflections, inversion, rotation), the Geometry of Circles, Items Related to the Pythagorean Theorem, Homothetic Figures, and Trisection.

Major Findings and Conclusions.—Possible use of the enrichment topics are presented. A rigorous and comprehensive treatment of geometry is defended.

42. HOHMAN, SISTER MARIE, O.P. The Comparative Value of Three Geometry Prognosis Tests and an Arithmetic Achievement Test in Predicting Success in Plane Geometry. (M.A., 1959, Catholic University of America, Washington, D.C.)

Major Faculty Adviser.—Rt. Rev. Msgr. Francis J. Houlahan.

Problem.—To answer two questions: (1) Does the Iowa Plane Geometery Aptitude Test (revised edition), the Lee Test of Geometric Aptitude, or the Orleans Geometry Prognosis Test give the best correlation with the Shaycoft Geometry Test (Form AM)? (2) Is the California Mathematics (Advanced Form AA) as good a predictor of success in plane geometry as any of the three aptitude tests?

Procedure.—Three aptitude tests were administered at the beginning of the school year 1957–58 in six geometry classes. Correlations were computed between these aptitude scores and end of the course scores on the Shaycoft Plane Geometry Test (Form Am).

Major Findings and Conclusions.—Although the results of the study seemed to show that for the group tested the Lee Test of Geometry Aptitude was a better predictor of success than any of the other three predictors used, statistical tests of the significance of the differences between the various correlation coefficients did not confirm its superiority. But statistical tests did affirm at the 10 percent level of confidence that the Lee test was a significantly better predictor of success in plane geometry than the California Mathematics Test, (Advanced Form AA).

43. HORTON, ROBERT E. Concept Formation in Freshman Mathematics for Engineers. (Ed. D., 1959, University of Southern California, Los Angeles.)

Major Faculty Adviser.—Leonard Calvert.

Problem.—To determine how the content and organization of the college freshman mathematics courses should be changed so that the mathematical concepts needed for modern engineering training will be available to the student when he needs them.

Procedure.—The current status of the freshman mathematics program, recent trends in the mathematics curriculum, and weight of opinion on integrated versus traditional course organization in mathematics were determined from the professional literature and college catalogues. Research reports on the mathematics needed by engineers in college and on the job, as well as those on learning theory applied to mathematics, were reviewed. From an analysis of nine unified freshman mathematics textbooks an optimum sequence was determined. Modern mathematical concepts were identified from a study of four recent textbooks emphasizing those. An outline for a freshman mathematics course was prepared from carefully developed curriculum criteria. A jury of authorities commented on the outline. One unit of the course was developed in detail.

Major Findings and Conclusions.—All colleges required at least 2 years of mathematics for engineers, including the elements of mathematical analysis and, in most cases, differential equation. Unified freshman mathematics courses are preferred. The superiority of concept learning over memorization was reported in several studies. Optimum learning order is from simple to complex concepts, and from broad concepts to details. Seventy-nine basic concepts were determined from the nine unified textbooks. From the modern textbooks 19 modern concepts were identified. It was concluded that the course should be unified around the function concept, with certain basic analytical concepts providing the problem-solving structure.

44. Jenni, Mary A. Exploration of Learning Situations Related to a Television-Centered Course in the Teaching of Arithmetic. (M.A.E., 1959, University of Florida, Gainesville.)

Major Faculty Adviser.—Kenneth P. Kidd.

Problem.—To determine the effectiveness of the learning situation related to a television-centered course, "The Teaching of Arithmetic."

Procedure.—The course was administered through individual study and activities, 6 seminars, and 16 weekly 30-minute telecasts. Eighteen of the 19 students were teachers. The course was evaluated by means of a questionnaire designed to determine the motivation of the learner, the effectiveness of the instructor-student communication, the extent of student involvement in the learning process, and the meaningfulness of the material taught.

Major Findings and Conclusions.—The learners were satisfied that the course was at least as valuable as a classroom course. It was concluded that the motivation was largely due to the telecast. The seminars supplemented the telecasts well. The meaningfulness of the content was largely due to the extraordinary care used in preparing the telecast. It seemed unlikely that the telecasts alone, however, could have produced the highly effective learning situation obtained.

45. Johnston, Aaron Montgomery. Arithmetic in Tennessee: A Survey of Teaching Practices, Grades One Through Eight. (1960, *University of Tennessee Record*, Knoxville.)

Problem.—To discover the current facts on specific important points of practice in the teaching of arithmetic in the State of Tennessee: Objectives in instruction; grade placement of content; time allocations; teaching materials and methods; and special problems.

Procedure.—A questionnaire calling for 129 responses was prepared and sent to a sample of 25 school systems. Reported data are based on returns from 666 teachers out of 1,894 who were sent questionnaires, representing 15 of the 25 school systems originally sampled. Despite the low percentage of returns and the fact that "it was difficult to determine the exact proportion of responses from rural and urban systems, Negro and white schools, good teachers and poor, experienced teachers and inexperienced," the researcher felt that "the returns were representative enough to make the findings significant."

Major Findings and Conclusions.—"Striking evidence" of wide variations in practice among Tennessee arithmetic teachers was found, with broad patterns of variation from grade to grade clearly evident. Certain discernible patterns of practice were so widespread as to be considered "normal" for the State. Many teachers are poorly prepared in method and content, and lack sufficient understanding of arithmetic to teach it properly. Specific findings were judged to provide useful clues to guide preservice and inservice education programs and arithmetic curriculum development programs.

46. KELLER, M. W., and SMITH, A. H. A Study of the Shortage and Placement of College Mathematics Teachers. (1959, Purdue University, West Lafayette, Ind.)

Problem.—To determine the extent to which qualified personnel are available to fill positions in the teaching of college mathematics.

Procedure.—In the fall of 1958 a questionnaire was sent to 76 collegiate institutions asking whether 162 positions, reported by them as vacant in 1957–58, had been filled by qualified appointees. Sixty-three questionnaires were returned, providing information on 144 positions of the 162.

Major Findings and Conclusions.—Twenty-five percent of those employed failed to meet the minimum-degree requirements for the position. For 76 of the positions for which the needed data were available, 28 percent of those employed did not meet the minimum requirements for the rank; they were, therefore, appointed to a lower rank. Of the 79 positions requiring a Ph. D. degree, only 50 were filled by appointees holding the degree.

47. KELLER, F. W., and SMITH, A. H. A Resource Evaluation of a Special Master's Program. (1960, Purdue University, West Lafayette, Ind.)

Problem.—To determine to what extent the Purdue Retired Armed Services Training Program (RASTP) for the preparation of teachers of undergraduate mathematics is acceptable to the colleges.

Procedure.—A pamphlet, describing the RASTP program, and a questionnaire were sent to all colleges, universities, and junior colleges in the United States. These institutions were asked whether men having the RASTP qualifications could fill positions in the teaching of mathematics, anticipated for 1959–60 and 1960–61.

Major Findings and Conclusions.—A total of 507 questionnaires, or about a third of those sent, was returned. Of a total of 700 positions listed for 1959–60, as many as 328, or 46.8 percent, would be available to men with RASTP qualifications. For 1960–61 the number available was 825 out of the 1,862 listed. About one-fourth of the institutions would not accept RASTP personnel. Many of these wanted Ph. D.'s in mathematics. It appeared that an RASTP graduate would have good opportunities to obtain a position in his geographical area.

48. KELLEY, CHARLES EDWARD. Trends in Secondary School Mathematics Education, 1955–60. (Ed. D., 1960, University of Missouri, Columbia.)

Major Faculty Adviser.—R. K. Watkins.

Problem.—(1) To show the trends in the mathematical content for grades 9 to 12 as indicated by the recommendations of the University of Illinois Committee on School Mathematics, the Commission on Mathematics of the College Entrance Examination Board, the School Mathematics Study Group, and the Secondary-School Curriculum Committee of the National Council of

Teachers of Mathematics, (2) to compare these recommendations with similar ones of the past three decades, (3) to indicate differences among these four groups.

Procedure.—The findings of these organizations were fitted into a brief historical summary for each grade. Tables were prepared showing relative emphasis on certain topics by grades. A course outline was prepared for each grade which, in general, synthesized the recommendations of the four groups.

Major Findings and Conclusions.—The trends revealed a broader sense of mathematical values on the part of present-day curriculum makers. The reports reviewed stressed mathematics for mathematicians rather than consumer mathematics for laymen. There has not been the fundamental change in mathematics that publicity about the reports seems to indicate. In 1960 the recommendations of the four groups with regard to content and sequence are in a fluid state. The 12th-grade courses presented considerable divergence.

49. KENNER, MORTON. Hilbert's Formalism and the Development of Geometry (Ph. D., 1959, Teachers College, Columbia University, New York.)

