Name: Milton B. Friesen Date of Degree: May 26, 1957

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Scope of Study: The needs of the complex technological society in which we live has increased the need for more training in science and mathematics. Mathematics is needed not only by the scientist but also by the average citizen. Since all mathematics must rest on a strong foundation of previous work, this report is a study of the subject matter offered in grades seven, eight, and nine. Of special interest is the "double track" program as proposed by the Commission of Post-War Plans of the National Council of Teachers of Mathematics. The proposal provides one track for training the scientist by the traditional courses and the other track for those students who will not need the specialized training but who will need a wide understanding of mathematics in its everyday applications if they are to be effective citizens. The materials used in this study are chiefly (1) courses of study from a number of states, (2) recent books and articles in periodicals written by authorities in the field, and (3) textbooks in current use.

ADVISER'S APPROVAL James H. Zant

THE SUBJECT MATTER CONTENT OF JUNIOR HIGH SCHOOL MATHEMATICS

By

MILTON B. FRIESEN

Bachelor of Science

Panhandle Agricultural and Mechanical College

Goodwell, Oklahoma

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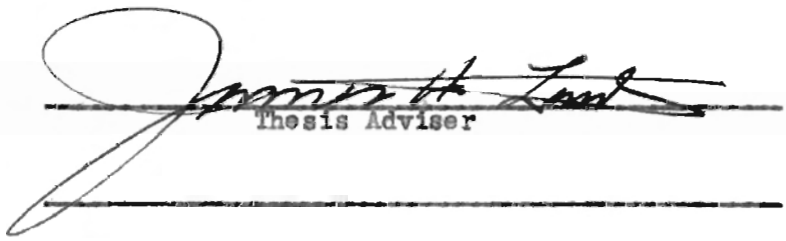

Thesis Adviser

Dean of the Graduate School

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CHAPTER I

INTRODUCTION

In America we have been made increasingly conscious of a serious threat to our way of life unless we increase the number of scientists, mathematicians and other technically trained personnel. We need more of them and we need them with a greater amount of training. We need them to work in and for a rapidly advancing technological industry. This industry, although replete with an astounding number of automatic labor saving devices, faces a shortage of trained personnel to make, maintain, and replace those devices and find new applications for them. For example, the modern electronic computor with its phenomenal capabilities will need 60,000 operators with mathematics majors ranging from B.S. to Ph.D. degrees in the next three to five years. Other industries are likewise looking for trained men and women to man their machines.

This technological advance also makes it necessary for the average man to have a wider understanding of science in general and mathematics in particular if he is to be an effective citizen.

Since mathematics has always been the hand-maid of science and since science and scientific principles are being used to a greater and greater extent in all fields including biology, statistics, and various social fields, the responsibility of a mathematics education to meet the present and future needs of our citizens is becoming more exacting.

The junior high school years are crucial ones in the development of potential scientists and mathematicians. It is in these years that a

sound foundation for future decisions must be established. Much good can be accomplished by the right approach and the right subject matter in mathematics and, on the other hand, great benefits may be lost if we fail. This report is a study of what is being done in the field of subject matter in the junior high school mathematics courses as shown by state curriculum guides, recent publications and textbooks.

CHAPTER II

THE OBJECTIVES OF JUNIOR HIGH SCHOOL MATHEMATICS

The problems of a sound program of mathematical instruction is not unique to the junior high school. It is the problem of the entire school from the first grade through the twelfth grade. The instruction of any one grade level must be related to that which preceded it. Therefore, in considering what the objectives of the junior high school are, we must consider the mathematical program as a whole and then, within this larger area point out the specific needs that should be met in the junior high school, grades seven, eight, and nine.

The overall objective is summed up in the first thesis of the Second Report of the Commission on Post War Plans:

> "Thesis I. The school should guarantee functional competence in mathematics to all who can possibly achieve it."[1]

In connection with this they recognize two aspects to be taken into consideration in secondary education:

> "The high school needs to come to grips with its dual responsibility. (1) To provide sound mathematical training for our future leaders of science, mathematics, and other learned fields, and (2) to insure mathematical competence for the ordinary affairs of life to the extent that this can be done for all citizens as a part of a general education appropriate for the major fraction of the high school population."[2]

This indicates that there should be an approach made to offer an enlarged mathematics program or at least revise the existing ones so that

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[1] The Second Report of the Commission on Post-War Plans. The Mathematics Teacher, 38:195-221, May 1945, p. 196.

