

ARE ANY PRINCIPLES OF ORGANIZATION OF GENERAL SCIENCE EVIDENCED BY THE PRESENT TEXTBOOKS IN THE SUBJECT?¹

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General Science has existed for a number of years, and it has attained a legitimate place in the curricula of many of our best high schools. After long experimentation, an introductory course in the scientific study of common things is now generally recognized as an essential part of the educational opportunities of our secondary schools.

Since its introduction into the schools, enough time has elapsed to enable us to consider that the period of experimentation has passed. Out of these years of experimentation, some definite opinions have crystallized. These are indicated by the organization of the courses in the textbooks of General Science, and by the results which several investigators have obtained from questionnaires filled out by many of our best science teachers.

Many administrators, and some science teachers, too, are not aware of the uniformity which occurs in the content of the courses given in the text books of general science. This uniformity is due, I believe, to the fact that the authors are agreed on the dominant aims and purposes of the subject. An examination of the prefaces of our best textbooks shows that the aims of the writers are essentially the same as those of the science teachers who replied to a questionnaire sent out by Mr. C. M. Howe, of Hughes High School, Cincinnati, in 1918, and to another sent out two years ago by a Committee on Reorganization of General Science of which Mr. Fred Barber was chairman and of which I was a member.

In the judgment of the eighty teachers of science who replied to Mr. Howe's questionnaire, the three leading *aims* in the teaching of general science in the first year of the high school should be to give each pupil:

1. Understanding, appreciation, and control of his everyday *environment*;
2. Appreciation of the *applications* of science in industrial and social life;
3. A fund of valuable *information* about nature and sciences.²

¹Read before the General Science Section of the C. A. S. & M. T., Soldan High School, St. Louis, November 25, 1921.

²From C. M. Howe; *Can and Should General Science be Standardized?* *School Science and Mathematics*. March, 1919, pages 248-255.

The dominant *purposes*, then, of General Science as determined by these three leading aims are to give each pupil the greatest possible understanding, appreciation, and control of his everyday *environment*; to acquaint him with some of the most important industrial and social *applications* of science; and to furnish as wide a fund of *information* about nature and science as time permits.

In the questionnaire sent out by the Committee on Reorganization of General Science, teachers were asked first to rank in order of their importance the three following aims:

1. The problem-seeing and the problem-solving aim;
2. The knowledge aim;
3. The appreciation aim.

Second, they were asked to rank in order of their importance six additional aims which were similar to the ones which Mr. Howe had previously used.

From the results obtained in this investigation, it was found that teachers ranked the first set of aims in the following order:

1. Problem-seeing and problem-solving aim;
2. Knowledge aim;
3. Appreciation aim.

From the six additional aims, the three which were selected as being the most important were the same as the ones which Mr. Howe found were considered of first importance. The ranking also of these three aims was the same for both groups of teachers.

Prefaces in our textbooks in General Science indicate that the writers recognize the same aims and purposes as those given by the teachers replying to questionnaires. Mr. Trafton, for example, in *Science of Home and Community*, says: Applications of science more and more dominate our lives. Any sane system of education must see to it that boys and girls living in the midst of these applications, which form such an important part of their everyday life, are educated in terms of this environment, in order that they may better appreciate it and adapt themselves to it." The authors, Mr. Barber and others, of *First Course in General Science*, believe that the primary function of first year General Science is to give, as far as possible, a rational, orderly, scientific understanding of the pupil's environment to the end that he may, to some extent, correctly interpret that environment and be master of it. These and similar expressions which may be found in almost any one of the textbooks, indicate that the present day tendency is to give the child an understanding of those

scientific problems which are vitally connected with his everyday life.

Recognizing the unanimity which exists in the three basic aims: *environment*, *application*, and *information*, consideration may now be given to the selection and the organization of the materials presented in our general science courses. Writers of textbooks and teachers of science are also quite generally agreed upon the organization of the subject matter of general science. They believe that the subject matter should be organized around the *interests* and *experiences* of the pupils rather than around the principles and laws of any branch of science.

In the replies to the questionnaire sent out by the Committee on Reorganization previously referred to, eighty per cent of the teachers expressed their preference for a course organized about natural units: those having some common process, or activity, or set of concepts functionally related to life, rather than about units having scientifically related principles as a core. In most of the textbooks the materials have been selected from the pupil's environment and then organized from the human rather than from the scientific point of view.

The organization of any course in general science will depend upon the selection of the materials for the course, and this selection in turn depends upon the aims of the course. With the aims so clearly defined, it is inevitable that the content of the courses as given in the textbooks is very uniform. Many do not know how similar the courses are, and others, opponents of the subject, are not willing to recognize the fact.

