What Should the National Academy of Engineering Do About Engineering Education? Proceedings of a Symposium, Oct. 13, 1966 (1967)

Pages
156

Size
7 x 10

ISBN
0309341876

National Academy of Engineering

WHAT SHOULD THE NATIONAL ACADEMY OF ENGINEERING DO ABOUT ENGINEERING EDUCATION?

A Symposium

October 13, 1966

United Engineering Center, New York City

The concerns that industry, government, academic institutions, and engineering societies have about engineering education will be discussed. The Symposium will consider the findings and recommendations outlined in some recent or continuing studies on engineering education, i.e. "Goals of Engineering Education" prepared by the American Society for Engineering Education, and "Continuing Engineering Education" prepared by the Joint Advisory Committee on Continuing Engineering Studies, sponsored by Engineers Joint Council, American Society for Engineering Education, and National Society of Professional Engineers. Discussion of what the National Academy of Engineering might do to aid in the advancement of engineering education will conclude the meeting.

Chairman: Eric A. Walker, The Pennsylvania State University, University Park, Pennsylvania

(The authors' manuscripts and/or remarks taken from the official transcript are photographically reproduced herein. Editing of remarks are the authors' own.)

CONTENTS

GENERAL INTRODUCTION

by

Eric A. Walker
President of the National Academy of Engineering

I think it might be wise to review for you once more just why we are here. We are not here to decide what ought to be done about engineering education. That may be the concern of a lot of you who are deans of engineering, but our primary concern as the National Academy of Engineering is what should the National Academy of Engineering do about engineering education, if anything. Let me say that many of the members of the Academy would not be disappointed if you here would tell us, "Look, there are too many people in the act already; you fellows stay out of it."

As you know, the National Academy of Engineering is a very young organization, quite unsure of itself, and quite afraid that it will take on things it is not able to handle. The National Academy of Engineering was born about three years ago when after a great many discussions among people in the Engineering Council for Professional Development, the Engineers Joint Council, the American Society for Engineering Education, it became apparent that there was a need for such an Academy.

The Engineers Joint Council took the lead in putting together a committee of 15 individuals to decide if an Academy was needed, and if so, how to establish it. The committee was chosen with representatives from the National Academy of Sciences and others who were not members of the National Academy of Sciences.

This committee of 15 decided that a National Academy of Engineering was needed, and that one ought to be established. Then the question came as to how to establish it. The obvious way of course was to ask the Congress to give us a national charter. Indeed, steps were taken to start this kind of action.

But there were members of the committee who felt that this was a little precipitous, that we ought to confer a little with the National Academy of Sciences, remembering that NAS does have an Engineering Divison of some forty members, to see if it might be possible to increase the size of the Engineering Divison of the National Academy of Sciences.

Yet we felt that the new organization should have approximately 300 members. Now, this is really too many for the National Academy of Sciences, because they have only about 700 members all told, and this would make the membership half engineers.

Nevertheless, the National Academy of Sciences felt it ought to do something to help us set up a National Academy of Engineering, and this was done by a device which certainly never would have occurred to any of us--using the charter of the National Academy of Sciences, and not going for our own charter. The charter of the National Academy of Sciences is broad enough to contain more than one Academy.

This seemed to us to be a very good way of getting things going, and so arrangements were made to establish a National Academy of Engineering under the charter of the National Academy of Sciences, with the understanding that the National Academy of Engineering would be independent. It would be parallel to the National Academy of Sciences as far as its operation through the National Research Council was concerned.

This is a rather involved setup and one that is giving us some difficulty, because at times we don't know to whom we are talking, but I think it has speeded up the formation of the National Academy by a least two years. It has given us a strong arm to lean on and considerable guidance when we have needed guidance.

Originally the National Academy of Engineering was established with 25 members: the 15 members of the committee, and 10 other members who were added from the ranks of the National Academy of Sciences. We set out to increase the membership as rapidly as was safely possible.

