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CERTAIN PHYSICS GENERALIZATIONS DESIRABLE FOR STUDENTS TO ATTAIN BEFORE TAKING THE PHYSICAL SCIENCE STUDY COMMITTEE'S HIGH SCHOOL PHYSICS COURSE

by

Dale D. Rathe

A DISSERTATION

Presented to the Faculty of

The University of Nebraska in the Teachers College

In Partial Fulfillment of Requirements

For the Degree of Doctor of Education

Department of Secondary Education

Under the Supervision of Prof. James A. Rutledge

Lincoln, Nebraska

THE UNIVERSITY OF NEBRASKA
TEACHERS COLLEGE
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TITLE

Certain Physics Generalizations Desirable for Students to Attain before Taking the Physical Science Study Committee's High School Physics Course

BY

Dale D. Rathe

IN PARTIAL FULFILLMENT OF REQUIREMENTS
FOR THE
DOCTOR OF EDUCATION DEGREE

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D.D.R.

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CHAPTER I

INTRODUCTION

Selection of Science Content

Selection of science content for general education has been a concern of science educators for many years.[1]

For the elementary school, selection of science content proceeds from concerns for (a) the learner, (b) the environment, (c) the body of knowledge comprising natural sciences (biology, chemistry, physics), and (d) the total school program.[2] These four identified areas embrace the major concerns in the selection of content for junior high schools also. Hale indicates agreement with these four areas as the basic concerns for content selection. Regarding the learner, however, she underscores that the student in the junior high school is an adolescent and

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[1]Concerns for selection of science content for general education are reviewed in three yearbooks of the National Society for the Study of Education (Chicago: the University of Chicago Press).

A Program for Teaching Science, 1932.
Science Education in American Schools, 1947.
Rethinking Science Education, 1960.

[2]Glenn O. Blough, and Others. "Developing Science Programs in the Elementary School." Rethinking Science Education. National Society for the Study of Education, Fifty-ninth Yearbook, Part I, (Chicago: the University of Chicago Press, 1960) p. 119.

therefore has certain physical, social, emotional, and mental characteristics somewhat different from other age groups.[3]

Environment as a concern in content selection for the junior high school is not to be construed in a narrow sense for as Hale said, it involves a "look at America and world society as it exists today--its ideals, its purposes, its problems, its direction--the climate of the times."[4]

"Science" itself should be understood by those who select the content for any level of general education. Science is not to be confused with technology. Science involves problem solving, but that is not its only function. Neither is it just a body of knowledge included in several disciplines. It appears to be knowledge involved with the endeavor of individuals to understand, interpret, and control man's environment. Basically, scientific activities are intellectual pursuits characterized by certain modes of thinking: discriminating observation, categorization, quantification, hypothetical explanation, analysis and synthesis, correlational thinking, and construction of scientific models.[5]

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[3]Helen E. Hale, "Quality Science for the Junior High School," Ideas for Teaching Science in the Junior High School, Washington, D.C., National Science Teachers Association, 1963.

[4]Ibid., p. 3.

[5]Ibid., p. 3.

The total school program must be considered in the selection of science content for general education programs. Science contributes its methods, its approach to problem-solving, and its informational content to enrich the whole school program and to give it new scope and depth. But a basic premise underlying the science program is that it should be in harmony with the total program of education. The content in such a program should help accomplish the total program's functions and purposes and supplement and complement these purposes rather than be separate and distinct.

Although these four concerns predominate in the selection of science content for general education today, they have not always done so.

An Historical Perspective

In earlier history of science instruction the selection of science content for public schools as revealed in reviews and the analysis by Francis D. Curtis stressed that efforts prior to 1931 concentrated mainly upon three methods. The kind and extent of subject matter was determined by (a) examining the textbooks written by science "experts", (b) examining periodicals to identify problems where science principles applied, and (c) using science-related problems of individuals in various occupations. His analysis revealed that in most science programs the

simpler content was emphasized in the initial courses while the more complex content, often over the same science topics, was emphasized in the more advanced courses.[6] By 1946 the gradual changes in science instruction as revealed by the Forty-sixth Yearbook of the National Society for the Study of Education included more attention to the nature of the learner, additional physical science content, and increased emphasis upon the functional aspects of science learnings. The Fifty-ninth Yearbook of the National Society for the Study of Education revealed that there were no serious criticisms of the aforementioned criteria for selection of content but that more consideration should be given to the role of science in society. When society changes, a re-evaluation of science in the light of that changed society is necessary.[7]

Summarizing Content for Selection Purposes

Investigation of selection of science content for purposes of general education through the years reveals

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[6]Francis D. Curtis, "Investigations Relating to the Content of Science Courses." A Program for Teaching Science, Thirty-first Yearbook of the National Society for the Study of Education, Part I, Bloomington, Illinois. Public School Publishing Co., 1932, pp. 109-19.

