WHAT MATHEMATICAL EXPERIENCES SHOULD BE PROVIDED EVERY STUDENT IN THE HIGH SCHOOL?

A Problem Submitted to the Graduate Division in Partial Fulfillment of the Requirements for the Course in Research Problems 390b

By

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CHAPTER I

INTRODUCTION

The Problem

Statement of the Problem. This study seeks to discover what must be offered every pupil in the field of high school mathematics. It is proposed to find the particular mathematical areas and skills that must be a part of the general educational equipment at the command of all high school students and graduates. In addition, an indication of the time that should be spent in acquiring these skills is sought.

Purpose of the Study. The purpose of the study is to provide a roster of topics which will cover all the basic skills and appreciations to be required of all high school students in their mathematics experiences. It is expected that this list will be of value to those adjusting their high school curriculum to best meet the needs of the students in relation to general education.

Need for the Study. The Harvard Committee on General Education has stated the place of mathematics in general education as follows:

> The complexities of organization and technology in modern industry, in government, and in the national defense make increasing demands upon the mathematical equipment and skills of the ordinary participant and worker. .....It helps build some of the skills and comprehensions that make the

effective individual.[1]

There is a great diversity of opinion regarding the necessary mathematical offerings in the high school. These vary from an insistence on a requirement of the traditional sequence of algebra, geometry, and trigonometry through a period of three or even four years to the view that no mathematics is necessary beyond the skills of arithmetic.[2] Probably neither of these extremes is adequate to meet the needs of modern youth.

In many schools mathematics holds a position of disrepute in the eyes of pupils, patrons, and administrators. This is largely due to the failure of the mathematics people to provide a proper curriculum. Some of the valid criticisms mentioned are:

> ..... much mathematics teaching and many types of courses in mathematics deserve the derogatory remarks .... leveled at them. .... a whole reorganization of the program in mathematics is needed.[3]

> .... our present traditional mathematics offerings serve about fifteen per cent of our high school population.[4]

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[1]Harvard Committee on the Objectives of a General Education in a Free Society, General Education in a Free Society, p. 161.

[2]National Council of Teachers of Mathematics, The Place of Mathematics in Secondary Education, p. 35.

[3]Myron F. Rosskopf, "The Place of Mathematics in General Education," School Science and Mathematics, XLIX (October, 1949), 565-570.

[4]William A. Gager, "Mathematics for the other Eighty-Five Per Cent," School Science and Mathematics, XLVIII (April, 1948), 296-301.

> The mathematics courses do not appeal to the pupil who is not planning to enter college, ... contain an abundance of materials for which people in general have little or no use, ... courses are too difficult, ... courses are disliked by many pupils.[5]

The mathematics curriculum must be revised to meet most effectively the needs of modern youth. Several authors have made suggestions on this matter.

> The schools.... are now confronted with the problem of deciding what they can do to improve the mathematical ability of those pupils and others in the community who are almost certain to need mathematics in their life work.[6]

> With the population of our high schools fast becoming a cross section of our country's population.... it is fitting that mathematics, the universal language of the social, economic, industrial, and atomic age .... be properly attuned to the rhythmn of the times.[7]

With these statements in mind, it is evident that there is a very real need for some up-to-date clear thinking and research on the matter of the high school mathematics curriculum.

Limitations of the Study. This study does not propose to discover how the important topics are to be organized into the curriculum. No suggestions will be made as to the proper year for a particular item or which items should be grouped

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[5]E. R. Breslich, "New Mathematics Courses," California Journal of Secondary Education, XXII (December, 1947), p. 461.

[6]W. D. Reeve, "Modern Trends in Mathematics Education," School Science and Mathematics, XLVIII (January, 1948), 21-23.

[7]Marguerite E. Wolfinger, "Mathematics Designed to Serve Differing Individual Needs," School Science and Mathematics, XLVIII (June, 1948), 453-458.

together in one course. The purpose is to discover what mathematical tools are necessary for every high school pupil. This problem is concerned with the "what" but not the "how", "where", or "when" of high school mathematics experiences.

Sources of Data

Published Material. Recent studies of trends and needs in mathematics, as well as high school curriculum in general, were surveyed to discover the modern concepts of the mathematical experiences necessary for all high school students. In some, a suggestion as to the proper time to be spent on this program was presented. The articles and publications which were studied were the following:

Harvard Committee on the Objectives of a General Education in a Free Society, General Education in a Free Society.

W. D. Reeve, "General Mathematics for Grades Nine Through Twelve."

E. R. Breslich, "Curriculum Trends in High School Mathematics."

Harold P. Fawcett, "A Unified and Continuous Program in Mathematics."

National Council of Teachers of Mathematics, The Place of Mathematics in Secondary Education.

Progressive Education Association, Mathematics in General Education.

Ben G. Graham et al., What the High Schools Ought to Teach.

W. R. Binns, "Mathematical Operations Used in Ordinary Occupations and Suggestions for Incorporating them in High School Mathematics."

The Check-List. Several texts in high school mathematics were studied to determine the content that is now provided. Only texts of a more general nature were studied. These texts were:

Applied Mathematics, Herbert E. Cobb.

General Mathematics, Schorling and Reeve.

Practical Mathematics, N. J. Lennes

Business Mathematics, R. Robert Rosenberg.

Mathematics We Use, Brueckner and Grossnickle.

The topics found in these texts were largely incorporated into the check-list.

Additional topics for the check-list were suggested by two published approaches to the problem. One of these was "Curriculum Trends in High School Mathematics" by Breslich. The other was The Place of Mathematics in Secondary Education published as the fifteenth yearbook of the National Council of Teachers of Mathematics.