[2] Ibid p. 195.

a greater number of students may benefit from it. The demands made on mathematics have increased not only in industry but in the everyday life of the average citizen. In grandfathers day the ability to compute accurately when dealing with whole numbers, fractions and percent was adequate but now we have advanced beyond that. The training that grandfather would have classed as specialized has invaded our homes. In the past we have done fairly well in training for leadership and specialized fields but we have fallen down in educating for citizenship competency.

Students planning to major in subjects other than mathematics in college are finding that the mathematical requirements in all fields have risen sharply. Students who drop out of school find that modern industry requires of its labor, skilled or unskilled, to be acquainted with the essentials of arithmetic, algebra and geometry.

Mathematical competence is required in the home and community activities, in the problems of consumership and public affairs, in leisure and recreational activities. These requirements are increasing and the responsibility of giving all who can an opportunity to become mathematically competent is becoming more challenging and important than ever.

The meaning of mathematical competence is best described in the check list prepared by a committee at the National Council of Teachers of Mathematics and included in The Second Report of The Commission on Post-War Plans.[3] It includes such items as the fundamental operations with whole numbers and fractions, use of tables, understanding of simple graphs and statistics, understanding and using geometry, measuring, formulas and equations, signed numbers, and the application and understanding of mathematics used in everyday life. These are the essential

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[3] Ibid.

part of practical mathematics that the average citizen will need and might well be taken as a goal to accomplish during the junior high school years especially since this will be the last formal mathematics training that some students will have.

Dr. Zant, in speaking of the aims for the grade school through the eight grade, says:

> "The mathematical aims for this period should include provisions for developing a genuine understanding and appreciation of the fundamental operations of addition, subtraction, multiplication, and division of whole numbers, decimals, and fractions, some idea of the principles and modes of thinking so well illustrated by mathematics, a substantial introduction to the mathematics of everyday life and a dependable foundation for life needs and for subsequent courses in mathematics."[4]

The National Committee on Mathematical Requirements broadly describes the junior high school mathematics as:

> "... an introductory, basic, exploratory course, in which the simple and significant principles of arithmetic, algebra, geometry, statistics, and numerical trigonometry are taught so as to emphasis their natural and numerous relations."[5]

The student during these years should be given an idea of the possibilities in the whole field of mathematics and of its many applications even in the more social aspects of life. He should be given the opportunity to explore his own abilities and secure information and experiences that will help him to choose more wisely his later courses in school and ultimately his life work. The teacher should point out to him the beauty of mathematics and its power for those who achieve mastery in it. By contrast, also, it should be pointed out what cannot be done without mathematics. The far-reaching implications of the student's choice are well summed up in these words:

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[4] James H. Zant "What are the Mathematical Needs of the High School Student" The Mathematics Teacher, 42:75-78, February 1949, p. 75.

[5] Lucien B. Kinney, Editor "Mathematics in Junior High School", The Mathematics Teacher, 49:33-36, January, 1955, p. 34.

> "The student who drops high school mathematics at the same time drops medicine, engineering, chemistry, biology, physics, economics, social science and psychology."[6]

Because the junior high school student's choice of vocation may change many times, the teacher's responsibility is increased to show him the whole field and the mathematical interrelationships of the various vocations. This is necessary so that he and his counselors will have the best possible chance of making the right final choice.

The junior high school has a four-fold responsibility that it must assume: (1) It must provide adequate and natural continuance of the work of the elementary school. The work must be built on the foundation of the previous experiences and must provide a link between them and the future mathematics courses. (2) It must correct, if at all possible, all mathematical retardation and shortages existing in any of the students. This is exceedingly difficult to do later on. Mathematics is one subject that is hard to "make up" or "pick up". (3) It must provide an expanding and deepening experience with the problems of every day living. This means that the concepts that the student has learned must be applied often and naturally to new and more difficult situations in keeping with the student's interests and needs, (4) It must strengthen and extend the foundations for subsequent experiences with mathematics.[7]

The junior high school years are a transition period. The students come in as children and go out as young adults. They are making many adjustments. Previously their activities were all directed and supervised by the teacher; now they are entering a period where they must start making their own decisions and move on their own initiative. Blessed is

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[6] William Betz, "Functional Competence in Mathematics - Its meaning and its attainment," The Mathematics Teacher, 41:195-198, March 1948, p. 195.