[7]Darrell J. Barnard, and Others. "The Role of Science in Our Culture." Rethinking Science Education. National Society for the Study of Education, Fifty-ninth Yearbook, Part I, (Chicago: the University of Chicago Press, 1960.), pp. 1-17.

many methods of content selection. One of these methods has been to attempt to identify that science content which was construed to be of importance, on one basis or another, for students to understand. Important content, however, appeared so vast that it was hardly manageable. However, by using summarizing statements, such as principles, generalizations, and concepts, it was possible to reduce much factual information of science into a more manageable whole. These statements, it was hoped, when understood by the student would contain the essence of much knowledge and be valuable to the student in interpreting his experiences with the physical world. In addition, the student might be better able to interpret his future experiences if he understood the summarizing statements which described the essence of these experiences. These statements had to exhibit rather broad applicability among science topics and yet be of value to the learner.

Efforts to select the significant content through identifying summarizing statements resulted in lists of principles and generalizations in many science areas.[8] An investigation which exemplifies many such efforts was conducted by Wise in 1941 and produced a list of physical science principles thought important for general education.[9]

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[8]See Chapter III.

[9]Harold E. Wise, A Determination of the Relative Importance of Principles of Physical Science for General Education. Unpublished doctoral dissertation, University of Michigan, 1941.

Wise compiled a list of principles in physical science and sought through the opinion of selected individuals to determine the relative importance of each statement for the purposes of general education. Today some credence is given to lists of major principles when considering content for science areas.[10]

Need for Content Re-evaluation

If important physical science content has been arranged into lists of principles and generalizations readily available for persons designing physical science courses it would seem unnecessary to re-assess any program once it was established. However, the fact that science content should be re-evaluated frequently and possibly changed as often is evident upon consideration of certain factors. There are many factors which merit consideration in the selection of science content and because of a dynamic society the value judgments placed upon these factors do change and new facets of our society may emerge. Examination of these factors reveals that the junior high school science content needs attention and possible revision.

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[10]For example see: (1) U.S. Department of Health, Education, and Welfare. The Major Principles of the Biological Sciences of Importance for General Education. Circular No. 308 (Revised and reprinted December 1962) May 1948. (2) U.S. Department of Health, Education, and Welfare. The Major Principles of Physics, Chemistry, and Geology of Importance for General Education. Circular No. 308-IV (Revised and reprinted December 1962).

One such variable factor is concerned with the objectives of science teaching. Objectives are changing and very possibly will continue to change. In speaking of objectives Hale stated:

> They reiterate the need to embrace ideas, overarching concepts, and relationships as an essential part of the curriculum.[11]

Goals for junior high school science courses as suggested in Policies for Science Education (1960)[12] show a change in emphasis from previous statements as exemplified by those of the 46th Yearbook of the NSSE.[13] If these more recent goals are significant, then the achievement of these goals might be accomplished more efficiently through re-assessing present content and possibly modifying it.

Carleton identified another factor that has changed the selection of science content for junior high school science programs. He stated that the junior high school science program needs re-evaluation because much of the science content formerly considered basic for junior

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[11] Hale, op. cit., p. 3.

[12] Frederick L. Fitzpatrick, (ed.). Policies for Science Education. (New York: Bureau of Publications, Columbia University, 1960).

[13] Science Education in American Schools. National Society for the Study of Education, Forty-sixth Yearbook, Part I, (Chicago: the University of Chicago Press, 1947) Chpt. III.

high schools is now included in elementary programs. Today, the science programs in the junior high schools are seldom the initial science programs for these students.[14]

But the change in programs has not been limited to elementary instruction. Extensive revisions are seen at the high school level. The Physical Science Study Committee, the Biological Science Curriculum Study, the Chemical Bond Approach, and the Chemical Education Materials Study have been responsible for producing revised programs and materials now in use in their respective areas. These programs are the results of large scale concentrated efforts to modify science programs at the high school level.[15] These programs appear quite specific in their approach to selection and presentation of science content.

A reason given for such extensive revisions by these groups appears in a position paper on curriculum published by the National Science Teachers Association. The statement reads:

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[14]Robert H. Carleton, and Others. "Improving Secondary-School Science." Rethinking Science Education, National Society for the Study of Education, Fifty-ninth Yearbook, Part I, (Chicago: the University of Chicago Press, 1960) pp. 153-7.