In an effort to determine what underlying scientific principles and fundamental concepts occur most frequently, I have made a careful examination of the following fourteen textbooks:

1. Barber, *First Course in General Science*. Henry Holt Company.
2. Brownell, *General Science*. Macmillan Company.
3. Caldwell & Eikenberry, *General Science*. Ginn and Company.
4. Clark, *An Introduction to Science*. American Book Company.
5. Elhuff, *General Science*. D. C. Heath Company.
6. Hessler, *The First Year of Science*. Benjamin Sanborn Company.
7. Hodgdon, *Elementary General Science*. Hinds, Hayden & Eldredge Co.
8. Lake, *General Science*. Silver Burdett Company.
9. Pease, *General Science*. Merrill Company.
10. Snyder, *First Year Science*. Allyn and Bacon.
11. Smith and Jewett, *Introduction to the Study of Science*. Macmillan Company.
12. Trafton, *Science of Home and Community*. Macmillan Company.
13. Van Buskirk and Smith, *The Science of Everyday Life*. Houghton Mifflin Company.
14. Weckel and Thalman, *A Year in Science*. Row, Peterson & Co.

A tabulation of the results of my investigation follows:

FUNDAMENTAL CONCEPTS AND TOPICS WHICH OCCURRED IN:

I. All Fourteen Texts.

1. Atmospheric pressure
2. Principle of and kinds of thermometers
3. Definitions and applications of humidity, dew point, condensation, saturation

II. Thirteen of the Fourteen Texts.

1. Oxidation
2. Transference of heat: conduction, convection, radiation
3. Soils, origin and composition
4. Study of weather maps

III. Twelve of the Fourteen Texts.

1. Composition of atmosphere
2. Winds, cause of and general circulation
3. Molds and Bacteria: structure, development, relation to diseases and decay
4. Foods and nutrition

IV. Eleven of the Fourteen Texts.

1. Study of the cell
2. Calorie, value of
3. Structure and function of parts of human eye
4. Heat, nature and origin
5. Electricity, elementary presentation of
6. Sanitation and diseases: germs, toxins, antitoxins, disinfectants, sterilization, vaccines, etc.

V. Ten of the Fourteen Texts.

1. Seasons, cause of
2. Gravity, definition
3. Pumps
4. Storms, causes and common types
5. Sewage disposal
6. Types of electric cells
7. Lighting systems: kerosene, gas, electric, acetylene

VI. Nine of the Fourteen Texts.

1. Properties of matter
2. Elements and compounds
3. Plants: structure and function of root, stem, leaves, flowers
4. Molecular theory
5. Water power and its applications
6. Manufacture of artificial ice
7. Steam engine, principle of action and application
8. Sound, nature of
9. Light, nature of and properties
10. Carbon dioxide: source, role in nature, fire extinguisher
11. Cell division and reproduction in plants and animals
12. Machines: lever, screw, pulleys, wheel and axle, inclined plane
13. Solution, especially as applied to hard and soft water
14. Vaporization.

VII. Eight of the Fourteen Texts.

1. Drainage and irrigation
2. Erosion
3. Distillation
4. Solar System
5. Physical and chemical changes
6. Heating systems
7. Magnetism
8. Acids, bases, and neutralization
9. Injurious insects
10. Osmosis
11. Filtration

12. Expansion of solids, liquids, and gases
13. Electric bell, telephone, telegraph
14. Ventilation, principle of and different systems
15. Combustion

VIII. Seven of the Fourteen Texts.

1. Siphon
2. Human ear, parts and functions of each
3. Weathering
4. Fertilization
5. Lenses, kinds
6. Day and night, cause
7. Capillarity
8. Gasoline engines
9. Plant nutrition

IX. Six of the Fourteen Texts.

1. Metric system
2. Density and specific gravity
3. Archimedes' principle
4. Survey of animal kingdom
5. Time, standard, etc.
6. Electrolysis
7. Fuels and carbon compounds

X. Five of the Fourteen Texts.

1. Human body, structure of
2. Energy: kinds, measures for
3. Life processes in animals
4. Pasteurization
5. Properties of protoplasm
6. Mechanics of respiration
7. Pollination and fertilization in plants

XI. Four of the Fourteen Texts.

1. Seed dispersal
2. Glaciers
3. Latitude and longitude
4. Cohesion and adhesion
5. Wind power
6. Human voice
7. Earthquakes and volcanoes
8. Parasites and saprophytes
9. River development
10. Economic botany

XII. Three of the Fourteen Texts.

1. Analysis and synthesis
2. Boyle's law
3. Hydraulic press

Total number of topics listed above, eighty-nine.

