## SOME EFFECTS OF THE WAR UPON THE MATHEMATICS CURRICULUM

 AND THE MOTIVATING FORCES AT WORK AS REFLECTED IN THE DALLAS CITY SCHOOLSTHESIS

## Presented to the Graduate Council of the North Texas State Teachers College in Partial Fulfillment of the Requirements

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## CHAPTER I

## INTRODUCTION

Mathematics may be "likened unto" a stream of water or a great river, capable at times of calamitous destruction and yet if properly harnessed, possessing all the benign properties and possibilities which enter into happy and prosperous living for mankind.

In time of peace due to human frailty, and misunderstanding and wrong concepts, the cry has been:
"River stay 'way from my door." Yet in time of war, when the need for this abundant water is felt, when as Sidney Lanier says in his Song of the Chatahoochie: When the dry fields burn, and the mills are to turn, and a myriad of flowers mortally yearn."

Then it is that our cry becomes:
"Come into my garden for the long black night has flown, for the little bush - itwas once a twig - into a tree has grown."

We do not need to remind ourselves that a bush has now attained the status of a tree, and that if the tree shall bear frujt of its kind it must have water and water in abundance.

Thus in pursuing the paths of peace we are not made mathematically conscious of our need of the mighty force which is to dominate our war effort. Yesterday, while plodding along like the proverbial plow-boy we consumed six months in the building of a cargo vessel; we did not dream that in a single black night of less than eight hours the bulk of
our fleet by a sneak attack from a treacherous enemy -of whose very existence we were ignorant-would be sent to the bottom of the ocean or so badly damaged as to require months and months of time for rem placement.

Little did we dream that the time element was so important that the number of months required to build a battleship at San Francisco could be reduced to less than that number of weeks and all this, we did not realize, is a product of our mathematical engineers working feverishly at blue prints, producing plans, specifications, working models meeting the most rigorous tests and requirements ever devised by the brain of man.

To discuss the effect all this war activity has had upon the Dallas Schools and to voice a protest against those who seek to discredit mathematics and at the same time to contribute a readable thesis upon the subject is largely the purpose of this study.

## What is Mathematics?

First of all, what is mathemetics? According to Webster, mathematics is that science, or class of sciences which treats of the exact relations existing between quantities or magnitudes, and of the methods by which, in accordance with these relations, quantities sought are deducible from other quantities known or supposed; the science of spatial and quantitative relations.

Wathenatics embraces three departments, namely, (1) Arithmetic, (2) Geometry, (including Trigonometry and Conic Sections) (3) Analysis, in which letters are used, including algebra, Analytical Geometry, and

Calculus. Each of these divisions is divided into pure or abstract, which considers magnitude or quantity abstractly, without relation to matter; and mixed or applied, which treats of magnitude as subsisting in material bodies, and is consequently interwoven with physical considerations.

A short definition more aptly referring to pure mathematics was given the writer by a German professor of mathematics in Columbia University as, "The science of avoiding computation."

In endeavoring to define more clearly the three parts of mathematics into which Webster divides the subject, we note that arithmetic is the "science of numbers", or the art of computation by figures and that Sir Isaac Newton gave to algebra the name "Universal Arithnetic."

Geomatry from two Greek words: ge, meaning the land, and metrein, meaning to measure, gave the Greeks the word 'geometria' whence our English word geometry meaning, literally "measuring the earth or land."

Mathematics arose from the absolute necessities of the world to deal with geometric forms, such as land areas in the valley of the Nile, the path of heavenly bodies and with the need for counting and computing. Passing over these early needs in later centuries more complex needs gave rise to the calculus. Today the control of form as in the architecture of bridges, modern skyscrapers, the stream-lining of automobiles and airplanes and of myriad forms useful and artistic is what mathematios means. It has been called the science of related quantities, and everyone is related to something or to someone else; to be is to be related.

It is herewith assumed that whoever sees fit to peruse these pages impelled by either necessity or pleasure or neither is sufficiently
familiar with the subject of mathematics and that therefore no further detailed analysis of its nomenclature is necessary or appropriate.

## REPORTS OF COMITTEES

Reports of War-Time Comittees
The effect upon mathematics teachers in 1942 and 1943 of reports that came to us of draftees and inductees failing in their mathematics tests was anything but pleasant, when we later discovered, however, that not all the blame was jusily laid at our door-and that failure, in many instances, was due to a teacher advisor who counseled against even enrolling in mathematjes courses. We were then able to look our fellow man straight in the eye-and some of us, due to human frailty, could not refrain from saying: "I told you so."

And later when counselors and deans of every high school were urged to "double your enrollment in algebra and triple the number of students taking trigonometry," we were then able to keep our chin up and with fair prospect of keeping it up indefinitely.

The following report ${ }^{1}$ was referred to by our high school supervisor as being most excellent and all teachers of mathematics were urged to make use of the suggestions contained therein.

SUMMARY
To the Mathematics Teachers:
The following sumary of the reports being made by
national wartime committees may help us, not only to add
interest to our reviews for final examination, but also
to serve our country through our students.

1. Mental Arithmetic. Taken ten minutes of each
$1_{\text {Prepared by E. Dice of the North Dallas High School in the summer }}$ of 1943.
class hour from the ninth through the twelfth grades to ask mental-arithmetic questions. While the roll is being taken or after the warning bell has rung, ask an idle boy to substract $3 / 4$ from $1 \frac{1}{2}$. There are nine seconds between sighting an attacking bomber and the release of the bomb. Fancy having time to use a pencill Too many of the 1943 high school boys and girls, caught in the do-only-thepleasant Maelstrom of the last decade, do not know the addition, subtraction, multiplication, and division facts of one-digit integers, much less extended notions. Try adding 7 and 9; subtracting 7 from 9, 9 from 7; multiplying 7 by 9 ; dividing 7 by 9 and 9 by 7 -in nine seconds If any time is left, try the same operations with -9 and -7 , or with $9 \frac{1}{2}$ and $7 \frac{1}{4}$. Paper and pencil, finger counting or tapping should not be allowed; drill for automatic responses.
2. Approximations. War and civilian work require intelligent approximation. A pilot who is his own nagigator has to estimate angles of drift; a homemaker who is her own buyer should know how to estimate the change she is to receive. At least she should know whether it is to be nearer nine cents or ninety-nine cents. With inexperianced salespeople and working mothers, school children will have to estimate money, ration points, and hours. Is $17 \times 19$ nearer 400 or 300 ? Is $200+17$ less than 10? Approxinate reasonable answers for all problems before solving.
3. Formplas and Fractions. These two f's are as important in winning the war as are the two wartine r's; rice and rubber. From arithmetic through Algebra 4, fractions and formulas may be combined. Given $A=1$ w, find $A$ when $1=10$ and $w=2 \frac{7}{2}$; when $1=19.5$ and $w$ 5.25, etc. Use formas for all areas, lateral and total; for volumes; for perimeters; and for interior and exterior angles of polygons. ( $(\mathrm{n}-2) 180$ is used hourly in artjillery.) Substitute common franctions, decimal frantions, common and decimal frantions, and mixed numbers in each formula. Stress the everyday fractions $1 / 2,2 / 3,1 / 4$, etc., not $17 / 19$ or $33 / 35$, though the latter fractions lend themselves to approximation practices. Cumbersome decimal fractions are in constant use. For instance, pieces of tubing 9.875 inches long are needed for certain parts of an airplane. 4. Algebra. In addition to the general suggestions given above, the algebraic topics to be stressed for wartime use are as follows: fundamental operations, easy equations (including proportion), each case in percentage viewed as multiplication with the unknown indicated by a letter, graphs, comon factors (one report added trial-and-error), fractions with monomial denominators (especially those found in formulas), the quadratic equation (two reports asked for only the type $x^{2}=k$ ), and simplification of radicals only as needed in using tables. Topies to be
eliminated or greatly reduced are special products, factors not named above, fractions with other than monomial denominators, all complex fractions, and complex work in radicals.
4. Geometry. Stress informal geometry, scale drawing-using grids (squared paper) to make scale drawings is of great importance-and metric scales; and do sufficient work in arithmetic, algebra, and numerical trigonometry to retain and extend skills previously acquired. The equal angles connected with parallel lines should be recognized upside down or at any slant. These angles are a preparation for artillery. Also include the reflex angle. Formal demonstrative geometry should be put in the background for the present. Field work with the angle, mirror, plane table, sextant, compass (a watch can be used as a compass if the sun is shining), etc., is of value. In solid geometry emphasize the fact that the spherical triangle is necessary for an intelligent understanding of navigation.
5. Trigonometry. Applied trigonometry (including the solution of triangles) is of more value right now than the unit circle, the theory of or the derivation of formulas, and identities. The slide rule, the transit, and the use of the artillery mill are desirable.