The check-list was submitted to a group of one hundred-twelve graduate students in education with teaching experience. It was felt that a random sampling would not give valid results in this investigation. The people who marked the check-list needed to have a background of experience and education which would provide them with a first hand knowledge of youth as

well as the aims of modern education.

Related Studies

Several similar studies have been reviewed by the author. Others have used different approaches to the same problem. Binns constructed a check-list of representative problems and gathered data on how many people had solved these particular problems since high school.[8] The operations most used were assumed to be the most important for inclusion in the mathematics courses. In a similar study Evans gathered information on current practice from several cities and also reviewed the topics covered in several texts.[9] Another study by Jones and others has indicated the trend toward more meaningful mathematics.[10] This report, however, presented no specific suggestions as to the proper content of the courses.

Two more comprehensive investigations in this field are also available. One published in nineteen twenty-three by the National Committee on Mathematical Requirements gave emphasis to the then dominant college preparation objective and suggestions for implementing it. This study was conducted while

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[8] W. R. Binns, "Mathematical Operations Used in Ordinary Occupations and Suggestions for Incorporating them in High School Mathematics."

[9] Willard Evans, "A Syllabus of Practical Mathematics for the Ninth Grade."

[10] Phillip S. Jones et al., "A Report on Progress in Mathematics Education," School Science and Mathematics, XLIX (June, 1949), 465-474.

the concept of formal mental discipline was prevalent.[11] The other, a more recent study, published as the fifteenth yearbook of the National Council of Teachers of Mathematics in nineteen forty presents suggestions for a course of study in the light of modern objectives for general education.

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[11]National Committee on Mathematical Requirements, The Reorganization of Mathematics in Secondary Education.

[12]National Council of Teachers of Mathematics, The Place of Mathematics in General Education.

CHAPTER II

FINDINGS OF THE STUDY

The data in this study were obtained from a survey of related studies and publications, and from a check-list constructed by the author. Texts in the field of secondary curriculum construction, as well as studies specifically related to high school mathematics, were used. Items used on the check-list were derived from these publications and several texts in high school mathematics. Blanks were provided for the addition of items any individual thought should be included in addition to those enumerated on the list. None was added by more than one person. These items are presented in the appendix as table VII.

Data Derived From Published Material

Many rather recent articles and publications have directed attention to the place of mathematics in the general education of the high school student. Several of these were studied by the author to find suggestions of the necessary content in high school mathematics. In all cases, the individuals or committees responsible for the publications have a broad background in education and a rather comprehensive study has usually been undertaken. In consideration of this, their suggestions should probably carry considerable weight.

Alberty tells of trends and advances in mathematics instruction which have occurred recently.

> The impact of the war upon mathematics has had the effect of hastening reorganization in order to make it serve human needs. Its application to aeronautics, navigation, and mechanics has tended to make it less dependent upon abstractions. Paralleling this development, reorganization in terms of its function of helping students to understand and utilize the scientific method has already made a beginning.[13]

> During recent years, plane geometry has been vastly improved through the 'Nature of Proof' concept that has been pioneered by Harold Fawcett, and worked out in the Ohio State University School. Instead of stressing the conventional theorems, he develops the nature of proof, particularly the place of definitions and assumptions in relation to the conclusions that are reached. Students are taught to be critical concerning radio and newspaper advertising, the sermons that they hear, the articles that they read, and in their discussions with their fellows. Subject matter is drawn from the daily living of the student. He comes to see that the methods of the mathematician and of the scientist may be generalized to apply to all aspects of living.[14]

A special committee report on secondary school curriculum prepared for the American Youth Commission has considered the needs of high school students in mathematics.

> Recent experiments have been tried in extracting from the conventional courses in mathematics the fundamental general principles which are bases of all precise thinking. Everyone should have a vivid understanding of the truth that an equation is of such nature that whatever is done with one side of the equation must be done with the other side if the equation is to remain valid. Everyone ought to know how to translate a table of figures into a graph which shows trends at a glance.

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[13]Harold Alberty, Reorganizing the High School Curriculum, p. 391.

[14]Ibid., pp. 109-110.

> Everyone ought to know something about functional relations.[15]

The Harvard Committee recommends the following as the proper minimum mathematics content and time allotment for high school pupils:

> The next stage in mathematical instruction {after the eighth grade}, and the last for those students who are least apt in the subject, should convey and appreciation of the use of formulas, graphs, and simple equations, and should develop some skill in solving right triangles trigonometrically. Even in the case of pupils who are not quick in mathematics, these last steps should require not more than half a year.[16]

The Progressive Education Association has published a treatise on the achievement of the proper general educational aims in secondary education. They list these basic concepts as the major ones needed by the student to "learn the nature of both mathematics and the problem-solving process, and to appreciate the values of a democratic society."[17]

1. Formulation and solution of problems.
2. Data
3. Approximation
4. Function
5. Operation

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[15]Ben G. Graham et al., What the High Schools Ought to Teach, p. 28.

[16]Harvard Committee, op. cit., p. 162.

[17]Progressive Education Association Commission on Secondary School Curriculum, Mathematics in General Education, p. 73.

6. Proof

7. Symbolism

Binns recommends the following as a result of a study conducted in nineteen thirty-eight:

> General mathematics should contain many problems concerning home expenditures, percentage, insurance, installment buying, measurement, areas, reading and constructing graphs, simple geometrical construction problems, and the very simplest algebraic equations.[18]

Reeve would have any mathematics beyond the ninth grade made elective. He states rather explicitly the areas to be covered in the ninth grade mathematics course required of all students.

