SCIENCE IN THE HIGH SCHOOL CURRICULA

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The place of science in the high school program is a subject that has been discussed by various groups from time to time over a long period. The importance placed upon it is determined somewhat by the group and their general interest in science in the high school program. The importance and recognition of the place of any particular subject will vary from group to group. I presume this is an advantage, because it keeps each subject area group conscious of each of the others, and at the same time requires the various subject groups to be well informed as to the contributions which each subject area can and will make to the general education program of our high school youth.

The importance of any particular field of study in the preparation of our youth cannot be passed off with general conclusions today as it may have been, let us say, at the turn of the century. The obligations of education in our modern scientific, technological, and ideological world imposes a serious burden upon the school if we are to prepare our youth to live successfully and to compete in our modern world. I believe it is necessary today in formulating the program of training for young Americans to give them as much information as possible in all areas of human endeavor so that they may be prepared to at least think in all of the areas which will modify and change their environment. Since all of these areas have a great deal of valuable material it becomes necessary to evaluate carefully the kind of subject matter and the areas which must be emphasized in order to plan a well-balanced training program.

No one can deny that science is one of the most important areas of training. Every living being is faced with the existence and effects of scientific principles every living minute. Each individual is a scientific bundle of facts—a living chemical laboratory. Every living thing represents chemistry at work as well as other phases of science.

When some portion of this chemical laboratory of life fails to function, a scientist skilled in that particular field must be called to determine the cause of this failure. To human beings this scientist is known as a doctor. In his examination and inquiry into the affected area, it becomes necessary at times for him to call upon other skilled scientists to assist him in determining the cause for failure. If it is possible to determine the cause of the failure or weakness, the physician then is in a position to prescribe treatment, which in many instances involves the adminis-

tering of other chemicals to assist in the correction. Or, some other phase of science may have to be utilized.

In agriculture when soil fails to give back to man what is expected or desired, he turns to a specialist in soil science to determine the cause, and when discovered, to recommend scientific treatment of the soil in order to restore its productivity. Usually it is a soil chemist who makes the analysis and prescribes the treatment.

When man in his ever-changing environment is faced with the need for a new machine, or, for instance, the construction of a bridge, a different type of scientist is called to work upon the problem and to prescribe, and as a result of his efforts, new machines are invented to lift burdens from and solve problems for mankind.

When man in his searchings discovers some new material previously unknown to man, a scientist is called to determine the content of this new material and to help determine the uses to which it can be put to serve mankind.

When progress has been made in certain areas and man is led to believe that a new force is suspected to exist in hidden areas, another scientist is called to begin research to determine the nature of the force —how it can be unlocked and made available. For a long time before the discovery of how the atom could be split and its force utilized, man was conscious of or believed that there was such a hidden force. The challenge was how to unlock this force to make it available. A few years ago this problem was at least partially solved. We hope and anticipate that for the most part this enormous force will be used to benefit mankind, but at the same time we know that scientific discoveries have also been used to destroy mankind.

We may state that all progress made by man from the beginning of time in the area of the physical world rests upon the work and the discoveries of scientists in some area. I believe we could agree that some of the improvements and strengthening of our belief in the spiritual side of man's life have come about as a result of knowledge gained in some phase of science. Yes, even the belief in our basic philosophy of the existence of God and the improvement of our spiritual welfare has been enhanced and strengthened as a result of our constant forward march in scientific areas.

Accepting the foregoing statements as true, it becomes evident that if man is to understand the world, the environment in which he lives, he must have at least some basic fundamental knowledge in the areas of science. Hence, in outlining the program of training for youth in our elementary and high school courses, we cannot neglect the importance of this area of essential knowledge.

Too often, it seems to me, the outline of subject matter which makes up our curriculum has not been well planned—especially in the field of science. In my humble judgment I feel that the scientific portion of our training program should be a continuous and developing program of study starting at the beginning of our formal education in the kindergarten or first grade. It should grow progressively and should be adapted to meet the particular grade level

in which the subject matter is utilized. It should thus continue in an orderly and well-organized fashion from the kindergarten through the high school.

There may be those programs of preparation in science for our youth which have a tendency to wander toward the realms of specialization, especially in the elementary school. I do not believe that this is good for the best interests of the program and the learner.

In the elementary school, especially in the middle and lower grades, it is not as important to study basic scientific principles as to use text material which recognizes and contains these fundamental principles without setting them forth as such. In this area, I believe it is essential that the child grow to understand his relationship to the scientific world in which he lives—the production of life in both the plant and animal kingdoms, and man's dependence upon these plants for his very existence.

In the upper grades it is essential that youth learns the importance, for example, of a balanced diet and its contribution to his physical welfare and to his general happiness and well being. The elementary school child should also be instructed in the areas of science which teach him why it is important that he learn to take proper care of his chemical laboratory which forms the house in which he lives.