Note. This brief summary is merely for possible use during our review weeks. The various reports (see bibliography at end) outline refresher and new courses for all types of students. The reports include the topics to be stressed for the different branches of the armed forces, for technical work, for scientific laboratories, and for industry. Throughout all reports, arithmetic is indeed the "queen of the sciences." Over and over again a plea is made for an emergency course in the twelfth grade for pupils who have not majored in mathematics. It should be nine-tenths arithmetic. Most of the committees call such a course advanced general mathematics and make elementary algebra, intuitive geometry, and nunerical trigonometry "subjects of the queen." The committees feel that mature pupils, even though mathematics is difficult for them, may grasp notions which they could not get when they were younger. The special classes offered in Dallas this spring semester are of this type. The text, Practice in Essential Mathematics, Refresher Course, by Grossnickle-Brueckner-Hance, the John C. Winston Company, Dallas, net price $81 \$$ (paper bound), is sufficiently full for new as well as for refresher work in the essentials. It has many war-time problems which will add interest to regular courses. A desk copy of any new text will likely supply usable material because the practical possibilities of the different phases of mathematics are being recognized daily.

Continuity of trainjng cannot be over-estimated. The sequence courses should be kept intact for those who have ability and mathematical aptitude. The more fine points the possible $10 \%$ to be selected for post-induction training can get, the better. Moreover, boys and girls who can learn mathematics will be needed for laboratory technicians and for research workers. If the war lasts long enough, civilian needs may become so argent that another $10 \%$ will have to be trained to do non-military work.

The 1943-44 counselors should be urged to triple the number of pupils taking trigonometry, to double the number taking algebra, and to encourage boys and girls who have ability to take solid geometry. Mathematics teachers should strive for close correlation with physics, biology, and chemistry. Teachers who learn definite applications of mathematics in military work certainly enliven as well as clarify certain topics; but the Army, the Navy, and the Civil Aeronautics Administration assured the committee who wrote Pre-Induction Courses in Mathematics (see bibliography) that if the elementary and secondary schools would teach basic mathematics thoroughly, that neither post-induction nor college mathematics would be difficult. This committee, after studying from twenty to fifty instructional manuals of each division and conferring with their leaders, agreed that basic mathematics, thoroughly taught and thoroughly learned, is the greatest contribution that can be offered by our public schools.

It is to be understood that omission of some phases of pure mathematics-for instance, numerous theories originally developed merely for the joy of learning have eventually benefitted mankind-is an emergency measure for the duration only; though it is to be hoped that this experience may improve the content and the teaching of mathematics as well as silence the omit-mathematics-and-domonly-the-pleasent-educationists. A Fortune survey printed in the December issue, shows that high-school youth have decided, though not al-ways tolerant, views concerning mathematics and teachers. It is a challenge to cur profession. We should try to imm prove both subject matter and teachers.

## Bibliography

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Science Teaching, and the two men named above from the Mathematical Association of America. These two men are also members of the National Council of Teachers of Mathematics.)

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Hart, Wm. L. "Progress Report of the Subcommittee on Zducation for Service of the War Preparedness Committee of the American Mathematical Society and the Mathematical Association of America with the Cooperation of the National Council of Teachers of Mathenatics and the Central Association of Science and Mathematics Teachers, " American Mathematical Monthly, Vol. 48, No. 6, June-July, 194l. Also, Mathematios Teacher, XXXIV (November, 1943), 297-304.

Kadushin, J. "Mathematics in Present Day Industry," Mathematics Teacher, XXXV (October, 194 ), 260-264. (Mr. Kadushin is in the Education Department of Lookheed Airoraft Corporation's Industrial Relations Office.)

Mallory, Virgil S., and Fehr, Howard. F. "Mathematical Education in War Time," Mathematics Teachers, XXXV (November, 1942), 291-298.

Mathematics Department of the United States Military Acadeny at West Point. A brochure on types of military problems involving only the use of elementary mathematics, prepared for high-school teachers of mathematics and reprinted by the Institute of Military Studies, University of Chicago, Chicago, Illinois.

Reeve, W. D. (Editor). Seventeenth Yearbook of the National Council of Teachers of Mathematics (A Source Book of Nathematical Applications) Bureau of Publications, Teachers College, Columbia Uniyersity, New York, 1942.

Roper, Elmo. What High-School Students Think," Fortune, December, 1942. (Sumnarized in The Education Digest, VIII (January, 1943, Cover 4.)

Smith, R. R. "Pre-Induction Courses in Mathematics," Mathematics Teacher, XXXVI (March, 1943), 114-124. (This report is by members of the United States Office of Education and of the National Council of Teachers of Mathematics. It has been submitted to and approved by the National Policy Committee for the High-School Victory Corps; the Civilian Pre-Induation Training Branch, Industrial Personnel Division, Services of Supply, War Department; the Training Division, Bureau of Naval Personnel, Navy Department; and the Civil Aeronautics Administration, Department of Commerce.) This report is also found in Education for Victory, VoI. I, No. 27 (A pril 1, 1943), 12-17.

Shuster, Carl N. Wathematics in Relation to Curriculum Adaptations, Pre-Induction Courses, and the Wictory Corps," Mathematics Teachers, XXXVI (April, 1943), 171-174. (This report is by the Defense Comittee of the National Council of Teachers of Mathematics and the Curriculum Advisory Committee of New Jersey.)

Stoddard, A. J. What the Schools Should Teach in WarTime," The Educational Policies Commission, Washington, D. C. (1943, $32 \mathrm{pp}$. ).

Wartime Handbook for Education. Curriculum Emphasis, Chapter VIII, pp. 18-33. Washington: National Education Association of the United States, 63 pages. (Reviewed in The Education Digest, VIII, March, 1943, 1-6.)

Report of the National Council
In September of last year (1944), every teacher of mathematics in the Dallas City Schools was given the following information: ${ }^{2}$

On February 25, 1944, the Board of Directors of the National Council of Teachers of Mathematics created the Post-mar Policy Commission for the study and improvement of mathematics program for the nation's schools in the post-war period. The first results of the Commission's thinking are embodied in a brief report which appeared in the May, 1944, issue of the Mathematics Peacher, reprints of which may be secured from the office of the Mathematics Teacher, 525 West 120 St., New York, 27 , N. Y. In this report the Commission pointed out that:

1. The school should insure functional competency in mathematics to all who can possibly achieve it.
2. We should differentiate on the basis of needs, without stigmatizing any group, and that we should provide new and better courses for that very large part of the schools' population whose mathematical needs are not well met by the traditional sequential courses.
3. Ne need a completely new approach to the problem of the somcalled slow learner.
4. The teaching of arithmetic can be and should be improved.
5. The traditional sequential courses in mathematics should be greatly improved.
The fundamental purposes of the Commission may be briefly sumarized as follows: to evaluate current mathematical

[^0]offerings of the nation's schools from Grade 1 through 14; to utilize the experience derived from the mathematical training programs of the armed forces; to find out to what extent the various phases of these programs have a counterpart in the problems and tasks of civilian life; to focus attention on shortages discovered in the mathematical training of competent young men coming from supposedly good schools; to consider possible remedial measures for improving the low competence in dealing with the fundamentals of arithmetic, as revealed by Army and Navy tests; to explore the possibilities of providing worth-while and essential mathematics courses for those students who have so often been overlooked or neglected in the preparation of the usual ourricula; and to encourage teachers to become better acquainted with, and to make wider use of multi-sensory aids such as have been developed and extensively used in connection with the mathematical training program of the armed forces.

When originally established, the Post-war Policy Commission consisted of five members; since then the personnel has grown to somewhat more than twice that number. At the present time the Commission is vigorously pursuing its major purposes by means of research, correspondence, personal interviews, and group discussions. Its second report is progressing rapidly and satisfactorily. It will probably be released in September, 1945. This report, somewhat more comprehensive than the first, will also be more concrete and specific in its recomendations. The Commission proposes to set forth certain positive, constructive theses which it is prepared to defend, and which are the result of its sober judgment and careful thinking, based upon the best evidence available. These propositions are not to be regarded in any sense as final or perfect, nor are they offered in a dogmatic spirit. They do, however, reflect the sincere convictions of the group as a whole, and it is earnestly hoped that they will influence the thinking of others for the ultimate good of all concerned.