Major Faculty Adviser.—Myron F. Rosskopf.

Problem.—To describe and clarify Hilbert's formalism.

Procedure.—Abstractive tendencies in the development of geometry were analyzed from Greek times, through the development of projective geometry in the 17th century, to the maturation of synthetic and non-Euclidean geometry in the 19th century. Hilbert's early work in the foundations of geometry was analyzed, and his development of metamathematical analysis studied.

Major Findings and Conclusions.—Hilbert moved informally to a higher level of abstraction in the form of metageometry. His concern with the method of models, noncontradiction, and independence in an axiom system was discussed in detail. It was shown how Hilbert attempted to overcome the weaknesses in this informal approach by a simultaneous development of logic and mathematics, leading to the science of metamathematics. The framework of this science—the axiomatic method, consistency, and mathematical existence—was considered. It was shown that the central method of mathematics, for formalism, is axiomatic.

50. KIMBALL, REVEREND THOMAS D. The Determination of Groups of Items Whose Variance Is Accounted for in Terms of One Only Factor. (M.A., Catholic University of America, Washington, D.C.)

Major Faculty Adviser.—Rt. Rev. Msgr. Francis J. Houlahan.

Problem.—(1) To determine, from the performance of boys in one elementary algebra achievement test, groups of items whose variance is accounted for in terms of one only factor.

Procedure.—Data used was from the study in progress of Sr. Rita Buddeke. A correlation matrix of tetrachoric coefficients of intercorrelations of given test items for boys was developed, the correlation coefficients are arranged according to Spearman's hierarchy, and statistical checks using Moore's modified formulas are applied.

Major Findings and Conclusions.—This study, using the Spearman-Moore technique, corroborated another study of factorial patterns appearing in the performances of boys and girls which made use of Thurstone's centroid method of factoring and oblique rotation of axes. This study identified factorially pure items for building tests of abilities involved in them.

51. KOCHNOWER, WILLIAM. Personality Factors Which May Contribute to Success in Mathematics. (Ed. D., 1960, Teachers College, Columbia University, New York.)

Major Faculty Adviser.—Howard F. Fehr.

Problem.—To determine whether the traits measured by a standardized personality questionnaire could distinguish a group of high school students whose mathematical achievement exceeds their average scholastic achievement from a comparable group whose mathematical achievement is equivalent to their average achievement.

Procedure.—A selected sampling of 434 ninth-, tenth-, and eleventh-grade students was used. Half of these demonstrated superior relative achievement and constituted the experimental group. The other half, matched by grade level, sex, geographical data and IQ, served as a control group. The Iowa Tests of Educational Development were used to separate the members of the two groups. The Institute for Personality and Ability Testing Humor Test was used to measure personality traits. The statistical analysis of multiple regression was employed. The raw scores on the personality questionnaire were treated as predictor variables, while the numerical values assigned to indicate membership in the control or experimental group was used as the criterion or dependent variables. Male and female subjects were treated separately.

Major Findings and Conclusions.—Of the 14 traits measured by the questionnaire only 2 appeared to be significantly related to the criterion for boys. The mathematically inclined male subject emerged as a sensitive, insecure, introspective individual who tends to avoid group activities. He clings to his own convictions, refusing to subordinate them to common group standards. In the female, the study produced no evidence relating personality to achievement in mathematics.

52. KREITZ, HELEN MARIE. Historical Number Stories for Use in Intermediate Grades. (1959, Ed. M., University of Texas, Austin.)

Major Faculty Adviser.—Frances Flournoy.

Problem.—To survey and describe available stories for intermediate grades on the history and development of the number system, number processes, and the system of measures; to suggest values derived from such and ways of using these stories in relation to skills taught; and to create original stories of this same kind.

Procedure.—Survey of literature, classification and description of available stories, and writing of original stories.

Major Findings and Conclusions.—Pupils indicated that they enjoyed and appreciated stories from which they can get and learn facts. Historical number stories could be used to stimulate interest in number, to create an appreciation for number, to reintroduce and review mathematical facts and processes, and to enrich the arithmetic program in the intermediate grades.

53. LANCASTER, OTIS, and ERSKINE, ALBERT. Achievement in Small Class, Large Class and TV Instruction in College Mathematics. (1961, Pennsylvania State University, University Park.)

Problem.—To determine the relative merits of teaching analytic geometry and calculus by small class, large class, and TV instruction.

Procedure.—For 2 consecutive years all freshman engineering students were divided by means of random numbers into three groups, corresponding to the three methods of instruction. The course in calculus followed that of analytic geometry. During the first year all of the freshmen were taught calculus by the small class method. During the second year some of the freshmen were taught by TV while others were taught by either small class or large class methods. This variation in teaching method was used both years in teaching analytic geometry.

To control the teacher variable somewhat, the teachers of the TV and large classes were interchanged the second year. Analysis of covariance was used to take student differences into account. The various groups were compared by means of final examination. A study was made of the hours of study and the number of dropouts associated with each of the methods.

Major Findings and Conclusions.—In order of achievement in analytic geometry the ranking was the large class, TV, and small class methods. This order was maintained in calculus during the first year of the experiment, but during the second year the TV method moved from second to first place. However, whether TV was or was not the method used in analytic geometry did not appear to influence this result. The percent of dropouts was least in the TV group during the first semester but greatest during the second. The TV students studied the most and the large class students the least.

It appears that the large class method was better than the other methods in terms of achievement and retaining of students, even though less study time was involved.

54. LINDSEY, WILLIE EUGENE, JR. A Study of the Major Causes of Arithmetic Difficulties for a Selected Group of Seventh-Grade Students at Melrose High School (Memphis, Tennessee) for the School Year 1957–58. (M.S., 1959, Tennessee Agricultural and Industrial State University, Nashville.)

Problem.—To determine some of the more probable causes of arithmetic difficulties of seventh-grade pupils at Melrose High School, Memphis, Tenn., for the school year 1957–58.

Procedure.—Thirty-five pupils were studied in relation to these factors: Arithmetic achievement (low), reading achievement, mental ability, visual and auditory acuity, study habits and attitudes toward arithmetic, and information regarding parents (schooling, occupation, etc.).

Major Findings and Conclusions.—Achievement in arithmetic reasoning was much lower than achievement in computation. This was coupled with a low reading achievement level. No relationship was found between arithmetic achievement and age, or physical disability, or socioeconomic conditions in the home.

55. LITWILLER, BONNIE. Modern Concepts of Mathematics Taught in the Junior Colleges in Illinois. (M.S., 1960, Illinois State Normal University, Normal.)

Major Faculty Adviser.—T. E. Rine.

Problem.—To determine the extent to which junior colleges of Illinois are including concepts of modern mathematics in their courses.

Procedure.—A questionnaire structured to find out about the mathematics curriculum and what concepts of modern mathematics were taught, was sent to all of the 29 junior colleges of Illinois.

Major Findings and Conclusions.—Only brief mention of modern mathematics was made in the junior college courses. The junior college teachers had an average of only two courses in modern mathematics. It was recommended that these teachers improve their preparation by taking more courses in modern mathematics and by individual study.

56. LOMBARDI, GEORGE R. A Pilot Study To Determine the Efficiency of the Iowa Tests of Educational Development in Predicting Grades in Mathematics of Senior Male Students in LaSalle Senior High School. (M.S., 1960, Niagara University, Niagara Falls, N.Y.)

Major Faculty Adviser.—James V. Deegan.

Problem.—To determine the efficiency of test 4 in the Iowa State Tests of Educational Development, "Ability To Do Quantitative Thinking," in predicting grades in algebra, geometry, and intermediate algebra.

Procedure.—Pearson Product.—Moment correlations were computed separately between test 4 and grades in algebra, geometry, and intermediate algebra for senior male students in LaSalle Senior High School, Niagara Falls, N.Y., 1957. The sample included 79 students for algebra, 50 for geometry, and 34 for intermediate algebra.

Major Findings and Conclusions.—Highest correlation was with algebra and next with intermediate algebra, both correlations being significant at the 0.01 level of confidence. The correlation with geometry was not significant. Tentative expectancy tables for counselors, teachers, and administrators were established using t-scores and percentile ranks for the local group.

57. LUETGE, ELVIE LOU. Providing for Individual Differences in Arithmetic. (Ed. M., 1959, University of Texas, Austin.)

Major Faculty Adviser.—Frances Flournoy.

Problem.—To study individual differences in arithmetic in a low fourth-grade classroom and to experiment with the use of various methods and materials in providing for these differences.

Procedure.—Used numerous observational techniques to note individual differences among children in arithmetic ability and to note factors possibly related to these differences in a casual way. On basis of observations, used various methods and materials to provide for individual differences.