Except for the phraseology and the time involved, no difficulty arises in a mere listing of the concepts given in textbooks. When one attempts, however, to analyze this subject matter, to place it in as few large units as possible, and to recognize the larger units most frequently used, the task becomes most difficult.

After the selection of the materials from the child's environment has been made, writers frequently group it about one of two centers: either the *home* or the *community*; occasionally both are used. It is then further divided into such topics as

atmosphere, water, methods of transportation, building materials, household chemistry, foods and nutrition, the universe, oxidation and its relation to life, and a multitude of others, all usually well chosen.

About the larger units or topics which I found occurring most frequently in the textbooks, I have attempted to formulate what might be termed a composite course by placing under these topics the fundamental concepts and scientific principles which I found occurring in the frequency which I have already given.

If I have succeeded in doing this without personal bias and with any degree of skill, I shall then have a standardized course based upon the courses as given in the textbooks which I have examined. Since a large number of representative books has been examined, I think that I am justified in presenting the following outline as a standardized course in General Science based upon the courses developed by the textbook writers, most of whom are or have been high school teachers.

OUTLINE OF STANDARDIZED COURSE BASED ON TEXTBOOKS.

I.

Atmosphere.

1. Physical properties and mechanics of gases
2. Chemical composition
 - elements, compounds, mixtures
 - molecular theory of matter
 - study of oxygen, nitrogen, carbon dioxide
 - oxidation
3. Atmospheric moisture
 - evaporation
 - humidity
4. Weather
 - air pressure
 - pumps
 - barometer
 - temperature
 - winds
 - storms
5. Respiration in plants and animals
 - hygiene of breathing
 - ventilation

Frequently included
under IV.

II.

Water.

1. Physical properties
2. Chemical composition
 - solution
 - hard and soft water
3. Mechanics of liquids
4. Distillation
5. Evaporation
 - refrigeration
 - manufacture of artificial ice
6. Water supply
 - source

- 7. purification
- 7. Sewage disposal
- 8. House piping
- 9. Hot water heating, often included under VI.

III.

Earth.

- 1. Its relation to the universe
 - stars and solar system
 - earth and its seasons
- 2. Soil
 - origin
 - physical structure
 - erosion and sedimentation
 - fertility
 - soil water
 - drainage
 - irrigation

IV.

Life on Earth.

- 1. Plants
 - cell, structure and activities
 - parts of plants and their functions
 - food production
 - food storage
 - reproduction
- 2. Animals
 - groups
 - human physiology (often omitted)
 - reproduction
 - insects and diseases
- 3. Bacteria, yeasts, and molds
 - human diseases
- 4. Hygiene and sanitation

V.

Foods and Nutrition.

- 1. Foods
 - need of
 - production
 - measurement of food—calorie
 - composition
- 2. Digestion
 - organs of
 - hygiene
- 3. Diet
- 4. Adulteration.

VI.

Machines, Work, and Energy.

- 1. Work of running water—water wheel, turbine, etc.
- 2. Work of simple machines
- 3. Measurements and kinds of energy
- 4. Heat
 - transmission of
 - fireless cookers
 - methods of heating our homes
 - coal
 - work done by heat—steam engine
- 5. Light
 - nature
 - color
 - human eye
 - methods of lighting our homes
- 6. Sound
 - nature

- human ear
- 7. Electricity and magnetism
 - measurement
 - electric generators
 - applications of electricity
 - electric bell
 - automobile
 - telephone
 - telegraph

In presenting this outline, my paper is concluded so far as the problem assigned me by your chairman is concerned. I can not refrain, however, from expressing a few convictions which have come out of the study made for the preparation of this paper and out of many years of observation and participation in the General Science movement:

1. Many of the courses in General Science include more material than can be given to first year high school pupils in one year.

2. Relatively too much emphasis is being placed upon the physical environment of the child. More civic biology should be included in many of the courses.

3. The project method is not feasible for the overworked teacher, for the one who has very large classes, nor for the beginner.

4. The years of experimentation in General Science need not be looked upon with the disapproval and contempt so frequently evident, for often even inexperienced teachers give better courses when all initiative and interest have not been destroyed by overstandardization of the subject taught.

5. There is a surprising unanimity in the aims and purposes of General Science and also in the subject matter included in the courses now given.

BIOLOGY AND PROJECT WORK.

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To visit a class in High School Biology, in which there is no adopted text-book, no formal recitation, and in which each student is working on an individual problem of especial interest to himself, may at first seem revolutionary, if not evolutionary. Yet the observer must be impressed by the spirit of activity and cannot but be interested in the variety of investigations going on in the laboratory.

There are many advantages to be gained from this form of project work, which I am conducting in the Francis W. Parker