> In the ninth year the function furnishes the central idea of the course and the simpler truths and constructions of geometry help to rationalize some of the more formal aspects of the algebra and later to furnish exercises for algebraic applications. .... Excessive formalism is greatly reduced and the emphasis is placed upon the function, the formula, and the graph.
>
> .... we introduce a great deal of informal geometry in the first year, followed in some cases, by a simple approach to demonstrative geometry only where it comes naturally and easily.
>
> The elementary ideas of numerical trigonometry .... are as easy for a ninth grader as anything else, once he understands the nature of similar triangles.[19]

Fawcett suggests that a unified and continuous program is necessary in mathematics.

> Mathematics.... is a system of ideas unified by

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[18] Binns, op. cit., p. 54.

[19] W. D. Reeve, "General Mathematics for Grades Nine through Twelve," School Science and Mathematics, XLIX (February, 1949), 99-110.

> a number of fundamental concepts which grow in meaning and significance for the student as his study of mathematics continues. ....Among the most important of these concepts are:
>
> 1. Number
> 2. Measurement
> 3. Relationship
> 4. Proof
> 5. Operation
> 6. Symbolism
>
> A program in mathematics designed to contribute to the general education of all our students will provide continuing and persistent emphasis on each of these six concepts.[20]

In a study of the mathematics necessary for intelligent citizenship, Breslich suggested the following basic mathematics for all high school students:[21]

1. Arithmetic
   - a. basic concepts
   - b. fundamental operations
   - c. ratio and proportion
   - d. square root
   - e. measurement
   - f. percentage
   - g. tables
   - h. verbal problems
2. Geometry
   - a. geometric concepts
   - b. direct measurement

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[20] Harold P. Fawcett, "A Unified and Continuous Program in Mathematics," School Science and Mathematics, L (May, 1950), 342-348.

[21] E. R. Breslich, "Curriculum Trends in High School Mathematics," The Mathematics Teacher, XLI (February, 1948), 60-69.

c. properties of geometric figures

d. indirect measurement

e. geometric constructions

f. cultural values of geometry

3. Algebra

a. algebraic concepts

b. fundamental operations

c. equations

d. ratio and proportion, variation

e. formulas

f. problem solving

4. Statistics

a. vocabulary of statistics

b. meaning of statistical data

5. Graphical Representation

a. read, understand, interpret graphs

b. comparisons

c. recognize trends

d. construct graphs

e. problem solution by graph

6. Numerical Trigonometry

a. sine, cosine, tangent

b. construction of small trigonometric tables

c. use of three or four place tables

Breslich indicates that the program required of every student will take one year.

The Fifteenth Yearbook of the National Council of Teachers of Mathematics presents the results of a comprehensive study of the place of mathematics in secondary education with recommendations for improving the curriculum in high school mathematics.[22] The proposed areas to be covered in the ninth grade general mathematics course which is the minimum requirement of all students is indicated in the following outline.

A. Arithmetic

1. Fundamentals

a. fractions

b. mixed numbers

c. decimals

d. per cent

e. mensuration

f. metric system

g. bookkeeping

h. approximate numbers

i. significant figures

j. estimating results

k. shortened methods of multiplying

l. social problems

2. Functional Topics

a. home-owning

b. mortgages

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[22]National Council of Teachers of Mathematics, op. cit., pp. 101-107.

c. taxes

d. installment buying

e. insurance

f. investments

g. automobile expenses

h. debts

i. risks

j. health

k. food

l. budgets

m. building and loan association

n. cooperative enterprises

B. Graphic Representation

1. Construction and interpretation of pictograms.
2. Construction and interpretation of broken line graphs.
3. Construction and interpretation of bar and circle graphs.
4. Construction and interpretation of graphs of formulas.
5. Fitting formulas to graphs.

C. Algebra

1. Use and interpretation on signed numbers.
2. Use of symbols to express ideas.
3. Meaning and importance of generalizing a problem and its solution.

4. Use of equations to solve problems which cannot be solved easily by arithmetic
5. Ratio and proportion
6. Dependence
7. Exponents
8. Square root by computation
9. Pythagorean relation

D. Trigonometry

1. Scale drawings
2. Similar triangles
3. Ratio of similitude
4. Define sine, cosine, tangent
5. Use tables to four decimals

The data above indicates considerable variation in the suggested mathematical needs of high school students. These differences must be resolved in order to establish the proper curriculum in mathematics for high school boys and girls.

Data Derived From Use of the Check-List

Positions Represented on the Survey. The check-list was returned by one hundred-fifteen graduate students in education. Of these, one had marked the check-list improperly and two indicated they had no teaching experience. After eliminating these three, there remained one hundred-twelve properly completed check-lists upon which this portion of the study is based.

The individuals cooperating in this study comprised a

broad representation of educational endeavor. Thirty-four were associated with elementary schools, seventy-two were working in secondary schools, and six were superintendents of schools. Table I presents in more detail the positions occupied by those returning the check-list. It should be noted that the discrepancy between the total occupations (one hundred twenty-six) and the number of people marking the check-list (one hundred twelve) is due to the filling of more than one position by one person (teaching two or more subjects, principal and teaching a subject, etc.). Considering the variety of the sampling, it would seem that the check-list results should indicate the general attitude of the teachers of this area concerning the essentials of the minimum mathematics curriculum in the high school.

