OBJECTIVES OF A GENERAL PHYSICAL SCIENCE COURSE

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In the past few years, much has been said and written about General Education, its objectives and methods. Curricula and courses of study in the liberal arts colleges have been revised and reorganized in view of the modern trend. Even the professional training programs in engineering, law, and medicine have felt the impact of the new programs. When one observes these changes, the question arises—"What has been the motivating factor that has led to this phenomenal change in education?" Basic to any General Education program is the desire of educators to contribute not to one narrow phase of the student's life, viz., the professional training but to all phases of human life, the total intellectual training of the student. In fact some have gone so far as to say that colleges and universities should perform all educational functions not adequately done by other institutions within our society. It is obvious that such a task is exceedingly difficult and complex. No sensible educator could expect to achieve such a panacea in a short period.

The translation of the objectives given by Hutchins[1], MacLean[2], Kelly[3], Wriston[4], and others have been mere samplings of the vast body of suitable subject matter available to achieve these objectives. Each program is the result of a subjective interpretation of the particular organizers. Wherever one looks one sees that science courses are included in these programs. The science teachers have responded to the demand to contribute. In fact, if the views of Dr. Duane Roller[5], expressed in recent paper, are accepted as representative, the task of the sciences is *not* that of just another course, but that of leadership. The sciences are in a favored position to contribute. The experimental evidence presented in support of our major laws and concepts is based upon controlled experiment. There can be no accusation of endoctrination or ulterior purposes attached to our efforts to teach principles. Our final conclusions may always be tested by further experiment without doing irrevocable harm to human society. Other fields of endeavor do not enjoy these advantages. If there is any group that can come near to saying that our principles are the truth, we can.

The question then arises, with all these advantages, what shall the contributions of the sciences be? There is quite general agreement on three objectives. These are:

1. To lead to an adequate understanding on the part of the student of the major facts and principles of the physical sciences.

2. To develop the ability of the student to do critical thinking.

3. To develop in the student a sensitiveness to the social implications of the sciences.

The first objective provides the frame work or superstructure of the course. Success or failure in making a worthwhile contribution in the general education program will depend upon the choice of facts and prin-

1, 2, 3, 4—Quotations from William J. Hagerty, *Current Issues in General Education*, *46*, 497-514, Sept. 1938.

5. Roller, Duane, *The Role of the Sciences in General Education*, Am. Phys. Teacher, *6*, 244, 1938.

ciples. No building is better than its foundation. Further, the design of the foundation is conditioned by the uses and function of the building. In a similar manner, the choice of facts and principles are conditioned by the other objectives of the course. Another factor in the choice of facts and principles is the needs and abilities of the students. The educational experiences of one group are not suitable for another. Variations in the high school training of students require special consideration at different institutions. A group with an intense intellectual curiosity will master principles that other groups will find uninteresting and dull. For the former group one may adopt an analytical, pure science approach, for the latter, one adopts a descriptive, or perhaps interpretative approach fairly bustling in startling facts. In the pure science approach, one must be prepared to omit many principles that are usually considered of major importance because of the lack of time. However the understanding will reach a higher level and probability of transfer to other fields is greater. In the descriptive approach more may "covered," but the understanding will probably be very low and the transfer *nil*. In experimenting with groups, the amount of material that young minds can memorize without understanding is amazing. This, however, is not as great a defect as it may appear because the large quantity of subject matter does make the student conscious of the influence of science upon our society. It may provide an easy approach to achieving our third objective. While I have no "a priori" objections to the interpretive approach, I do feel that there is a danger in going too far afield. With the vast amount of actual physical sciences to be taught, there is little time for teaching the social sciences. As it is, time will not permit adequate treatment of the few principles taught in conventional courses.

This brings up another dilemma. There seem to be no criteria for the division of time and emphasis between facts and principles. How much background (facts) must be presented in order to assure adequate understanding of the broad generalizations (laws and principles). Isolated facts have no value nor do the broad generalizations unless the student has had the educational experiences that make them real. Here the dilemma can only be solved by agreement of a suitable definition of the term 'adequate understanding.' If one can determine a series of representative situations to which the student may be expected to transfer his knowledge, one can reach a suitable standard for the understanding of these principles. In conventional courses, we are guided by the ability of the student as evidenced by his success or failure in the next course. Usually in the general course there is no follow up. Reliance must be placed upon the subjective opinion of the organizers and administrators of the course. This must be done, free from departmental prejudices. The organizers (note the plural form) must attempt to recognize their own weaknesses and examine their choices in as objective manner as possible. Calm and deliberate consideration of this problem by representatives of each department usually solves this problem providing the representatives are interested in developing a unified approach to science.

