Journal of the Minnesota Academy of Science

Volume 23 | Number 1 Article 16

4-1955

Trends In Science Courses

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mitting a view of the normal spectrum adjacent to the absorption spectrum provided by an acetone or alcoholic extract of chlorophyll placed in the cell. A piece of frosted glass may be used as a viewing screen, placed directly in front of the exposed surface of the filter. This addition is especially helpful when a powerful artificial light source is used. No wave length scale is provided on the filter, but an idea of the scale may be obtained by using a fluorescent desk lamp which emits blue, green, and yellow mercury lines at 435, 546, and 758 millimicrons respectively. The locations of these lines and any other marks may conveniently be made on the surface of the frosted glass screen.

The apparatus was built at a cost of about fifteen dollars. For those who do not consider themselves adept at construction, a simpler model may be made using a cardboard microscope slide box and a few pieces of cellophane tape to hold the items together. The device may be used by several students at one time; the instructor may point out various features with the full assurance that the student and the instructor are observing the same region of the spectrum. Finally, the normal and the absorption spectra are displayed side by side so that comparisons are easily made.

TRENDS IN SCIENCE COURSES

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Frequently the question arises as to what is being done in high school and college science courses. This paper attempts to bring out some of the more important aspects of three factors which are relevant to the question: trends in enrollment; characteristics of science instruction offered; and recent innovations and their implications.

Trends in Enrollment. What we teach depends, in part, upon whom we teach. Since 1870 high school enrollments have been rapidly increasing, and though the general population has also increased, the *percentage* of students of high school age enrolled reflects the remarkable increase in high school attendance. In Figure 1 we see that the rapid increase in the percentage of students attending high school is now leveling off. However, the number of students that enter high school will continue to rise. The increase in school attendance has meant that the students may differ in some ways from those who attended earlier schools. For example, they differ in their aspirations—in 1880 about three-fourths of the youth in high school went on to college, whereas in 1950, less than one-fourth of high school graduates entered college (EPC, 1952).

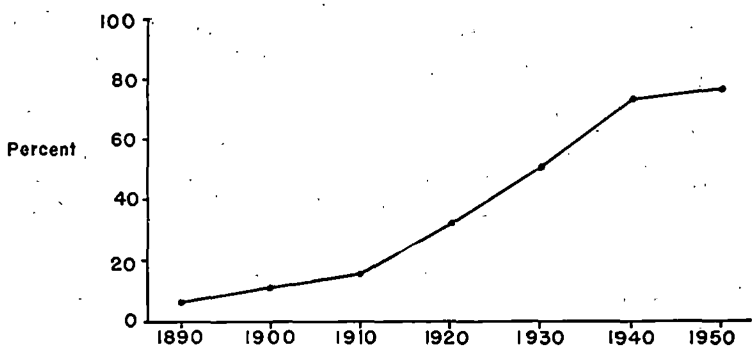

Fig. I. Percentage of population 14-17 years of age enrolled in high Schools in the U. S. (Based on data from the Biennial Survey of Education, 1948-50.)

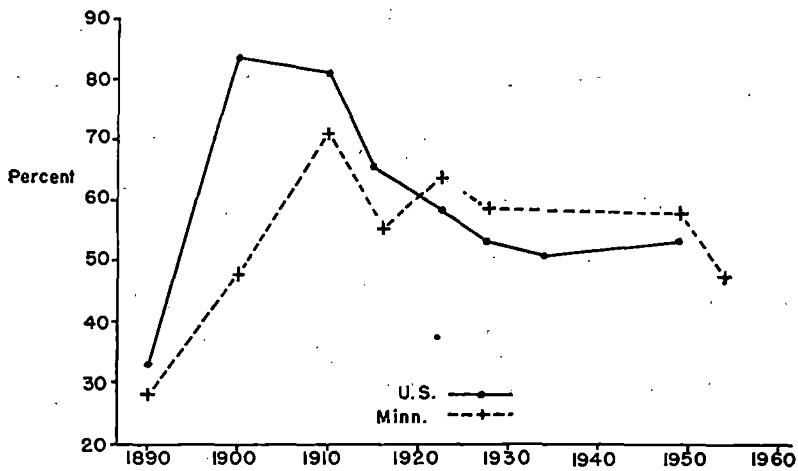

Fig. 2. Percentage of students in the last four years of high school enrolled in science classes. (Based on data from the Biennial Survey of Education, U.S. Commissioner of Education, Report, and Minnesota State Department of Education.)