[7] Mary Rogers "Possible Articulation for Junior High School with the Elementary School and with the Secondary School, The Mathematics Teacher 38: 252-8, October 1945.

the teacher who accepts this challenge and helps them on their way, better prepared for whatever vocation they may choose to follow.

CHAPTER III

THE SUBJECT MATTER CONTENT OF SEVENTH GRADE MATHEMATICS

The choice of subject matter for the seventh grade mathematics is made more significant by the fact that the students who enter this grade have a wide variety of educational backgrounds. The student is at a crucial stage in his life. He has many adjustments to make socially and educationally. Instead of only one teacher to direct all of his activities, he may now have as many teachers as he has subjects. As a result the teacher is farther removed from him and he becomes more and more only a name in the grade book. He must learn to move under his own power.

The students vary greatly in their mathematical abilities. Some have been carefully taught and have become fairly proficient in computation. Others, not so fortunate, have either through lack of teaching or lack of natural ability not accomplished as much. The students coming from different classrooms have been taught the concepts and processes of mathematics in different ways. Some have studied a larger amount of subject matter. Some are interested in mathematics; others are not. The personal differences are at a peak. The students vary in their plans and probable future needs. All of these are factors that challenge the teacher as he faces the task of instructing boys and girls in the mathematics that will help them now and also when they assume their roles in an adult world where functional mathematical ability is a must.

The variety of needs and background call for a reteaching and review. The work must be closely geared and related to previous work. The concepts

taught in previous years must be reviewed in a variety of new and more difficult experiences. A rehashing of old experiences will not do. The teacher must teach for the understanding of a process rather than teaching the process as a mechanical manipulation. This is especially true as the previous teachers may have presented concepts by different methods. The teacher must take the student where he is and work from there.

Along with the program of review and reteaching, a continuing testing program is essential to discover the student's abilities and needs. Deficiencies must be removed as early as possible so that the student can progress further. The aim should be to develop a reasonable degree of mastery of the four fundamental operations and procedures for checking results. The program must be flexible to allow for continuous adjustment to the student's growth and needs. Since he will learn best that which has meaning to him, the concepts should be applied to his everyday problems and he should be shown their further applications in life. New concepts must be brought in and related to previous ones. The student must be introduced to the mathematical principles necessary to understand our increasingly complicated environment and to show, at least in a limited way, the role of mathematics in the various fields of human endeavor.

Most of the authorities agree that the work of grades seven and eight are closely connected. The Pennsylvania State Curriculum guide plays down the grade level and suggests teaching these two years as a bloc.[1] W. D. Reeve would include all three grades in one unit.[2] The Second Report of the Commission on Post-War Plans includes three theses that refer directly

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[1]Course of Study, Mathematics in Secondary Schools, Bulletin 360, Commonwealth of Pennsylvania. Department of Public Inst. Page 71.

[2]William David Reeve "What Should be the Nature and Content of Junior High School Mathematics?" The Mathematics Teacher, 48:413-415, October 1955, p. 414.

to these two grades:

> "Thesis 9. The mathematical problem of grades seven and eight should be essentially the same for all normal pupils.".

They should:

> "a. Provide an adequate, organic continuation of the work of grades one through six.
> b. Provide a substantial beginning in achieving functional competence.
> c. Provide a dependable foundation for subsequent courses in mathematics."

> "Thesis 10. The mathematics for grades seven and eight should be planned as a unified program and should be built around a few broad categories."

> "The program should be organized around (1) numbers and computation; (2) the geometry of everyday life; (3) graphic representation; and (4) an introduction to the essentials of elementary algebra, formulas and equations."

> "Thesis 11: The mathematics program of grades seven and eight should be so organized as to enable the pupils to achieve mathematical maturity and power."[3]

Thus the seventh grade functions as a vital connecting link between the work that was arithmetic in the lower grades and the more technical and abstract mathematics that the student will receive later. It is a period of strengthening the stakes and reinforcing the structure of his mathematical house.

