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Science Education

PROGRAMS FOR HIGH SCHOOL SCIENCE AND MATHEMATICS IN WARTIME

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Our schools are making adjustments to meet the urgent needs of our country at war. In the sudden transition from a peace to a wartime basis, considerable variation in procedures likely exists. Out of these experiences and out of the investigations and deliberations of various educational, governmental, and military agencies, there are gradually being formulated policies and programs aimed toward the effective preparation of youth for their participation in the important tasks of the day. We attempt in this paper to consider the major problems involved in adapting, expanding, and improving the programs in high school science and mathematics for wartime conditions. It is convenient to classify the problems under five groups: 1. The needs for the services of young people, 2. Provision of programs adjusted to the abilities and previous training of various groups of high school students and geared to wartime needs, 3. The efficient selection of students, boys and girls, for the several patterns of courses, 4. Securing competent instruction in view of the scarcity of science and mathematics teachers, and 5. Securing essential teaching materials and equipment.

It is elementary that the first consideration of a planned program should be based upon an analysis of the needs for the services of young people. Four primary needs have been pointed out: 1. Practical technicians for the armed forces and for industry, 2. A continuous supply of scientifically trained workers for the armed forces and war industries, 3. A continuous supply of scientifically trained workers for civilian life and industry, and 4. Labor service of boys and girls in business and in agriculture.

An army of 7,500,000 men is anticipated by the end of 1943; in addition, the Navy and Coast Guard will be increased by several hundred thousand men. This indicates that practically all eighteen and nineteen-year-old boys, physically competent, will soon be inducted into the armed forces and that boys of seventeen may be expected to be inducted almost immediately upon reaching eighteen. Out of every 1,000 men inducted into the army, 630 are assigned to duties requiring specialized training. Most of the training required is practical and does not require a long period of time. The requirement of skilled personnel on the part of the Navy is even higher. Normally the Army and Navy send men without training to their specialists' schools, but the enormous expansion has over-

taxed these facilities and civilian agencies have been urged to take over as much as possible of this technical training. Moreover, the expansion of the war industries and the induction of many trained workers into the armed forces from industry has brought about a shortage of men and women workers with essentially the same technical training required as for those in the specialized branches of the armed forces.

The 1943 quota of 100,000 air cadet trainees must draw from 30 to 40 per cent of the boys in each high school graduating class. The quota will be greater in subsequent years. Thirty-eight men with specialized training are required to keep a Flying Fortress in the air.

In addition to those technically trained for such positions as machinists, auto and airplane mechanics, electricians, radio operators and repairmen, telegraph linemen and repairmen, and other skilled workers, men and women with thorough scientific and technical training are continuously in demand for service and research in the armed forces and in civilian life and industry. In normal times there are less than 1,000 physics majors in the colleges. Only one person out of every 2,000 in this country is a trained chemist or chemical engineer. It is estimated that Germany has a ratio of three chemically trained persons to every 2,000. Physicists, meteorologists, radio engineers, electrical, mechanical, and other engineers, chemists, biologists, doctors, and nurses are among those most needed. A continuous supply of young men and women must be provided for training in these scientific fields.

A shortage of farm labor exists in many parts of the country. The significance of agriculture in the war effort is brought into prominence when we note that the United States, in addition to feeding its civilian population and its vast armed forces, must also export increasing quantities of food to allied nations and to occupied countries. There is also a scarcity of workers in most business fields. More and more boys and girls of high school age will be called upon for full assistance during the summer and for part-time assistance during the remainder of the year by the development of work-study programs. There are 3,350,000 boys and girls aged sixteen and seventeen now in school, of whom it is estimated that one-half will be at work by next summer.

A major responsibility, then, of high school teachers of science and mathematics and administrators, is the provision of a program geared to the needs of the war and industrial machine. We shall restrict our attention here to the programs which are essentially those of the secondary schools. It will not be possible to describe the programs in detail but the fundamental features will be delineated.