Major Findings and Conclusions.—Found these to be the most effective methods and materials for provision for individual differences: Grouping children into two or three groups ("too many groups can hinder any of the groups from receiving proper attention"), using audiovisual aids, using concrete and semi-concrete materials, providing for group activities, and playing games. Found more difficulties due to cognitive factors than to nonintellective factors.

58. MACCIA, FRANCES A. The Status of the Mathematics Program for Above-Average Students in Fifty-Six New Jersey Junior High Schools in the Spring of 1960. (1960, Montclair State College, Upper Montclair, N.J.)

Problem.—To determine whether an accelerated or an enriched mathematics program for the above-average or gifted students was being offered in the 96 junior high schools in New Jersey in the spring of 1960, or was being planned for the fall of 1960.

Procedure.—A questionnaire was mailed to the principal of each of the 96 junior high schools in New Jersey and the responses analyzed.

Major Findings and Conclusions.—Of the 9 schools with 1,000 or more students, all offered either acceleration or enrichment programs in mathematics; all 11 schools with neither acceleration or enrichment had fewer than 999 pupils. A total of 12 schools had only an acceleration program, 19 had only an enrichment program, while 14 had both. Of the schools with neither acceleration or enrichment, 9 percent were planning to start acceleration, 9 percent an enrichment program, and 18 percent were discussing possibilities.

59. MALAN, JUNE R. An Experiment with a Recently Developed Test for Ninth-Grade Mathematics. (M.S., 1960, University of Kansas, Lawrence.)

Major Faculty Adviser.—Gilbert Ulmer.

Problem.—To answer two questions: (1) Did the achievement on traditional mathematics made by students who studied a new curriculum in ninth-grade mathematics compare favorably with the achievement of students who were taught by traditional methods and materials in the same school? (2) Did the new material stimulate a greater degree of apparent interest as shown by increased enrollment in elective second-year mathematics courses?

Procedure.—The experimental group consisted of four classes, two taught by each of two teachers throughout the school year 1959–60, using the materials of the Development Project in Secondary Mathematics, developed at Southern Illinois University. The control group consisted of two classes taught by another teacher using traditional materials. Students were assigned randomly to the six classes. Arithmetic scores on the California Arithmetic Test given in the eighth grade were obtained as pretest scores. Otis Quick Scoring Test scores were obtained. The criterion of ninth-grade achievement was performance on the Lankton Algebra Test, given near the close of the year. The technique of analysis of variance and covariance was employed to compare achievement of experimental and control groups, intelligence and pretest scores being held constant.

Major Findings and Conclusions.—The students in the experimental group achieved significantly higher on the standardize' algebra test than did the students in the control group. In the experimental group 75 percent indicated at the end of the year that they intended to continue with second-year mathematics, while only 34 percent in the control group planned to continue.

60. MALETSKY, EVAN M. The Relative Merits of Several Methods of Teaching Probability in Elementary Statistics. (Ph. D., 1961, School of Education, New York University, New York.)

Major Faculty Adviser.—John J. Kinsella.

Problem.—To test the relative merits of three methods of teaching certain topics in elementary statistics.

Procedure.—The first method involved a formal introduction to the theory of probability using the basic concepts of sets. The second gave this introduction through traditional mathematics. The third involved an intuitive introduction to probability. A unit of instruction was prepared for each of the methods. The first group consisted of 25 students, the second 30, and the third 28. The same instructor taught all three groups. Tests of mathematical competence and statistical inference were constructed and administered. The duration of the experiment was one semester.

Major Findings and Conclusions.—Initial differences among the 3 groups of students, randomly selected from 12 sections, were taken into account by analysis of covariance. There were no statistical differences at the 5-percent level in problem-solving ability in probability and statistical inference among the three groups, although the results seemed to favor the methods using sets.

61. MAMARY, ALBERT. A Study of High Ability Students' Success and Failure in Mathematics. (M.A., 1960, University of Minnesota, Minneapolis.)

Major Faculty Adviser.—Donovan A. Johnson.

Problem.—To determine reasons for success and failure in mathematics of high-ability students; to determine characteristics of high-ability students significantly associated with success or failure; to get some suggestions for improving the teaching of mathematics.

Procedure.—The study was conducted with the entire senior class of University High School, University of Minnesota, in 1959–60. The Lorge-Thorndike (nonverbal) Intelligence Test, Iowa Test of Educational Development (quantitative thinking) and the Differential Aptitude Abstract Reasoning and Spacial Relations Tests were used to define high ability. Students, who maintained a B+ or better average in mathematics from grades 7 through 12, were considered successful. Students who had a C— or less average and were not currently enrolled were considered unsuccessful. There were 12 students in each group. Information was gathered by means of an interview based on the following areas: Student attitude toward mathematics; parental attitudes; teacher attitudes; inherent difficulties of mathematics as a course of failure; study habits, hobbies, and amount of study time; pupil's own analysis of the causes of success or failure; effects of student teachers. The data collected were analyzed by the Fisher-Yates Test of Significance for 2 x 2 Contingency Tables.

Major Findings and Conclusions.—The successful students had regular study hours, studied without radio or television, had chores to do at home, found mathematics useful, had parents who were good in mathematics, did not expect better grades in other courses, had elementary teachers who enjoyed arithmetic, and did not get behind in their work. Unsuccessful students felt they would have been more successful if they had been in a slower moving group and thought their teachers taught only to the top few. The successful students thought that a successful student did not try to relate mathematics to anything, that insight into mathematics was an important reason for success, that to be successful one should not memorize it, and that one had to work hard to succeed in mathematics. The students felt that poor teachers give too much drill, do not care if the individual gets the material, teach only to the top few, are not interested in the subject, and are out of touch with how students feel.

62. SISTER ROSE MARIAN. The Effect of Student Constructed Assignments on Certain Factors in Mathematical Achievement and Retention. (Ph. D., 1959, School of Education, New York University, New York.)

Major Faculty Adviser.—John J. Kinsella.

Problem.—To determine the effect of student constructed assignments on achievements in algebraic content, problem-solving ability, and critical thinking during a college freshman liberal arts course in the introduction to mathematics.

Procedure.—An experimental group of 22 students and a control group of 19 were used. The control variables were initial mathematical achievement and intelligence. During the semester each member of the first group constructed 21 assignments which were worked by a second student and checked by a third. Tests of algebraic content, problem solving, and critical thinking were given at the beginning and end of the experiment, and, for the evaluation of retention, 4 months after the end of the semester.

Major Findings and Conclusions.—There was a statistically significant difference in favor of the experimental group in algebraic content, problem solving, and critical thinking at the end of the semester and, also, 4 months later.

63. MAY, KENNETH O. An Undergraduate Training Program in Mathematical Research. (1960, Carleton College, Northfield, Minn.)

Problem.—To find more effective ways of stimulating undergraduate students in mathematics to show initiative and to do original work.

Procedure.—During 1956–60 various devices were used to solve the problem. Among these were honors sections for freshmen and sophomores, special honors problems, publicly posted problems of the month, colloquia for advanced students, research projects involving student-faculty collaboration, and a publication reporting the results of these endeavors.

Major Findings and Conclusions.—The devices used had a significant impact on student activity. The most effective devices appeared to be honors problems, the colloquia, student-faculty collaboration, and the local publication. Unless students in honors sections were held to the same standards and amounts of routine work as the other sections, they tended to do less well than their fellows in the regular sections. It seems that honor work should be only a supplement to regular courses, and that enrichment rather than acceleration is most effective.

64. MCKINLEY, JAMES E. Relationship Between Selected Factors and Achievements in a Unit on Probability and Statistics for Twelfth-Grade Students. (Ed. D., 1960, University of Pittsburgh, Pittsburgh, Pa.)

Major Faculty Adviser.—Alex J. Ducanis.

Problem.—To prepare and teach a unit on probability and statistics for high school seniors and to analyze the relationship between certain factors and achievement in the unit.

Procedure.—The unit was prepared and taught to 217 students in 10 schools for 13 class periods. Measures of total intelligence, language intelligence, nonlanguage intelligence, reading comprehension, and previous experience in mathematics were correlated with a measure of achievement on the unit of work.

Major Findings and Conclusions.—A significant gain in achievement was shown by the students during the study. The achievement of students in the college preparatory curriculum was significantly greater than the achievement of students in other curriculums. The consensus of the participating students and teachers was that such a course would be a valuable addition to the high school curriculum.

65. MCMAHON, DELLA L. An Experimental Comparison of Two Methods of Teaching Percent to Seventh-Grade Pupils. (Ed. D., 1959, University of Missouri, Columbia.)

Major Faculty Adviser.—Ralph E. Watkins.

Problem.—To compare initial learning and retention of learning if seventh-grade pupils are taught percent by the ratio method or the conventional method.

