

LIBERAL EDUCATION

in Our Engineering Colleges

By EARNEST C. WATSON

MANY OF YOU probably consider my subject, "Liberal Education in Our Engineering Colleges," as paradoxical. Not so long ago, this would have been the case, but that time has passed, or is rapidly passing. In fact I propose here to expound and defend the thesis that many of our engineering schools today are providing a better liberal education than are some of our so-called liberal arts colleges and universities. I know that this is not universally true, but I think I can convince you that it is more often true than is generally realized. But even if I do fail in establishing this thesis, I can at least point up, in a rather striking manner, the changes that are taking place in our better engineering and scientific schools.

Please do not misunderstand me. This will not be an attack upon the liberal arts colleges. On the contrary, I firmly believe that the liberal arts colleges are a vital part of the system of higher education in this country and should be supported and strengthened in every possible way. But I also believe that they should be willing to profit by the experience which the engineering colleges have had, and are having, in resisting pressures which produce over-specialization; for, unfortunately, the liberal arts colleges, it seems to me, are experiencing—and in some cases yielding to—similar pressures at the present time. I should like to begin by quoting from a brochure issued recently by one of our best known engineering colleges:

"There may never have been a time, really, when the specialist was not a mainspring of society. But even if there has ever been such a time, now long gone, we live today in an age in which the specialist has become indispensable. We live in an age when the amount a

man must know about his specialty is truly formidable.

"These circumstances have generated many fears about the education of specialists. It is well known that they are among the most intelligent and the most influential members of our society. We sometimes fear lest, in the necessary pursuit of their specialization, they shall not have time to develop a sense of proportion about the whole society of which, after all, even the noblest specialism is but a small part. Although developing a sense of proportion has to happen within the individual and over a considerable time, we suspect that the nature of his education may have something to do with his interest in developing such a sense.

"If the specialist does not develop this sense, those who worry about him and about society have two antipodal apprehensions. One is that the specialist, concentrating on his specialty, will let the rest of the world go by with the Pharisaical plea that it is 'out of his field.'

"The opposite fear is that the specialist may charge into difficult problems, confident in his skill in his own field, transposing that real skill to a fancied wisdom in another, and behave, as Ortega y Gasset suggests, with all the petulance of one learned in his own special line.

"No one in his senses would try to improve the situation by diminishing the skills of the specialists, by trying to turn back the clock. This could lead only to social disaster. Indeed, we actually need more specialists and better ones—they must know more about their specialty in the future, not less.

"On the other hand, it also appears that specialists will on the whole continue to exercise increasing influence on affairs outside their specialty. And this is the basic reason why those who are engaged in educating

specialists in America are so concerned about the liberal education of the specialists.”*

This is a problem which worries every educator who is concerned with the training of men for the professions. American engineering schools are, however, particularly concerned because of their realization that engineers and scientists are playing, and will continue to play, an increasingly important role in national and international affairs. They are key men, perhaps *the* key men of modern civilization.

This concern began developing about thirty years ago when some of our leading engineers, themselves graduates of engineering schools, pointed out that our engineering graduates, while well-trained technically, did not have the general background to assume the larger administrative positions that were opening up because of this country's rapid industrial development. They realized that in general engineers had not engaged in great policy-making experiments, but had remained essentially hired men without voice in ultimate policy or planning. And so these leading engineers began sending their own sons to liberal arts colleges for a few years before letting them enter engineering school.

This is certainly one possible solution to the problem, and it is still the procedure that is followed by the medical profession. However, some engineers and scientists, and in particular the great physical chemist, Arthur Amos Noyes, felt that it was not the best solution.

