



The Goals of University Research

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The university is viewed as an institution for sharpening men's intellectual abilities and focusing them on mankind's basic problems. Research seeks knowledge as a step toward understanding.

AS the title suggests, I am not proposing today to argue about the desirability or importance of research, about its cost, or about the shortage of research people or research funds. All these things can be taken for granted here.

But I am going to take the liberty of reflecting for a few moments on another subject, which possibly should also be taken for granted; namely, the place of educational institutions in the advance of science and technology.

Clearly, in order that my remarks on this subject should make sense, I must explain what kind of an educational institution I am talking about and I must state my own philosophy of what such institutions should be.

Obviously, I am not going to be talking about either public or private elementary or high schools, or even junior colleges. Nor shall I try to encompass the problems of the separate liberal arts college. In fact, in order that I may stay within an area which has relevance to the interests of this audience, I shall speak only of such institutions of higher education which are commonly called universities.

I must admit that I have a highly prejudiced, almost emotional, feeling about universities. I happen to think that they are about the most important institutions in the Western World. I believe they have made contributions to western civilization—physical, intellectual, and spiritual contributions—which are beyond the power of any man to compute or to comprehend. And I believe that the nature of the civilization that our grandchildren will inherit on this earth will depend in a critical, possibly in a decisive, degree on what our universities do, or fail to do, in coming years.

I believe in this decisive role of the university, not because I deprecate the role of our other educational, religious, and political institutions, but I believe that the way in which civilization changes over the centuries is largely determined by how men use their heads. The university, as I view it, is the spearhead of man's efforts to make better use of what is in his head. It is at the university that men's intellectual

abilities are sharpened and are brought to focus on mankind's basic problems. At the university, man's intellectual forces are mobilized for the attack on those great unknowns which lie just beyond the frontiers of knowledge. It is the role and the task of the university to be eternally dissatisfied—dissatisfied with man's inadequate knowledge; dissatisfied with the ways in which he uses his knowledge. Thus, the chief aim of a university must be, not merely to help individual men to learn more, but to help mankind to know more.

And that is about as succinct a way as I know of expressing the goal of a university: to help mankind to know more. In seeking this goal, the specific mechanism available to the university is called research. The purpose of university research then is to enlarge man's understanding of the world, his understanding of his fellow men and of himself.

You will note that I have used interchangeably the phrases, "to know more" and "to understand more." I do this without apology—and, in fact, with emphasis. To know and to understand are not quite synonymous. For, though one normally cannot understand without knowing, we frequently know things we do not understand. Yet the goal of research must be not merely to acquire knowledge for its own sake, but to secure knowledge as a step toward understanding. A research project collects facts—experimental data—not solely to prepare tables of numbers, but as an aid to finding or perfecting a theory, an interpretation, an understanding of the phenomenon. Furthermore, in science we must be most exacting in judging how far understanding has been achieved. In science we require that understanding shall be quantitative, not merely qualitative, and that it lead to the ability to predict. We require that our theory explain all the related facts, not just some of them, that it describe accurately in advance all experiments which we perform. We also aim for theories which have simplicity, elegance, beauty. Reaching an understanding of things not only satisfies an intellectual desire, but an emotional or aesthetic one too.

To repeat, then, the goal of a university is to help man

Revised text of an address presented before the AIEE Summer and Pacific General Meeting, Los Angeles, Calif., June 21-25, 1954.

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learn more and to help man understand more. Research in science, technology, and other fields is essential to the fulfillment of the university's mission. However, it is also obvious that the research undertaken must be devoted solely to achieving that mission—achieving understanding.

This is the reason why the research in a university—whether it be in science or in engineering—must, above all else, stick to fundamentals. No one questions, of course, that the job of the scientist is to do “basic” or “fundamental” research. But it is too often assumed that the job of the engineer is to avoid fundamentals and to invent gadgets. This is, of course, nonsense. The engineer in a university has just as much obligation to stick to the fundamentals in his field as the chemist or physicist in his. The university civil engineer is not concerned with designing just another bridge or dam, but with developing new practices, new principles, new materials, new methods of structural design. The mechanical engineer does not simply invent an improved governor for a steam engine; he tries to advance understanding of thermodynamics, of solid and fluid mechanics, of the structure of matter, the nature of vibrations, of fatigue, etc. I need not tell this audience the job of the electrical engineer.