Procedure.—Four middle-ability classes and one low-ability class were taught percent by the ratio method, and an equal number of classes were taught by the conventional method. (In all, 245 seventh-grade pupils from two Waterloo, Iowa public schools were involved in this sample.) At the end of a 5-week teaching period a final percent test constructed by the investigator was administered to all subjects. Six weeks later a retention test was administered.

Major Findings and Conclusions.—There seemed to be no difference between the ratio and conventional methods in developing ability to interpret statements about percent. The ratio method resulted in greater computational skill with percents and in more permanent learning than did the conventional method. Neither method was successful with pupils of low mental ability.

66. McTaggert, Helen Patricia. A Factorial Study of the Problem-Solving Ability of Fifth-Grade Girls. (Ph. D., 1957, Catholic University of America, Washington, D.C.)

Major Faculty Adviser.—Rt. Rev. Msgr. Francis J. Houlahan.

Problem.—To compare the factor patterns of arithmetic performance of fifth-grade girls with the factor patterns of fifth-grade boys and sixth-grade girls.

Procedure.—Factor analysis based on data from a battery of 21 subtests administered to 373 fifth-grade girls and 363 fifth-grade boys during a 2-week period in November 1957.

Major Findings and Conclusions.—For fifth-grade girls, identified three primary factors: (1) A verbal factor calling for both general and specific skills in reading comprehension and vocabulary meaning; (2) an arithmetic factor involving ability to perform fundamental operations in arithmetic as well as to demonstrate an understanding of number relationships; and (3) an approach-to-problem-solving factor involving an ability to compare and organize data prior to the solution of a problem presented in verbal, arithmetical, or spatial form. A comparison of factor patterns for fifth-grade girls (this study) and sixth-grade girls (a companion study) revealed that the sources of variance for the former were more clearly defined than for the latter. Comparison of factor patterns for fifth-grade girls and boys showed a marked difference in the case of factor C which, for boys, was identified as a spatial factor rather than the approach-to-problem-solving factor identified for girls.

67. Milligan, Merle W. An Inquiry Into the Selection of Subject Matter Content for College Freshman Mathematics. (Ed. D., 1961, Oklahoma State University, Stillwater.)

Major Faculty Adviser.—James Zant.

Problem.—To develop a process for the selection of content for a modern course in college freshman mathematics, and to apply the process to the construction of such a course in a specific college.

Procedure.—Objectives were first selected after a study of the relevant literature. Seventeen criteria for selecting content were obtained from similar sources. Subject matter topics were rated by using these criteria at one of four levels of significance. A selection of topics was made and ordered in a cyclic, spiral way.

Major Findings and Conclusions.—Application of the process seemed to show that it was possible to select a modern course in freshman mathematics satisfying the objectives and criteria. Not all topics contained in traditional books were rated low, nor all topics in modern textbooks rated highly. In general, topics related to an early introduction of the calculus and to mathematical structure were rated highly; those primarily concerned with detailed manipulatory techniques in college algebra, trigonometry, and analytic geometry were ranked relatively low. The logical, sequential nature of mathematics leads to some modifications of a course based on criteria and objectives alone.

68. MOTT, EDWARD RAYMOND. An Experimental Study Testing the Value of Using Multisensory Experiences in the Teaching of Measurement Units on the Fifth- and Sixth-Grade Level. (Ed. D., 1959, Pennsylvania State University, University Park, Pa.)

Major Faculty Advisers.—P. W. Bixby and C. G. Corle.

Problem.—To evaluate the effectiveness of prearranged multisenory materials on attitude toward school subjects, quantitative understanding, and computational skill.

Procedure.—Pre- and posttesting of control (N=70) and experimental (N=175) pupils in (1) attitude toward school subjects, (2) quantitative understanding, and (3) computational ability. During the experimental period the experimental group was given every opportunity to use multisensory aids during arithmetic measurement classes; no attempt was made to influence the control group as to time, method, and aids used.

Major Findings and Conclusions.—Both experimental and control groups gained in quantitative understanding and in computational skill, but the difference between experimental- and control-gain was not significant in either instance. Neither group showed a significant increase in attitude scores when the factors of sex, mental age, and a combination of these two factors were taken into consideration.

69. NOVELLO, REVEREND RUSSELL R. Differential Factors in Algebraic Computation for High-Achieving Boys and Girls. (Ph. D., 1960, Catholic University of America, Washington, D.C.)

Major Faculty Adviser.—Rt. Rev. Msgr. Francis J. Houlahan.

Problem.—To determine what factors in algebra are used by high achievers; to compare such factors in order to recognize the grouping of abilities underlying high achievement in algebra.

Procedure.—The 65-item algebra test of the 1959 Affiliation Test Program of the Catholic University of America was administered to about 6,000 ninth-grade pupils. Those who attained a score at or above one standard deviation from the mean were selected as high achievers. Coefficients of tetrachoric correlation were calculated on those items (43 in number) which more than 15 percent and less than 85 percent succeeded in answering correctly. Thurstone's Centroid Method of Multiple Factor Analysis was applied to each matrix to discover the factor loadings. The axes were rotated to the position of the factors which are identified and named.

Major Findings and Conclusions.—The boys' factors are described as follows: (1) A dual-functional relationship factor; (2) a powers and roots achievement factor; (3) a computation from verbal presentation factor; (4) a factor requiring insight into the functional relationships with numbers; (5) a linear equation-functional relationship factor.

The girls' factors are described as follows: (1) A functional relationship factor stressing symbolization; (2) a number factor stressing functional relationship; (3) a number achievement factor stressing directed or signed numbers; (4) an equation-functional relationships factor; (5) a directed number operations factor.

70. PAIGE, DONALD DEAN. An Experimental Unit on the Quadratic Function. (M.A., 1960, Iowa State Teachers College, Cedar Falls.)

Major Faculty Adviser.—H. C. Trimble.

Problem.—To construct, teach, and evaluate a 4-week unit for the teaching of quadratic functions in ninth-grade algebra.

Procedure.—A 4-week unit on quadratic functions was introduced with major emphasis on graphs throughout to an experimental group. A control group was matched on the basis of mathematical achievement. A specially constructed test was adminstered to both groups and score differences subjected to the t-test for significance. In addition differences in student reactions in the two classes were tabulated by the investigator. The regular classroom teacher also wrote a summary of impressions.

Major Findings and Conclusions.—Performance differences favored the experimental class and the hypothesis of no difference rejected at the 5-percent level of confidence. The tabulated reactions of students in terms of questions, attention, contributions, and spontaneity favored the experimental group 32 to 23. The regular teacher observed that the experimental group was superior with respect to interest before and after class, use of notes, attitude toward proof.

71. PAINE, ALAN H. Developing Procedures for Establishing Programs of Mathematics Education in Certain Type Colleges with Special Reference to Marlboro College in Vermont. (Ed. D., 1960, Teachers College, Columbia University, New York.)

Major Faculty Adviser.—Howard F. Fehr.

Problem.—To develop a procedure for establishing a mathematics program in a certain type of liberal arts college.

Procedure.—Bard, Bennington, Goddard, Sarah Lawrence, and Marlboro College were studied. These five have common philosophies, aims, and objectives. They are described as experimental, based on students' needs, and influenced by the philosophy of John Dewey. The historical and philosophical development of the colleges, the evolution of their mathematics programs, and procedures for establishing a mathematics program were studied.

Major Findings and Conclusions.—In this study the following procedure developed involved informing the faculty of the proposal and progress of the program; determining the general aims and philosophy of the college; studying the present program thoroughly; determining learning experiences, teaching methods, evaluation procedures, and plans for developing courses; trying out the program experimentally; evaluating the program and revising it, if necessary.

72. PAYETTE, ROLAND F. Report of the School Mathematics Study Group Curriculum Evaluation. (1960–61, Educational Testing Service, Princeton, N.J.)

Problem.—To answer the following questions: (1) Does the SMSG curriculum detract from student achievement with respect to traditional mathematical skills? (2) Does the SMSG curriculum result in a measureable extension of developed mathematical ability beyond that of conventional mathematics instruction? (3) How effectively is the SMSG curriculum communicated to students at various levels of scholastic ability?

Procedure.—Evidence pertinent to question *one* was secured in the following manner. A group of teachers (CA), selected at random from a group of teachers willing to teach the SMSG curriculum for the first time, provided their students with conventional mathematics instruction. A second group of teachers (EA), selected at random from a group of teachers willing to teach the SMSG curriculum for the first time, provided their students with mathematics instruction based on SMSG materials. There were approximately 30 teachers in each of the two groups, CA and EA, at each of five grades, 7, 9, 10, 11, and 12.

Students of CA teachers and students of EA teachers were administered common tests of scholastic aptitude and knowledge of mathematics in the fall of 1960, and common tests of traditional mathematics and SMSG mathematics in the spring of 1961. The tests were designed for the various grade levels and curriculums involved in the study.