The imminent problem for teachers of science and of mathematics in the high school is: "How can the instruction in science and in

mathematics be made most effective to meet the needs for the services of boys and girls, here and now?" The central problem is: "What can be done for those in the last one or two years of the high school?" The principal proposals relate to what modifications should be made immediately in the established courses or sequences in science and mathematics and what supplementary courses should be introduced. The supplementary courses are designed largely for students, not now following the science and mathematics sequences, with the aim of providing a technical and mathematical background so as to shorten the time needed to train them for simple technical jobs after induction into the armed forces. In some instances refresher courses have been recommended presumably for those students who at one time possessed knowledge of science or mathematics.

PRE-INDUCTION COURSES

The Pre-Flight Aviation Training Program (1) was introduced early due largely to the cooperation of the Army, the Navy, the U. S. Office of Education, and the Civil Aeronautics Administration. The high schools are contributing to this program (1) by providing basic training in physics and mathematics; by special emphasis in these courses on the mastery of the principles of physics related to aeronautics and on acquiring facility in the use of mathematical calculations; and (2) by the provision of specialized courses in pre-flight aviation to boys that are qualified.

To provide some of the technical training necessary for the boys previous to induction, the U. S. Army and the U. S. Office of Education (7) have prepared a series of pre-induction courses. These courses are based upon an analysis of Army jobs and emphasize work with machines, tools, and electrical and mechanical devices. The three elementary courses in electricity, machines, and shop work are one-semester courses; the other two, Fundamentals of Automotive Mechanics and Fundamentals of Radio, are one-year courses. These courses should be open to selected students and offered in high schools where competent instruction and equipment can be provided.

Effective instruction in aeronautics, navigation, and in radio must be based upon an adequate background in mathematics and the physical sciences, attained previously or concurrently with the specialized courses.

ADJUSTMENTS IN HIGH SCHOOL PROGRAMS

It is generally agreed that the conventional courses in physics, chemistry, biology, and the sequential courses in mathematics are providing good preparation for further scientific work in college. The recommendation made for modification in the content of these subjects relates chiefly to the elimination of some topics, the intro-

duction of wartime and industrial application, the provision of more laboratory experience with practical problems, and more careful teaching, aiming at a functional knowledge of the fundamental ideas and processes. Since most of the proposals have been made for specific courses or areas, the discussion here will follow that form. The most complete and informative recommendations for programs in science and mathematics are those of the Cooperative Committee on Science Teaching (1). The Committee membership was made up of two members from each of five national organizations: American Association of Physics Teachers, American Chemical Society, Mathematical Association of America, Union of American Biological Societies, National Association for Research in Science Teaching. This source and others specified in the reference list provide the main content of our discussion. Physics and mathematics have been the fields chiefly discussed since they apparently contribute most directly to the essential types of training, and it is in these fields that Army and Navy representatives have pointed out the greatest deficiencies in the background training of youth occur. Other fields of science, however, have direct contributions to make as will presently be pointed out.

PROPOSALS FOR HIGH SCHOOL TRAINING IN PHYSICS

The principal modifications in the regular physics course reside in the applications made. It is emphasized that physics courses should provide laboratory experiences with engines, radio receivers, model planes, shop tools, and other materials and equipment directly related to applied science in military and civilian service. Elimination of some of the customary content, having little or no relation to the phases of war and industrial effort, should make possible the required applications.

The War Department recommends that every boy in the eleventh and twelfth grade should devote one or two class periods a day to work in the pre-induction courses. If all boys in these grades are eligible to take this work, it will have to stress practical applications and eliminate much of the advanced abstract material. It would appear that students without sufficient basic preparation in mathematics and science should not be enrolled in specialized courses that require such preparation since this would greatly impede the progress of qualified students.

It has been recommended that a fundamental physical science course with laboratory work should be offered in the tenth grade. Emphasis should be given to the significant applications of physics, chemistry, and related physical sciences. This course could provide the basic preparations for the pre-induction and other specialized courses in the eleventh and twelfth grades.