Science is for young men

Dr. Noyes pointed out that elementary science, since it is closely allied with keen boyhood interests, is absorbed better in the early years. Moreover, he was impressed by the interesting fact that many of the greatest scientific discoveries have been made by young men in their early twenties, and he clearly sensed what has now been well established by numerous vocational aptitude tests that vocational interests have definitely crystallized, in the case of over two-thirds of the population, before they are 19 years of age. As a result, he felt very strongly that students should begin their scientific studies early, before their interests and enthusiasms are diverted, and should not postpone getting into a creative scientific and engineering atmosphere until their graduate years. He also realized that cultural interests, on the other hand, usually awaken late and should be approached with a mature mind.

As a result, at the California Institute of Technology, although it is in many ways primarily a graduate school, able students have for the past thirty years been taken directly from the high school, while their enthusiasm for science or engineering is at its height, and have been immersed in a creative and research atmosphere where, right from the start, they have been allowed to study intensively the fundamentals that underlie all the scientific and engineering fields. At the same time, however, *and this I wish to emphasize*, they are

required to devote a minimum of a quarter of their time to work in history and government, literature, economics, philosophy, psychology and the like—not for two years, but for four years; and even for five, if they go on for the master's degree.

These humanistic studies are not of the survey type, which are so likely to be superficial. Instead, they try to provide each student with as deep a knowledge as possible of a few intellectual disciplines, in which the ways of thinking are likely to be quite different from those in science and engineering. They, therefore, serve to enlarge the student's mental horizon beyond the limits of his immediate professional interest and thus better qualify him to realize his opportunities and fulfill his responsibilities as a citizen and member of society.

Humanities at Caltech

And the men who teach these humanistic studies are coming to be as distinguished in their own fields as are those who teach the scientific and engineering disciplines; in short, as distinguished as any in the nation. This we are accomplishing, even though we do not offer graduate work in these fields, partly because we have the Huntington Library as a close neighbor; but more especially because we are paying fair salaries and are allowing time for creative and scholarly work by requiring only relatively light teaching loads. Also the necessary funds for research are provided, as well as leaves of absence with full pay when facilities for the desired scholarly work are not available here.

Moreover, all members of the humanities staff at Caltech have to be good teachers as well as competent scholars for, whether they like it or not, they are forced by the fact that they are teaching at an engineering school to think both deeply and continually about why they are teaching what they are, and how they can improve their offerings both as to content and manner of presentation. In the liberal arts colleges, on the other hand, the liberal arts courses are taken for granted and do not have to be well taught. The instructor at Caltech, however, is being asked continually by his students, "Why should I be required to take this course?" and frequently by his colleagues, "Why should valuable time be taken from the professional courses I am teaching to provide for the sort of thing you do?" As a result, he discovers a new perspective in his teaching. He finds he has a mission and that this mission is closely related to that of his colleagues in other areas.

But you may well ask what the effect has been upon the professional success of our engineering graduates of our emphasis upon the humanities and the basic sciences at the expense of the traditional engineering applications. When we first introduced this program, our engineering staff all believed that our students would have to go on for a fifth year largely devoted to the applications in order to compete successfully with the graduates of other engineering schools. It was soon demonstrated, however, by their actual performance

* Bulletin of the Massachusetts Institute of Technology

that in the long run they did at least as well in industry as the graduates of these other engineering schools and that they almost without exception performed better in graduate work. We are now convinced that thorough basic training and greater breadth of background more than compensates for any lack of knowledge of the immediate applications. This provides a strong argument against the validity of the claims that more and more of the student's time must be devoted to work in his field of specialization if he is to be adequately prepared for graduate work.

But even so, the liberal education of our students is not left entirely in the hands of the humanities staff, for physics, chemistry, and even mathematics are generally recognized as liberal arts and in the hands of master teachers make a very real contribution to liberal as well as to special education. And I am sure that even our professional and graduate courses, when properly taught, add much to the moral and ethical character as well as to the technical competence of our students. It seems to me also, as Dean Dennes of the University of California has recently argued, that such basic notions as value, purpose, law, meaning, evidence, etc. are better taught as a part of our regular courses than in special courses artificially designed for the purpose.