Specifically, the Second Report of the Post-War Policy Comission will deal with the following problems and issues:

1. Improved Teaching of Arithmetic.
2. Functional Competency in Mathematics.
3. The Mathematics of the Junior High School.
4. The Traditional Sequential Courses in Mathematics.
5. Courses Differentiated According to Needs.
6. Mathematics in the Small High School.
7. Counselling in Connection with Mathematics.
8. Multi-Sensory Aids in Mathematics.
9. Mathematics in the Junior College.
10. The Education of Teachers with Respect to Arithmetic and other Branches of Mathematics.

The Commission will at all times be grateful for any suggestions and comments, as well as the reactions of readers to its published reports. Frank criticism as well as helpful ideas will be welcome.

## Admiral Nimitz' Report

A by-product of the war is the revitalization of mathematics. With mathematics in every phase of war-and in every phase of peace,-though not always recognized as such-meachers of mathematics must furnish an exhibition of marvelous self-control in not saying: "I told you so" to educators who have minimized the value of this basic science. Not only have they minimized and made mathematics elective, but in many instances, they have dropped it from their high school. curriculum.

This absurd, deplorable attitude toward mathematics has hampered our war efforts, and has cost us money, time and men. Admiral Chester W. Nimitz, in a report dated November 12, 1941 said:

A carefully prepared selected examination was given to 4200 freshmen at 27 of the leading universities and colleges of the United States. Sixty-eight per cent of the men taking this examination were unable to pass the arithmetical reasoning test. Sixty-two per cent failed the whole test which included also arithmetical combinations, vocabulary and spatial relations, the majority of failures were not merely border line, but were far below passing grade. The same lack of fundamental education presented and continues to present a major obstacle in the selection and training of midshipmen for commissioning as ensigns V-7, of 8,000 applicants, all college graduates, some 3,000 had to be rejected because they had no mathematics or insufficient mathematics at college.

The experience which the Navy has had in attempting to teach navigation in the Naval Reserve Officers : Training Corps units and the Naval Reserve Midshipmen Training Program ( $V-7$ ) indicates that 75 per cent of the failures in the study of navigation must be attributed to the lack of adequate knowledge of mathematics.

With such a report as the above and coming from such an authoritative source the mathematics teachers of Dallas were not at all surprised at the statement of our high school supervisor to the effect that: "Instead of being complacent over the proved importance of our subject, we should, beginning September 11, 1944 work as we have never worked beofre, to keep mathematics in its rightful place, 'in the sun'."

Two main objectives of an outline furnished teachers of mathematics at that time were:

1. To list essential fundamental topics in pure mathematics.
2. To list a few of the exact uses of the various fundamental topics.

These topics, we were told, should be mastered to the extent that our armed forces from Berlin to Tokio, can apply them with intelligence and to the extent that future civilization may not be hampered by "halfbaked" notions of mathematics. The Army, the Navy and the Civil Aeronautics Administration assured the Committee who wrote Pre-Induction Courses in Mathematics ${ }^{3}$ that if the elementary and secondary schools would teach basic mathematics thoroughly, neither post-induction nor college mathematics would be difficult. This Preunduction Comoittee after studying from twenty to fifty instructional manuals of each divis sion and conferring with their leaders, agreed that basic mathematics thoroughly taught and thoroughly learned, is the greatest contribution that can be offered to our war efforts by the teachers of mathematics in our public schools.

[^1]
## CHAPIER III

BROADENING OUR SCORE

Under topics referred to as "fundamental" they are the same essential topics which have always been emphasized by the experienced teacher of mathematics, in fact a recital of them here is deemed unnecessary since it resembles very closely the table of contents of nearly any good standard text in the respective subjects of arithmetic, algebra, geometry and trigonometry. There is, howerer, one important exception to the above, that of navigation. The topic, navigation, is more significant than was the case a few years ago when a navigator was thought of only as one who directed the course of a vessel at sea.

Today, however, we have new concepts of navigation; not only is the navigator required to study minutely the details involving regular scheduled routes such as from New York to Liverpool, but he must familiarm ize himself" with the behavior of currents, depth, capacity, and character of harbors all over the world. Indeed the navigator mast know the sea, the earth and the sky and the waters down under the sea. Marine Navigation calls for celestial navigation. Polaris must serve as a reckoning point in the northern hemisphere and the Southern Cross when south of the equator. And when neither constellations are visible the compass and $\log$ of the vessel are relied upon to furnish "dead reckoning." In fact we are having so many different kinds of navigation
that recently we have coined a new word "avigation," meaning the navigation of the air by an aviator or pilot.

The demand for aviators, pilots, aeronauts (this last word is now largely supplanted by the new word avigator) bombers, paratroopers, technicians, machinists, etc. has become so great that it was necessary to inaugurate the subject aeronautics. A better name in keeping with our new ideas above referred to would perhaps be avigation.

The following is representative of an entire year's work in the subject both as to topics and the time required for each:

Dallas High Schools
Dallas, Texas

AERONAUTICS 1-2
(Tentative Outline)

$$
\text { Session } 1944-45
$$

Textbook: Science of Pre-Flight Aeronautics for High Schools, Aviation Education Research Group, Teachers College, Columbia University. The Macmillan Company, Dallas, 赖.32.

First Semester, pp. 1-436
First Division, pp. 1-148
Second Division, pp. 149-287
Third Division, pp. 288-434
Second Semester, pp. 436-791
First Division, pp. 436-587
Second Division, pp. 588-764
Third Division, pp. 765-791

Aeronautics 1

Book I. Principles of Airplane Structure
Part I. Aircraft History and Design
Ch. 1. Development of Aircraft, pp. 1-15, 2 days
Ch. 2. Types of Airplanes, pp. 16-22, 1 day
Ch. 3. Recognition of Aircraft, pp. 23-39, 5 days
Part.II. Airplane Materials and Stresses
Ch. 4. Aircraft Materials, pp. 40-53, 3 days Ch. 5. Stresses on Airplane Structure, pp. 54-67, 3 days

Part III. Structure of Parts of the Airplane
Ch. 6. Airplane Wing Structure, pp. 69-87, 3 days
Ch. 7. Fusilages, pp. 88-105, 3 days
Ch. 8. Landing Gears, pp. 106-118, 2 days
Ch. 9. Empennage (Tail Structure), pp. 119-126, 1 day
Ch. 10. Safetying, pp. 127-135, 1 day
Ch. 11. Operation of Controls, pp. 136-145, 2 days

Second Division
Book II. Human Factors in Flight
Ch. 12. Flight Regulations of the C.A.A., pp. 149-169, 10 days
Ch. 13, Certification of Pilots and Planes, pp. 170-177, 4 days
Ch. 14. The Human Body and Its Limitations, pp. 178-189, 2 days
Book III. Aerodynamies
Part I. Keeping the Plane Aloft
Ch. 15. Scientific Principles Underlying Lift, pp. 192-206, 3 days
Ch. 16. Forces on the Wing, pp. 207-221, 2 days
Oh. 17. Factors Affecting Lift, pp. 222-231, 1 day
Part II. Moving and Controlling the Airplane in the Air
Ch. 18. Drag and Power Considerations, pp. 232-241, 1 day
Ch. 19. Propellers, pp. 243-249, 1 day
Part III.
Ch. 20. Longitudinal Stability, pp. 250-261, 1 day
Ch. 21. Lateral and Directional stability, pp. 263-271, 1 day
Ch. 22. Control Surfaces, pp. 272-279, 1 day
Ch. 23. High lift Devices, pp. 280-287, 1 day