TABLE I

POSITIONS REPRESENTED BY THOSE MARKING CHECK LIST

Position	Representation
Elementary Schools	
Teacher	22
Principal	15
Secondary Schools	
Science	11
Industrial Arts	11
Coach	11

TABLE I -- continued

Position	Representation
Mathematics	11
Social Science	8
Commerce	7
English	4
Physical Education	3
Home Economics	2
Music	1
Printing	1
Driver Education	1
Director of Guidance	1
Dean	1
Principal	10
Superintendent of Schools	6

Response to Fundamental Operations. Every topic included under fundamental operations was checked at least a few times. If everyone were to be satisfied, all topics would be included for all students. However, the time element, as well as the consideration of utility, will probably make it necessary to eliminate those topics which seem to be of least importance. The fundamental operation which received the most response was item four of Part A which was "Calculation of per cent."

Ninety-four per cent of those responding recommend that all high school students spend some time on this topic. The item receiving the least response was number five of Part D which was "solution of right triangles by trigonometry." Only twenty per cent of the group felt there was a necessity for this topic to be covered by all high school students. Less than fifty per cent of the respondents marked the lower forty-one per cent (least popular nineteen) of the topics. Table II presents the detailed ranking of all the topics listed under fundamental operations with the most chosen first and the least chosen last.

TABLE II

RANKING OF RESPONSES TO FUNDAMENTAL OPERATIONS

Rank	Fundamental Operation
1	Calculation of per cent.
2.5	Addition, subtraction, multiplication, and division of decimals.
2.5	Reading and interpreting graphs.
4	Addition, subtraction, multiplication, and division of common fractions.
5	Reading of tables.
6	Meaning of positive and negative numbers.
7	Understanding of meaning of point, line, angle, prism, triangle, tetrahedron, quadrilateral, etc.
8	Construction of simple statistical graphs.

TABLE II -- continued

Rank	Fundamental Operation
9	Measurement of weight approximately.
10.5	Measurement of length approximately.
10.5	Rounding off approximate numbers.
12	Measurement of angles with protractor.
13	Calculation of ratio.
14	Addition, subtraction, multiplication, and division of whole numbers.
15	Solution of formulas.
16	Determine common areas and volumes by formula.
17	Organize statements in coherent logical sequence.
19	Solve algebraic expressions in one unknown.
19	Construction of parallel lines, perpendicular lines, etc.
19	Construction of accurate scale drawings.
21	Meaning and use of statistical terms as "mean", "median", etc.
22	Discover flaws in reasoning of proofs.
23.5	Add, subtract, multiply, divide algebraic expressions.
23.5	Use of metric units.
25	Determine maximum and minimum points from a graph.
26	Use of computing machines to add, subtract, multiply, and divide.
27	Square root by computation.
28	Add, subtract, multiply, divide signed numbers.

TABLE II -- continued

Rank	Fundamental Operation
29	Transferring a line segment by use of dividers or compass.
30	Construction of algebraic equations for verbal problems.
31.5	Interpolation in reading and interpreting graphs.
31.5	Meaning and use of literal number expressions.
33	Conditions for congruence and similarity of triangles, etc.
34	Graphical representation of a formula.
35	Solution of right triangles by Pythagorean Theorem.
36	Sketching geometric figures.
37	Determine rate of change from a graph.
38	Meaning and use of exponents.
39	Calculation of per cent of error.
40.5	Solve algebraic expressions in two unknowns.
40.5	Factor algebraic expressions.
42	Solution of geometric proofs.
43	Calculation by use of slide rule.
44	Meaning and use of radicals.
45	Measurement by use of vernier and micrometer calipers.
46	Calculation by use of logarithms.
47	Solution of right triangles by trigonometry.

Response to Functional Applications. The general response to the functional application topics was much stronger than to the fundamentals. The least popular item "Find American price per unit from quoted foreign price and unit" was checked on thirty-four per cent of the papers. The most recommended items, "Household accounting","Cost of installment buying", and "Finding discounts and commissions" were all marked by ninety-five per cent of the educators. Fifty per cent of the respondents recommended all except the lower fourteen per cent (four least popular) topics. Table III presents the ranking of the topics listed under functional applications.

TABLE III

RANKING OF RESPONSES TO FUNCTIONAL APPLICATIONS

Rank	Functional Applications
2	Household Accounting.
2	Cost of installment buying.
2	Finding discounts and commissions.
4	Cost of owning a home.
5.5	Buying food.
5.5	Making and following a budget.
7	Computation of insurance and taxes.
8.5	Saving money.
8.5	Cost of owning a car.
10	Filling out income tax forms.

TABLE III -- continued

Rank	Functional Applications
11	Investments in general.
12	Calculation of ordinary and compound interest.
13	Find area of field, volume of tank, etc.
14	Elementary heat (comparison of fuels, insulation, etc.).
15	Marketing farm and industrial products.
16	Estimating probable cost of house built from a particular set of plans.
17	Calculation of profit and loss.
18.5	Simple mechanics (law of lever, efficiency of motors, etc.).
18.5	Simple electricity (ohms law, reading k.w.h. meter, etc.).
20	Computation of depreciation.
21	Find height of building, distance across river, etc., by length of shadow, outdoor triangle, etc.
22	Appreciation of the contribution of mathematics to the progress of civilization.
23	Buying and selling of stocks and bonds.
24	Gathering and tabulating statistical data from community.
25	Appreciation of geometric designs and ornaments in buildings and surroundings in general.
26	Elementary surveying.
27	Simple navigation.
28	Find American price per unit from quoted foreign price and unit.