The State of Indiana Department of Public Instruction (8) through the cooperation of a committee of high school and college

representatives has prepared a plan for an emergency physics course in high schools. The course is offered to selected high school juniors and seniors. It is of one semester's duration. This course should prove to be an especially effective one. Excellent descriptions of lecture-demonstrations, of simple student experiments, and fundamental content with especial emphasis to wartime applications drawn from Field Manuals and Technical Manuals of the War Department are presented. Simple home-made equipment is abundantly utilized.

PROPOSALS FOR HIGH SCHOOL TRAINING IN MATHEMATICS

The United States Office of Education (6), cooperating with the Civilian Pre-Induction Training Branch of the War Department, the Training Division, Bureau of Naval Personnel, and representatives of vocational education, appointed a special commission to make a special study of the mathematical needs of war activities and to prepare a report for the use of high school teachers of mathematics. For this report, approximately 50 of the Army instructional manuals, covering occupations for which there is the greatest training need, 20 Navy training manuals, the training manuals of the Civil Aeronautics Administration, and about 50 unit courses used in the Federal-State Program of Vocational Training for War Production Workers were analyzed to determine the types of mathematics used and the mathematical background involved.

The report of the Commission states: "The armed services and the supporting war industries need boys and girls trained in the proficient use of mathematics varying from a real mastery of arithmetic fundamentals and such practical uses as are found in courses in general mathematics to the uses of higher mathematics in meteorology, ballistics, and other branches of science. Girls trained in mathematics are needed to replace men in industrial and other civilian positions which require the same range of use of mathematics."

Only the major features of this Report can be given here. For the abler students now enrolled in grades eleven and twelve, with little or no systematic mathematics beyond the eighth grade, the Commission has presented a rather detailed outline of a one-year "Emergency Course in Mathematics." There is also developed an emergency refresher course for high school pupils who are near graduation or induction, but who are not at present studying mathematics. Finally, definite recommendations are made for modifications in the sequential courses, Algebra, Plane Geometry, Plane Trigonometry, and Solid Geometry, with many practical applications from physics, shop and industry, engineering, navigation, artillery fire, and other applied fields.

THE WARTIME PROGRAM IN HIGH SCHOOL CHEMISTRY

Neither supplementary nor emergency courses in high school chemistry have been recommended. It is believed that the present courses will require little change to make them effective, in meeting the critical needs for the preparatory training of youth in the present emergency and in post-war adjustment and reconstruction. Emphasis in instruction should be placed upon fundamentals with application appropriately geared to war needs. Improvement in laboratory instruction is indicated. New emphasis should be placed in the following areas of application:

1. Chemical principles fundamental in the War Department's pre-induction courses.
2. Production and analytical work in electro-chemical and metallurgical operations. Where local chemical industries exist, the high school course should contribute to the training of youth who may be assigned to this work as essential.
3. The conservation of natural and man-made resources should be stressed. Knowledge of the geography of chemical resources and of the chemical industry is fundamental.
4. Chemistry should supplement the student's knowledge acquired in biology as it relates to nutrition, to principles of water purification and sewage disposal, to effective use of antiseptics, drugs, vitamins, and the like.
5. The effective use of chemical principles involved in both plant and animal growth. The simpler principles of organic chemistry should be included in the high school chemistry course.

THE WARTIME PROGRAM IN HIGH SCHOOL BIOLOGY

The present high school course in biology, usually a tenth grade subject, offers many opportunities for the acquisition of information and of skills of special importance in the present national emergency. The content needs to be expanded and improved. Laboratory work involving controlled experimentation should be included. Students at the eleventh grade level should have the opportunity to enroll in a basic biological or physical science course if they have not taken such in the tenth grade.

The shifts in emphasis or the alteration of content in terms of the war effort involve the following points:

1. The fundamental facts concerning the structure, functions, and care of the human body should be acquired. Matters of first aid and hygiene are essential to prospective aviators, soldiers, sailors, factory workers, and others.
2. The role of bacteria and fungi in personal hygiene, public health, water supply, and sewage disposal.
3. The utilization of plant products in the production of food, clothing, shelter, medicine, plastics, and in fermentology.