Outside the curriculum

Finally, we are not neglecting that factor in the education of an undergraduate which lies outside the formal curriculum. The Institute encourages a reasonable participation in student activities of a social, literary or artistic nature, such as student publications, debating, dramatics, and music; and all undergraduates are required to take regular exercise, preferably in the form of intercollegiate or intramural sports. In fact, California Institute students not only engage in student activities, athletics, and social affairs, but they engage in them *more*, on the average, than do other college students.

The Caltech undergraduate can (and does) take part in a wide range of campus activities, including an efficient student government organization, and an honor system that really works. He can (and does) engage in religious activities arranged and sponsored by his own Y. M. C. A. He can (and does) have access to a comprehensive library of recorded music which he listens to in a comfortable lounge. (This facility is, in fact, in use on an average of 14 hours a day.) He can (and does) sing and play good music under a trained leader, and hear concerts by leading string quartets, instrumentalists, vocalists, and symphony orchestras. He can (and does) attend extra-curricular lectures on music theory and appreciation. He can (and does) participate in Saturday classes in art under an experienced teacher. He can (and does) attend lectures by authorities in varied fields. He can (and does) make good use of a Public Affairs Room where magazines, newspapers, government documents and educational material from

all over the world are received regularly by air mail. And, believe it or not, Caltech students, entirely on their own initiative, have started publishing a literary magazine.

So, in short, every effort is made to carry on a well-rounded, well-integrated program which will not only give the student sound training in his professional field but will also develop character, wisdom, taste, ideals, breadth of view, general culture, a sense of values and physical well-being, as well as intellectual power.

Specialization and general education

But you say, isn't this just what the liberal arts college is set up to do and actually does better than an engineering school can do? Admittedly, I have too little first-hand information to appraise fairly the general education programs of the liberal arts colleges. I have, however, observed what is probably a better than average sampling of the graduates of our liberal arts colleges among the students who come to the California Institute for graduate work, and frankly I am not always happy with what I see. In many, if not the majority of cases, these liberal arts graduates are more highly specialized than our Caltech graduates and have actually had less work outside their field of specialization than have our own students. Moreover, the liberal education they have had has mostly been concentrated in their first two years of college, when they were still too immature to derive much benefit from it. As a result, in order to satisfy our requirements for the master's degree, they have, much against their will, to make up undergraduate prerequisites—not in science and engineering, but in the humanities.

Liberal education and liberal arts

I have also examined the curricula offered by a number of liberal arts colleges, and when I have had the opportunity I have spot-checked the program cards of randomly selected students. My findings may not be typical but for what they are worth, they are as follows:

(1) The amount of time which a liberal arts student is required to spend outside his field of specialization is no greater than in an engineering school. Many so-called liberal arts institutions grant the B.A. and M.A. degree on programs of study that include less than 20% of humanistic courses, and I know of Bachelors of Arts whose total studies in the humanities consist of a course in English composition and a course in citizenship.

(2) Students in liberal arts colleges are in general encouraged to complete their general education requirements during the first two years.

(3) The subjects allowed for satisfying the general education requirements are often either so diverse as practically to defeat the purpose of providing the basic core of a liberal education or are survey courses that do not require of the student any deep digging outside his field of specialization.

(4) The demand of specialization and the desire to

prepare students adequately for graduate work have caused the introductory courses, not only in the sciences but also in the humanistic and social fields, to become steps in the ladder of professional advancement rather than the introduction to liberal disciplines. Thus many of their values for a liberal education have been lost.

What all this adds up to is that while a student probably can obtain a liberal education in a liberal arts college, he often fails so to do, particularly if he is interested in going on for graduate work. As Oliver C. Carmichael, President of the Carnegie Foundation for the Advancement of Teaching, wrote recently, "the liberal arts college has to some extent lost its identity and its position as a dominant element in higher education. It has become more a service agency teaching the tools of learning, introducing the student to the broad fields of knowledge through elementary or watered-down survey courses, providing pre-professional courses for medicine, law, the ministry, nursing, etc., and preparing students for the graduate school through a kind of specialized training in some field, styled his major. The broad liberalizing program in terms of which the college is usually described simply does not exist in many institutions called colleges of arts and sciences."