This has been one of our biggest problems. It is not easy to identify distinguished engineers who have made their name as engineers. It is fairly easy to recognize deans, presidents of corporations, and so forth, but there has been an insistence that the man know something about engineering and have successfully prosecuted an engineering project. It is not easy to recognize such engineers. The Membership Committee has worked very hard. It is a very important committee because it is going to shape the character of the Academy. Now our membership has risen to about 95. Last night the Council of the Academy requested the Membership Committee to add one hundred more members as soon as possible. I don't think we are very sanguine about this. I don't think the Membership Committee thinks it can do it, but this at least is our aim; we do want to move the membership up as rapidly as possible.

We regard the National Academy of Engineering as a working Academy. Membership is not just an honor. It is a ticket to do some work. And the Academy has been requested to do many, many things--many more than it is able to do, or has the manpower to do. Therefore, we have established a Project Committee to look at all requests to do things, and then decide which ones we will take on and which we will not.

Now the purpose of this meeting is for everyone who has anything to say about what ought to be done about engineering education to speak up.

The Project Committee is here. From this meeting it expects to get its evidence. Then it will make a recommendation to the Academy as to whether or not it should do anything about engineering education.

One of the first things the Academy wants to know is what are other people doing. That really is the purpose of this meeting. Anyone who knows what anybody is doing about engineering education should lay it on the table in order that you, as an audience, can look at it. Later this afternoon you can express yourselves as to what you think the Academy ought to do. Later in the day you will be given a very short questionnaire to fill out and sign or not, as you wish; if you want to give the Project Committee any guidance, this will be your opportunity to do so.

Before I leave the subject of the National Academy of Engineering, I would like to mention one other committee. It has just been established and is called COPEP, the Committee on Public Engineering Policy. One of the reasons the Academy was formed was to speak out on matters concerning public policy in engineering. To speak for the Academy, this committee has been formed, and it will consider issues it thinks are important, and speak out on them in the name of the Academy.

Now we will move on to the purpose of the meeting, which is to find out what people are doing and saying about engineering education.

STATISTICAL ANALYSIS OF THE CURRENT STATUS OF ENGINEERING EDUCATION

By

Robert H. Roy
The Johns Hopkins University
President, American Society for Engineering Education

Time, like so many other things in nature, has a disarming quality, which makes prospective obligations seem much less formidable than they really are. When President Walker wrote to me three months ago to ask that I give a "Statistical Analysis of the Current Status of Engineering Education" and that I do so in ten minutes, the awkward nature of the task appeared to be inversely proportioned to the square of its remoteness in time, was obscured by the attractions of this meeting, and beguiled by the flattery of invitation. As this moment has drawn closer, so also has realization that acceptance of such an assignment can most properly be regarded as evidence of insanity. So, when I have done, hopefully on schedule, please allow your mercy to season justice.

Descriptive statistics are inherently dull and those pertaining to engineering education are very well known to all of you - and would on repetition be even duller. I am not, therefore, going to present, much less attempt to analyze, arrays of already familiar data. Instead, on the premise that what has passed is prologue, I have selected from among the many numbers a few which seem to presage future developments in our profession. If you believe that these selections reflect my own aspirations for the future of professional engineering, you will be right.

For purposes related to the general subject of this meeting, data on enrollments and degrees for the post-war years may suffice for argument and conclusions. Since 1949, according to the article by Dunham in the February

1966 number of Engineering Education,* bachelor's level enrollments throughout the United States have increased from a total of about 181,000 in 1949 to nearly 216,000 in the fall of 1965, an increase just under 20 per cent based upon the 1949 figure. As is well known, however, these end point figures have deceptive attributes: within the period, enrollments declined after the wave of veterans receded; there was impact from the unfortunate publicity about more engineers than jobs, and also from changes in the college age population. Thus, engineering enrollments at the pre-baccalaureate level have fluctuated within the period; it has only been since 1962 that there have been continued annual increases.

During this same 17-year period, part-time enrollments at the bachelor's level have increased from about 13,000 in 1949 to roughly double that amount in 1965. Since these figures are included in the totals previously given, they may serve to indicate that full-time enrollment has increased by less than 20 per cent, by only 14 in fact. These data also are suggestive of growth in continuing education, about which another word will be said later.