Book III. Aerodynamics (Continued)
Part IV. The Plane in Flight
Ch. 24. Climbing Flight, pp. 288-293, I day
Ch. 25. Gliding Flight, pp. 294-303, 1 day
Ch. 26. Taking off and Taxiing, pp. 304-309, 1 day
Book IV. Aircraft Engines
Part I. Construction and General Principles
Ch. 27. Principles of Aircraft Engines, pp. 311-325, 2 days
Ch. 28. Engine Requirements and Types, pp. 326-331, 1 day
Ch. 29. Airplane Engine Construction, pp. 332-349, 3 days
Part II. Cooling and Lubricating Systems
Ch. 30. Aircraft Engine Cooling Principles, pp. 350-356, 1 day
Ch. 31. Aircraft Engine Lubricants, pp. 357-365, 1 day
Ch. 32. Engine Lubrication Principles, pp. 366-371, 1 day
Ch. 33. Aircraft Engine Fuels, pp. 372-378, 1 day
Ch. 34. Carburetion Principles, pp. 379-397, 2 days
Ch. 35. Principles of Ignition, pp. 398-4i33, 2 days
Part III. Instruments and Propellers
Ch. 36. Aircraft Engine Instmments, pp. 414-426, 2 days Ch. 37. Propellers, pp. 427-435, 2 days

Review and Final Examination: I week

## Aeronautics 2

First Division
Book V. Meteorology
Part I. What Causes Weather?
Ch. 38. Nature of the Atmosphere, pp. 436-455, 3 days
Ch. 39. The Role of the Sun in Producing Weather, pp. 456477, 3 days
Ch. 40. The Moisture of the Atmosphere, pp. 478-501, 4 days
Ch. 41. Clouds and Air Stability, pp. 502-524, 4 days
Ch. 42. Air Masses, pp. 525-539, 4 days
Ch. 43. Fronts, pp. 540-562, 6 days

Part II. How Weather Forecasts are Made and Distributed
Ch. 44. Obtaining the Necessary Weather Data, pp. 563-575,
2 days
Ch. 45. Maps, Charts, and Forecasts, pp. 576-587, 2 days

## Second Division

Part III. What the Efficient Airman Does about Weather Hazards
Ch. 46. Perils of Storm and Ice, pp. 588-601, 3 days
Ch. 47. Other Weather Hazards, pp. 602-615, 2 days
Book VI. Commanications (Optional)
Ch. 48. Introduction, pp. 624-627, 1 day
Ch. 49. The International Morse Code, pp. 628-635, 2 days
Ch. 50. The semaphore, pp. 636-641, 1 day
Ch. 51. Principles of Radio, pp. 642-661, I day. (Only brief treatment of radio)

Book VII. Air Navigation
Part I. Charts
Ch. 52. Chart Projections, pp. 665-679, 2 days
Ch. 53. Chart Reading, pp. 681-697, 4 days
Part II. Piloting
Ch. 54. Contact Flying, pp. 698-707, 3 days
Part III. Dead Reckoning
Ch. 55. Instruments, pp. 708-726, 4 days
Ch. 56. Basic Problems of Dead Reckoning, pp. 727-748, 4 days
Ch. 57. Wind Triangle, pp. 749-764, 3 days

Third Division
Ch. 58. Interception, pp. 765-776, 8 days
Oh. 59. Radius of Action, pp. 777-791, 12 days
Fifth Week
First Day: Review of C.A.R.
Second Day: Review of Engines and Theory of Flight
Third Day: Review of Meteorology
Fourth Day: Review of Navigation
Fifthr Day: Test on These Topics
Sixth Week: Final Examination

## COMITHEES ${ }^{\text {I }}$

C. V. Ballard, Chairman Guy Allen
Mildred Carter
Buford A. Cates
Lillie Mae Finnegan
E. M. Fulton

Bailey Hargrave
W. F. Hunter

Approved: W. T. White<br>Assistant Superintendent<br>in Charge of High Schools

9/1/44

## Supervisory Suggestions

In September 1944 the Dallas Board of Education issued a pamphlet
to mathematics teachers which contained the following suggestions:
Plane Geometry Suggestions
I. Vocabulary. Build a usable geometrical vocabulary. Without a working knowledge of geometrical words, geometrical thinking is impossible. Be able to illustrate and to recognize each word. Try to be exact; for instance, if talking of a "radius" or a "chord", say "radius" or "chord"-not this "line".
II. Observation. Search nature, art, and industry for geometrical forms. Note the forms which are congruent, proportional, similar, symmetrical, etc.
III. Experimentation. Use measurements with ruler and protractor, paper cutting, and paper folding to discover geonetrical truths.
IV. Construction. Encourage practice with ruler and compasses to discover further truths. State that the proofs of the constructions are to come later. Gradually develop an apprecation of accuracy, ability, to visualize, and the uses of construction in drafting and indirect measurements.
V. Nature of proofs. Use directed study to introduce demonstrative geonetry; for assignments which students

The personnel of this committee is composed of mathematics teachers
he Dallas Public Schools, Dallas, Texas. in the Dallas Public Schools, Dallas, Texas.
cannot prepare with understanding invite momorization, create dislike for geometry, and build up wrong notions. Study with open books. Emphasize the fact that a reason from a group of accepted reasons (assumptions, previously proved theorems, etc.) has to be given as an authority for each statement made. For instance, given $\mathrm{a}=\mathrm{b}$ and $\mathrm{d}=\mathrm{d}$, select an assumption which gives one the authority to say $a+c=b f d$. Discuss intelligent selections. For instance, one would not likely select "two angles and included side" to prove two triangles congruent if two sides are given equal. Any individual may choose his own assumptions just as Euclid or the author of a text chose his. Of course, if the chosen assumptions are wrong, the proofs based on these assumptions are wrong; hence, assumptions in life where prejudices and feelings are involved should be carefully examined. Each week one may borrow one or two life problems from Professor Fawcett (Thirteenth Yearbook of the National Council of Teachers of Mathematics), but numerous proofs from elementary geometry offer the beginner more reliable practice material in the nature of proof and in precise thinking. Geometrical proof's should, with conscious effort towards transfer of training, eventually school one to examine everyday propositions with some degree of accuracy.
Solid Geometry
Note: Solid Geometry is recommended in a recent statement of the College Entrance Examination Board with respect to its new Comprehensive Mathematics Test. Solid Geometry Suggestions
I. Three-dimensional thinking. Help the pupil to build spacial concepts, to develop imagination, to extend two-dimensional thinking to three-dimensional thinking, and to learn more of the nature of proof.
II. Formulas. Derive solid-geometry formulas and use these formulas to solve problems of form and structure. Notice that the formulas used in arithmetic and algebra are proved and given meaning in plane and solid geometry. Frequently the race is benefitted by using the product of pure mathematical thinking without realizing the origin of this prom duct. Lose no opportunity to emphasize these origins.
Trigonometry
Note: The ensineer-minded instructor is tempted to skim or omit identities. War needs support this practice; however, we should bear in mind that trigonometry is a college-preparatory course and that identities are important in college mathematics.

## Alsebra 4

Note: If time has been saved, as suggested, during the
first twelve weeks, there should be time to do more than merely skim the topics of Algebra 4. Previously too much time has been devoted to review of Algebra 1, 2, 3. Pupils who do not elect Trigonometry should, with individual instruction from teacher and classmates, study the elementary principles--including logarithmsso as to be able to apply them in college mathematics. Since the trend in most schools is to present these topics as early as the junior high school, college professors under-rate pupils who cannot read tables or apply easy laws.

## Algebra 4 Suggestions

I. Vocabulary. Students of Algebra 1-3 are hesitant about using mathematical terms. This awkward mathematical vocabulary gives the college instructor a bad impression and should be remedied in Algebra 4. Furthermore, a college freshman cannot follow the lecture of his professor unless he knows that a first-degree equation is the same as a linear equation, that solving imprt for r is the same as changing the subject of the formula to r , etc.
II. Time. Important time-saving devices are these: (1) long assignments, (2) definite outlines, (3) incidental reviews or reviews as needed ( $A$ student can and will review out of class if he sees that there is to be no set review, sees that the class is on a time schedule, and sees an "F" between him and his diploma. He can study with other pupils and his prepared class question can be on an Algebra 1-3 topic which has never been clear to several of his classmates, etc.), (4) a basic or unusual exercise on the board to be thought of while the roll is being checked, (5) an exercise assigned to an indiVidual who will explain it to the class on a specified day, (6) fifteen minutes of each hour to lay foundations for subsequent difficult topics or topics which have to be assimilated gradually, (7) one or two definite questions carefully thought out by students to be answered daily or weekly by the teacher (Spontaneous pertinent questions answered at intervals, too, of course, though random questions and the endless ramifications of a fine point can play havoc with the time budget necessary for a crowded course), and (8) brief questions to be answered orally as well as important facts and agreements to be wedged in between bells. (One important agreement is the standard one pertaining to the order of the fundamental operations.)