Evidence relative to question *two* was secured in the following manner. The students of CA teachers were compared with students of EA teachers on the basis of their performance on SMSG tests.

Data relevant to question *three* was derived by plotting SMSG test score distributions according to differing SCAT levels. Then, overlap among SMSG test scores was sought for students of high, medium, and low scholastic aptitude.

An additional facet of this study was the concern for results that might be attributable to Hawthorne or experimental effect. In order to establish some control over the influence that participating in an experiment is alleged to exert on experimental results, an additional comparison of traditional mathematics achievement was made.

A group of teachers (CC) was randomly selected from the populations of mathematics teachers from the large school systems who participated in the study. Their participation included only the administration of SCAT and achievement tests of conventional and SMSG mathematics in the spring of 1961. These teachers did not know that they would be asked to participate in the study until shortly before the spring administration of tests. Hence it is hypothesized that their instruction was not influenced by knowing that they were in an experiment.

Major Findings and Conclusions.—In general, students exposed to conventional mathematics have neither a pronounced nor a consistent advantage over students exposed to SMSG mathematics with respect to the learning of traditional mathematical skills.

Students exposed to SMSG instruction acquire pronounced and consistent extensions of developed mathematical ability beyond that developed by students exposed to conventional mathematics instruction.

Regarding the Hawthorne effect, comparisons of achievement on conventional and SMSG tests for students of CA and CC teachers indicate unequivocally that there is no advantage in favor of students of CA teachers, those teachers who knew they were in an experiment. The CC teachers provided instruction in conventional mathematics only.

Scholastic aptitude is far from the whole story in predicting achievement in SMSG. The necessity for additional predictors of SMSG achievement becomes particularly acute in the upper grades. Additionally, the large range of achievement scores for all SCAT levels at all grade levels casts doubt on traditional means of selecting students for ability grouping in mathematics instruction. Finally, there is positive evidence to suggest that students at all SCAT levels can learn considerable segments of SMSG materials.

73. PETTOFREZZO, ANTHONY. A Comparison of the Relative Effectiveness of Two Methods of Teaching Certain Topics in Solid Analytic Geometry to College Freshman. (Ph. D., 1959, School of Education, New York University, N.Y.)

Major Faculty Adviser.—John J. Kinsella.

Problem.—To compare the effectiveness of the vector method approach and the traditional approach in teaching certain topics of solid analytic geometry.

Procedure.—Two groups of students, randomly assigned to the investigator for instruction in freshman engineering mathematics at the Newark College of Engineering, Newark, N.J., were matched in terms of intelligence, average grades during the fall semester, and knowledge of solid geometry. One group was taught solid analytic geometry for 4 weeks by the vector method, the other group by a method making use of the algebra of numbers. The same instructor taught both groups.

Major Findings and Conclusions.—Although there was a constant margin in favor of the experimental group at all levels of ability, the differences were not statistically significant at the 5-percent level.

74. PITTS, RAYMOND J. Understanding the Structure of Number Systems. (1960, Los Angeles State College, Los Angeles, Calif.)

Problem.—To determine the extent to which elementary teacher trainees can acquire an understanding of closure, associativity, identities, inverses, commutativity, and distributivity, and can apply these concepts to number systems commonly used in the elementary school.

Procedure.—A test designed to appraise understanding of the structure of number systems, in terms of comprehension, translation, and application, was administered to 44 preservice elementary teachers at the end of a three-unit course in arithmetic, in which "understanding of the structure of number systems" was one of four objectives. The responses were analyzed in terms of the percent of correct responses.

Major Findings and Conclusions.—Over 80 percent of the responses to items dealing with the comprehension of identity, commutativity, and the properties of a group were correct. However, the ability to apply these properties varied greatly. Most errors occurred in examples involving rational numbers. The students did not seem to have enough understanding of the inverse to apply it with facility.

75. POPEJOY, WILLIAM D. An Experimental Study of Two Curricular Organizations of First-Year Mathematics at Colorado State College. (Ed. D., 1959, Colorado State College, Greeley.)

Major Faculty Adviser.—Dale O. Patterson.

Problem.—To determine the relative effectiveness of teaching college algebra, trigonometry, and analytic geometry separately or teaching a course integrating them.

Procedure.—Pairs of students were matched on bases of college ability scores, a mathematics pretest, and years of high school mathematics. One member of each pair was given the separate subject course and the other the integrated course. Tests in algebra were given at the end of the fall, winter, and spring quarters; in trigonometry at the end of the winter and spring quarters; and in analytic geometry at the end of the spring quarter.

Major Findings and Conclusions.—Achievement in algebra and trigonometry is independent of the type of organization. The achievement in analytic geometry of those in the integrated plan exceeded, by a statistically significant amount, that of the other group. Those with 3 or more years of high school mathematics scored consistently higher in algebra and trigonometry than those with fewer than 3 years. Achievement in algebra increases over the year; no gain or loss in trigonometry occurs after a quarter.

76. PRESSLER, EVELYN. A Study of Classroom Grouping in Second-Grade Arithmetic. (Ed. M., 1960, University of Texas, Austin.)

Major Faculty Adviser.—Frances Flournoy.

Problem.—To study the achievement of second-grade children when two types of grouping for instruction were used: intraclass grouping and whole-class instruction.

Procedure.—Pre- and posttesting with standardized achievement test; also testing with teacher-made instrument. Experimental group (two classes) was divided (each class) for separate instruction into two groups: High third based on achievement, and the rest of the pupils. Control group was not separated for instruction within each of the two classes.

Major Findings and Conclusions.—Found no significant difference in achievement, regardless of ability level, between experimental and control groups. Suggests that the full value of the subgrouping was probably not measured by the tests. Contends that, if the faster pupils had been accelerated in content rather than given just enrichment, differences would no doubt be large.

77. ROBINSON, GEORGE A. Strategies in the Teaching and Learning of Concepts: An Analysis by Symbolic Logic. (Ph. D., 1960, University of Illinois, Urbana.)

Major Faculty Adviser.—K. B. Henderson.

Problem.—To make a logical analysis of heuristic strategies available to a learner in acquiring a concept and to his teacher as a director of learning; to present a theoretical model for directing research in the teaching of concepts; and to facilitate programing a teaching machine which employs feedback.

Procedure.—Symbolic logic was used to analyze the strategies and to propose a theoretical model for subsuming them.

Major Findings and Conclusions.—Heuristic strategies available to the teacher and learner in the presence and absence of feedback were analyzed. The theoretical model consisted of using logical equations to represent the concept to be taught and the learner's idea of what the concept is. When the concept is a single valued function of n concepts already known, the possible structure for the concept to be taught are associated with the vertices of a 2^n dimensional cube. The difference between the teacher's and learner's idea of a concept is also shown by the difference between two vectors. The machine known as the ILLIAC is programed to compare the teacher's and learner's idea of a concept and to correct defects in the learner's conjectures.

78. ROSS, ARNOLD EPHRAIM. Report on the Program for Gifted High School Students at Notre Dame University. (1961, University of Notre Dame, Notre Dame, Ind.)

Problem.—To discover and develop scientific talent early.

Procedure.—Each applicant to the Notre Dame N.S.F. summer program is sponsored by high school mathematics teacher and finally selected by a committee of the Notre Dame teaching staff on the bases of discussion with the teacher-sponsor and such available evidence as achievement, interest, autobiography, special questionnaire, and academic record. The 54 students came from 15 States representing 18 public, 18 parochial, and 3 private schools. There were 8 seniors, 29 juniors, 14 sophomores, and 3 freshmen. Rigidity in selection was avoided lest the gifted nonconformist be overlooked. The 1960 summer program was preceded by a weekly class during the academic year 1957–58. The summer program involved a number theory course for all, and a few qualified students attended a course in higher algebra. Projects and project counselling were also a part of the program.

Major Findings and Conclusions.—Limited only by maturity boundaries, the young people were brought into contact with the best scientific thinking of the day. In general, projects did not provide the best outlet for students' energies in a short intensive summer session. The program, ambitious as it was, could not deal with the vital concerns of experimental science because of limitations of resources. However, much was done in mathematics and abstract thinking generally. Working with gifted young people is a very exacting task.

79. RYAN, SR. BERNADETTA. A Comparison of the Concepts of Teaching First-Grade Arithmetic as Shown in the Professional Writings of Five Arithmetic Specialists. (M.A., 1959, Catholic University of America, Washington, D.C.)

Major Faculty Adviser.—Rt. Rev. Msgr. F. J. Houlahan.

Problem.—To discover the concepts of arithmeticians as to the nature of first-grade arithmetic, the content, and the teaching methods they propose.

Procedure.—Analysis of the professional writings of W. A. Brownell, M. L. Hartung, and G. S. Macvaugh. [Editor's Note: The other two of the five specialists were not specified in the research report.]