Such a general outline as this should be so well worked out that at every grade level the material would be adjusted to the understanding of that age group. In many instances some of this material can be well integrated with other areas or subjects so as not to make the material too elaborate or voluminous. I believe in addition to this it would be possible, even in the elementary school, to prepare additional scientific materials to be used by those children who show strong potentialities in the field of science and who at the same time possess what, for lack of a better term, we call a "high intelligence quotient." In approaching this problem, teachers in the classroom must recognize that if the hidden potentials of our children are to be developed, we must offer continuous challenges to them which will whet their appetities, increase their desires, and help them to progress in the ever-challenging world in which we live.

In high school it is possible to offer a new specialized approach in the field of science. We move into the areas of chemistry, physics, biology, earth science, and health. It is possible then for the student to learn and understand the chemistry and physics of the world in which he lives and how dependent man is upon this knowledge if he is to live understandingly, successfully, and happily.

In both the areas of elementary and high school scientific courses, the school should utilize as source material, insofar as possible, the local environment in which the student finds himself. This tends to tie together the purely scientific phase of man's interest and the practical side of man's life. It enables the teacher to make clear to the student the importance of both of these areas in the life of human beings.

I recognize that probably not all students should be required to study

these specialized fields of science. But the courses should be required of all students who show that they possess excellent scientific potentials, a high degree of intelligence, or special potentials in the field of teaching, research, medicine, physics, engineering and chemistry. I believe that the teacher of science has a responsibility to the student to discover, if possible, some of his tendencies and, when discovered, to afford him the opportunity of further developing these potentials.

I am not well enough informed on the outline of high school courses to know whether or not the following idea is in existence or whether it is a practical one, but I do believe it holds a challenge which might well be considered and utilized, especially in large high schools where it can be organized for the benefit of that group of students who show the potentials to which I have referred.

The idea is this: That it may be well to offer as elective courses certain prerequisite courses in the specialized fields of science which would enable the instructors to discover the students' likelihood of scientific potentials in any particular science area. When these courses have been completed, the school should organize more specialized courses in certain areas of science which would give the more gifted child greater challenges in fields of exploration and so assist him in developing these hidden qualities. As I say, I am not sure whether or not this principle is used in our American high schools, but I believe it is worthy of consideration if we are to offer to the more able group of children greater challenges than the general courses offer at present. It might be well for those who show ability to be classified into groups where they could move forward more rapidly, especially in the general courses. This would permit them to go into the more specialized courses at an earlier date and complete them within the prescribed period of time which we usually allot to the secondary school.

I have heard it charged that in some high school courses of study there has been a tendency to reduce rather than to enlarge the science offerings. Where this has been the practice, I am of the opinion that it would be impossible for the teacher to have sufficient opportunity to discover the hidden potentials of those who come under his instruction. This could have bad results, not only in helping the child discover his talents, but also in denying to the scientific world, abilities which we all know are needed now more than ever before.

Many of our high school courses have been organized around the theory that high school science courses should be chiefly concerned with the presentation and memorization of scientific facts. It is true that a certain amount of this is necessary, but for the most part the courses should be organized on the problem-solving basis. I believe, too, that many scientific facts will be more easily learned and mastered when approached from the problem-solving point of view rather than from the point of view of merely memorizing the facts as such. You in this organization, are very conscious of this. However, I believe that you have a responsibility to the other areas of education in making known

to them these conditions, for the reason that no particular subject of study in the high school is wholly independent of all other areas of study. The high school program of training is an overall program and each subject is interrelated with the other, and we must recognize this in outlining and organizing the program of education in our secondary schools.

In utilizing the "problem-solving" method of approach, the student begins to learn what I conceive to be the difference between *research* and re*search*. I have known individuals in my time who used these words interchangeably. While it may be true that the dictionary might not make a distinction, I believe that from the scientific point of view there is a real difference. The first, *research*, as I conceive it, means merely a review of the areas already covered, to discover known facts and principles; but the second term, re*search*, means a critical and exhaustive investigation, possibly through experimentation, in an effort to discover new principles and unknown facts. Handling courses in science in this fashion, when properly directed, gives the student fundamental and important training in the scientific approach and tends to develop techniques in the field of research. It leads him, and I think desirably so, to the point where he is not willing to accept the expression of a mere opinion, but rather to examine critically to discover whether or not a given statement is true or false.

As I have already pointed out above, it is the duty of every teacher, including the teacher of science, to help each student discover his hidden potentials, to utilize every opportunity to encourage the child from kindergarten through the high school to enter into activities and projects in an effort to help him to discover his talents, and when once discovered, to lend to him every encouragement and opportunity to develop that hidden gift at the particular grade level in which the child finds himself at any particular period of time as he moves through the formal educational program.

To me this is highly important, because today as never before, our very existence as a nation depends upon the successful training and development of the abilities of our young people in all areas of learning, and especially in the fields of science. Under our system of government, with our concept of freedom and liberty, the individual is free to direct his talents any way he sees fit and should be allowed to push the horizon farther out in his particular specialization. To make such opportunities possible places a heavy responsibility upon the teachers in our classrooms, from kindergarten through high school, but they must carry it if we are to give our best.