The university engineer is thus in an extremely critical position, intermediate between the pure scientist on the one hand and the industrial designer or inventor on the other. To some extent he does the things which the industrial engineer thinks the scientist ought to do—but in which the scientist has lost interest. The physicist is engrossed in the problems of nuclear forces; who is going to develop the fundamentals of nuclear technology? It's a long step from Fermi's first chain reaction to the first economical power plant with a great deal of room in between for fundamental engineering research. The same is true in any field. This is the proper place for university research in engineering.

Another point the university must watch is to be sure that the goals of sponsored research and unsponsored research are the same. Clearly, if the goal of research in a university is understanding, then this goal is equally valid regardless of who is paying for the research. It is true that the degree to which a university can advance toward its goal of understanding will depend upon the availability of funds. But no funds should be large enough to purchase a deviation, delay, or abandonment of that goal. The university is not a supermarket where a customer should expect to find any article he wants. It is not a job-shop, prepared to turn out a custom-built gadget for each and every comer. A university is not even a bank which likes to handle money just for the sake of handling money. When money diverts effort from proper goals, then the university is literally being robbed—no matter how much “overhead” allowance is attached to the contract. A big budget which is supporting things the university has no business doing is a sham—and the real university may be suffocated under the load of padding it is forced to carry around.

It is high time, for example, that universities ceased the practice of accepting any and all gifts or contracts just because they appear to come “free.” Gift-horses most emphatically should be looked in the mouth. I know of many colleges that have accepted gifts which have proved liabili-

ties, not assets—gifts which, though “free”, actually cost money—and which diverted effort and funds from proper tasks.

I have heard of an institution in which half the electrical engineering department is busily engaged in designing radar antennas—not because they are seeking to understand the radiation of electromagnetic waves, but because an Air Force contract for such gadgeteering was available. The excuse was that they could hire three more engineers that way and these men sometimes helped with the teaching. On the same principle, I suggest that the college lease and operate a five-and-dime store, so that the people who work in it can also, on the side, teach economics, marketing, human relations, and business English.

I don't want anyone to think I am unaware of the problems of financing higher education. I spent 4 years working on a Commission which studied the subject. We didn't find any easy answers. But I did not become convinced that the problem would be solved by financing things that were not higher education.

I must, of course, at this point call attention to the fact that, for better or for worse, the modern university has committed itself to carry on activities which have little relation to higher education. The state universities render a variety of services to the agricultural community which might be more appropriately handled by some sort of farm bureau. They test milk, water, fuels, and lubricants and render many other services to the local community. Most important, the universities have been called upon, and have patriotically and properly responded, to help the national defense in time of emergency. The contributions which universities have collectively made in this area are beyond calculation.

But we should not be led into thinking that designing weapons of war is a normal and proper function of a university as a university. It is an emergency function rendered, in part, because special technical talents are available in universities and, in part, because certain administrative problems are avoided and because better people are attracted to university-operated laboratories. I believe there are sometimes even indirect benefits to the teaching or research program of the institution. If the program—which is usually “secret”—can be housed and operated far from the campus as a separate establishment, it is possible that no harm will ensue.

But we should not confuse the operation of special defense facilities or services for the government with the normal educational functions of a university. We must take on these extra services, by all means, when it is necessary, desirable, or patriotic to do so. But we must get rid of them too, when possible. And in any case, in times of peace, they must not destroy the major functions of a university which are important to national defense too.

On the other hand, I must hasten to point out that the normal, proper goals of a university have in recent years been enormously advanced by federal funds under research contracts or grants. Agencies like the National Science Foundation, the Public Health Service, the Office of Naval Research, and others have rendered conspicuous service in supporting research programs in science and engineering

which the universities themselves originated as a desirable part of their programs but which they could not finance. There should be more funds available for these agencies to use in this way. These funds have been wisely administered and have been a tremendous boon to science and to universities.