Major Findings and Conclusions.—The concepts each specialist holds as to the nature of first-grade arithmetic are similar, but there is a great difference in content and method.

80. SAAR, HOWARD CHESTER. Dimensional Analysis: Its Application to Secondary Mathematics. (M.S., 1960, Illinois State Normal University, Normal.)

Major Faculty Adviser.—Clyde T. McCormick.

Problem.—To answer the following questions: (1) How much knowledge of dimensional analysis do high school students have? (2) Can the elementary aspects of dimensional analysis be taught with understanding to high school students? (3) To what extent can the concept of dimensional analysis be included in the existing curriculum? (4) Can the results of teaching elementary aspects of dimensional analysis in the secondary school be evaluated?

Procedure.—A teaching unit on dimensional analysis was developed and taught to an experimental high school class. A pretest and a final examination on dimensional analysis were constructed and administered. Student opinions regarding interest, length, and difficulty of the teaching unit were recorded.

Major Findings and Conclusions.—High school students in mathematics and physics have slight knowledge of dimensional analysis. Elementary aspects of the topic can be taught with understanding at their level. The extent to which it can be included in the curriculum depends on the willingness of mathematics and physics teachers to attempt a new approach to a traditional problem. Nothing need be removed from or added to the curriculum. Results of teaching dimensional analysis may be evaluated satisfactorily by a carefully developed examination program.

81. SANDERLIN, JERALDINE FRANKLIN. The Relationship of Intelligence and Reading Ability to Arithmetic Problem-Solving Ability of Fourth-Grade Pupils, Dunn Avenue School, Memphis, Tenn. (M.S., 1960, Tennessee Agricultural and Industrial State University, Nashville.)

Problem.—To ascertain the relationship, at the fourth-grade level, between ability to solve arithmetic reasoning problems and factors such as intelligence and reading ability.

Procedure.—Analyses of intelligence, arithmetic, and reading test scores.

Major Findings and Conclusions.—Intelligence was not a major factor in relation to problem-solving ability. Comprehensive reading skill was more highly related to problem-solving ability than was word concept skill.

82. SCHAFFNER, SUE. Episodes in the Development of Pi and Their Use in Stimulating Interest Among Students of Mathematics. (M.A., 1960, College of Education, Ohio State University, Columbus.)

Major Faculty Adviser.—Harold P. Fawcett.

Problem.—To select interesting episodes in the development of the transcendental number *pi*, and develop them in such a way that they would be in interest to both junior and senior high school students.

Procedure.—A brief account of highlights in the development of the number *pi* is given. Then those episodes which are thought to be of greatest interest to students are developed in more detail in a way in which students will enjoy reading about them. Each account is followed by study guides for both junior and senior high school students. The study guides suggest problems and projects in which the students can use the information and procedures from the previous account. References where the students can find additional material are given for each episode. Finally, the uses of *pi* are listed and suggestions are made to teachers as to how they may use the material most effectively.

Major Findings and Conclusions.—Episodes in the development of *pi* can be developed into a number of worthwhile and interesting units for junior and senior high school students.

83. SCHUMAKER, JOHN A. Trends in the Education of Mathematics Teachers. (Ph. D., 1959, School of Education, New York University, New York.)

Major Faculty Adviser.—John J. Kinsella.

Problem.—To trace the development of programs for the education of teachers of senior high school mathematics from 1920 to 1958, determine trends in the evolution of curriculums with emphasis on mathematical content, and to make recommendations for future practice.

Procedure.—One hundred forty institutions graduating the largest number of mathematics teachers in 1957 in each State were selected, and their programs for preparing such students were studied by means of catalogue data and a questionnaire sent to the heads of the mathematics departments.

Major Findings and Conclusions.—From a median minimum requirement of 24 semester hours of mathematics for a teaching major in 1920–21 the number rose to 27 in 1957–58. The corresponding numbers for a minor were 12 and 18, and for professional courses 21 and 24. In 1920–21 the most common courses required beyond the calculus were differential equations, theory of equations, history of mathematics, advanced calculus, and solid analytic geometry. From 1920 to 1958 the courses showing considerable increase in popularity were college geometry, mathematics of finance, and elementary statistics.

The influence of national committee reports was not supported by evidence. These usually reflected practices already in operation in many institutions.

Over the entire period it was apparent that requirements for the future teachers were influenced most by the nature of the secondary school curriculum.

84. SINGER, JESSIE JACKSON. A Study of Problem Solving and Computational Topics in Arithmetic Textbooks Published between 1920 and 1960 for Grades Three Through Six. (M. Ed., University of Texas, Austin, 1960.)

Major Faculty Adviser.—M. Vere DeVault.

Problem.—To determine the changes in problem solving and computational topics in arithmetic textbooks for grades 3 to 6 that have taken place during the past 40 years.

Procedure.—Analysis of 13 textbook series, grades 3 to 6, published during the period 1920–60 by two major publishers.

Major Findings and Conclusions.—Many changes made during the 40-year period were in harmony with research findings relative to the teaching of problem solving and computational skills. At the same time, many of the recommendations stemming from research had not been utilized in the development of textbook materials.

85. SISTERS OF MERCY. Problem Solving. (Mathematics Department, St. Xavier College, Chicago, Ill.)

Problem.—To determine how to improve pupils' ability to solve verbal mathematical problems.

Procedure.—Cooperative "action research" and study involving 20 elementary teachers and members of the mathematics and education departments of St. Xavier College, Chicago.

Major Findings and Conclusions.—Much mathematical learning must be done in relation to the other school subjects children are studying. Special work should be incorporated in the reading program in order to learn how to read quantitative material better.

86. SMART, ROBERT EDWIN. An enrichment Program in Modern Geometry for the Senior High School. M.A., 1960, College of Education, Ohio State University, Columbus.)

Major Faculty Adviser.—Harold P. Fawcett.

Problem.—To devise a method and prepare materials for the informal presentation of basic ideas of non-Euclidean geometry, projective geometry, and topology to high school students, and to evaluate the effectiveness of the presentation.

Procedure.—The available literature on these topics was studied and a set of 30 enrichment lessons suitable for use by high school students was prepared. These lessons were presented as enrichment materials to 10th- and 11th-grade plane and solid geometry classes, and the effectiveness of the presentation was studied by evaluating papers which the students wrote on these topics.

Major Findings and Conclusions.—Much of the extensive popular literature devoted to modern geometry is well suited for presentation to high school students. An informal, intuitive presentation of topics emphasizing the historical development and utilizing such points of departure as the Euclidean parallel postulate, the concept of parallel projection, and Euler's theorem proved to be stimulating and well received. Forty-four students who engaged in the study of enrichment materials on non-Euclidean geometry and projective geometry and who wrote a paper on these topics showed a mastery on the average of 28 of the 37 major points upon which the papers were evaluated.

87. SMITH, EUGENE P. A Developmental Approach to Teaching the Concept of Proof in Elementary and Secondary School Mathematics. (Ph. D., 1959, College of Education, Ohio State University, Columbus.)

Major Faculty Adviser.—Harold P. Fawcett.

Problem.—To explore and make explicit some methods for emphasizing the concept of proof in elementary school mathematics and for nourishing the growth of this concept in *all* secondary school mathematics classes.

Procedure.—This study involved analytical descriptive research. Proof is defined in the study as "that which convinces." The nature of proof as a continuously evolving concept in mathematics is analyzed from both the child development and mathematical points of view. The study includes a review and criticism of the literature on children's thinking especially as it relates to logical reasoning, an analysis of the concept of proof in mathematics as an evolving concept, and suggestions for teaching proof in elementary and secondary school mathematics.

Major Findings and Conclusions.—There is considerable evidence to support the thesis that the logic of young children is not congruent to adult logic. Perceptible movement toward adult logic appears to begin in most children around 11 or 12. An individual's concept of proof in mathematics develops and matures from a dependence on empirical evidence and inductive and informal reasoning processes toward deductive, abstract, formal reasoning.

The nature of proof is analyzed under the general headings of probable inference and necessary inference. Fourteen major understandings ~~associated~~ with probable inference and 26 major understandings associated with necessary inference to which the teaching and learning of mathematics can contribute are presented with specific suggestions for teaching the concept of proof in arithemtic, algebra, geometry~~, and trigonometry.~~

88. SPILLANE, DANIEL PAUL. Attitudes of Pennsylvania Secondary School Mathematics Teachers Toward the Inclusion of Analytic Geometry, Calculus, and Statistics in the High School. (Ed. D., 1959, University of Pittsburgh, Pittsburgh, Pa.)

Major Faculty Adviser.—C. M. Lindvall.

Problem.—To record and analyze the responses of teachers to questions involving the feasibility and the value of offering analytic geometry, calculus, or statistics in high school and to the question concerning the type of student most able to take these courses.