Note: Breslich says that much time is often wasted by attempting to draw from the pupil, by means of questions, information and knowledge which he does not possess and therefore cannot give.
III. Theory. Since the more mature students of this course should be able to appreciate the theory back of opera.tions and laws which have hitherto been more or less mechanical, both old and new topics should be presented with this thought in mind.

Uses of Mathematies
The most oustanding use of any topic in any branch of mathematics is the part it plays as the supporting princiole of subsequent principles. For instance, the four fundamental operations in algebra are supporting principles of the equation; the equation supports the problem or becomes a formula. Problems and formulas are used to make dollars; and making dollars is a use which justifies learning to individuals who are unwilling to study for mental satisfaction. Moreover, continuous attention to the way in which each principle supports each succeeding principle until finally a dollar-and-cents-isable combination of principles is reached (1) makes clear the beautiful relationships in mathematics; (2) enables the student to use these relationships to review and to remember the intricate mechanical processes of the subject; and (3) becomes perchance a factor in the building of an orderly mind.

The National Council of Teachers of Mathematics Seventeenth Yearbook, A Source Book of Mathematical Applications, classifies the uses of mathematics under arithmetic, algebra, geometry, and trigonometry; gives, in alphabetical order, dozens of uses and sub-uses of specific topics such as angles, circles, fractions, etc.; and includes problems, illustrative drawings, and solutions. In the following brief outline only a few suggestive topics, most of which occur in all branches of mathematics could be sketched. These uses may be supplemented by further reading, by personal experience, and by conferences with other teachers. Conferences with the teachers of physics and of shop should be especially fruitful because the Fundamentals of Electricity include information and understanding which are basic to thirty-five army occupations; the Fundamentals of Machines, to twenty-five; the Fundamentals of Radio, to thirteen; and the Fundamentals of Automotive Mechanics, to twenty-six. Of course mathematios is basic to all ninetynine of these occupations, and to an incalculable number of other occupations.

Naturally, the 1944 student, as well as his teacher, is most interested in war needs; yet neither teacher nor
pupil should lose sight of the multitudinous uses of mathematics in peace.
I. Integers. Serial numbers on identification tags and rifles contain as many as eight digits. The national debt may contain several times eight digits. Integers are used in reading stock lists, in equipment numbers, in speedometer mileage, in radio frequencies, in blue-prints, in counting off in infantry drill and in automotive units and in pacing to determine distances.
II. Fractions. Fractions are used in calculating seam allowances, in finding tap and die sizes, in calculating depth of cut in machine work, in determining amounts of ingredients in mixtures (in cooking, in mixing concrete, etc.), in making pay deductions, in marking weather maps, in figuring difference between the earth's north and magnetic north, in figuring position of airplane betwreen two isogonic lines.
The daily page of the Air Almanac gives the G.H.A. (Greenwich Hour Angle) for 10 minute intervals, thus necessitating interpolation. Interpolation involves fractions, usually in proportion form. Dentists use proportion to change gold from higher to lower carat. In photograph proportion is valuable in showing comparisons of enlarged pictures. The musical effect of two tones sounded together depends upon the ratio of the frequency of their vibrations. To save wood Japan reduced the standard diameter of match stioks from . 072 to .06 of an inch. A man's hat, size $63 / 4$, fits a head measuring $211 / 4$ in.; size $67 / 8$ fits $215 / 8$ in. Hat sizes increase by 1.8 to correspond to $3 / 8$ in. increase in head size. The complex fraction is used in electricity to calculate resistances and capacities in parallels and series respectively. Algebraic fractions are indispensable in the work of the Signal Corps. In collaboration with the Men's and Women's Mathematics Clubs of Chicago the Signal Schools have made large posters showing the many uses of mathematics in the Signal Corps. These posters may be had by addressing Signal Schools, 6th Service Command, 20 N. Wacker Drive, Chicago, Illinois.
III. Graphs. Graphs are used in determining direction in heavy gun fire, in discovering the location of artillery, in determining the height of points on a terrain (from a map showing contour lines), in scouting and reconnaissance, in radio and signal commnications. in airway traffic control, in seacoast artillery, in "wave form" in radio, in statistics (the statistical graph is used in constructing bomb-proof shelters), in blueprint reading, stc.
IV. Formilas. A national committee (see p. of this outline) says "formulas are used in practically all branches of the armed services." They are equally important in peace, especially the evaluation of formulas. A few interesting formulas are these:

1. The area and volume formulas in plane and solid geometry are used in studies of wing loading, design of planes, selection of structural materials, etc.
2. A close approximation to the normal weight of an individual over 5 feet in height is given by the formala $w=5.5(\mathrm{~h}-60) \neq 110$ ( h being height in inches): for individuals less than 5 feet tall, use w $=110-5.5(60-\mathrm{h})$.
3. The total number of hours h of sleep which a child should have in one day is $h=8+\frac{18-a}{2}$
(a being age in years).
4. The blood pressure $P$ of a person should be $P=110 \neq \frac{a}{2}$ (a being age in years).
5. The focal distance $f$ of a lens may be determined by measuring the distance $\alpha$ from some object to the lens and the distance $\overline{1}$ of its image from the lens: $\frac{1}{f}-\frac{1}{d} \neq \frac{1}{I}$.
 where $L$ is inductance and $C$ is capacity.
6. On a dry road with the best of braking conditions a car traveling at the rate of $\underline{\underline{r}}$ miles per hour can stop in d feet after danger is realized: $d=.045 r^{2}+1.1 \mathrm{r}$.
7. The effect of a drug is modified by many conditions, the age of the patient being one. Young's rule is $d=\underline{a}+12$ where $\underline{a}$ is the age of the child and d a is the denominator of a fraction the numerator of which is 1 ; then $1 / d$ times the adult dose is the dose for the child. 9. $P=.004 \mathrm{v}^{2}$. Pressure of wind (in lbs. per sq. ft.) gainst a vertical surface is approximately $.004 \mathrm{v}^{2}$ where $\mathbb{Z}$ is the velocity in miles per hour.
V. Triangles. Triangles are used in technique of fire, in aiming circle, in machine cams, in cylindrical drums, in optical instruments, in carpentry, in field artillery (indirect fire for concealed location for guns, elevation of gun-mangle of site or angle of elevation or depression from gun to target), in resultant of motion (diagonal of parallelogram, hence involving a triangle), etc.
VI. Circles. Circles are used in measurements. A mil is about 1.6400 of $360^{\circ}$. As yet schools have no
tables for using mils. A radian is about $5^{\circ}$; remember 1/ 6 of the circle is $60^{\circ}$ and the length of the chord of this $60^{\circ}$ arc is the radian. The rotation of the earth and the seeming movement of the stars gives a "sidereal" day of 23 hrs .56 min .4 sec . This day is considered in navigation. Small circles and great circles on a sphere should be connected with circles of latitude and meridians of longitude on the earth's surface and with great-circle sailing. (Relations of figures on a sphere lead directIy to terrestrial geometry). Circles (arctic, anarctic, etc.) separate zones; the tropical, subm tropical, cyclonic, etc. All of these are used in celestial navigation.
VII. Constructions. Constructions are used in making maps and charts employed in meteorology, in navigation, in aeronautics, etc. (In aeronautics constructions are used in measuring dimensions drawn to scale of landing strips, enlargements of landing fields, international use of airways, possible vast new commercial markets, wing shapes, placing of wingslow, middle, high, umbrella, etc.--tail structures, etc.)
VIII. Similarity. The principle of similarity is used in relationships anong automotive parts, in pattern making, in recognition of airplanes in flight, in map construction, in drafting, in forestry, in photography, etc.
IX. Exponents. Exponents are used in formalas and are extensively used in higher mathematics. (One of the examinations given by Texas A. and M. College to entering freshmen this sumer contained exponents only.)
Algebra 2
8. The effective horsepower of a motor is 980. This is 980 . This is $83 \%$ of the rated horsepower. What is the rated horsepower? (Answer, 1181 hp. )
9. Using $C=5 / 9\left(F-32^{\circ}\right)$, find (a) the Centigrade temperature if the Fahrenheit temperature is $44.5^{\circ}$; (b) the Fahrenheit temperature if the Centigrade is 490; (c) the temperature at which the readings on the Centigrade and on the Fahrenheit scales are equal. (Answers: (a) $6.9^{\circ}$; (b) $120.2^{\circ}$; (c) $-40^{\circ}$.)
10. A listening post 62 miles away from an airdrame warns that an enemy bomber is over the post and is headed at a very low altitude directly for the airdrome. The bomber's speed is 190 miles per hour. If an interceptor requires 2.5 minutes to take off, and it flies at 310 miles per hour, how long after
receiving the warning will it be before the enemy plane is intercepted? (Answer, 9 minutes)
11. A boy weighing 100 lbs . is seated 8 feet from the fulcrum (point of support) of a teeter board. Another boy weighing only 70 lbs . is seated on the other side of the board. Where must the second boy sit in order to create a balance? (Answer 11.4 ft. )
12. Ignoring the weight of a bar 4 ft . long, find its center of gravity if a 2 lb . weight is suspended from one end and a 7 Ib . weight from the other end. (Answer, $8 / 9 \mathrm{ft}$. from 7 lb . weight)
13. The rate of climb $r$ of an airplane in feet per minute is given by the formula, $r-33.000 \mathrm{H}$ where $H$ rem presents the available $\quad$ horseporer, and $W$ is the weight of the airplane in pounds. What is the rate of climb of an airplane weighing 22,000 lbs., if the available horsepower is 1650? (Answer, 2475 ft . per min.)
14. An airplane has a ground speed of 172 knots directly away from an airplane carrier, and has a possible speed of 164 knots back. It has a gas supply for 2 hours. After how long a time must the pilot turn back to the carrier? (Answer, 58.6 min.)
15. A pilot flies a certain distance with a tail wind. If his air speed (that is, without considering the wind) is 210 miles per hour, what is the velocity of the tail wind if it takes him 2.1 hr . to go, but 2.7 hr . to return? (Answer, 26 miles per hr .)
16. Two bombers set out at the same time from two bases 630 miles apart and fly towards each other with speeds of $200 \mathrm{~m} . \mathrm{p} . \mathrm{h}$. and $220 \mathrm{~m} . \mathrm{p} . \mathrm{h}$. respectively. After what time will they meet, and how far has each gone? (Answers: $1 \frac{1}{2} \mathrm{hrs}. ; 300 \mathrm{mi} \cdot ; 330 \mathrm{mi}$. )
17. A bomber carries a certain number of $448-1 b$. bombs and 5 times that number of $56-10$. bombs. If the total weight of the bombs is 2912 lbs.e; find how many heavy and light bombs there are. Answers: 4; 20)
18. The wing span of a Whitiley bomber is approximately twice that of a Vought F4J-1 and 4 ft . more. If 10 Whitleys side by side take up the same space as 21 Voughts side by side, find the wing span of each. (Answers: 40 ft.; $84 \mathrm{ft}$. )
19. Two light bombs and 5 heavy bombs weigh 672 lbs., while 4 light bombs and 3 heavy bombs weigh 560 lbs. Find the weight of each. (Answers: $56 \mathrm{lbs} . ;$ 112 lbs.)
20. If an airplane is traveling with the wind, its ground speed is 190 mph , but if the wind is dead against it, its speed is 110 mph . Find the speed of the plane in still air, and also the speed of the wind. (Answers: $150 \mathrm{mph} ; 40 \mathrm{mph}$.
21. An ordnance factory, in producing 70,000 of a certain type of aerial bomb, used 3,780,000 lbs. of explosive. If 10 lbs . less were required for a new type bomb, how many could be made, using 136,000 lbs. of explosive more than was used under the first contract? (Answer: 89,000.)
22. A bomber squadron passes overhead en route to its objective 420 miles ahead. The speed is estimated to be 210 miles per hour. Six minutes later the fighter escort is heard overhead, but due to lowlying clouds the fighters' speed could not be estimated. How fast were they going if they overhauled the bombers 50 miles short of the objective? (Answer: 222.6 m. p.h.)
23. A destroyer convoying a group of ships moving due west at 10 knots leaves the convoy and tracks a submarine due south for two hours at 25 knots. What speed must the destroyer make to rejoin the convoy in $2 \frac{3}{2}$ hours? (Answer: 26.9 knots.)
24. A meteorological balloon is freed from a coastal airport. If it rises 3 ft . for every 8 in . of horizontal drift, how high would it be when directly over an observer $3 \frac{1}{4}$ miles away in the direction of drift? (Answer: $145 / 8 \mathrm{mi}$.
25. A shore battery has scored 30 hits and 24 misses on a towed target. They still have 16 more shells to fire. How many hits must they get to obtain an average of 60\%? (Answer: 12.)
26. One cruiser, by reason of its higher speed, can cover a specified patrol area in 3 days while a second cruiser can do it in 4 days. How many days will it take both to cover this area? (Answer, $15 / 7$ days.)
27. How much zinc mast be added to 50 lbs . of an alloy of equal parts tin and zinc to make a new alloy which is 70\% zinc? (Answer: $331 / 3$ Ibs.)
28. A mixture of 5 gals. of glycerine and 3 gals. of water is available for filling the recoil cylinders of a deck gun. For winter maneuvers, a mixture of $3 / 4$ glycerine is needed. How much water or glycerine mast be added? (Answer: 4 gal. glycerine.)
29. A marksman fires a ranging shot at a metal target and hears it strike 5 seconds after firing. If sound travels at 1100 ft . per second and the velocity of the bullet is 1860 ft . per second, what is his range? (Answer: $3456 \mathrm{ft}$. )
30. An airplane has a fuel capacity of 200 gallons, and it uses 200 liters per hour. How long could this fuel last? (1 liter - 1.06 qts.) (Answer: 3 hr . 46 min.)
31. A long-range bomber when cruising at $160 \mathrm{~m} . \mathrm{p} \cdot \mathrm{h}$. uses 20 gal. of gasoline per hour. How many gallons would be used on a 20000 mile journey? (Answer: 250 gal.)
32. A Hawker Hurricane has an initial climb of 2400 $f t$. per minute. How far does it climb in 36 seconds at this rate? (Answer: $1440 \mathrm{ft}$. )

## CHAPTER IV

## SECOND REPORT OF COMISSION ON POST-MAR PLANS

Since preparation of first part of this thesis was begun the Second Report of the Commission on Post-War Plans has been made available and this report is expected to influence the course of study and our program of instruction during the coming year of 1945-16.

This report is too long to be repeated in full; it consists of thirty-four theses, all dealing with the conditions which we have reason to believe will exist after the war with Japan is over.

Twenty of these theses deal with grade school and high sohool courses, the remaining fourteen deal with the junior college, the education of mathematics teachers and multisensory aids in mathematical instruction.

They are in part as follows:
Thesis 1. The School Should Guarantee Functional Competence in Mathematics to All Who Can Possibly Achieve It. Is it fair to ask? "Does anyone know what we mean by functional competence in mathematics, or is it a vague phrase?" The answer is that the meaning has been fairly clear for over twenty years-the most authentic analysis having been given in the 1923 Report of the National Committee on Mathematical Requirements on the Reorganization of Mathematics in Secondary Education which for the first time listed in considerable detail the specific
mathematical objectives for citizenshi.p. Moreover, we can now define functional competence in mathematics more concretely by utilizing the experiences of the armed forces. They are offered as questions in the following check list:

1. Can the pupil operate effectively with whole numbers, common fractions, decimals, and per cents?
2. Has he fixed the habit of estimating an answer before he does the computation and of verifying the answer afterward?
3. Does he have a clear understanding of ratio?
4. Is he skillful in the use of tables as, for example: interest tables, tables of roots and powers, trigonometric functions, income tax tables, etc.?
5. Does he know how to use rounded numbers?
6. Can he find the square root of a number by table or by division?
7. Does he know the main guides that one should follow in collecting and interpretating data; can he use averages (mean, median, mode), can he make and interpret a graph (bar, line, circle, the graph of a formula, and of a linear equation)?
8. Does he have adequate ideas of point, line, angle, parallel lines, perpendicular lines, triangle (right, scalene, isosceles and equilateral) parallelogram (including square and rectangle) trapesoid, circle, regular polygon, prism, cylinder cone, and sphere?
9. Can he estimate, read, and construct an angle?
10. Can he use the Pythogorean relationship in a right triangle?
11. Can he, with ruler and compasses construct a circle, a square, and a rectangle, transfer a line segment and an angle, bisect a line segment and an agle, copy a triangle, divide a line segment into more than two equal parts, draw a tangent to a circle, and draw a geometric figure to scale?
12. Does he know the meaning of a measurement, of a standard unit, of the largest possible error, of tolerance, and of the statement "a measurement is an approximation?"
13. Can he use certain measuring devides, such as an ordinary ruler, other rulers (graduated to thirty-seconds, to tenths of an inch, and to millimeters), compasses, protractor, graph paper, tape, calipers, micrometer?
14. Can he make a scale drawing and use a map intelligently?
15. Does he understand the meaning of vector, and can he find the resultant of two forces?
16. Does he know how to use the most important metric units (meter, centimeter, millimeter, kilometer, gram, kilogram)?
17. In measuring length, area, volume, weight, time, temperature, angle, and speed, can he convert from one commonly used standard unit to another widely used standard unit; e. g., does he know the relation between yard and foot, inch and centimeter, etc.?
18. Gan he use letters to represent numbers; 1. e., does he understand the symbolism of algebra - does he know the meaning of exponent and coefficient?
19. Does he know the meaning of a formula - can he, for example, write an arithmetic rule as a formula, and can he substitute given values in order to find the value for a required unknown?
20. Does he understand signed numbers, and can he use them?
21. Does he understand what he is doing when he uses the axioms to change the form of a formula or when he finds the value of an unknown in a simple equation?
22. Does he know by memory certain widely used formulas relating to area, volumes, and interest, and to distance, rate, and time?
23. Does he understand the meaning of similar triangles, and does he know how to use the fact that in similar triangles the ratios of corresponding sides are equal?
24. Can he, by means of a scale drawing, develop the meaning of a tangent, sine, and cosine, and can he use a three- or fourplace table of these ratios to solve a right triangle?
25. Can he solve simple verbal problems (in arithmetic, algebra, geometry, and trigonometry)?
26. Does he have the information useful in personal affairs, home, and community; e. g., planned spending, the argument for thrift,
understanding necessary dealings with a bank, and keeping an expense account?
27. Is he mathematically conditioned for satisfactory adjustment to a first job in business; e. g., has he a start in understanding the keeping of a simple account, making change, and the arithmetic that illustrates the most common problems of commuications, travel, and transportation?
28. Does he have a basis for dealing intelligently with the main problems of the consumer; $I^{\text {e. } g \text {, the cost of borrowing money, }}$ insurance to secure adequate protection against the numerous hazards of life, the wise management of money, and buying with a given income so as to get good values as regards both quantity and quality?

Thesis 2. We Must Discard One For All the Conception of Arithmetic As A Mere Tool Subject. For a good many years arithmetic has had such a classification, because of the claim that it has never been used as an end in itself, but only as a means of dealing with the quantitative aspects of situations which are largely non-quantitative. By the same criterion history is also a tool subject and so is geography.

Thesis 2. We Must Think of Arithmetic as Having Both a Mathematical Aim and a Social Aim. The fundamental reason for arithmetic is social. No one can produce a valid reason for an arithmetic which is sterile and functionless. If arithmetic does not contribute to effective living, it has no place in the elementary curriculum.

The mathematical ain relates to the content of the subject matter, the essential skills and fundanental operations. It is not a matter of having to choose between the mathematical aim and the social aim. We must realize both aims through our teaching. The next five theses are intended to show how this goal may be achieved.
$I_{\text {For a more detailed and definite statement see The Role of Nathe- }}^{\text {men }}$ matjos in Consumer Education; single copies may be secured without cost Irom the National Association of Secondary School Principals, 1201 16th St., N. W., Washington, D. C.

Thesis 4. We Must Give More Momasis and Much More Careful Attention to the Development of Meanings. Unless children understand what they learn and know when and how to use arithmetic it is more or less a failure. We must develop both mathematical and social meanings; and meanings have not been properly emphasized in classroom instruction. Consider the common practice of giving children rules instead of developing them; for example of telling children where to write quotient figures in division instead of helping them to see that their positions are predetermined by the principles of place value; or of telling children to invert and multiply (a short cut, ) when they divide by a fraction inm stead of developing a rational explanation by use of a common denominator. And lastly consider how we frequently have taught the process of measurement and the units we used.

In the past, children have been required to master various tables and it has been presumed by their teachers that if they could recite the tables from memory without a mistake that such glib verbalism was evidence of sound learning. Such conclusions are not true either in the field of arithmetic or in other subject matter areas.
(a) Meanings do not just happen nor can they be imparted directly from teacher to pupil by memorizing the language pattern which contains the meaning. Instead meanings grow out of experience as that experience is analyzed, and recalled and reorganized in the thinking of the learner. In a word, the child creates the meaning, and the role of the teacher is that of a guide and he is not a proper guide unless he can
provide the child with relevant experiences which bring about the desired understandings.
(b) Meanings are not all-or-none affairs; they are purely relative; it is wrong to asser that a child does or does not have an understanding. He may understand a thing well enough for one purpose but not well enough for another, the problem then is to help him extend and enlarge the area of his understending.

Thesis 2. We Must Abandon the Idea that Arithmetic Can Be Taught Incidentally or Infomally. It has been a popular notion for the last fifteen or twenty years that arithmetic can be satisfactorily taught in terms of the pupils "interests and needs".
(a) It is unlikely that children left to themselves will have enough number experiences or an adequate variety of experiences to develop a feeling of need for any but the simplest of arithmetical ideas and skills such as counting, etc.
(b) Few teachers are sufficiently sensitive to the quantitative aspects of events to recognize them and to point out in ordinary situations or to arrange for their presence in activity units.
(c) When an effort is made to fuse arithmetic into activity units, not all children profit equally. Usually the more capable children "run away" with the project.
(d) Number ideas and skills are not learned as such when they occur only as parts of larger experiences.

True, these larger experiences may arouse a feeling of need and thus motivate learning and they may provide excellent opportunities to apply ideas and skills that have already been acquired. But they cannot produce or guarantee the learning.

One learns little about the chemical nature of sea water by being immersed in it, or about the mechanical principles of a machine by operating it.
(e) Mathematics, including arithmetic has on inherent organization. This organization must be respected in learning. Teaching, to be effective, must be orderly and systematic; hence arithmetic cannot be taught informally and incidentally.
Thesis 6. We Must Realize that Readiness for Learning Arithmetical Ideas and Skills is Primarily the Product of Relevant Experience and Not the Effect of Merely Becoming 0lder. Of late the so-called stepped-up curriculum has been rather generally accepted. Systematic instruction in arithmetic is ferred to Grade 3; the multiplication and divisrion combinations are postponed a year or two, until Grade 4 or 5 or 6; the last computations with common fractions appear in Grade 6 or 7, instead of in Grade 5, and so on. The assumption is that children by reason of their greater "maturity" in later grades will easily learn ideas and skills which were difficult when taught in the traditional grades.
(a) There is no magic in birthdays. So far as learning the school subjects is concerned increase in age makes for readiness only to the extent that extra time gives opportunity for relevant experience. Postponement of arithmetical topics
can by itself be only a questionable device for removing learning difficulties.
(b) The earlier years are wasted. Children are deprived of ideas and skills which could give them control over their environment and their activities.

Thesis 7. He Must Learn to Administer Drill (Repetitive Practice) Much Wore Wisely. The pendulum swings from one extreme of excessive drill to the other extreme of no drill. It is possible to expect from drill both too much and too little. Drill - having children do the same thing, over and over again - cannot develop understanding. For this purpose varied experiences are called for. But once the desired degree of meaning has been generated, repetitive practice reduces the meaning to an easily managed thought pattern, it gives the learner confidence in what he does, and it protects the meaning against forgetting. In the case of skills, it makes for efficiency of performance and leaves a basis for the building of later mastery.

From this, it follows that drill is to be prescribed not in this or that grade, but at the critical time with respect to each separate idea and skill. This critical time comes in the last stage of learning, when earlier steps have been completed and when mastery is the goal.

Because of the rather long and exhaustive nature of the report the remaining theses except those relating to the Junior College will be given without further coment since they wre largely corollaries to previous ideas we have already treated in this thesis.

Thesis 8. W䛧 Must Evaluate Ieaming in Arithmetic More Comprehensively Than is Common Practice.

Thesis 2. The Mathematical Program of Grades 7 and 8 Should Be Essentially the Same for All Normal Pupils.

Thesis 10. The Mathematios for Grades 7 and 9 Should Be Planned As A Unified Program and Should Be Built Around A Few Broad Categories.