This marked increase in the percentage of children attending high school has been brought about by a variety of factors, one of which is the change in curriculum offerings. As new subjects appeared in the schools, some of the students were siphoned from other subjects. Thus science courses reduced the enrollments in certain classical subjects, and later, other courses reduced the science enrollments. More important than the quantitative changes in science courses has been the shift in the types of science courses offered. In terms of the percentage of students enrolled, the shift has been toward the more general types of science courses. Figure 2 shows that the percentage of students enrolled in science courses has been changing, Minnesota enrollments following quite closely to the national figures. Though the national and Minnesota enrollment percentages appear to have leveled off, recent data from the Minnesota State Board of Education show a definite drop in the percentage of high school students enrolled in science. If this drop remains, and is also present in the national figures, those of us interested in science should be quite concerned.

One encouraging trend is the general increase in the amount of science taught in the elementary grades. Some of the programs are very well organized to aid the elementary teacher with a limited training in science. Ashley (1955) describes a plan where "science consultants" participate with the elementary teachers in planning and teaching topics in science.

Characteristics of Science Instruction. When science first entered the high school, it was largely a subject in which the instructor doled out the information for the students to memorize for later regurgitation. The assumption underlying this method of teaching was based on the idea that if a student had information about science, he would be able to use this information when the need arose. Though facts will always be an essential component of science instruction, when the principal emphasis is on facts and not on understandings or appreciations the value of the instruction may be seriously questioned. For example, the teaching of health was largely a presentation of facts about nutrition, disease vectors, etc. Since 1930, this type of instruction has been hailed as an essential aspect of the science program; however, there is evidence that taking science courses does little more than make the student more confident of his health misinformation (Leonard & Eurich, 1942). Despite the questionable results achieved by the traditional "fact-teaching" method, some studies suggest that this remains the most typical type of science instruction (Anderson, 1949, Novak, 1954).

General science courses are becoming more and more popular. This illustrates, in part, how a new type of science course is entering the curriculum to meet the needs of a different type of student in a changed society. In Minnesota, science is a required subject in the 7th, 8th, and 9th grades, and though variations exist, the students are exposed to a considerable amount of science before they reach the more traditional high school science courses. In systems where the elementary as well as the junior high school science program is well developed, the characteristic chapter-by-chapter coverage of the course textbook results in much duplication of material. Worse than this, little opportunity exists for student projects, or other creative work. Nevertheless, studies suggest that most of the science teachers focus their attention on the completion of the material in the textbook (Anderson, 1949, Novak, 1954).

Laboratory work presents two discouraging aspects. First, teachers very often report a lack of sufficient time to maintain a satisfactory laboratory program. Inadequate funds are also a problem, but if more time were available, many materials could be obtained free, or constructed. Secondly, laboratory work often involves the use of laboratory manuals in a manner which requires merely a completion of steps outlined and the insertion of answers (often predetermined) in the appropriate blanks. Laboratory problems are, typically, only problems to the writer of the laboratory manual, and except in classes where the discussions are carefully oriented toward the laboratory work, the "experiments" are hardly more than busy work. Johnson (1950) reports that more than half of the schools in the United States allow at least two hours per week for laboratory work; hence, at least in the schools in the upper fifty percent, the time allotted to laboratory work is not seriously short of that which may be most profitable, if well used.