Procedure.—Correlations were computed between favorableness of teachers' attitudes toward each of the subjects and other factors such as their feelings of competency to teach the courses, credits in mathematics, experience, and size of the school.

Major Findings and Conclusions.—Teachers were favorable to the inclusion of all three subjects but their favorable attitudes did not show a high relationship with any of the factors mentioned above.

89. SPRAKER, HAROLD STEPHEN. A Study of the Comparative Emergence of Creative Intellectual Behavior During the Process of Group and Individual Study of Mathematics. (Ed. D., 1960, University of Virginia, Charlottesville.)

Major Faculty Advisers.—William C. Lowry and Frank W. Banghart.

Problem.—To investigate the relative emergence of creative intellectual behavior in mathematics during group and individual study, and its relation to factors such as intelligence and achievement.

Procedure.—Data were derived from 180 urban seventh-grade pupils, 87 of whom were involved in small-group instruction and 93 in work as individuals. Both groups studied two SMSG units during a 6-week period. All pupils were given standardized tests of mental ability and of arithmetic achievement; they also were given a special test of creativity. Creativity was defined as "the ability to produce original or unusual applicable methods of solution for problems in mathematics. It was measured on the creativity test by asking the pupils to solve mathematical problems in as many ways as they could . . . the number of unique solutions to each problem on the test was taken as the criterion measure."

Major Findings and Conclusions.—There was no significant difference between the mathematical creativity scores of pupils working in groups and those working as individuals when the scores were adjusted for IQ and arithmetic achievement. Correlation between IQ and creativity was 0.59; and between arithmetic achievement and creativity, 0.66. Based on three ability-level groupings, mean creativity scores increased from low- to average- to high-ability groups.

90. STEPHENS, LOIS, and DUTTON, WILBUR H. Retention of the Skill of Division of Fractions. (1959, University of California, Los Angeles.)

Problem.—Is there a significant difference between the retention of the skill of division of fractions by children taught by the common denominator and the inversion methods?

Procedure.—Data were derived from experimental-control pairs, matched on the bases of IQ and scores on a test of division of fractions given in May following instruction (common denominator method for one group, inversion method for the other), and tested again in September on the first day of school.

Major Findings and Conclusions.—No significant difference in retention between the two groups was found. It is suggested that both methods be taught and pupils then allowed to select the one they prefer.

91. STONEKING, LEWIS WILLIAM. Factors Contributing to Understanding of Selected Basic Arithmetical Principles and Generalizations. (Ed. D., 1960, Indiana University, Bloomington.)

Major Faculty Adviser.—Ronald Welch.

Problem.—To determine what factors contribute to the understanding of selected basic mathematical principles.

Procedure.—Administration of researcher's test of basic mathematical principles to a sample of students in grades 8 to 12 in the State of Indiana, and sophomores, juniors, and seniors in a teacher education program; analysis of testing data in relation to selected factors.

Major Findings and Conclusions.—The factors of age and student teaching experience did not add to the understanding of basic mathematical principles. The factors of teaching experience, level of academic preparation, and number of semesters of high school mathematics were related positively to the understanding of basic mathematical principles.

92. STORY, LUCRETIA CORDELIA. Procedures for Evaluation of Textual Materials for Teaching Basic Mathematical Understandings in the Arithmetic Curriculum of the Elementary School. (M.S.E., 1960, Drake University, Des Moines, Iowa.)

Major Faculty Adviser.—William Gardner.

Problem.—To develop criteria which could be used by elementary teachers in evaluating materials and procedures to be used in teaching basic mathematical understandings in the arithmetic curriculum of the elementary school.

Procedure.—Review of literature, leading to the development of a rating scale.

Major Findings and Conclusions.—The evaluation instrument developed may serve as a model for teachers to use, but the criteria should be modified to fit local needs.

93. STRIGHT, VIRGINIA M. A Study of the Attitudes Toward Arithmetic of Students and Teachers in the Third, Fourth, and Sixth Grades. (M. Ed., 1960, Indiana State College, Indiana, Pa.)

Major Faculty Adviser.—George A. W. Stouffer, Jr.

Problem.—To study current attitudes toward arithmetic on the part of children and teachers, to note changes (if any) from third to fourth to sixth grade, and to compare the attitudes of boys and girls.

Procedure.—Administration of a revised form of the Dutton Attitude Scale to 29 teachers and 1,023 pupils, grades 3, 4, and 6.

Major Findings and Conclusions.—Contrary to popular opinion, at all three grade levels a very large proportion of both boys and girls like arithmetic and feel it is useful; also, the majority of teachers sampled definitely enjoy teaching arithmetic. In all three grades, girls liked arithmetic better than boys.

94. TAYLOR, FRANCIS B. Development of the Testing of Statistical Hypotheses. (Ph. D., 1959, Teachers College, Columbia University, New York)

Major Faculty Adviser.—Howard F. Fehr.

Problem.—To give a critical account of the historical development of the testing of statistical hypotheses, and to relate this development to the growth of statistics as a college subject in the United States.

Procedure.—The history of the testing of hypotheses was studied and related to the types of courses taught at present in the United States.

Major Findings and Conclusions.—The principle of inverse probability originated by Bayes in 1763 and generalized by Laplace in 1812 was a first step in the development of hypotheses testing. A significant second step was the work of R. A. Fisher in suggesting ways of using sampling distributions to make probability statements about certain hypotheses. A third step was related to the work of Neyman and Pearson in deciding on best tests of hypotheses. In modern times such tests have led to mathematical abstraction that are very difficult for those engaged in applications of probability and statistics.

In the United States there has been a shift from an emphasis on descriptive statistics to statistical inference. It is recommended that separate college departments of statistics be formed to secure a better balance between theory and practice, and that publication of shorter works devoted to full length treatment of particular topics be encouraged.

95. THOMPSON, GEORGIANNA F. The Study of the Use of the Deductive and Inductive Methods for Teaching Ninth-Grade Mathematics at the Shannon High School, Shannon, Miss. (M.S., 1960, Tennessee Agricultural and Industrial State University, Nashville.)

Problem.—To study the use of the inductive method and of the deductive method of teaching in ninth-grade general mathematics.

Procedure.—In this study, "deductive method" means the method of study, research or argument in which specific applications or conclusions are derived from assumed or established general principles. "Inductive method" is a teaching procedure based on the presentation to the student of a sufficient number of examples of a particular phenomenon to enable him to arrive at general relationships implied by the evidence. A class of 43 students was taught general mathematics by the deductive method during the first semester and by the inductive method during the second semester. In September the students' level of achievement was measured by a quantitative understanding test. In January achievement after a semester of the deductive method was measured by a second test on problem solving. In April achievement was measured after a semester of the inductive method by a third test on basic computation.

Major Findings and Conclusions.—Although the problem-solving test contained some problems similar to the quantitative understanding and the basic computation test, the scores made by students indicate that there was not enough similarity in the tests to determine which teaching method is better. It was observed that weekly recitations and test performances were best during the second semester when the inductive method was used.

96. TREACY, SISTER MARY DENIS, O.S.F. The Effect of Interest-Centered Take-Home Tests on Learning in Elementary Algebra. (Ph. D., 1959, New York Univeristy, New York.)

Major Faculty Adviser.—John J. Kinsella.

Problem.—To discover what part "take-home" tests based on individual interests play in the development of problem-solving ability, critical thinking, and general efficiency in elementary algebra.

Procedure.—The study was conducted in a 4-year girls high school in Newburgh, N.Y., during 1956–57. There were 33 freshmen in the experimental group and 30 in the control group. For matching the groups, the Terman-McNemar Test of Mental Ability, the Seattle Algebra Test, and the Watson-Glaser Test of Critical Thinking were administered. Every 5 weeks the control group was given a conventional test during a class period and the experimental group was given an interest-centered "take-home" test to be completed at home and returned in 10 days. The take-home test was based on information from two tests—the Seattle Algebra Test and the Kuder Preference Record Vocational ((eight) problems based on the former test and 22 problems based on the latter). In June, the Watson-Glaser Critical Thinking Appraisal was readministered and the Lankton Algebra Test was given.

Major Findings and Conclusions.—The experimental group profited more from testing to testing than did the control group. The interest-centered tests did not have any appreciable effect upon general efficiency in elementary algebra nor did they have any marked effect upon the students' ability to solve problems.

97. TREDWAY, DANIEL C. A Statistical Comparison of Two Methods of Teaching Percentage. (Ed. D., 1959, University of Wyoming, Laramie.)

Major Faculty Adviser.—George E. Hollister.

Problem.—To make a statistical comparison of two methods of teaching percentage.