Time to Be Spent on Mathematics. The majority of the respondents seem to feel the present Kansas requirement of one year of high school mathematics is inadequate. Fifty per cent of those marking the check-list suggested four or more semesters as the minimum time to be spent by all high school students in acquiring the necessary skills and experiences in mathematics. Only thirty-three per cent indicated that two semesters or less would be sufficient. Table IV presents in more detail the treatment of the time requirement by those marking the check-list.

TABLE IV

SUGGESTED NUMBER OF SEMESTERS OF MATHEMATICS

Proposed number of semesters	Responses	Percentage
No answer	6	5%
1	1	1%
2	36	32%
3	13	12%
4	41	37%
5	2	2%
6	10	9%
7	0	0%
8	2	2%
15	1	1%

Comparison and Interpretation of Data

Determination of Necessary Fundamental Topics. It was necessary to weigh and evaluate the several possible fundamental topics to determine which should be included for all high school students. Quite a variety of items were suggested in the published materials. The most important were chosen on the basis of more or less common agreement among the sources. The following seem to be worthy of inclusion on this basis:

1. Use of formulas
2. Solve equations
3. Read and construct graphs
4. Functional relations
5. Elementary trigonometry
6. Statistics
7. Approximation
8. Operation
9. Proofs
10. Symbolism
11. Per cent
12. Measurement
13. Geometrical constructions
14. Informal geometry
15. Concept of number
16. Ratio and proportion
17. Use of tables
18. Cultural values of geometry

19. Fractions and mixed numbers
20. Decimals
21. Metric system

Those items on the check-list were selected for inclusion which had been marked by over fifty per cent of the respondents. This made necessary the inclusion of the twenty-six most popular items. The following items were in this category:

1. Calculation of per cent.
2. Addition, subtraction, multiplication, and division of decimals.
3. Reading and interpreting graphs.
4. Addition, subtraction, multiplication, and division of common fractions.
5. Reading of tables.
6. Meaning of positive and negative numbers.
7. Understanding of meaning of point, line, angle, prism, triangle, tetrahedron, quadrilateral, etc.
8. Construction of simple statistical graphs.
9. Measurement of weight approximately.
10. Measurement of length approximately.
11. Rounding off approximate numbers.
12. Measurement of angles with protractor.
13. Calculation of ratio.
14. Addition, subtraction, multiplication, and division of whole numbers.
15. Solution of formulas.

16. Determine common areas and volumes by formula.
17. Organize statements in coherent logical sequence.
18. Solve algebraic expressions in one unknown.
19. Construction of parallel lines, perpendicular lines, etc.
20. Construction of accurate scale drawings.
21. Meaning and use of statistical terms as "Mean", "Median", etc.
22. Discover flaws in reasoning of proofs.
23. Add, subtract, divide, multiply algebraic expressions.
24. Use of metric units.
25. Determine maximum and minimum points from a graph.
26. Use of computing machines to add, subtract, multiply, and divide.

Functional Topics to Be Included. Less attention was given to the presentation of functional topics by the sources surveyed. However, the following were recommended for inclusion by at least two authors:

1. Home expenditures.
2. Insurance and taxes.
3. Debts and installment buying.
4. Home-owning.
5. Mortgages.

Those marking the check-list responded strongly to the functional topics. Inclusion of the ones marked by at least fifty per cent of the respondents necessitated a list of

the twenty-four most popular items which follows:

1. Household accounting.
2. Cost of installment buying.
3. Finding discounts and commissions.
4. Cost of owning a home.
5. Buying food.
6. Making and following a budget.
7. Computation of insurance and taxes.
8. Saving money.
9. Cost of owning a car.
10. Filling out income tax forms.
11. Investments in general.
12. Calculation of ordinary and compound interest.
13. Find area of field, volume of tank, etc.
14. Elementary heat.
15. Marketing farm and industrial products.
16. Estimating probable cost of house built from a particular set of plans.
17. Calculation of profit and loss.
18. Simple mechanics.
19. Simple electricity.
20. Computation of depreciation.
21. Find height of building, distance across river, etc. by length of shadow, outdoor triangle, etc.
22. Appreciation of the contribution of mathematics to the progress of civilization.

23. Buying and selling of stocks and bonds.
24. Gathering and tabulating statistical data from the community.

Combined List of Fundamental and Functional Topics. The lists above were combined into the following outline by combining similar statements from published material and the check-list.

I. Fundamental Experiences for All High School Students

1. Calculation of per cent.
2. Addition, subtraction, multiplication, and division of decimals.
3. Reading and interpreting graphs.
4. Addition, subtraction, multiplication, and division of common fractions.
5. Reading of tables.
6. Meaning of positive and negative numbers.
7. Informal geometry.
8. Cultural values of geometry.
9. Construction of simple statistical graphs.
10. Measurement of weight approximately.
11. Measurement of length approximately.
12. Approximation.
13. Measurement of angles with protractor.
14. Ratio and proportion.
15. Addition, subtraction, multiplication, division of whole numbers.

16. Solution of formulas.
17. Organize statements in coherent logical sequence.
18. Solve algebraic expressions in one unknown.
19. Geometric constructions.
20. Scale drawings.
21. Statistics.
22. Proofs.
23. Add, subtract, multiply, divide algebraic expressions.
24. Metric system.
25. Determine maximum and minimum points from a graph.
26. Use of computing machines to add, subtract, multiply, and divide.
27. Elementary trigonometry.
28. Functional relations.
29. Concept of number.

II. Functional Topics for All High School Students

1. Household accounting.
2. Debts and installment buying.
3. Finding discounts and commissions.
4. Home-owning.
5. Buying food.
6. Making and following a budget.
7. Insurance and taxes.
8. Saving money.
9. Cost of owning a car.