A study of available state curriculum guides and textbooks shows that a program of reteaching and review is the practice. The previous number experiences in the fundamental processes are reviewed. Percentage problems dealing with the social experiences in the home, school and community are introduced. Scale drawing and ratio are extended by the use of floor plans and maps. Measurement is extended and the basic concepts of geometry are introduced by the use of angles and other simple geometric figures. The concept of volume and area are extended. The students are

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[3]The Second Report of the Commission on Post-War Plans. The Mathematical Teacher, 38:195-221, May 1945, p. 204.

given experiences in making and reading graphs. The concept of rounding off numbers is developed in connection with graphs and estimating answers. Algebra is usually limited to the introduction of symbols in formulas. Written problems are used and related to the student's experiences. The alert teacher should use these problems and introduce local life situations for the students. A vocabulary of new words is valuable to help the student check his understanding.

A suggested outline of minimum essentials for the seventh grade is included as a part of this report.

The seventh grader when he is finished with the work as outlined should be well on his way to achieving computational competency. Most of his deficiencies and retardation should be made up so that he will be able to achieve mastery during the next two years even as he achieved additional skill and understanding in the seventh grade work.

SUGGESTED MINIMUM ESSENTIALS IN SEVENTH-GRADE MATHEMATICS

I. Number System.
- A. Understanding of place value.
- B. Ability to read numbers through billions.
- C. Learning to use rounded numbers.

II. Reteaching the finer fundamentals with whole numbers.
- A. Aim for 100% accuracy and understanding.
- B. Develop an appreciation for the fundamentals and an ability to choose the correct process in a problem situation.
- C. Emphasize checking of results.

III. Reteach Common and Decimal fractions.
- A. Teach for understanding and meaning.
- B. Understanding the reasons for processes used in
  1. The four fundamental processes.
  2. Reducing the lowest terms.
  3. Changing mixed numbers to improper fractions and reverse.
- C. Ability to use common fractions or decimals interchangeably.

IV. Problem solving.
- A. Learning to read and interpret problems.
  1. Decide what problem asks.
  2. Discard unrelated facts.
- B. Learning to judge the reasonableness of answers.

V. Graphs as a means of comparing data.
- A. Teach for high degree of mastery in interpretation and medium skill in construction.
  1. Pictographs, bar graphs, line graphs, divided bar and circle graphs.
     a. choosing proper units to fit data.

VI. Percentage.
- A. Learning to use percent, common fractions and decimals interchangeably. Emphasize thirds, fourths, fifths, sixths, and eights.
- B. Finding the percentage of a number.
- C. Finding what percent one number is of another.

VII. Measurement and Geometry.
- A. Become acquainted with units most commonly used for length, weights, liquid and dry measure and time.
  1. Show all measurements are only approximations.
- B. Develop skill with denominate numbers.
- C. Introduce metric system and show similarity to our money system.
- D. Recognize lines (straight, curved, broken), (perpendicular, parallel), recognize acute, obtuse, right angles.
- E. Recognize square, rectangle, parallelogram, triangle, hexagon, circle.
- F. Learn use of protractor for measuring and constructing angles.
- G. Develop formula for perimeter and area of rectangle, square, parallelogram, triangles.
  1. Express formula in words and in symbols.

H. Develop concept of circle.
I. Develop understanding of volume of rectangular solids.

VIII. Ratios.
A. Introduce ratios as a way of comparing numbers.
B. Use ratios in simple scale drawings.

IX. Business practices.
A. Keeping simple accounts.
B. Filling out simple bills and receipts.
C. Banking practices.
1. Checking account, savings account, deposit slips, checks.
D. Making change.

CHAPTER IV

THE SUBJECT MATTER CONTENT OF EIGHT GRADE MATHEMATICS

The work of the eight grade mathematics is closely related to the work of the seventh grade. With the reteaching and review experienced during the seventh grade, the eight grade student should achieve mastery in computation and a broader view of the mathematics, that will be such an important part of his future schooling and of his adult life. His ... to read and analyze written problems should be brought to a high level of efficiency. His added maturity and social consciousness will stimulate his interest in the social aspects of mathematics. As a result of this, much emphasis should be placed on problem solving with special consideration being given to the social uses of arithmetic. The student should be given the opportunity to use the ideas and skills he has acquired to solve his own problems. He should see that arithmetic is not an end in itself but a means toward satisfactory performance of every-day duties of home and community life.