[15]Further understanding of these programs can be gained by reading reviews in the official publication of the American Association of Physics Teachers, the American Institute of Biological Sciences, and the American Chemical Society. The Physical Science Study Committee's work is described in the next section of this investigation.

> A basic premise of each of these groups is that science instruction in most schools is out-of-date and fails to present an understanding of the objectives and methods of scientific inquiry. Programs in the elementary schools and junior high schools manifest the same obsolescence.[16]

Because high school programs have received massive and extensive revisions, Calandra suggested similar efforts should be given to revision of the elementary and junior high programs.[17]

Another factor for re-evaluating junior high school content besides the changes in elementary and high school programs is the increased amount of knowledge becoming available for inclusion in physical science courses.

"Scientific knowledge is 'increasing exponentially' in this century," stated H. Bentley Glass.[18]

With science knowledge increasing so rapidly it appears that only a portion of it can be included in programs of general education. This implies that the content which is selected should be significant and valuable to the learner. That which is selected would be most appropriate if it would exhibit wide applicability to most of the total

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[16]National Science Teachers Association. The NSTA Position on Curriculum Development in Science. National Science Teachers Association, (Washington, D.C., 1962).

[17]Alexander Calandra, "Some Observations on the Work of the PSSC." Harvard Educational Review. Vol. XXIX, Winter 1959, p. 20.

[18]H. Bentley Glass, "The Biology Teacher in a Racing World." School Life. Vol. XLV, No. 1, October 1962, p. 10.

content of science or have counterparts in major science areas. Fragmentary knowledge would have lesser importance. This idea is reported by Finlay in reviewing the committee's work on the Physical Science Study Committee's high school physics course. He stated:

> The committee has chosen to select subject matter and organize it with the intent of providing as broad and powerful a base as possible for further learning both in and beyond the classroom. Through its materials the Committee seeks to convey those aspects of science which have the deepest meaning, the widest applicability.[19]

The fact that basic ideas and generalizations deserve attention in science courses is borne out by research upon how long generalizations are remembered by students. In reviewing the emphasis so-called facts of science should have in science courses in contrast to the emphasis upon "understanding science generalizations," Barnard reported:

> It has been found that up to 70 percent of the specific facts learned in a science course are forgotten within one year after the completion of the course. The loss in understanding of generalizations and in ability to apply generalizations is very much less.[20]

The K-12 programs stress the importance of having an appropriate sequence of science courses so that greater

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[19]Gilbert C. Finlay, "Secondary School Physics: The Physical Science Study Committee." Progress Report-1959 Educational Services Incorporated, Watertown, Mass., 1959, p. 37.

[20]J. Darrell Barnard, What Research Says to the Teacher: Teaching High-School Science. National Education Association, Washington, D.C., 1956, p. 7.

articulation and coordination of courses result. Support for K-12 programs is drawn from the premise that certain science learnings are appropriate for every grade level and that students can and should achieve in science at each grade level. Therefore, each science course should build upon former courses by re-emphasizing that content which seems necessary and by deepening and broadening the understandings already conceived.

As stated previously, the elementary science program has undergone considerable change. The high school physics course has had considerable revision. Therefore, if articulated programs are desired, a revision of the junior high school science program should be accomplished and, in so doing, some consideration should be given to the changes in elementary and senior high school science programs.

The most recent extensive revision in high school physics has been the Physical Science Study Committee's (PSSC) high school physics course. After four years of preparation it was published in complete form in 1960 and has been inaugurated into many school systems since then. Because it has been available for review for some time, many persons are well acquainted with it. Numerous reviews of it have been given in professional science journals since its inauguration.

Consideration of these factors gave the investigator two impressions which appeared important and interesting in

considering selection of physical science content for junior high school physical science programs.

The first impression had to do with generalizations in the scheme of science. Generalizations appear to be able to embrace the essence of much science knowledge when they are understood. Presently science knowledge is increasing at such a rapid pace that attention cannot be given to all of it so selection of the most suitable is highly desirable. When understood by a student a generalization can often serve as a basis for interpreting hitherto unknown phenomena. Furthermore, generalizations if understood are retained longer than the so-called facts of science.

The investigator is supported by others in the significance placed upon generalizations in science. Barnard reported:

> In terms of the subject matter objectives of science it is quite obvious that science teachers should be teaching for growth in understanding generalizations of science.[21]

The second impression of the investigator in selection of physical science content is the need for articulation and coordination of courses. One of the main proposals of the Thirty-first Yearbook of the National Society for the Study of Education was the developmental

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[21] Ibid., p. 8.

twelve-year program.[22] Yet as recently as 1960 the national convention of the National Science Teachers Association had as its theme, "Current Science and the K-12 Program."