10. Filling out income tax forms.
11. Investments.
12. Calculation of ordinary and compound interest.
13. Find area of field, volume of tank, etc.
14. Elementary heat.
15. Marketing farm and industrial products.
16. Mortgages.
17. Calculation of profit and loss.
18. Simple mechanics.
19. Simple electricity.
20. Depreciation.
21. Find height of building, distance across river, etc. by length of shadow, outdoor triangle, etc.
22. Appreciation of the contribution of mathematics to the progress of civilization.
23. Gathering and tabulating statistical data from the community.

Time to Be Used for High School Mathematics. None of the sources used recommend more than one year of required mathematics in the high school. Half of those answering the check-list recommend at least two years. Perhaps a compromise might recommend three semesters; especially since a clear majority (sixty-two per cent) of the respondents recommend at least that number of semesters. In any event, the time could vary in relation to local community needs and particular needs of the students.

CHAPTER III

SUMMARY AND CONCLUSIONS

Summary

This study proposes to determine the topics necessary for inclusion in the mathematical experience of all high school students. In addition the author sought some indication of the number of semesters of mathematics that should be required of all high school students. The data were secured from a survey of related studies and a check-list which was filled out by one hundred twelve graduate students in education with teaching experience. The author's interpretation of the data from literature and responses to the check-list is as follows:

1. The Fundamental Experiences most recommended were: calculation of per cent; addition, subtraction, multiplication, and division of decimals; reading and interpreting graphs; addition, subtraction, multiplication, division of common fractions; reading of tables; meaning of positive and negative numbers; informal geometry; cultural values of geometry; construction of simple statistical graphs; measurement of weight approximately; measurement of length approximately; approximation; measurement of angles with protractor; ratio and proportion; addition, subtraction, multiplication, division of whole numbers; solution of formulas; organize statements in coherent logical sequence; solve algebraic

expressions in one unknown; geometric constructions; scale drawings; statistics; proofs; add, subtract, multiply, divide algebraic expressions; metric system; determine maximum and minimum points from a graph; use of computing machines to add, subtract, multiply, and divide; elementary trigonometry; functional relations; and concept of number. Particular attention should be given to the teaching of these fundamentals in high school mathematics. Many of these experiences will be a review for mastery of skills introduced in the elementary school. Others will be entirely new to the student.

2. The Functional Applications most recommended were the following: household accounting; debts and installment buying; finding discounts and commissions; home-owning; buying food; making and following a budget; insurance and taxes; saving money; cost of owning a car; filling out income tax forms; investments; calculation of ordinary and compound interest; find area of field, volume of tank, etc.; elementary heat; marketing farm and industrial products; mortgages; calculation of profit and loss; simple mechanics; simple electricity; depreciation; find height of building, distance across river, etc. by indirect measurement; appreciation of the contribution of mathematics to the progress of civilization; and gathering and tabulating statistical data from the community.

All these functional applications of mathematics to real life situations should be introduced to the student. There are other topics which might apply to specific local

conditions but those mentioned here have more or less universal appeal and application and so should be included for all.

3. A rather strong majority of those responding to the check-list proposed at least three semesters as the minimum mathematical requirement in high school, half of the total number checking the list suggested at least four semesters. On the other hand, none of the published material proposed that the program for every student cover more than two semesters.

Conclusions

The findings of this study indicate that the following conclusions are justified:

1. Instructors and authors of textbooks of mathematics should assure the inclusion of the following items in the experience of the high school student:

A. Fundamental Topics

Calculation of per cent.
Operations with decimals.
Reading and interpreting graphs.
Operations with common fractions.
Reading of tables.
Meaning of positive and negative numbers.
Informal geometry.
Cultural values of geometry.
Construct simple statistical graphs.
Measurement of weight approximately.
Measurement of length approximately.
Approximation.
Measure angles with protractor.
Ratio and proportion.
Operations with whole numbers.
Solve formulas.
Organize statements in coherent logical sequence.
Solve algebraic expressions in one unknown.

Geometric constructions.
Scale drawings.
Statistics.
Proofs.
Operations with algebraic expressions.
Metric system.
Determine maxima and minima from graphs.
Use of computing machines.
Elementary trigonometry.
Functional relations.
Concept of number.

B. Functional Applications

Household accounting.
Debts and installment buying.
Finding discounts and commissions.
Home-owning.
Buying food.
Making and following a budget.
Insurance and taxes.
Saving money.
Cost of owning a car.
Filling out income tax forms.
Investments.
Calculation of ordinary and compound interest.
Find area of field, volume of tank, etc.
Elementary heat.
Marketing farm and industrial products.
Mortgages.
Calculation of profit and loss.
Simple mechanics.
Simple electricity.
Depreciation.
Practical applications of indirect measurement.
Appreciation of contribution of mathematics to the progress of civilization.
Gathering and tabulating statistical data from the community.

2. All students should probably be expected to take at least three semesters of mathematics in high school. This should not be an iron-clad practice, but capable of some adjustment to the capacity and attitude of the student.

3. Further study should be undertaken. The inclusion of the items added to the check-list by the respondents would

give additional information as to their value.

4. A study should be made of the time allotment necessary for each of the topics suggested for inclusion in the high school mathematics experience for all students.

BIBLIOGRAPHY

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Books

Alberty, Harold, Reorganizing the High School Curriculum. New York: The Macmillan Company, 1947. 443 pp.

Brueckner, Leo J. and Foster E. Grossnickle, Mathematics We Use. Chicago: John C. Winston Company, 1948. 308 pp.