4. Plant and animal breeding with special reference to increased production and lowered costs of production.
5. Conservation of soil, forests, and grasslands; improved agricultural practices.
6. Greater emphasis on field work and applied ecology.
7. The victory garden or school garden should be closely related to the instructional program in science, nature study, and nutrition; also the relation of nutrition to rationing, school lunches, and consumer's education should be stressed.

Many uses for biology specialists in the war effort have been found. Some are:

1. Handbooks of poisonous and edible plants are under preparation for each of the geographic areas of operations.
2. Processing of natural camouflage for retention of foliage and color by means of hormone sprays.
3. Production of seedless fruits and the rooting of cuttings; significance in the production of turpentine, for example.
4. Solving problems of food spoilage—in transit and in storage.
5. Technological use of fermentive bacteria and molds in production of alcohol and ethylene glycol for use in explosives, synthetic rubber and plastics.
6. Production of American oil and fiber plants to replace materials previously imported; milkweed floss, for instance, has proven to be a superior substitute for cork and kapok as an insulation material and for buoyancy in life preservers and aviator's clothing.

THE SELECTION OF STUDENTS FOR THE WARTIME PROGRAM

The effectiveness of the several programs in the sciences and in mathematics is dependent upon the selection of students of those characteristics for which different courses have been designed. If students are enrolled in courses for which they are poorly prepared in background or for which they do not have the aptitude they merely impede the progress of qualified students. It is also of importance to identify boys and girls who have the aptitude but who have not enrolled in courses in science or in mathematics. Most of the emergency courses have been designed for such students.

It is recommended that the high school population should be screened according to their aptitude for work in physical science and in mathematics. The Cooperative Committee on Science Teaching reports that aptitude tests for this purpose have been developed by Pennsylvania State College in collaboration with the Department of Physics of the University of Iowa and at Purdue University by a committee of the Department of Physics and the Division of Educational Reference. Perhaps the Cooperative Test of Comprehension and Interpretation in the Natural Sciences would

be useful for purposes of selection. The New Physical Science Aptitude Examination published by the Bureau of Education Research and Service, State University of Iowa, would likewise be a valuable test for selection purposes. Comprehensive tests in the fundamentals of arithmetic, including whole numbers, common fractions, decimals, and per cent are suggested for selecting students for the emergency and refresher courses in mathematics. Previous school marks in science and mathematics, the results from intelligence tests, and other school records that might be available should supplement the scores on the aptitude tests as the basis for selection.

TEACHING MATERIALS AND EQUIPMENT

Obviously one of the fundamental needs for the effective operation of the wartime program is the availability of materials for instructional purposes. In well-meaning attempts to fill the need many new publications are becoming available, some of which hastily improvised and uncritically edited or checked by competent authorities may disseminate misinformation, wrong interpretation, or fail to present fundamental information.* Even by the trained science and mathematics teacher these publications may be frequently uncritically accepted. When one contemplates the increasing number of incompetent teachers who will be handling more and more of these wartime courses, the need of authoritative publications and of those adapted to the purposes of the courses and to the abilities of the students cannot be too greatly stressed.

It is likely that many schools do not have the minimum essential equipment for carrying on a wartime program. It may be possible for the resourceful teacher to build some pieces of equipment necessary for demonstration and students' experiments and to assemble second-hand equipment. Wide use will have to be made of visual aids such as lantern slides or projections of figures from war manuals. Exhibits, maps, and posters are other teaching aids of importance. Priorities in some cases may be necessary to secure indispensable materials. The War Production Board district offices can furnish information to schools and supply copies of forms and orders.

SECURING TEACHERS IN WARTIME

The problem of securing teachers of science and mathematics for the high schools is becoming more and more basic. A substantial number of schools do not have teachers of science and mathematics at this time and the shortage is becoming increasingly acute. Further increases in enrollment in physics, in pre-induction courses, and in mathematics will contribute to the problem. The problem is further complicated by the decline in enrollment in teacher education.