Statistics for bachelor's degrees granted during this period are reflective of the same forces. Between 1949 and 1965 the numbers declined from about 42,000 to 32,000, showing an annual decrement for each year from 1949 to 1954, when there was a low-point of less than 20,000, followed by a mixture of increments and decrements each year thereafter. The number of bachelor's degrees granted each year during the past decade has been remarkably stable, hovering above 30,000.

*Ralph E. Dunham, "Engineering degrees (1964-65) and enrollments (fall 1965) in institutions with one or more ECPD-accredited curricula," Engineering Education, Feb. 1966, pp. 181-197.

In contrast to these familiar data for the bachelor's level are the equally familiar but far more impressive figures for advanced degrees. At the master's level total enrollments have nearly tripled, increasing from 15,000 in 1949 to more than 43,000 in 1965. As in the case of bachelor's degree data, the magnitude of the increase has been markedly affected by part-time enrollments, which have increased five-fold, from 4700-odd to more than 25,000 but, even so, full-time enrollments have risen by some 75 per cent. Again, the part-time data are reflective of the growing need for continuing education.

Degree data are comparably impressive. In 1949, 4783 master's degrees were bestowed; in 1965 there were 11,933 such candidates, about two and one-half times as many. The data show some annual ups and downs during the early part of the period but, significantly I think, there has been a steady increase year after year since 1953, when the lowest figure was recorded. The increment has varied but it has been an increment every year for more than a decade.

If these increases at the master's level are regarded as impressive, data for the doctoral level must be characterized as spectacular. Enrollments have risen steadily from 2541 in 1949 to nearly 14,000 in 1965. Of these, full-time students numbered 2386 in 1949 and 9480 in 1965, augmented by a giant part-time leap from only 155 in 1949 to 4263 in 1965. The respective factors for these increases are 5.5, 4.0, and 27.5. Clearly, for these data it is more suitable to deal in whole numbers than in percentages.

Doctor's degrees granted have risen in the same way: from 417 in 1949 to 2102 in 1965, a five-fold increase, with the 1965 figure anticipating the Office of Education's projection for 1969.

At my own institution, where doctor's degrees in engineering have been conferred since the School of Engineering was founded in 1914, it took 35 years to award the first 100 such degrees but during this time we ranked fifth among the nation's engineering schools. During the following 15 years or so we have granted another 250 doctor's degrees - and, have sunk to 35th in national ranking.

I introduce this personal note by way of leading to conclusions, for these data are, as you all know, intensely personal in their impact, capable of arousing antagonism as well as support, passion as well as reason. My own interpretation is that engineering is coming - indeed, must come - of age as a learned profession. Those who are members of the National Academy of Engineering personify precisely this; they are truly represenative of the learned profession that we aspire to become, and I hope most devoutly that their influence upon engineering education may be to foster our continued development in this historically inevitable and eminently desirable direction.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION
GOALS FOR GRADUATE ENGINEERING EDUCATION

by

Joseph M. Pettit
Stanford University

It has been a little bit of a puzzle to know exactly what to present here to you today. However, what I have tried to do is bring to the meeting a few things that will be in our pre-final or Interim Report. I think it is quite clear that the National Academy probably ought to wait until that report is in its hands before forming too many conclusions.

I have tried to pick out a few items that I might put before you in something like ten minutes, and these are personally selected. Some of you who were at the ECPD meeting in Denver have seen these.

The recommendations that I am presenting for the National Academy are purely my own; these may or may not be in the Interim Report when it emerges. The draft of the report has not gone to the committee, or to our Board of Analysts. So I am not really speaking officially on behalf of the Goals Committee or the staff or my Board of Analysts.