Cobb, Herbert E., Applied Mathematics. Boston: Ginn and Company, 1911. 260 pp.

Graham, Ben G., et al., What the High Schools Ought to Teach. Washington, D. C.: American Council on Education, 1940. 36 pp.

Harvard Committee on the Objectives of a General Education in a Free Society, General Education in a Free Society. Cambridge: Harvard University Press, 1945. 267 pp.

Lennes, N. J., Practical Mathematics. New York:The Macmillan Company, 1936. 392 pp.

Leonard, J. Paul, Developing the Secondary School Curriculum. New York: Rinehart and Company, 1946. 551 pp.

National Council of Teachers of Mathematics, Eighth Yearbook, Teaching of Mathematics in the Secondary School. New York: Teachers College, Columbia University, 1933. 264 pp.

National Council of Teachers of Mathematics, Fifteenth Yearbook, The Place of Mathematics in Secondary Education. New York: Teachers College, Columbia University, 1940. 253 pp.

National Committee on Mathematical Requirements, The Reorganization of Mathematics in Secondary Education. Hanover, N. H.: The Mathematical Association of America, Inc., 1923. 627 pp.

Progressive Education Association Commission on Secondary School Curriculum, Mathematics in General Education. New York: D. Appleton-Century Company, 1940. 412 pp.

Rosenberg, R. Robert, Business Mathematics. New York: The Gregg Publishing Company, 1946. 560 pp.

Schorling, Raleigh, and William David Reeve, General Mathematics. New York: Ginn and Company, 1919. 479 pp.

Thayer, V. T., et al., Reorganizing Secondary Education. New York: D. Appleton-Century Company, 1939. 471 pp.

Periodical Articles

Breslich, E. R., "Curriculum Trends in High School Mathematics," The Mathematics Teacher, XLI (February, 1948), 60-69.

Breslich, E. R., "New Mathematics Courses," California Journal of Secondary Education, XXII (December, 1947), 461.

Commission on Post-War Plans of the National Council of Teachers of Mathematics, "Guidance Report of the Commission on Post-War Plans," The Mathematics Teacher, XL (November, 1947), 315-339.

Fawcett, Harold P., "A Unified and Continuous Program in Mathematics," School Science and Mathematics, L (May, 1950), 342-348.

Gager, William A., "Mathematics for the Other Eighty-Five Per Cent," School Science and Mathematics, XLVIII (April, 1948), 296-301.

Jones, Phillip S., et al., "A Report on Progress in Mathematics Education," School Science and Mathematics, XLIX (June, 1949), 465-474.

Reeve, W. D., "General Mathematics for Grades Nine through Twelve," School Science and Mathematics, XLIX (February, 1949), 99-110.

Reeve, W. D., "Modern Trends in Mathematics Education," School Science and Mathematics, XLVIII (January, 1948), 21-33.

Rosskopf, Myron F., "The Place of Mathematics in General Education," School Science and Mathematics, XLIX (October, 1949), 565-570.

Wolfinger, Marguerite E., "Mathematics Designed to Serve Differing Individual Needs," School Science and Mathematics, XLVIII (June, 1948), 453-458.

Unpublished Material

Binns, W. R., "Mathematical Operations Used in Ordinary Occupations and Suggestions for Incorporating Them in High School Mathematics." Unpublished master's thesis, Kansas State Teachers College, Pittsburg, August, 1938.

Evans, Willard, "A Syllabus of Practical Mathematics for the Ninth Grade," Unpublished master's thesis, Kansas State Teachers College, Pittsburg, July, 1937.

APPENDIX

Check-List

Please state your occupation _____
(supt., h. s. Eng., el. teach., etc.)

Please indicate by a check mark the topics in the following list you believe should be part of the mathematical instruction for <u>every</u> pupil in high school.
Use blanks to add any items necessary.

I. Fundamental Mathematical Processes.

A. Number and Computation.

_ 1. Addition, subtraction, multiplication, and division of whole numbers.
_ 2. Addition, subtraction, multiplication, and division of common fractions.
_ 3. Addition, subtraction, multiplication, and division of decimals.
_ 4. Calculation of per cent.
_ 5. Calculation of ratio.
_ 6. Square root by computation.
_ 7. Reading of tables.
_ 8. Use of computing machines to add, subtract, multiply, divide.
_ 9. Measurement of length approximately (nearest $\frac{1}{4}$ in., etc.).
_ 10. Use of metric units./weight
_ 11. Measurement of ~~length~~ approximately (nearest ounce, etc.).
_ 12. Solution of formulas.
_ 13. Meaning and use of literal number expressions.
_ 14. Meaning and use of radicals.
_ 15. Meaning and use of exponents.
_ 16. Calculation by use of slide rule.
_ 17. Calculation by use of logarithms.
_ 18. Measurement by use of vernier and micrometer calipers
_ 19. _____
_ 20. _____
_ 21. _____
_ 22. _____

B. Geometric Form and Space Perception.

_ 1. Understanding of meaning of point, line, angle, prism, triangle, tetrahedron, quadrilateral, etc.
_ 2. Conditions for congruence and similarity of triangles, etc.
_ 3. Construction of parallel lines, perpendicular lines, etc.
_ 4. Construction of accurate scale drawings.
_ 5. Measurement of angles with protractor.
_ 6. Transferring a line segment by use of dividers or compass.
_ 7. Solution of geometric proofs.
_ 8. Sketching geometric figures.
_ 9. Determine common areas and volumes by formula.
_ 10. _____
_ 11. _____