In order to meet the future needs the student will be taken further into the field of algebra and geometry. The concepts of these subjects will be introduced by extending concepts that he has already learned. Thus, where in the seventh grade algebra was used in the formulas for finding areas, this concept will now be extended to other formulas. The concepts of geometry will be extended from the mere recognition of figures to a definition of them. He will learn to do some of the basic constructions. The concept of percentage will be extended in problems dealing

with commission, less and gain, successive discounts, etc. The applications of mathematics in business practices will be extended. He will acquire appreciation of taxes and insurance. Successful completion of this years study will be marked by mastery in the fundamental processes and a fair understanding of the basic concepts of algebra and informal geometry.

MINIMUM ESSENTIALS FOR EIGHT GRADE MATHEMATICS

I. The fundamental processes.
   A. Review of the processes using intergers, fractions, and percent. (Teach for high degree of mastery.)
   B. Extend understandings of number relationships.
   C. Continued use of processes in applied problems.
   D. Develop habit of checking answers.

II. Geometry and measurement.
   A. Review development of formulas for area of rectangle, triangle, parallelograms, approximate nature of measurement.
   B. Develop and use the formula for the area of a circle.
   C. Review the volume of rectangular solid and develop formula for volume of cylinder, cone, pyramid, sphere.
   D. Find lateral areas of rectangular solids and cylinders.
   E. Teach facts about right triangles and its use in problem solving.
      1. Pythagorean theorem.
      2. Finding square root of numbers from table or by division.
   F. Understanding of ratio and porportion as applied to scale drawing and similar triangles; indirect measurements.
   G. Constructing perpendiculars, bisecting angles.
   H. Study geometric design and symetry.

III. Percentage (teach for business information and medium degree of efficiency.)
   A. Review fundamental equivalent forms.
   B. Finding a number when the percent is given.
   C. Work with percents larger than 100% and less than 1%.
   D. Applying percent to profit and loss, discount (single, successive), interest, increase, and decrease, commission.

IV. Graphs.
   A. Extending the understanding of graphs as means of comparing. data by reading and interpreting bar, line and circle graphs.
   B. Constructing graphs to picture quantitative situations.

V. Business practices.
   A. Banking, savings, and investments.
      1. Introduction to commonly used forms; checks; notes, deposit slips.
      2. Forms of investments; stocks, bonds, mortages.
      3. Forms of savings: postal savings, building and loan association.
   B. Insurance.
      1. Understanding the principle of "shared risk".
      2. Knowing principle of life insurance, property, health and accident.
   C. Taxes.
      1. Understand the necessity of local, state, and federal taxes as way of paying for government services.
      2. Studying the kinds of taxes.

VI. Algebra.

A. Further development of formulas as algebraic shorthand.

B. Developing understanding of equations and using simple equations in solving problems.

CHAPTER V

THE DOUBLE TRACK PROGRAM IN GRADE NINE

After considering the more or less settled and established mathematical programs of the seventh and eighth grade, one is perplexed with the turmoil he finds at the ninth grade level. It is like a man jumping on his horse and galloping away in all different directions. There has been agitation since the junior high school program was organized to teach a mathematics course that would be of a more practical nature than the compartmentalized traditional algebra course that was being offered at this level. The Commission on Post-War Plans suggested a "double-track" program to meet the needs of the student who will use the traditional course in a later mathematics career and also to meet the needs of the larger group who will not need the specialized training. The Commission's 12th Thesis reads:

> "The large high school should provide in grade nine, a double track in mathematics; algebra for some and general mathematics for the rest."[1]

(The large high school is defined as one with more than 200 pupils).

Many different approaches have been used in solving or trying to solve the double track problem. Much difficulty has resulted because general mathematics has never been clearly defined. The range of topics is as wide as the field of education itself. Often there has been opposition from teachers and administrators who did not see the challenge of teaching a mathematics for the masses. As a result general mathematics

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[1] Ibid, p. 205.

has fallen into disrepute and algebra has often received an unwarranted halo that has only added to the confusion. Several unsatisfactory solutions are given in the Commissions Report.[2] If only general mathematics is offered the objection is raised that it delays the capable student who wants to pursue a mathematics program in high school and college. This objection is not valid in the majority of high schools since only a few schools will carry a full four year course of the traditional subjects. The objection also overlooks the fact that in a properly administered general mathematics program the student will receive the fundamentals of algebra and geometry so that in future courses he could combine the second and third semester algebra in one year and in the same manner the fundamentals of plane and solid geometry could be taught in one year. The Minnesota curriculum guide suggests intermediate algebra immediately following the general mathematics.[3] This would eliminate any delay and the loss that the student might have had in subject matter would be more than made up by the greater functional competency that he has acquired.[4] Another unsatisfactory solution is in teaching only algebra and requiring all to take it. If the course is kept at a high level so that it challenges those who are capable it usually leaves the average and below average student frustrated and lacking the mathematical understanding that he needs. On the other hand, if the course is "watered down" so that the slower student can get it, it loses its challenge and interest for those who will need it for their future mathematics and denies them the more complex experiences that would be so valuable to them. Other unsatisfactory solutions are

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[2] Ibid, p. 204.