Figure 1 emphasizes a point in our findings, namely that we have a growing national enterprise of increasing numbers of engineering students seeking advanced degrees. Some of the numbers Dean Roy has referred to earlier, i.e. the bachelor's curve at the top. The dashed lines are approximations of a long-term trend if you plot the actual data back to 1900. They may not seem like a very good fit during the short-time span, but they are indeed national trends. One notes

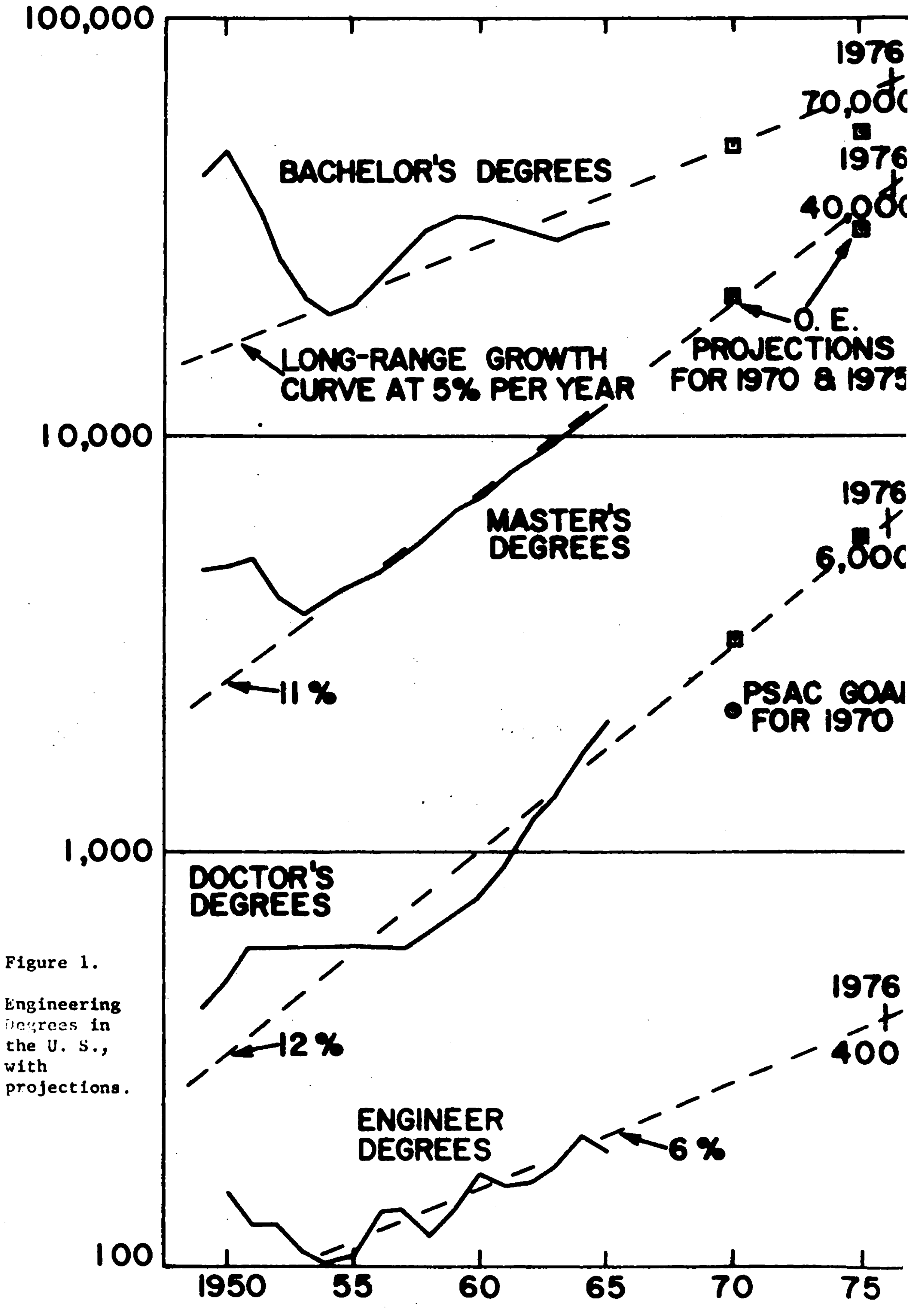


Figure 1.

Engineering Degrees in the U. S., with projections.

severe fluctuations above them and below them as wars and depressions have come and gone.

There are indicated some Office of Education projections, which Dean Roy also alluded to. They happen to fall quite remarkably on these dashed trend lines, though they were, I think, projections without regard to our data, and our data without regard to theirs.