However, a proper research program in any field should not be abandoned, distorted, or harmed by taking on irrelevant work for which funds happen to be available—and then pretending that this irrelevant work strengthens the program which it has damaged or displaced.

There is one aspect of university research which may need clarification. You will note that in talking about research and education, I have used these terms almost interchangeably. I have spoken of research as a part of the function of higher education. I could equally well have spoken of education as a function of research. Some of you may be wondering whether I am going to discuss the conflict between teaching and research.

The answer is “No”—I haven’t heard of the conflict! I have heard a lot of argument about how many hours a teacher should devote to research, but none that convinces me of a real conflict. If the purpose of a university is to advance understanding, then it follows that both the understanding of the student and of the teacher ought to go together. How a man can really teach science or engineering without acquiring a consuming curiosity about the many things that are unknown is beyond me. And how one can get a glimpse of the unknown without an equally consuming desire to tell it to others who will carry it on is also a mystery. An inquiring mind must be the chief possession of university people—and that’s the only kind of a mind that can either explore the unknown or stimulate students. I think history has shown that, with but few exceptions, research laboratories go dead when not stimulated by the continued intrusion of fresh young minds. And teaching establishments also go dead when not infused by the inquiring spirit of scholarship.

I am afraid that there is a vast public relations job to be done to assist the public in understanding the real role of the university and of science. Why is it that there has grown up the widespread impression that science and gadgeteering are the same thing? Why is it that so many people—including some in industry and government—believe that the universities are in the business of making and selling gadgets? These same people have often heard that universities need money. So they naturally conclude that by buying a gadget from a university, they kill two birds with one stone—they get the gadget and take credit for helping the university. How can we make them see that actually they may be robbing the university?

Possibly we in science and engineering have overemphasized our gadgets—including the weapons—that we do produce. Possibly we need to get back to fundamentals in our public relations, and tell the world that the main purpose of science is not to produce bombs, guns, and radar, or even refrigerators, radios, and color television. Possibly we should come out boldly and unashamedly and tell the truth—the aim of the scientist and engineer is to advance human understanding. We should admit that we believe

in human understanding for its own sake. We believe humans differ from the beasts largely in their ability and their urge to learn, to know, to comprehend. Men climb Mt. Everest, explore the bottom of the sea, sail to the far corners of the earth, explore the atom, the crystal, and the stars, all because they are born explorers, because men are always challenged by the unknown.

We need to go even further and re-emphasize the value of the inquiring mind. How few people there are who think of the university as primarily the meeting ground for inquiring minds. More people think of the professor as a person who earns an easy—and deservedly meager—living by reading dull lectures from dusty notes before drowsy students. Yet these same people send their sons and daughters to college in the belief that from these same courses they will learn to make a handsome living, as well as learn to be good people, patriotic citizens, and wise parents. The college graduate is supposed to know all the facts about the history of the United States, and not too much about the rest of the world; he should be alert, suave, a good public speaker, an acceptable member of the best society, and a good Republican. As he goes into business or industry, he must be humble enough to do the most menial tasks, but must never be caught uninformed on the most difficult problem. He should—but I need not extend the list of attributes which are variously expected of the students who have studied under these dull professors. The only attributes which are usually not insisted upon are that the student be inquisitive, that he be thoughtful, that he have a zest for learning and a zest for life; and that each of these qualities shall have been appreciably sharpened or enhanced by the college experience. We recognize that in training a prize fighter he must be toughened by strenuous exertion, and matched against skilled opponents. But we are afraid of intellectual toughening. We are fearful to let our young people wrestle with the toughest problems and ideas, thus learning for themselves how to find the truth—the truth about science, philosophy, economics, and politics.

It is this failure to understand the essential role of colleges and universities as tougheners of the mind, stimulators of curiosity, as the ringside of intellectual conflict that makes for much of the unjust, exasperating, and damaging criticism which higher education is now undergoing—criticism which has caused reduced or distorted financial support, unreasonable restrictions on faculties, a widespread distrust and castigation of intellectuals.