[3] Course of Study A Guide for Instruction in Mathematics, Curriculum Bulletin No. 20, 1953, Department of Education, St. Paul, Minnesota, p. 156.

[4] H. Vernon Price "We Can Remove the Stigma from General Mathematics", School Science and Mathematics, 47:446-450, May 1947, p. 448.

teaching commercial arithmetic in the ninth grade or teaching work based on an extended program of arithmetic. The first fails because of the immaturity of the students and the second fails because it usually administers only larger does of medicine that did not help in the earlier courses.

The most logical solution to this problem would be to teach a course in general mathematics including those basic concepts of algebra and geometry that would more nearly meet the needs of the majority of students. It would give those who are interested a "flying start" in algebra and geometry. It would also help them in that the mathematics they will use in college will be taught to them just before they graduate, enabling them to do better work in their first college courses. Consideration must also be given that this general mathematics course will be terminal for some of the students. Surely, the student will be functionally more effective with a general course than with the more abstract notions of algebra or geometry that very few adults put to practical use.

Another way of meeting the problem and one that is frequently used is to offer a choice of either general mathematics or algebra. This is especially useful in larger schools where there are a number of sections of the same class. This creates a problem in selecting the course that the student is to take. A part of this problem stems from the fact that algebra will often be selected by the student because of its prestige. Also there are those capable students who would do excellent work in algebra but elect the general mathematics as an easy way out. Both are problems that must be handled by counseling with the student and often with his parents. The decisions should not be based on student whim or parental aspiration. Often it is the parents who are misinformed and

do not realize that changes can be made for the student's benefit. It must be impressed on the minds of the student and his parents that the only difference in the courses is their aim. The course content of general mathematics can and should be such that it is as difficult and as exacting as algebra. It should require as much thought and effort as any other good mathematics course. Far from being a "dumbbell" course, its outcome should be every bit as vital as the outcome from the algebra course. The course should be unexcelled in its applications of basic mathematical concepts to real life situations.

On what basis should the decision be made? To put it simply, the decision should be made by the counselor and student working together and using the broadest scope of information possible. The Pennsylvania Course of Study for mathematics offers these suggestions as a basis for the decision:[5] the student's past mathematical record, the teacher's estimate of the student's ability to profit from the extended program, the student's scores on mathematical and general aptitude tests, and the parental interests, desires, and powers of support as related to the student's extended education. Other authorities and curriculum guides are in close agreement with this. One thing is certain; the selection should not be made on scholastic ability alone, either to force a student into algebra or to force him into general mathematics. Human nature being what it is, counselor and student may make a mistake in the choice of a course but by using the widest scope of factors possible, these mistakes will be held to a minimum.

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[5]Course of Study, Mathematics for Secondary Schools, Bulletin 360, 1952. Commonwealth of Pennsylvania, Department of Public Instruction, Harrisburg, Pennsylvania, p. 105.

A special problem is created in the small high schools that make up the largest portion of the entire high school population. Where the large high school can section the class into two separate courses and then section the courses to get a more homogeneous grouping, the small high school may have barely enough students for a single course. Here, again, the curriculum guides and other authorities favored the teaching of general mathematics as the one subject but made provision for algebra by suggesting: (1) alternate courses in which general mathematics and algebra are taught in alternate years, (2) teaching two classes in one period, or (3) making provisions to have students take a correspondence course under the supervision of the school. It would be quite logical that algebra could be taught as an elective following general mathematics. Teaching the two classes in one period could have the advantage of correlating some areas, such as graphs, for the mutual benefit of both classes.

A decided advantage of a general mathematics program in the ninth grade is that the student and his counselors are in a much better position to evaluate the student's needs and prospects. It should function to interest him in mathematics. His added maturity will make the student more aware of his limitations or capacities and help him to progress faster in any subsequent mathematics he may choose to take.