Procedure.—The experimental groups were taught the three cases of percentage as parts of a total process. An emphasis was placed on an understanding of the three types of problems and the relationships among them. The control groups were taught by methods presented in the arithmetic textbooks which in general teach each case as a separate entity. Six teachers taught experimental groups and five taught control groups over a 2-year period from 1957 to 1959 in the junior high schools of Cheyenne and Laramie. Two tests limited to the three cases of percentage without applications were given—the first immediately after a 20-day teaching period, the second was given 30 days after the first test. An intelligence quotient from the California Test of Mental Maturity was available for all 552 pupils in the sample. The data were treated with an analysis of covariance to determine whether or not there had been a significant difference of learning and retention between the two groups.

Major Findings and Conclusions.—(1) The method tested provided significantly better learning than the usual methods presented in textbooks, (2) the learning of the three cases of percentage as a complete unit provided superior retention of pupils of average intelligence, (3) the period of 20 days was an adequate amount of time to devote to teaching percentage when the experimental method was used.

98. VOGELI, BRUCE RAMON. The Mathematics Program of the Soviet Secondary School: Its Status and Innovations. (Ph. D. 1959, University of Michigan, Ann Arbor.)

Major Faculty Adviser.—Phillip S. Jones.

Problem.—To answer the following questions: (1) What is the current nature and status of the mathematics program of the Soviet secondary schools? (2) What trends, if any, are discernible in the recent Soviet curricular revisions in the area of mathematics? (3) What relation do these trends bear to Soviet educational policy as stated in publications in the area of mathematics education?

Procedure.—The following were analyzed in detail: The arithmetic syllabus, the secondary school mathematics syllabus, the four standard arithmetic textbooks, the six standard secondary school mathematics textbooks, the six standard problem books, and the secondary school graduation examination in mathematics.

Major Findings and Conclusions.—Three interrelated factors or trends were largely responsible for changes in the Soviet mathematics program from 1952 to 1959: (1) Stress on applications, (2) a trend to lightening the pupil's academic load, and (3) desire on the part of Soviet educators to modernize or raise the scientific level of their secondary school mathematics program. Other reforms as a result of proposals by the Soviet premier in the fall of 1958 are just getting underway. The full nature and impact of the combined lengthening of the years in the secondary school and the increase in the amount of work experience were yet to be determined at the time of the study.

99. WADE, OLETA M. A Study of the Program for Teaching Basic Addition and Subtraction Facts in State-Approved Arithmetic Textbooks for First and Second Grades in Texas. (Ed. M., 1960, University of Texas, Austin.)

Major Faculty Adviser.—Frances Flournoy.

Problem.—To compare the organization and presentation of the basic addition and subtraction facts in the four State-adopted texts for grades 1 and 2 for the 1958–59 school year; to assess the effectiveness of using one of these four programs at the second-grade level.

Procedure.—Analysis of the four texts involved; testing and opinion as basis for evaluating one of the four programs in 16 second-grade classrooms.

Major Findings and Conclusions.—At each grade level the texts differ among themselves as to scope, organization, and presentation of facts included. At the second-grade level, differences in symbolism and vocabulary also are in evidence. The majority of teachers who evaluated one of the second-grade programs felt that children could have gone beyond the material provided in the text itself.

100. WALLACE, MALVINA TRENT. Individual Differences in Arithmetic of Fourth-Grade Pupils. (Ed. M., 1960, University of Tennessee, Knoxville.)

Major Faculty Adviser.—A. M. Johnston.

Problem.—To identify individual differences in arithmetic abilities of fourth-grade children, including differences in ability, achievement, and interest.

Procedure.—Analysis of data from three fourth-grade classes derived from tests of intelligence, achievement, and subject interest.

Major Findings and Conclusions.—Found an IQ range of from 80 to 146, and an achievement range of 5 years; also found that arithmetic was the second most popular subject, with the interest level being essentially the same for boys and girls.

101. WILSON, JOHN D. An Analysis of the Plane Geometry Content of Geometry Textbooks Published in the United States Before 1900. (Ed. D., 1959, University of Pittsburgh, Pittsburgh, Pa.)

Major Faculty Adviser.—John A. Nietz.

Problem.—To trace and analyze the evolution of the plane geometry content of geometry textbooks published in the United States before 1900.

Procedure.—Title pages and prefaces were studied. The fundamental assumptions, such as axioms, postulates, definitions, symbols, and the treatment of parallel lines, were analyzed. The propositions were analyzed to provide information on the number of demonstrated theorems, the nature of the theorems, the form of demonstrations, and geometric constructions. Student exercises were classified by purpose and type.

Major Findings and Conclusions.—Student exercises consist mostly of descriptions of changes in content. There was more evolution in student exercises than in any other part of the geometry textbooks. In general there has been more evolutionary development in plane geometry textbooks than has been commonly believed.

102. WOOD, WALTER H. General Mathematics Needed in Industry (M.S., 1959, Kansas State College, Pittsburg.)

Major Faculty Adviser.—R. W. Hart.

Problem.—To determine which courses in college mathematics are most desirable for a person intending to go into industry after graduation.

Procedure.—Questionnaires were sent to several companies that employ applied mathematicians. These companies were asked to rate a group of college mathematics courses as "most desirable," "desirable," or "not needed."

Major Findings and Conclusions.—The 12 courses that were rated the highest by the applied mathematicians are differential equations, applied mechanics, advanced calculus, matrix theory, mathematical statistics, theory of probability, functions of complex variables, numerical analysis, higher algebra, vector analysis, theoretical physics, and Fourier series. Those rated lowest were modern synthetic geometry, topology, non-Euclidean geometry, higher plane curves, projective geometry, quality control, number theory, advanced analytical geometry, introduction to mathematical thought, differential geometry, and theory of groups.

103. WOODBURY, RULAN D. An Evaluation of Methods of Teaching Ninth-Grade Mathematics at the Cedar City Junior High School. (M.S., 1959, Brigham Young University, Provo, Utah.)

Major Faculty Adviser.—Percy E. Burrup.

Problem.—To evaluate the methods of teaching ninth-grade mathematics at the Cedar City Junior High School.

Procedure.—The following measures were taken: An intelligence quotient, Forms X and Y of the Cooperative Mathematics Achievement Test at the beginning and at the end of study, algebra achievement by the Cooperative Algebra Achievement Test, an open-end question to assess changes in attitudes and feelings, Kuder Preference Record.

Major Findings and Conclusions.—General mathematics achievement is greater when first-year algebra students are taught by the spiral or functional method in comparison with the traditional method. General mathematics achievement is greater when students are taught by the pace method in a general mathematics class in comparison with the traditional method. General algebra achievement is greater when students are taught by the traditional method using a standard first-year algebra book in comparison with the functional method using a book incorporating a spiral approach to the subject. Positive responses toward mathematics are greater when algebra students are taught by the traditional method as compared with the spiral or functional method. Positive responses toward mathematics are greater when general mathematics students are taught by the traditional method as compared with the paced method. There is no definite relationship between general achievement in mathematics and the computational area score of the Kuder Preference Record.

104. ZAHNKE, EUGENE A. An Experimental Study of Two Procedures for Teaching the Four Fundamental Operations With Signed Numbers. (M.S., 1960. Central Connecticut State College, New Britain.)

Major Faculty Adviser.—Margaret C. Weeber.

Problem.—To investigate the advantages of teaching a unit on signed numbers in elementary algebra in which students formulate their own rules for the four fundamental operations.

Procedure.—Two units on signed numbers were presented to three elementary classes at Bristol Central High School. One class was a control group and received instruction from the chapter on signed numbers in "Algebra, First Course" by Schorling, Clark, and Smith. The other two classes received special instruction which enabled them to formulate their own rules for signed numbers. The special instructional material was obtained mostly from Unit One, "The Arithmetic of Real Numbers," *High School Mathematics*, UICSM. The accuracy of performance on the four fundamental operations of signed numbers was compared in the experimental and control groups. Students in the two groups were first matched on the bases of intelligence and ability to do arithmetic computation.

Major Findings and Conclusions.—Difference in performance of the two groups was not statistically significant. The experimental unit could be taught in place of the conventional unit without loss of competence. Students in the experimental classes were more enthusiastic about their homework assignments.

105. ZELECHOSKI, ROBERT JOSEPH. The Learning of Signed Numbers in Grades Seven, Eight, and Nine. (Ed. D., 1960, Pennsylvania State University, University Park.)

Major Faculty Adviser.—F. A. Miller.

Problem.—To learn the effects of mental age, algebra aptitude, and grade level on the learning concepts and fundamental skills in handling signed numbers.

Procedure.—Signed numbers were divorced from algebra and taught to the entire student body in a junior high school in 25 preplanned lessons. Product-moment zero order, triserial, partial and multiple correlations were used to analyze the data.

Major Findings and Conclusions.—Mental age is the strongest factor influencing the learning of the special lessons on signed numbers.

U.S. GOVERNMENT PRINTING OFFICE: 1963 O—675708