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Volumes have been written on this topic and it would be the height of temerity to assume that anything really new could be contributed in this paper. Opinions, of course, differ and one justification for this discussion lies in the exchange of ideas which it may provoke. Another reason for discussing this subject stems from the present movement in colleges and secondary schools to inject the concept of so-called "general education" into the curriculum. The best-known effort of this sort is centered in Harvard College and has been reported in the volume "General Education in a Free Society." The general education idea postulates that, regardless of the vocational aims of the student, certain basic training should be given to everyone. I say training, rather than subjects, because the plan does not propose that everyone should study the same subjects. It is true that the Harvard report divides the field into four areas. These are the social sciences, the sciences, the humanities and the extra curricular or non-academic activities. Yet not all students would pursue the same courses in each area. "General education", quoting the report, "is distinguished from special education, not by subject matter, but in terms of method and outlook." Too often we teachers of science present our subjects as though our only aim was to prepare experts or specialists in our field. We fail to relate our field to the economic and social areas of living. We neglect to point out how the scientific method and even scientific techniques can be applied for greater efficiency in the kitchen, the shop, the office, the store. We miss the many opportunities to point out how the accuracy and system and conciseness of science can, by (shall we say) transfer of training, help the student to prepare business reports or book reviews or even papers like this, which are intelligible and even logical to the listener or reader. We fall short in stressing that the openmindedness and critical approach of science should make the student more tolerant, more analytical, less superstitious. In many other ways science instructors fail to offer students the full implications of the subject. We would not imply, of course, that the general education of the student is the sole premise of science. In fact, the purpose of this paper is not to discuss any new movement entitled General Education. It is, rather, to examine the processes by which we, as teachers and students of science in junior and senior colleges and universities, can help to make availlable to Iowa schools the best and most professional job of teaching.

It is doubtful if we can rank the various aspects of general educational training in order of importance, nor even in a logical sequence. We will not attempt this, but will divide this field into ten sections and take up the more general ones first.

1. How master a new field. This attainment can be rationalized through the problem of how to study a new subject. Techniques seem simple and self-evident to the scholar but they represent a constant battle for the neophyte. And in their mastery he usually fails to realize that the principles are equally applicable to a college subject, an industrial job, a professional problem, or a domestic situation. What procedures and attitudes should we strive for? We can mention only a few. First, how tackle the field (or a lesson). This calls for perspective—an over-all view. It means a rapid, but thoughtful survey of the assigned chapter (and equally, of a real-life situation). The major points and their subdivisions should be laid out and the general ideas under each should be noted. It may be sufficient that an infant be concerned with but one step at a time, but the adult must foresee the goal and envision the entire pattern leading to that goal. Yet details must not becloud the larger pattern, and so the student must learn to discriminate and assign ideas to their relative importance. How beautifully such a technique fits into what may be termed a real-life situation as well as into a college study problem!

Perhaps we should rate first, instead of second, the case against "dilly-dallying" in the mastery of a new field. This is extreme, but I well recall, in the case of a young friend of mine, that the first indication of mental deterioration was a growing inability to make decisions—a tendency to postpone doing the unpleasant task Applied to the normal student, he should learn to start the task of study promptly and vigorously—not to postpone it or day-dream or gaze about or merely 'doodle". Then, having gotten under way, he must learn to concentrate, to become oblivious to his surroundings, to direct every mental power to the mastery of the material at hand. This is not an inherited but an acquired ability and, once acquired, it is an ability which pays dividends when applied to any task. The instructor in a laboratory subject observes countless examples of manual concentration—or the lack of it. At one extreme is the student whose entire attention is centered on his work He makes every move count. He knows exactly what he is doing. And his experiments are finished well in advance of the class. At the other extreme is the wool-gatherer who stands and looks around, picks up a piece of equipment and lays it down aimlessly, makes several trips to a dispensing shelf or stockroom when one would serve the purpose, and assembles an apparatus as a 3-year-old might a set of blocks.