Thesis 11. The Mathematics Program of Grades 7 and 8 Should Be So Organized as to Enable the Pupils to Achieve Mathematical Maturity and Power.

Thesis 12. The Targe ${ }^{2}$ High School Should Provide in Grade 2 A Double Track in Nathematics, Algebra for Some and General Mathematics for the Rest. Such provision is in vogue in the Dallas Schools.

Thesis 13. In Most Schools First-Year Algebra Should Be Evaluated in Terms of Good Practice.

Thesis 14. The Sequential Courses Should Be Reserved for Those Pupils Who, Having the Requisite Ability, Desire or Need Such Work.

Thesis 15. Teachers of the Traditional Sequential Courses Must Emphasize Functional Competence in Mathematics.

Thesis 16. The Main Objective of the Sequential Courses Should Be to Develon Mathematical Power.

Thesis 17. The Work of Each Year Should Be Organized Into A Few Iarge Units Built Around Key Concepts and Fundamental Principles.

Thesis 18. Simple and Sensible Applications to Many Fields Must Appear Mach More Frequently in the Sequential Courses than They Have in the Past.

Thesis 19. New and Better Courses Should Be Provided in the High

[^2]Schools For A Large Fraction of the School's Population Whose Mathematical Needs Are Not Well Met in the Traditional Sequential Courses.

Thesis 20. The Small High School Can and Should Provide A Better Program in Mathematics.

Thesis 24. All Students Who Are Likely to Teach Mathematics In Grades 1-8 Should, as a Minimum, Demonstrate Competence Over the Whole Range of Subject Matter Which May Be Taught in These Grades.

Thesis 25. Teachers of Mathematios in Grades 1-8 Should Have Special Course Work Relating to Subject Matter as Well as Eo the Teaching Prodess, As Detailed Below.

Thesis 26. The Teacher of Mathematics Should Have A Wide Background in the Subjects He Will be Called Upon to Teach.

Thesis 27. The Mathematics Teacher Should Have a Sound Background in Related Fields.

Thesis 28. The Mathematics Teacher Should Have Adequate Training in the Teaching of Mathematics, Including Arithmetic.

Thesis 29. The Courses in Mathematical Subject Matter for the Prospective Mathematics Teacher Shoula be Professionalized.

Thesis 30. It Is Desirable That A Mathematics Teacher Acquire A Backrround of Experience in Practical Fields Where Mathematics is Used. Some of the teachers in Dallas have been Civil Engineers, Designers, Sheetnetal workers, Bricklayers, Surveyors, Blue Print Readers.

Thesis 31. The Minirum Training for Mathematics Teachers in Smal1 High Schools Should Be A College Minor in Mathematics.

Thesis 32. Provision Should Be Made for the Continuous Education of Teachers in Service. This is true of the Dalles City Schools.

Thesis 32. Mathematics Teachers Need to Give Careful Consideration to the Possibilities of Multi-Sensory Aids.

Thesis 34. The Resourceful Teacher of Mathematics Should Be Given Competent Guidance in the Production, Selection, and Use of Slide Films. Such practice is increasing in Dallas.

In conclusion, let it be repeated that the foregoing Report is tentative and provisional. It does not offer final solutions, but submits a set of theses which, it is hoped, will stimulate further deliberation and discussion among the nation's educators, administrators, and teachers of mathematics. It should also be stated that the Report is the result of intensive group conferences and of much correspondence. Such discussions by local groups should resolve differences of opinion as to certain details. Absolute agreement under ordinary circunstances is not to be expected. Nevertheless most of the theses of this report were endorsed unanimously and all others were approved by a substantial majority of the members of the Cormission.

## CHAPTER V

## SUMMARY AND CONCLUSIONS

The Necessity for Mathematics
Fifteen years ago, a prominent educator from New York speaking in McFarlin Auditorium, Dallas, maintained that much of the curriculum in our high schools was useless. The speaker was careful not to name the subjects which he thus condemned. Nevertheless, one of our history teachers, in a written report of the speaker's address (requested by the High School Principal) stated that when the speaker mentioned "useless" subjects, she could not help but think of geometry.

Now, let's see, if geometry is as useless as the teacher of history believed.

The writer of this thesis maintains that geometry is an altogether highly important useful and basic subject, and that the study of the same tends to make effective the powers and forces for good that are latent in the individual. He further hopes that he may be pardoned for referring to two articles, one a letter written in August, 1944; the other a citation written in Lay, 1945, both of which are submitted in answer to the history teacher's claim that geometry is a useless subject. They are as follows:

August 20, 1944
Somewhere in Germany
Mr. R. N. Smith
W. H. Adamson High School Dallas, Texas

Dear Mr. Smith:
Wish I could tell you where I am and just what we are doing but guess you get all you need to know from papers printed in the U.S. You may not remmber me, but you remember you had a habit of nicknaming people who just go by their initials and in high school I went by the name of A. P. so you called me Alonzo Penrod. Tell, of late, I have been thinking of you and thought maybe you'd like to know that I am using the Trig. and solid geometry you taught me everyday and it is certainly helpful.

Your friend,
/s/T. Sgt. Arthur P. Wiley, Jr. 38437702, APO New York, N. Y.

The following citation proves that Sergeant Wiley was correct, the fact that he used his mathematics everyday is evidence that it was both useful and effective. He graduated from high school in $19 / 2$ and then took a post graduate course in geometry and trigonometry in 1942-43.

HEADQUARTERS 3OTH INFANTRY DIVISION OFFTCE OF THE COLMANDING GENERAL Old Hickory
AWARD of the BRONZE STAR MEDAL Citation

Technical Sergeant Arthur P. Wiley, Jr., 38437702, 120th Infantry Regiment, United States Army, is awarded the Bronze Star for heroic achievement and service from 18 August 1944 to 21 January 1945, in France, Belgiurn, Holland, and Germany. Sergeant Wiley performed his duties as a squad leader, and later as section leader and platoon sergeant of a heavy weapons platoon in an outstanding manner. His thorough knowledge of the weapons and tactics of a heavy machine gun platoon have enabled him to furnish

# excellent supporting fire for the advancing rifle troops. On his own initiative, Sergeant Wiley has undertaken to train and orient reinforcements in his unit with the result that they have quickly become effective members of the platoon. The leadership and courage displayed by Sergeant Wiley reflect great credit upon himself and the Armed Forces. Entered military service from Texas. 

L. S. HOBBS

Major General-U. S. Arry
Commanding

Conclusion
In a city such as Dallas is and hopes to be, we cannot get along without mathematics. As this is being written (August, 1945), Dallas has fallen behind San Antonio and is third in population in Texas, Houstion being first.

The industrial activities of all progressive cities are those which are directed toward producing better conditions governing the employment of labor and capital. Mathematical research has long been developing more efficient machinery and better housing conditions, better and faster and safer transportation. Houston with its inland waterways and San Antonio with its huge military installations have temporarily at least an advantage over Dallas; but in our post-war planning with more and better highways, with the improvement of public buildings, with constant effort at removing slums and squatter settlements and at removing the cause of the same, and in their place providing parks and playgrounds and swirming pools and flowers and birds and trees, and adequate facilities for public education, larger and improved zoological gardens, it is believed that in a short time, a village (between Dallas and Fort worth) which boasts that it is halfway between half a million people will be in the very center of two million souls.

## Paraphrasing the language of the Psalmist David (Psalm 139:9), if

 I take the wings of the morning and fly upward in my jet propelled ajrplane into that realm which is denied even to the birds of the air, due to the rarity of its oxygen, behold I am there by reason of the contribution that mathematics and mathematical science have made in my propellerless vehicle. If I descend by a submarine into the uttermost depth of the sea, where the pressure is so tremendous that only a few of the deep sea fish may exist, I have attained such depth only because mathematical engineering has found the way to make my visit a safe one. If I stand before a microphone and utter a few words of truth, the vibrations of ny feeble voice have been transmitted at a velocity equal to that of light and such speed is attained only because mathematical precision and research and discovery have made vibrations in one locality available to the entire world.
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[^0]:    2
    Report prepared by Committee of Mathematics Teachers named by Supervisor of high schools at group meeting.

[^1]:    3 Report of National Committee in Mathematics Teacher, Vol. XXXVI (March, 1943). Also in Education for Victory, Vol. I (April, 1943).

[^2]:    $2_{\text {By a large high school the Commission means a school with more than }}$ 200 pupils.