The second objective, *the development of the ability to do critical thinking* has often been termed *'the knowledge of and ability to apply the scientific method.'* There is little to be gained by arguing terminology as long as agreement can be found in the meaning of the terms. Surely, the scientific method of approach to problems can only be achieved through critical thinking. Also, critical thinking cannot be done in many cases without an application of the scientific method; yet, in critical thinking, certain skills are required which scientists have not always considered their task to teach. For this reason, I choose what, in my opinion, is the more inclusive term. First of these skills necessary to do critical thinking is the ability to recognize assumption. This

ability is fundamental to work in the sciences. It finds applications in arguments ranging from the basic philosophies of our social and political life to advertisements for cold remedies, if you please. No single method for recognition of false arguments is more than this, and thus this training must be stressed in our program. Another skill in critical thinking was first stated by Alpheus Smith[6].

The ability to 'critically analyse data and draw inferences from these data'. In our daily lives, we usually rely upon others to make our observations. Various agencies of government and private enterprises have as their function the obtaining and organization of data and the drawing of inferences therefrom. Often these inferences are drawn by so called experts with ulterior motives. It is thus an advantage to train the individuals of our society to distinguish between true and false inferences from numerical and other types of data. This skill involves a familiarity with many forms of tabular and graphical representation, the significence, rules and dangers of interpolation and extrapolation; the distinction between an actual observation and an inference; and finally, the relevance or irrelevance of the data to the argument at hand. The latter ability is combined with the ability to recognize assumptions.

Another aspect of this objective is the ability to reason logically and to judge the nature of proof. This involves the various forms of proof discussed most often in good courses in Euclidean Geometry. If the students do not have this ability, it is up to the sciences to attempt to meet this need.

This objective in my opinion is the lasting contribution of the sciences. It involves much philosophy and some mathematics. Inclusion in a course of science may be justified on the grounds these abilities are necessary for the understanding of the principles of science. If the philosophy courses are given to achieve these objectives, there will be more time for science Surely, the level of the course could be raised if the students had these skills.

The last objective to develop in the student a sensitiveness *to the social and economical implications of the sciences* can be achieved in several ways. Perhaps in the economic field, one may stress the efforts of science in the direction of achieving greater efficiency and in the conservation of raw materials and resources. The influence of scientific creations and discoveries on our modes of living is another approach. Perhaps the most difficult is the approach of giving the influence of the sciences on our modes of thought. In any one of the three, a complete picture may be achieved. In the interpretative approach one starts here and proceeds to give those principles relating to the particular problem being studied. As I mentioned before there is danger here in that one may go too far afield. For this reason, in many courses, especially, those using the pure science approach, this objective is achieved indirectly. Here the student is expected to see the application of scientific principles to his daily life. How great this transfer is, is difficult to measure. Nevertheless, it is one of our objectives.

In this paper, I have tried to give the significance of the objectives in physical science courses at the college level. To be sure, the present courses are not achieving all of these objectives. The principal difficulty is in the amount of time. The time is all too short. There are two possibilities that can eliminate this difficulty. First is that the present courses which for the most part, stress the first objective may be taken

6. Smith, Alpheus W., R. W. Tyler, L. M. Heil, *Evaluation of Student Achievement in the Physical Sciences*, *5*, 102, 1937.

by the highschool, and yielding more time for an analytical approach at a higher level. The other alternative is the extension of the general education program to the complete four years, leaving specialization to a later period. Under these conditions, the sciences can justify in terms of these objectives, twice to three times the present allotment in time.

Either alternative is at a great distance. For the present, science courses must make an adequate contribution within the given interval time in spite of the difficulties. Constant cognizance of our objectives, experience, and critical analysis of content and method have yielded vast improvements. There is still a long road ahead for we have undertaken a difficult task. If the progress we have made in the past years continues, eventual success is assured.