The curves for master's degrees and doctor's degrees are the ones I would direct your attention to; they climb at much steeper rates than the bachelor's degree curve. At the bottom I have also shown the intermediate two-year earned degree, which is called at some schools the degree of engineer.

As shown in Figure 2, if you plot a ratio of master's degrees to bachelor's degrees, you see that in 1950 there was only a ten percent ratio of master's degrees to bachelor's degrees. Now we are up to about 40 percent. It is climbing and will reach 50 percent, I think, by 1970.

My interpretation of this trend is that there is a social force that pervades more than just engineering, one of personal aspirations for higher levels of formal education. This is evident especially in engineering, however; there are some incentives which the students perceive and which professors convey in talking to students. These incentives are not fully evident in our national policy, or in guidance literature provided by ECPD or others.

The employer situation is shown in Figure 3, which shows substantial encouragement of graduate study. The data come from a part of the study in which we surveyed 4,000 engineers in industry and

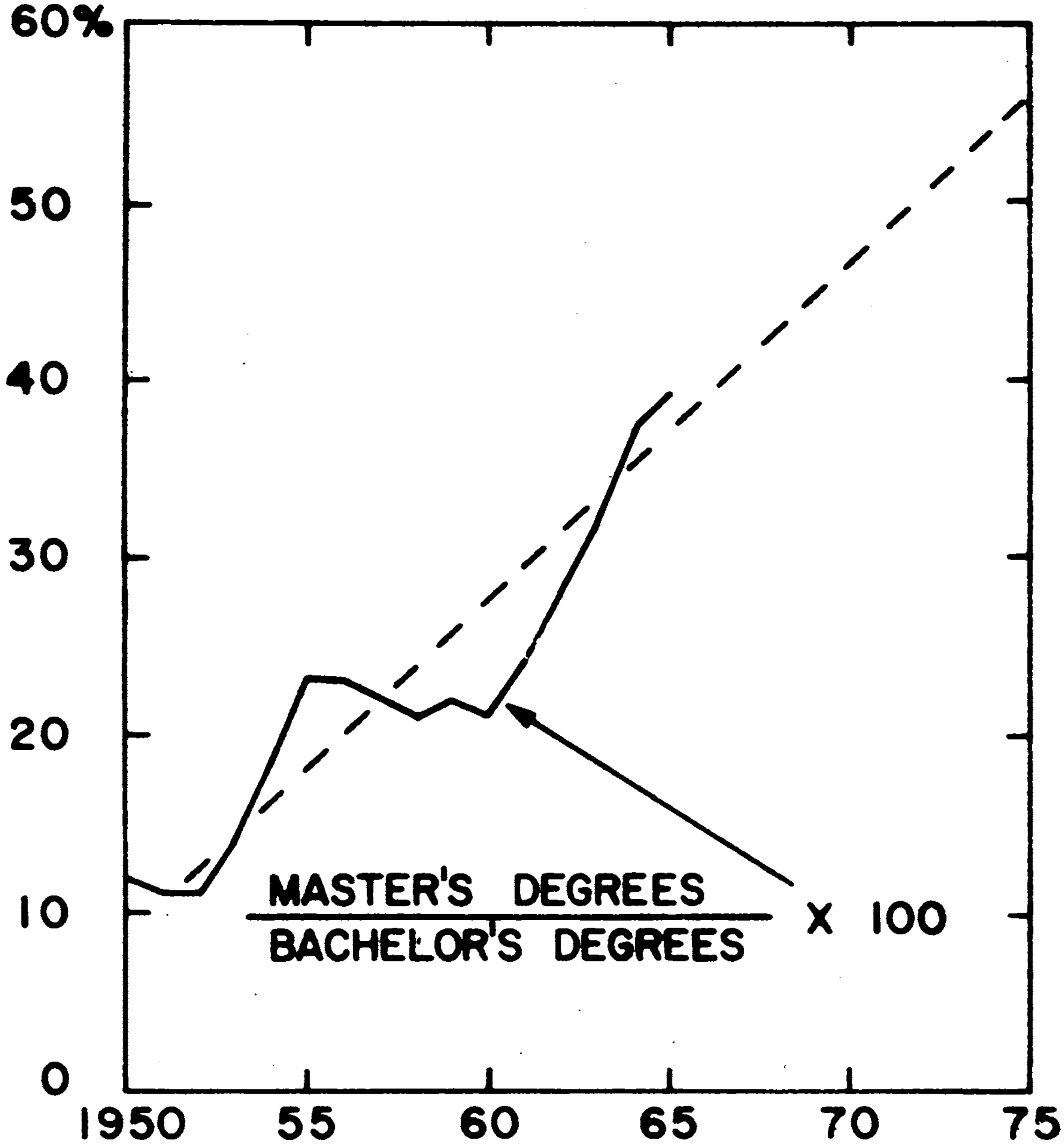


Figure 2. Master's degrees as a percent of bachelor's degrees for the preceding year (engineering only). (Note: The dashed line in the figure is drawn as a straight-line approximation to the actual curve solely for the purpose of extrapolating to 1975.)