Recent Innovations and Their Implications. If we look at the total picture, the tremendously high percentage of children enrolled in school, their varied interests and abilities, the importance of products of science in daily life, the need for critical appraisal of these products, the rising need for scientifically trained personnel, the immensity of the knowledge in any field of science, and many other factors, the traditional and widely used approach of "surveying" a science would appear to be an anachronism. We can no longer hope to cover the important aspects of a field of science. There are too many important aspects, and those which are important (or interesting) to one student may mean nothing to another. An approach is needed which will allow the student to do much more of some things than is possible in a survey course. Necessarily, fewer topics must be considered. We need a classroom where the student can study a topic to the point where he becomes emotionally concerned about scientific work. A classroom where the activities are limited to the reading of the textbook, where laboratory work constitutes the satisfactory addition of answers to the laboratory "cookbook," does more than fail to develop an attitude of "scientific skepticism." It encourages the acceptance of answers from questionable authorities, or from experiments that are not really experiments.

It is unlikely that any teaching procedure can be described which is truly new, since good teachers have employed a variety of successful methods for hundreds of years. However, under the conditions that exist in the high schools and colleges today, instruction which places the principal emphasis on more than the teaching of facts appears to be an innovation. A variety of techniques have been tried at the high school level, and reported in journals. At the college level, some of the more notable and promising attempts have been outlined in a volume edited by McGrath (1948).

At Princeton a course has been designed for the express purpose of teaching something of the methodology of science (cf. Rogers, 1949). Facts have their place, but they are not the center of attention. The laboratory is so arranged that a student must actually find answers to problems. More than that, he must figure out how to attack the problem.

It may be argued that all science courses attempt to accomplish these ends. No doubt many instructors hope to teach students something about scientific methodology. However, the pressure of time weighs so heavily when one attempts to "survey" a science, that individual student activities are all too often squeezed out of the schedule. The press of time also limits the possible approaches which may be utilized in developing a topic.

Perhaps the best single characteristic of the newer methods is the small number of topics considered. A semester course may present as few as three or four topics. For example, one topic may be "diffusion phenomena." Here the instructor would bring in facts, many of which are already familiar to the students—motion of molecules, variation in size, mass, and velocity of particles, perforated nature of "membranes," etc. Old knowledge could be fused with new. The more sophisticated class might consider the probability of net molecular motion, or the role of chance in diffusion phenomena. Students with a historical proclivity may choose to consider the development of diffusion and molecular concepts up to present day interpretations of certain physical and biological processes, i.e., osmosis. Each student may approach the topic from a somewhat different basis. And yet, all would have certain facts and principles in common. The method may appear "utopian" and impracticable, but it has been tried and it works.

Equally as important as the content of the course are the examinations which must test for many of the same learnings that the course hopes to impart. Too often examinations completely neglect the measurement of the student's ability to gain insight into problems and to attack the problems in a manner which is scientifically acceptable. Students soon become aware of this, and inasmuch as their grades are based on the examinations, their efforts are usually directed principally toward those learnings which will bring success on the examinations.

The method at Princeton, and similar approaches at some other colleges, are important not because they are novel, but because of the unique possibilities they provide. The lectures are more than a deluge of facts and principles—they are also a carefully organized set of ideas which may give the student some insight into the nature of science, may even stimulate him to the point where he feels he would like to be a member of the scientific group. And if the student becomes interested in teaching science, the class may teach him how to solve problems experimentally, not by the substitution of anwsers from the textbook to the laboratory manual. Nor will the student rely on a textbook as his sole source of reference material. We are to a great extent slaves to our habits; therefore, let's try to inculcate those habits which are needed in both our future teachers and lay citizens. Let's explore the possibilities of these newer methods of teaching in our science classes.

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PROGRAMS FOR THE PREPARATION OF TEACHERS OF THE PHYSICAL SCIENCES AND MATHEMATICS

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THE STATUS OF SCIENCE EDUCATION

Science education seems to have arrived at a critical stage both from the standpoint of enrollment and availability of science teachers. Youth seems to be beginning to wonder if science offers a fruitful and desirable career. There are also factors operating to reduce the number who are preparing to become teachers of science. Statistics on enrollments in junior and senior high school courses in science and on colleges preparing teachers of science seem to support this trend of events.

A sample survey[1] by the United States Office of Education of the status of enrollment in science courses covering the first