Since developmental integrated programs are desirable in science,[23] it seems that some attention should be given to high school science courses when planning junior high science programs. A course which should receive this attention when planning the junior high school program is the Physical Science Study Committee's (PSSC) high school physics course. It has been in existence for a sufficient length of time for many persons to become well acquainted with it. Therefore, it seemed appropriate to the investigator that a review of the PSSC physics course should be made primarily with regard to the generalizations inherent within this course when attempting to determine pre-PSSC physical science content.

Upon examination of the PSSC physics course, the investigator found major changes in the content and philosophy of PSSC physics from that of the more traditional

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[22] A Program for Teaching Science. National Society for the Study of Education, Thirty-first Yearbook, Part I, (Bloomington, Illinois: Public School Publishing Co., 1932).

[23] Robert H. Carleton, and Others. "Improving Secondary-School Science." Rethinking Science Education, National Society for the Study of Education, Fifty-ninth Yearbook, Part I, (Chicago: the University of Chicago Press, 1960), pp. 158-9.

high school physics course. A brief review of the PSSC physics course is given in the next section.

The PSSC Physics Course

The Physical Science Study Committee (PSSC) was comprised of a group of university and secondary school physics teachers who worked to produce an improved high school physics course. Begun in 1956 at the Massachusetts Institute of Technology, this project was financially supported by the National Science Foundation, The Ford Foundation, and the Alfred P. Sloan Foundation.

A large part of the credit for PSSC physics should go to Professor Jerrold R. Zacharias of the Massachusetts Institute of Technology for his organization and pace-setting for the committee. The PSSC course, however, is the work of several hundred persons, mainly college and high school physics teachers, contributing over a period of four years. Professor Francis L. Friedman of the Massachusetts Institute of Technology also must be given much credit for his role in developing the textbook and contributing greatly to other parts of the program. PSSC physics is the result of innumerable individual contributions, of extensive trials in many schools, and of a process of revision over a three-year period.[24]

[24] Physical Science Study Committee, Physics, (Boston: D.C. Heath and Co., 1960), pp. 641-3.

Informal discussions in 1956 among college physics teachers revealed widespread concern for, and need to improve, the high school physics course. One weakness was that it did not represent physics from the point of view of the modern scientific community. So much additional information had been added to the high school course in recent years that it was difficult to gain unity among all the topics. Also the increased amount of material had made the high school text unwieldy and encyclopedic in nature. Much of this new material reflected technology and detracted from the teaching of physics generalizations.

Therefore, it became evident that much material would by necessity be omitted. However, the committee organized at the Massachusetts Institute of Technology in the summer of 1957 desired to include generalizations which contained the essence of a large number of physics topics and could be applied to a wide range of physical phenomena. This committee of college physics teachers felt that a few topics should be studied in depth. After much discussion the following criteria were judged to be important for selection of the subject matter. Each item should: (1) stress major achievements in physics; (2) give insight into the way in which these powerful ideas were conceived, nurtured and sometimes overthrown by even more powerful ideas; (3) present a unified story by which the interconnections within physics were explained; and (4) show

physics as a human activity comparable in significance with the humanities, the languages, and other high school studies. Some physics topics of considerable significance and interest had to be omitted but with reluctance.[25]

First drafts of the course were tried in pilot schools with revisions forthcoming the following summer. This led naturally to the involvement of high school teachers and a consideration of student reactions. Three years of increased involvement of more pilot schools, including summer revisions terminated in the present text.[26]

Elbert P. Little gave a brief review of the course content and format in 1959.

> The course outline is in four major sections. The first deals with the basic concepts of which the student must have some understanding before he can pursue a worthwhile study of the subject matter of science: Time, distance and motion; the nature of measurement; the atomic structure of matter and the molecular interpretation of chemistry. The presentation is through general concepts rather than specific definitions, and the student makes some contact at once with most of the subject matter with which he will deal later in greater depth.[27]

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[25] Gilbert C. Finlay, "Physical Science Study Committee: A Status Report," Progress Report-1959, Educational Services Incorporated, Watertown, Mass., 1959, p. 23.

[26] Physical Science Study Committee, Physics, D.C. Heath and Co., Boston, 1960.

[27] Elbert P. Little, "The Physical Science Study Committee," Harvard Educational Review, Vol. XXIX, No. 1, Winter, 1959.