Today with various types of ideologies competing in their efforts to prove which is best, the free mind is more important than ever before. You and I as teachers, and you in the field of science, must constantly strive toward and always emphasize this important principle. It is only with the improvement and the utilization of this basic philosophy that we will be able to maintain what you and I believe to be most important—free people with free minds in a free society.

To make it clear why I place so much importance on the above, we can turn to the work-a-day world to see how great our national need is in the various fields of science. We must continue to develop constructively to meet those ever growing needs.

(1) It is well known that the field of nursing is in great need of more skilled people if we are to look carefully and methodically into the curative field of human ailments. Along with the need for nurses, we are all very conscious of the fact that our country needs more good doctors. Unless we move conscientiously forward in our training areas with the knowledge of these shortages and utilize every opportunity to encourage and develop the potentials in our youth, these needs will never be met.

You are well acquainted with the high quality of academic preparation which is needed in the field of medicine. For instance, in our own University of Illinois College of Medicine, for several years now, no prospective doctor has been permitted to enter unless his scholastic average was at least 4. This means that you and I have to shoulder a responsibility in pointing out to the student the necessity of constant and earnest application during his period of preparation if he shows potentials and has a desire to enter this specialized field. While it is true that good doctors may come from those who do not meet this requirement, yet due to lack of facilities to train, it becomes necessary as a screening device to select those with a high quality of preparation. As a result of the standards which have been at least temporarily adopted, seldom do they have failures because of lack of ability.

(2) The same story can be told in the area of physical sciences: engineers are in great demand, and so are capable physicists, research chemists, research specialists in physiological sciences.

These illustrations point out the necessity and importance of our efforts in helping the nation to discover the young peoples' potential abilities and the use to which they can be turned. This general responsibility rests only in part on the shoulders of the high school teachers in the field of science. But the high school science teachers have an opportunity which, to the best of my knowledge and belief, has not been utilized as it should be. I believe that they have a responsibility of working with the teachers in the elementary schools in helping to develop and to organize desirable material which should be included in elementary science courses. I think the high school teachers of science would render a great service to the youth of this nation if from time to time they could meet with the elementary teachers interested in science and point out to them some of the responsibilities which they owe to the children in addition to that of merely instructing or teaching the materials at hand. This kind of cooperation and support would greatly strengthen the elementary courses and encourage the teachers to render to children an even greater service than they are giving today. I believe that when work of this type is done in the elementary school, the child who enters high school comes better prepared and with a better attitude than

he would otherwise possess. I am not sure just what has been done in this particular area, but I believe it is a challenge to the high school teachers of science.

Of course, I recognize some of the problems with which you will be faced when approaching this problem as I have suggested. The approach can come through an overall study of curriculum work. It can come in general teachers' meetings. If these meetings are democratically developed as they should be today, the subject could be planted in the minds of the elementary teachers so that the request would come from them. This, to me, would be most desirable for it has been my experience that when individuals suggest problems for study, they approach the problems with more enthusiasm, and as a result, the outcomes are more substantial, more applicable, and so more useful than they otherwise would be. We must remember in handling this particular problem that the formal training of the elementary teacher requires only a small amount of preparation in the field of science. This must be recognized when offering help and suggestions to them.

There is one other suggestion which I feel that I should make before closing. I am certain that as teachers, and more especially you as teachers of science, are often approached by youngsters who have the idea that all discoveries have been made, all the frontiers have been eliminated, and that there is no challenge for youth today. How very wrong those youngsters are, words fail to relate. In my judgment the youth of today is faced with greater opportunities and challenges than youth of any previous generation. Science and technology have opened up new frontiers which to date have only been glimpsed. Let me give one illustration to make clear what I mean. Recently it was my privilege to talk with an internationally known chemist. We discussed only one area of knowledge in this vast field of chemistry, the soy bean. This chemist informed me that the number of products which are now coming from the soy bean and which have been made possible by the industrial chemists is small compared to what the potentials are in that particular area. He stated further that in his humble scientific judgment there was no one particular thing which human beings need and desire which cannot, through the field of chemical research, be found in the soy bean. The challenge is one of the greatest which human beings have ever faced.

We can also turn to the area of technology, the field of engineering, and allied fields. The challenges are as great and, yes, I think the area of science has more to offer in the way of frontiers in this modern day than any frontiers faced by generations of the past. We might add, too, that the field of medical research and efforts to discover treatments for the relief from human suffering and pain is just opening up. We all know that in the last few years large amounts of money have been spent and many people have been working in the field of medical research in an effort to find relief and curative treatment for such diseases as polio, cancer, and others. Yes, the place of science in the high school program must be balanced with the total pro-

gram, but its importance cannot be overemphasized because there is no area of human interest, human welfare, and human security which these scientific areas do not touch and modify. It seems to me that these are challenges which you and I as teachers must face and to which we must apply all our abilities if we are ever to give our high school students the opportunities which I have enumerated, as well as others left unsaid. To the degree that we succeed we shall make available the great latent potentials of youth for the future welfare of our nation.