Such lack of efficiency is closely related to another quality to be acquired in mastering a new field. I refer to system and organization. Since science is, by definition, an organized body of knowledge, it is eminently fitted to inoculate this quality into a student. If a member of a class is doing poorly, it is almost invariably true that his lecture notes are lacking both in system and in substance. They are jotted down carelessly and heterogeneously. They are not arranged by headings and subheadings. Not infrequently science and

English and economics and mathematics are beautifully garbled and hashed in one notebook, to produce a fine case of mental indigestion. The same carelessness is evident at his laboratory working table and within his desk. Does careful training of the future science teacher in system and order transfer into other fields of endeavor? Well, if a scientist is disorderly in his home, his office and even in his hobby workshop, we would be inclined to question his results in quantitative measurements. Certain it is that a housekeeper, trained in those particulars, can save countless steps and hours from the so-called drudgery of housework and employ them in recreational or community interests. And, further, this challenge of devising efficiency methods for the humdrum tasks of life, in and out of the schoolroom, imputes to them a zest and interest not otherwise obtainable.

Before turning from this matter of mastering a new field, may we present one other factor—the time factor. One notable science educator calls it the "time study" habit. If we have a week's vacation in which to do a short, unpleasant task, we are tempted to leave it until the eleventh hour of the last day. When a student sits down to study and places no time limitation on the task, it proves to be a task with a capital T. If, on the other hand, he decides to accomplish it in, say an hour and a half,—no more—he is apt to work against time. To a degree, he has the attitude of one who must complete an hour-long examination within the hour.

2. Having presented some of the aspects of the learning or mastery process, we turn to a second section of general education. Let us label it "Discrimination" — the desire and ability for thinking critically, analytically. Instructors are sometimes illogical and inaccurate. Textbooks, even, are written by erring humans. Yet how seldomly does an instructor hear the voice of an Isaiah from his pupils! Either through inertia or timidity or false tact our students accept without question the information which the instructor presents. It is as though the man up front had been sworn to tell the truth, the whole truth, and nothing but the truth; and to challenge him would be contempt of court. Carried over into daily life, this training would cause the citizen to analyze political pronouncements; it would invite the consumer to question, perhaps discount considerably, the claims of advertisers and promoters; it would make the investor far more critical of securities offered him.

3. Social amenities. If we are to accept as one area of general education the contributions of well-balanced extra-curricular interests, then certainly they should help to develop the socially acceptable individual. To feel and appear at ease in a social group, to be able to carry on a conversation with a new acquaintance, to behave as an agreeable associate under all conditions, to be far removed from the man who always ate syrup with his peas so they would stay on his knife, to appear well-groomed by adult (not college sophomore) standards—these are a few of the outcomes for which we should consciously strive in the education of our science students. They may

not affect grades, but they certainly count heavily in the popularity and success of the college product in later years.

4. Business ability. With this section and those to follow, we turn to the academic fields. Relatively few college curricula offer the type of course which gives some concentrated business training. Perhaps such is impractical. But certainly, an understanding of personal financial and business dealings, of the factors which mean profit and loss to the young scientist and to his future employer, of reaching decisions which may mean penury or affluence when he reaches retiring age—the need for these understandings certainly justifies business training for the college student, science or otherwise.

5. Social sciences. Most college curricula require a certain minimum in this area. Yet it is usually possible to limit the field to government, or economics or history or sociology. Most valuable from the applied angle would be an understanding of economics. In one sense this is true because not infrequently the scientist in industry later steps into an executive position, where he needs to know the laws and principles underlying industry. As an educated man, who must associate and converse with other of his station in life, he should also be acquainted with the principles of government—especially American government, and through a study of history, he should know something of our heritage, of past great social and political movements, and of the relation of cause to effect in the affairs of mankind.

6. English and speech. When our past graduates return for a call after they have had applied scientific experience, it is impressive that they nearly all make the same comment. In effect they say, "see that your science majors learn how to write a clear-cut, concise report; how to prepare an article worthy of publication; and how to prepare and acceptably deliver public addresses." Some make such comments with a tinge of regret in their voices because in these particulars they have been tried and found wanting. In a business group—perhaps not in a college group—there would appear some skepticism as to the value of literature to the science teacher. This variance of opinions disappears in the field of constructive English and speech. We believe that he should be thoroughly drilled in the art of clearcut direct expression, both written and oral. Organization of material, sentence structure, punctuation and the knack of unstilted, informal expression should be emphasized. The ability to prepare a speech without too great expenditure of time and to present it so as to impress the audience will prove an asset on many occasions. These accomplishments in the field of English are expected, by the public, of a college-trained man.