It would be exceedingly interesting if objective tests could be conducted on a nationwide scale to evaluate the results of the various and sundry general education programs that are under way in many of our colleges and universities. To the best of my knowledge such tests have not yet been conducted. Nevertheless, I should like to cite the results of two types of test which are available. These results, it seems to me, shed some light upon the major question of how good a job of liberal education the engineering colleges are doing. More particularly, they refute the charge which is so often made that the engineering student has no interests beyond mechanical gadgets and only a rudimentary sense of values.

Some test results

You might expect engineering students to score well on the College Entrance Board mathematics aptitude tests—and of course they do. But would you expect that more than 75% of Caltech students do better than the national average on the verbal aptitude test? And does it surprise you that on a nation-wide test of college sophomores, taken by 11,700 students in 128 predominantly liberal arts colleges, Caltech students topped the lists by a considerable margin?

The facts are these: In the spring of 1952, Caltech participated in the National College Sophomore Testing Program. The tests, which were designed to measure objectively the students' abilities and interests in major areas of college study, were of three types: (1) an English Test, covering *Mechanics of Expression*, *Effectiveness of Expression* and *Reading Comprehension*; (2) a General Culture Test, including *History and Social Studies*, *Literature*, *Science*, *Fine Arts*, and *Mathematics*; and (3) a Contemporary Affairs Test, indicat-

ing current interest in and information about *Public Affairs*, *Science and Medicine*, and *Literature and Arts*.

When the scores of the 128 participating colleges were ranked, Caltech stood third in the English Test with a score of 66.3. A women's liberal art college was first with a score of 67.1 and a coeducational liberal arts college second with a score of 66.6. In the General Culture Test and the Contemporary Affairs Test, Caltech students were way ahead of the rest. On General Culture Caltech scored 203, with the second college scoring 161.9, the third college 160. On Contemporary Affairs Caltech scored 67.9, the second college 54.8, the third college 53.8.

The liberally-educated man

A recent committee report by members of the faculties of Andover, Exeter, Lawrenceville, Harvard, Princeton, and Yale, entitled *General Education in School and College*, characterizes "the liberally-educated man" as follows:

"The liberally-educated man is articulate, both in speech and writing. He has a feel for language, a respect for clarity and directness of expression, and a knowledge of some language other than his own. He is at home in the world of quantity, number and measurement. He thinks rationally, logically, objectively, and knows the difference between fact and opinion. When the occasion demands, however, his thought is imaginative and creative rather than logical. He is perceptive, sensitive to form and affected by beauty. His mind is flexible and adaptable, curious and independent. He knows a good deal about the world of nature and the world of man, about the culture of which he is a part, but he is never merely 'well-informed.' He can use what he knows, with judgment and discrimination. He thinks of his business or profession, his family life, and his avocations as parts of a larger whole, parts of a purpose which he has made his own. Whether making a professional or a personal decision, he acts with maturity, balance, and perspective, which comes ultimately from his knowledge of other persons, other problems, other times and places. He has convictions, which are reasoned, although he cannot always prove them. He is tolerant about the beliefs of others because he respects sincerity and is not afraid of ideas. He has values, and he can communicate them to others not only by word but by example. His personal standards are high; nothing short of excellence will satisfy him. But service to his society or to his God, not personal satisfaction alone, is the purpose of his excelling. Above all, the liberally-educated man is never a type. He is always a unique person, vivid in his distinction from other similarly educated persons, while sharing with them the traits we have mentioned."

This is, I believe, the type of man that our better engineering schools, as well as our liberal arts colleges, are trying to produce. It is absolutely essential that our specialists be such liberally-educated men if our democratic society is to survive.