CHAPTER VI

THE SUBJECT MATTER CONTENT OF NINTH GRADE MATHEMATICS

To evaluate the choice of subject matter content in the ninth grade general mathematics, the purpose of the course must be considered. One such purpose is to correct those weaknesses which may arise because some of the work previously done in the lower grades has been deferred to later years. Along with other subjects there are more topics that must be taught in mathematics so that as earlier courses become overloaded, some of the topics are upgraded. Even within the grades under consideration this has happened in that the elementary concepts of geometry as used in the seventh grade caused some topics to be shifted to the eighth grade which then shifted some topics into the ninth grade. The work of the ninth grade in providing training in arithmetic, graphic representations, algebra, geometry, and numerical trigonometry fills the needs of a student who will use them in subjects like physics, chemistry, economics, shopwork and science. It shows more clearly how each subject is reinforced and made clearer and more helpful by the other. Reeve puts it in this way:

> "The organizing and unifying principle of the general mathematics course should be the idea of functional relation - the dependence of one quantity upon another."[1]

In general mathematics the student is introduced to the basic concepts which then are applied to practical situations, laying a foundation for the more difficult mathematics which is to follow.

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[1] W. D. Reeve "General Mathematics for Grades 9 to 12". School Science and Mathematics. 49:99-110 February 1949, p. 101.

The ninth grade mathematics should, if at all possible, help the student to achieve functional competence as defined by the Check List mentioned in Chapter One. This course is often needed to achieve this competence because of the upgrading of topics from lower grades. The general mathematics will also function to unify the mathematics programs of secondary schools in the rural areas where the grade school and high school are separate and the pupils from many outlying grade schools are brought to a central high school for their secondary education.

The scope of general mathematics varies greatly in the curriculum guides and even more so in the textbooks that were checked. Some of the books were only an extension of the work done in the last two grades and contained very little algebra or geometry. Others went to the other extreme by devoting much time to algebra. As there is always the danger of crowding too much work into a general mathematics course, the greatest responsibility for selecting the topics to be covered and the amount of time alloted to them falls on the teacher. It is the teacher who must judge the needs of the class and select those areas that will be most applicable to the local situation.

The scope should include a review of arithmetic based on diagnostic tests and followed by remedial reteaching as indicated. There should be an extension of the concepts of geometric forms, their measurements and their application in life situations. There should be an extension of algebra and additional experiences in interpreting and understanding graphs and the ability to present data in graphic form. There should be many written problems involving the mathematics of personal living, earning money, budgeting, intelligent buying, saving and banking. The mathematical situations should become progressively more difficult and have very definite implications for living in an adult world.

A suggested outline for the minimum essentials is included as a part of this report.

MINIMUM ESSENTIALS FOR NINTH GRADE GENERAL MATHEMATICS

I. Review of fundamental processes. (Teach for mastery).
   A. Integers, fractions, decimals, percent.
      1. Apply in written problems, check answers.
      2. Rounding off numbers, significant digits.

II. Business practices.
   A. Banking and investments.
   B. Percentage applications; profit and loss, commission, increase and decrease.
   C. Insurance.
   D. Taxes.
   E. Installment buying.
   F. Budgets.
   G. Public Utilities.

III. Graphs and Statistics.
   A. High degree of skill in reading and interpreting data from graphs in every day life.
   B. Ability to convert data into graphical form.
   C. Understanding elementary statistical terms; mean, mode, etc.

IV. Geometry and Measurement.
   A. Ability to recognize and define angles, triangles, rectangles, etc.
   B. Construct perpendiculars, parallel lines, triangles, rectangles.
   C. Understand formulas connected with right triangles.
      1. Use in indirect measuring.
   D. Ratio and porportion.
   E. Scale drawing; house plans, maps, shop drawings.
   F. Volume of solids; including cones, spheres, pyramids.

V. Algebra.
   A. Simple linear equations involving two steps.
      1. Axioms applied to equations.
   B. Formulas.
      1. Substitution in and evaluation of simple formulas.
      2. Emphasis on formulas as shorthand.
   C. Exponents and roots.
   D. Fundamental processes applied to monomials.
   E. Graphing linear equations.
   F. Signed numbers.
      1. Definition and understanding.
      2. Operations with signed monomials.
   G. Changing form of literal equation or formula.
   H. Variation and dependence.
   I. Factoring.