Universities, teachers colleges, and liberal arts colleges, as well as

* See Willem J. Luyten. "Air-Age Teaching or Misinforming". *Science*, Vol. 97, No. 2513. Pp. 201-202; February 26, 1943.

state departments of education, are making temporary adjustments in requirements for majors and teachers' certificates, are attempting to recruit people for professional training, and in most cases are accelerating their programs. One fundamental problem is that of paying teachers of science and mathematics sufficient to hold them in the profession. Teacher training courses in physics and mathematics subsidized in recognized training centers has been accepted as a policy by the United States Office of Education. Meanwhile the schools are making many administrative changes in the attempt to meet the problem of teacher shortage. Frequent means are: (1) to change from the 6-6 to the 8-4 plan, (2) to increase teachers' load, (3) for the superintendent to take extra work, (4) to hire local married women, (5) to increase class size, and (6) to raise salaries.

WARTIME ADJUSTMENTS IN MINNESOTA HIGH SCHOOLS

The question may be raised as to what adjustments in the science and mathematics programs are under way in Minnesota schools. A recent survey carried on under the auspices of the Minnesota Council of School Executives, the Minnesota Association of Secondary School Principals, the Minnesota Association of Elementary School Principals, and Directors and Supervisors of Instruction has, among numerous other items of information, reported new courses in science and mathematics which have been added to the high school curriculum and topics or new units which have been added to the established courses in these fields. Not all of the detail can be presented here but some of the major findings are reported. Questionnaires were sent to all high schools and graded schools listed in the State Educational Directory on February 1, 1943; 353 returns were used in the tabulations presented.

The new courses of most frequent occurrence were:

Pre-flight aeronautics	108
Review or refresher math.	31
Higher mathematics	18
Higher algebra	19
Trigonometry	16
Solid geometry	14
Radio	14
Physics	12
Advanced arithmetic	11
Radio-Morse-International Code	10
Glider construction	8
Geometry	8
Pre-induction electricity	6
Basic electricity	6

The topics or new units added most frequently in mathematics were:

	Grades	High School
More drill in arithmetic	169	176
Applications to aeronautics . .	26	205
Applications to navigation . . .	12	163
Testing seniors in math.	104

The topics or new units added most frequently in science were:

	Grades	High School
Aeronautics	17	185
Meteorology	6	132
Photography	4	68
Radio repair	3	66
Health	73	160

THE PRESERVATION OF VALUES

The program for science and mathematics in wartime, as presented in this paper, is not in some respects a program that we would recommend in peacetime. There should be many compensating gains, however. The insistence on making science and mathematics functional in wartime should carry on into the numerous problems in post-war adjustment and reconstruction: the importance of the training of youth in science and in mathematics must be equally demonstrated for peacetime as for wartime. Certainly science and the applications of the method of science can contribute much to the solution of post-war problems. The effective implementation of the process of science requires: (1) leaders and administrators qualified to appraise the results of scientific work and ready to apply them to the problems of the day, (2) a body of active young scientific workers not merely engaged in extending the boundaries of knowledge in science but who have a disposition to apply the scientific method to social and economic problems, and (3) a body of public opinion sufficiently informed and powerful to overcome opposition to policies or actions unscientific in character. Teachers of science and mathematics should be able through their teaching and through their own behavior to contribute much to the implementation.

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COURSE CONTENT FOR PRE-FLIGHT AERONAUTICS IN SECONDARY SCHOOLS

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ABSTRACT

On the basis of several years teaching the War Training Service courses in aviation for military pilots, suggestions are given to high school teachers on course content and teaching procedure.

Since aeronautics is applied physics and mathematics, students should be urged to obtain as much work as possible in these fields. Teachers of aeronautics have been encouraged to obtain a background in the field by attending seminar courses in colleges. At present, the government has set up such a course at the State Teachers College at Mankato where 64 hours of work is given.

If possible, students should be taken to an airport where a plane can be carefully examined and the nomenclature studied as well as the function of its parts.

To date the best textbook in the field is "Science of Preflight Aeronautics for High Schools".¹ The "Flight Preparation Series"² of texts should form part of any high school library on aeronautics.

Navigation, because of its paramount importance in flight, should probably receive more emphasis than any other phase of the aeronautics course.

¹ Columbia University, Teachers College. Aviation education research group. 1942. Published by the Macmillan Company.

² This series is published by the McGraw Hill Book Company.