C. Graphic Representation.

_ 1. Graphical representation of a formula.
_ 2. Construction of simple statistical graphs.
_ 3. Determine maximum and minimum points from a graph.
_ 4. Determine rate of change from a graph.
_ 5. _____
_ 6. _____

D. Elementary Analysis.

_ 1. Meaning of positive and negative numbers.
_ 2. Rounding off approximate numbers.
_ 3. Meaning and use of statistical terms as "mean", "median", etc.
_ 4. Solution of right triangles by Pythagorean theorem.
_ 5. Solution of right triangles by trigonoMetry.
_ 6. Construction of algebraic equations for verbal problems.
_ 7. Add, subtract, multiply, divide algebraic expressions.
_ 8. Factor algebraic expressions.
_ 9. Solve algebraic expressions in one unknown.
_ 10. Solve algebraic expressions in two unknowns.
_ 11. Calculation of per cent of error.
_ 12. Add, subtract, multiply, divide signed numbers.
_ 13. _____
_ 14. _____
_ 15. _____

E. Logical and Relational Thinking.

_ 1. Organize statements in coherent logical sequence.
_ 2. Discover flaws in reasoning of proofs.
_ 3. Reading and interpreting graphs.
_ 4. Interpolation in reading and interpreting graphs.
_ 5. _____
_ 6. _____

II. Functional Topics to which the above items should be applied in the Classroom.

_ 1. Finding discounts and commissions.
_ 2. Filling out income tax forms.
_ 3. Find American price per unit from quoted foreign price and unit.
_ 4. Elementary surveying.
_ 5. Find height of building, distance across river, etc. by length of shadow, outdoor triangle, etc.
_ 6. Simple electricity (ohms law, reading k.w.h. meter, etc.).
_ 7. Find area of field, volume of tank, etc.

_ 8. Simple mechanics (law of lever, efficiency of motors, etc.).
_ 9. Appreciation of geometric designs and ornaments in buildings and surroundings in general.
_ 10. Simple navigation.
_ 11. Appreciation of the contribution of mathematics to the progress of civilization.
_ 12. Buying and selling of stocks and bonds.
_ 13. Gathering and tabulating statistical data from community.
_ 14. Computation of depreciation.
_ 15. Household accounting.
_ 16. Computation of insurance and taxes.
_ 17. Cost of installment buying.
_ 18. Calculation of profit and loss.
_ 19. Making and following a budget.
_ 20. Calculation of ordinary and compound interest.
_ 21. Cost of owning a car.
_ 22. ~~Making and following a budget.~~
_ 23. Cost of owning a home.
_ 24. Buying food.
_ 25. Investments in general.
_ 26. Saving money.
_ 27. Elementary heat (comparison of fuels, insulation, etc.).
_ 28. Marketing farm and industrial products.
_ 29. Estimating probable cost of house built from a particular set of plans.
_ 30. _____
_ 31. _____
_ 32. _____
_ 33. _____
_ 34. _____
_ 35. _____
_ 36. _____

Please state here the minimum number of <u>semesters</u> you believe <u>every</u> high school pupil should spend in completing his work in mathematics.

_____ semesters.

Thank-you for your cooperation in this survey.

Sincerely,

John Scott

TABLE V

RESPONSES TO EACH ITEM IN CHECK LIST

Item	Number of Responses	Percentage
Section I		
Part A		
1	78	70%
2	94	84%
3	96	86%
4	105	94%
5	79	71%
6	55	49%
7	92	82%
8	57	51%
9	82	73%
10	62	55%
11	83	74%
12	77	69%
13	48	43%
14	27	24%
15	20	36%
16	29	26%
17	25	22%
18	26	23%

TABLE V -- continued

Item	Number of Responses	Percentage
Part B		
1	88	79%
2	47	42%
3	73	65%
4	73	65%
5	81	72%
6	50	45%
7	31	28%
8	44	39%
9	76	68%
Part C		
1	46	41%
2	87	78%
3	59	53%
4	43	38%
Part D		
1	91	81%
2	82	73%
3	64	57%
4	45	40%
5	22	20%
6	44	44%

TABLE V -- continued

Item	Number of Responses	Percentage
7	62	55%
8	36	32%
9	73	65%
10	36	32%
11	39	35%
12	51	46%
Part E		
1	74	66%
2	63	56%
3	96	86%
4	48	43%
Section II		
1	106	95%
2	99	88%
3	38	34%
4	47	42%
5	74	66%
6	80	71%
7	88	79%
8	80	71%
9	55	49%
10	39	35%

TABLE V -- continued

Item	Number of Responses	Percentage
Section II (continued)		
11	71	63%
12	68	61%
13	66	59%
14	77	69%
15	106	95%
16	103	92%
17	106	95%
18	82	73%
19	104	93%
20	90	80%
21	102	91%
* 23	105	94%
24	104	93%
25	91	81%
26	102	91%
27	87	78%
28	86	77%
29	83	74%

*Item number twenty-two duplicated number nineteen so does not appear in the tabulation.

TABLE VI

ADDITIONS TO THE CHECK-LIST

Portion of Check-List	Items added in blanks
Section I	
Part A	Computation of heat units.
	Advanced arithmetic in senior year.
	Thinking problems for rapid calculation.
Part B	Originating their own geometric problems.
Part C	Practical Use of graphs.
Part E	Interpolation in tables.
Section II	
	Making change in business.
	Social Security.
	Writing checks and keeping checking account.
	Legal matters often confusing, i. e., license tags.
	Cost of vacation trips.
	Trends and cycles in inflation prices.