VI. Mathematics in everyday life.
   A. Application of the foregoing concepts in written problems within the student's experiences.

CHAPTER VII

THE SUBJECT MATTER CONTENT OF ALGEBRA FOR GRADE NINE

To make the subject matter content of algebra meaningful to the student it must be related to the fundamental concepts as developed in arithmetic. These concepts are broadened and strengthened as a gradual transition to a workable understanding of the terminology, notation, and symbolism of algebra is made. Since the information and skill in the essentials of arithmetic are rapidly lost unless they are used, there should be opportunities for systematic review with reteaching if necessary. Opportunities for renewing number skills in computation with whole numbers, fractions, and decimals should be made. The course should develop logical thinking in developing a problem-solving approach in connection with everyday situations. The student should learn to formulate and evaluate formulas and to translate data into an equation and solve the equation. He should see algebra as a "shorthand" way of expressing mathematical relationships. He should also be able to estimate with reasonable accuracy the desired answer and use this as a check for computations. Above all he should appreciate the function of algebra in everyday life, in the sciences, and as a foundation for higher mathematics. The student should know that algebra is the universal language of the mathematician and the scientist and that a high degree of skill is essential if he is to succeed in any technical field.

MINIMUM ESSENTIALS IN NINTH GRADE ALGEBRA

I. The formula.
- A. Meaning, substitution and evaluation.
  - 1. Use in area, volume, etc.
- B. Constructing formulas from simple rules.
- C. Changing form of formula.

II. Equations.
- A. Using the four axioms in solving equations.
- B. Solve equations using several steps.
  - 1. Check by substituting back in equation.
- C. Solving systems of linear equations and checking.
- D. Graphing linear equations.

III. Directed Numbers.
- A. Use in solving problems, formulas, and equations.
- B. Removing parentheses in problems.
- C. Using with operations involving monomials and polynomials.

IV. Factoring and special products.
- A. Remove monomial factors.
- B. Differences of squares with integeral coefficients.
- C. Factoring form $x^2 - bx - c$

V. Algebraic fractions.
- A. Add and subtract two fractions.
- B. Multiply and divide two fractions with factorable numerators and denominators.

VI. Graphs, their meaning and use.
- A. High degree of skill in interpreting and reading current graphs.
- B. Construct graphs from data.

VII. Powers, roots and radicals.
- A. Powers of monomials and their use in multiplication and division.
- B. Meaning of square root and radical.
  - 1. Use of fractional exponents instead of radical.
- C. Rationalizing the denominator.
- D. Adding, subtracting, dividing, multiplying radicals.
- E. Applications of square root.
  - 1. Extracting square root of a number.

VIII. Quadratic equations.
- A. Solving by factoring.
- B. Solving by completing the square.
- C. Applying quadratics in problems.

IX. Ratio, variation, porportion.
- A. Meaning and application.
- B. Similar triangles.
- C. Right triangles formulas.
- D. Trigonometric ratios.
  - 1. Meaning.
  - 2. Numerical values
  - 3. Applications within pupils understanding.

X. Review of computational skills.
   A. Review of real life problems to maintain skills of top efficiency.

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VITA

Milton B. Friesen

Candidate for the Degree of

Master of Science

Report: THE SUBJECT MATTER CONTENT OF JUNIOR HIGH SCHOOL MATHEMATICS

Major Field: Natural Science

Biographical:

Personal data: Born near Hooker, Oklahoma, March 23, 1915, the son of Jacob E. and Elisabeth Friesen.

Education: Attended grade school near Hooker, Oklahoma; graduated from Buhler High School, Buhler, Kansas, in 1934; received the Bachelor of Science degree from the Panhandle Agricultural and Mechanical College, Goodwell, Oklahoma, with a major in Industrial Arts, in May, 1939; completed requirements for the Master of Science degree in May, 1957.

Professional Experience: Taught school at Adams, Oklahoma, 1943-1944; served as principal in Eureka Consolidated School, Baker, Oklahoma, 1944-1954 supervised the Post Oak Mission School, Indiahoma, Oklahoma, 1954-1955; taught science and mathematics in Balko High School, Balko, Oklahoma, 1955-1956; member of the National Science Foundation Supplementary Training Program for High School Science Teachers, Oklahoma Agricultural and Mechanical College, 1956-1957.