7. Mathematics. Under the eighth heading we shall consider the versatile teacher who can handle all of the sciences of the high school curriculum—the type that every prospective science teacher should aspire to. He would be a very inefficient physics teacher who was not well versed in mathematics. Chemistry, astronomy and, to

some extent, biology draw upon mathematical conceptions. This area is more closely related to the sciences than is any other field. Of widest application is algebra, but trigonometry and the calculus are constantly referred to in physics and physical chemistry. We must also bear in mind that the more ambitious high school science teacher will aspire to a graduate degree. Graduate work presupposes a thorough grounding in undergraduate mathematics, especially for the physical sciences. It should not be an over-statement to remark that any young person who is greatly averse to mathematics should not make science his field of special interest.

8. All major sciences. After considerable experience, and election to a large city system, the high school science man may be permitted to handle only one science—his specialty. That privilege must usually be earned by an apprenticeship in smaller systems where he must handle courses in the physical sciences, in biology and sometimes in geology. Such a prospect demands that he be qualified to instruct from the elementary textbooks of all of these sciences. A similar need arises even in the teaching of general science. Minimum preparation should include animal and plant biology, inorganic and organic chemistry, mechanics, sound and light, heat, electricity, and magnetism, geology and descriptive astronomy, with additional courses in his field of special interest. This specialization in one field is especially necessary if he wishes later to do graduate work in that field. It is, of course, essential that the prospective science teacher acquire an understanding of instructional techniques, that he have at least a minimum of training in methods; but it is also highly important that he have a thorough grounding in subject matter.

This matter of preparation in all the major sciences is not, some will contend, a part of general education for science teaching, but of special training. At any rate, it is on the border-line, because it is too frequently evident that the young teacher is qualified to handle only one or two sciences.

9. Languages. Few college trained individuals will question the cultural value of the languages if they are pursued long enough to include a study of literature in the original language. English translations often destroy the beauty of the original meanings, and often there is no English equivalent which conveys the more delicate shade of meaning of a foreign word. Yet if 40 to 50 per cent of the undergraduate's credit hours are to be applied to science, there are not enough left for extended language study. Then what is the case for languages? Statistics show that relatively few men remain in high school teaching indefinitely. Either they acquire advanced degrees and join college faculties or they enter other lines of work. Graduate work in science includes the ability to read German and French and the Ph. D. degree requires an examination in these two languages. Obviously the undergraduate years are the period for their study. German is the more difficult for the average student and if only one language can be taken it had best be German. Now, it is a reading knowledge over which the candidate is examined—not the litera-

ture. Would it be heresy, then, to suggest that one year of each language be studied, with emphasis on constructions and general vocabulary? Then urge the student to do systematic reading in foreign texts in the subject of his special interest. He thus learns the vocabulary of his science and meets some of the constructions typical of it.

10. Appreciation of the Arts. This division of the general education of the science student has been left until the last because its inclusion is debatable. It implies that one should acquire the ability to appreciate great music, paintings and sculpture, and even great literature. With it might go an amateur proficiency in some type of manual work, such as molding in clay, sketching and painting, or cabinet work. To many science specialists, these cultural subjects are an unnecessary luxury. For others they represent satisfactions which are almost priceless.

In the body of this paper there have been discussed ten areas which make up the general education of the college science student. Perhaps the choices are faulty. Certainly the list could be extended, and desirably so, if more than four years were required for a baccalaureate degree. It is not vulnerable to one criticism; lack of concreteness.

One school of educators will contend that our entire philosophy is wrong. They would hold that since education is efficient only to the extent that it contributes to the achievement of educationally sound objectives and since *general* education should cut across the entire student population, it must stress the individual first. It must assist him in his personal development and adjustment; it must sensitize him to the problems of everyday living and increase his facility in solving them; it must be concerned, in fact, with his total personality. With such a philosophy this paper takes issue only to this extent. Instead of attempting the rather intangible task of applying education to developing the individual and trusting that he will acquire the ten areas as a by-product of his general education, this paper is predicated on the philosophy that the mastery of the ten areas is the immediate goal. If they are skillfully taught the proper development of the "total personality" will be an almost certain concomitant.

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