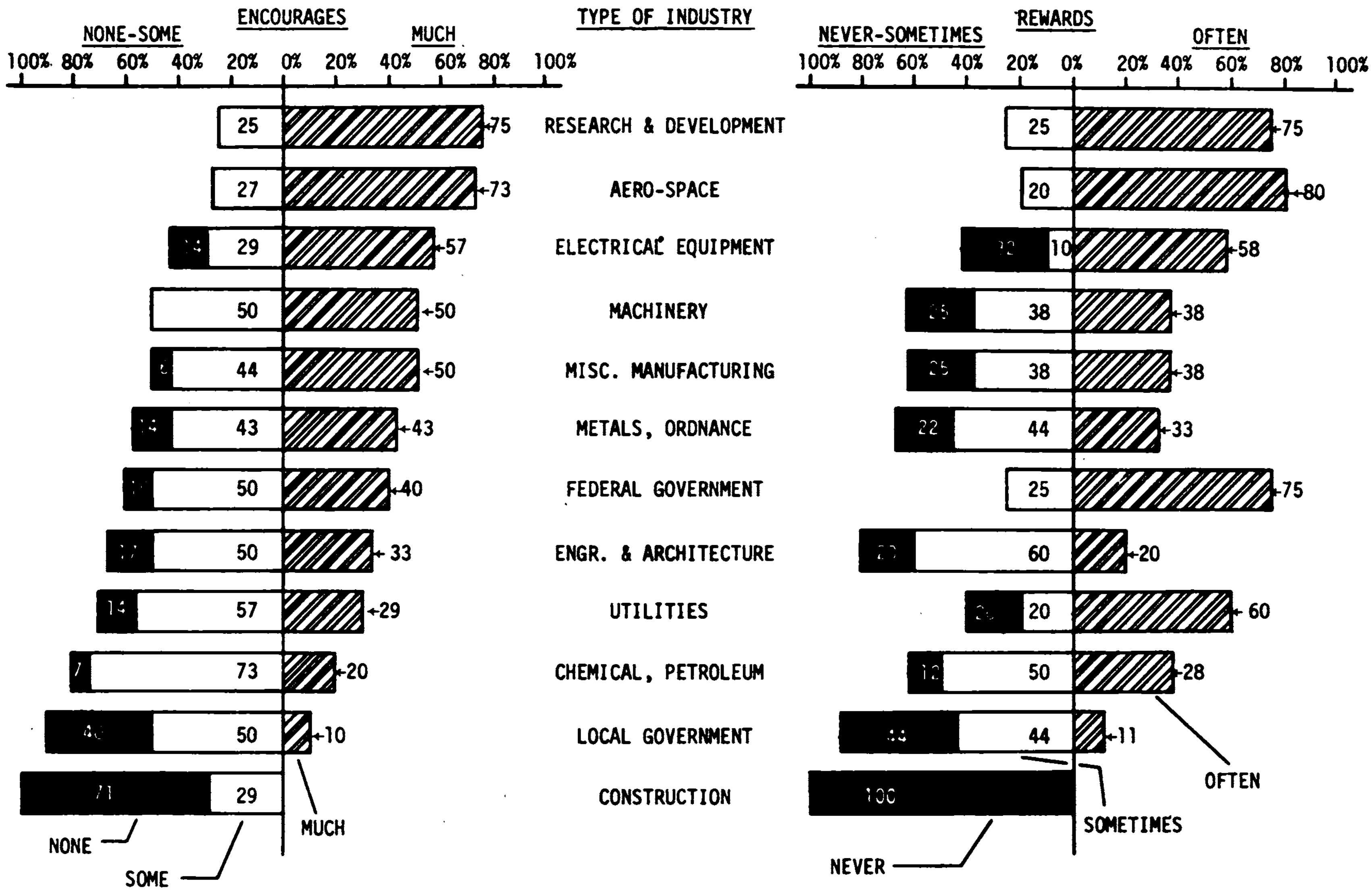


Figure 3. Encouragement and Reward for Advanced-Degree Work. (Based upon the survey of opinions of personnel managers.)

government. This is the response of personnel directors to the question of whether their employer was encouraging and/or rewarding graduate education. Clearly most of them are encouraging or rewarding, either much or some. The construction industry apparently does not reward graduate work at all. This is an exception.

So the employment situation has been encouraging the aspirations, reflecting at least a willingness and at most a need on the part of industry and government to engage an increasing number of engineers with advanced degrees.

Looking at it from another point, which I think the National Academy might, we have here in the U. S. engineering students an important under-developed natural resource, an intellectual capacity for higher levels of learning and capability to serve in our technological society. I will illustrate this by some data.

Consider Table 1, in which it can be seen that only 11 percent of our engineering population with college degrees (setting aside that group who are "engineers" according to statistical census data, but not having degrees in engineering or anything else) now have advanced degrees. On the other hand, in physics 36 percent have advanced degrees. Even that might seem small to you, but you realize that the liberal arts colleges turn out lots of people who are physics majors, but who don't become professional physicists. You can see that in engineering we have really quite a large undeveloped manpower resource compared to other professional fields.