I think that all of the goals, the objectives, and the activities of a university can be brought to a focus if we think of the university as primarily a center of creative thought. It is a truism to say that all of the changes in civilization, all of changes in the way in which we live and think, have come as a result of the creative thinking of individual men and women. There are many people who appear to believe that the political and social institutions and the physical equipment of modern civilization have all somehow flowed automatically into our possession like products from the end of an enormous unthinking production line, rather than from the creative thought of individual human beings.

This creative thinking is a slow and frequently painful

process. It was probably a hundred thousand years after man discovered fire before he learned to make fire do his mechanical work for him. Man's climb from his primeval state has been a long one partly because getting new ideas is so hard. We may often think that in some ways man has not progressed much since his early days, or has even regressed. But sometimes it is even hard to think of ideas which will take one backward! Nevertheless any change, whether it is eventually regarded as a good one or a bad one, has been the result of creative thought.

Now in the early days creative thought came about more or less accidentally on the parts of those few people in each generation who got new ideas. As civilization advanced, those who were interested in the examination and exploitation of new ideas banded themselves together and sometime along in the 14th or 15th century there emerged the idea of a university as a community of scholars: a community of those who were interested in creative thinking. The university enormously stimulated the advance of creative thought and it is today the prime institution in our society devoted to the stimulation of creative thinking.

It is, of course, true that not many of the hundreds of thousands of students who go through American universities

each year even learn to think, and a still smaller number learn to do creative thinking. But the small number who do learn are those upon which the future of this country and of the world so heavily depends. These men and women who not only can think but can think of new thoughts, who can invent ideas that are different, are humanity's most priceless possession.

At the same time, thinking new and different ideas is a dangerous business. Such ideas must be critically examined, must be tested, must even be attacked. Wholly new ideas are seldom easily understood. Those who deal with new ideas are often subject to the criticism, and even the disdain of their fellow men.

Paradoxically enough, however, the scholars in a university also know that to a slowly increasing extent the public now acclaims those who contribute new ideas, especially if they are new ideas for gadgets which give physical pleasure to many people.

The good and important thing about a university, however, is that it encourages the development of new ideas, even though their practical value is still not evident or is unknown. For it is only through new ideas that men make their dreams come true.

Pleasures of Development Engineering

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A TRAVELER who had crossed the seven seas, seen many countries, and visited many people, finally came back to his home. He was asked, "What did you find in common all over the world?" He answered, not without a smile, "A certain tendency to laziness."

I think that he was right. Leonardo da Vinci discovered the law of inertia, that things if left undisturbed, will continue to stay where they are or drag along with uniform motion. This is true not only for material bodies, but also for people, for institutions, organizations, industrial enterprises, in short for every manifestation of human life. This inertia, this tendency to laziness, will prevail, will dominate life, unless something is done about it. In engineering, this is primarily the job of the development engineer, to overcome inertia and to further progress.

As a development engineer, this has been my job since

In his address on the occasion of receiving the Eta Kappa Nu Award to the Outstanding Young Electrical Engineer of 1953, Dr. Abetti discusses the challenge, and compensations, of his work as a development engineer.

my graduation 5¹/₂ years ago. At that time I became an insulation development engineer for the General Electric Company and a good friend of mine, K. K. Paluev, warned me, "Watch out, development

engineering is 5 per cent inspiration and 95 per cent perspiration." At first I was a little worried, but then I reflected that this is exactly what happens with my favorite sport: mountain climbing. Ninety-five per cent of the time you spend panting under a heavy load, slowly climbing higher and higher. The remaining 5 per cent is spent on top of the world, looking down from the lofty height you have finally reached. Now, if mountain climbing is my favorite sport and relaxation, it is only because I enjoy it. Similarly, I chose development engineering as my work, because I enjoy it, because I find many pleasures in it.

SUBJECTS FOR DEVELOPMENT

THESE pleasures of development engineering may be classified into two categories: the pleasure of developing things, and the pleasure of developing people.

Essentially full text of an address presented at the Eta Kappa Nu Annual Recognition Dinner, January 18, 1954.

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