Table 2 shows what the top fifth of the senior class of 1952 in all different fields was thinking about graduate work. In engineering,

FIELDS OF SPECIALIZED STUDY FOR HIGHEST ACADEMIC DEGREE (1960), BY EDUCATIONAL ATTAINMENT (1960)
(COLLEGE DEGREE POPULATION)
(Per Cent)

Field of Specialized Study	Base N	Bachelor's	Bachelor's Plus	Master's	Doctorate	Advanced Degree
Physics	40,309	19	45	18	18	36
Psychology	151,456	45	21	25	10	35
Other physical sciences	51,485	29	40	26	6	32
Technical specialty	20,769	23	47	29	1	30
Education	468,091	45	27	26	2	28
Chemistry	213,777	38	36	10	17	27
Field not reported	728,528	43	30	23	4	27
Health fields	305,207	33	41	17	9	26
Biological sciences	189,277	46	30	19	5	24
Humanities	564,245	43	35	20	2	22
Secondary school teaching	632,161	49	30	20	1	21
Elementary school teaching	682,379	57	23	19	1	20
Agricultural sciences	103,023	72	9	18	2	20
Mathematics and statistics	103,258	60	26	11	4	15
Other specialty	1,256,632	60	24	13	2	15
Social Sciences	544,091	49	40	8	3	11
Engineering	666,154	57	32	10	1	11
Total N	6,720,842	50.2	29.7	16.8	3.3	20.1

Reference: The United States College-educated Population: 1960, Report 102, National Opinion Research Center, University of Chicago (Chicago, October 1965), p. 24

Table 1.

UNDERGRADUATE MAJOR AND PLANS FOR GRADUATE WORK FOR 1962 COLLEGE GRADUATE

(Top fifth of class)

Undergraduate Major	Number	Percentages for Graduate Plans		
		Next Year	Later	Never
Pre-medicine	500	90.4	7.4	2.2
Physics	838	65.1	29.9	4.8
Chemistry	1,491	55.9	33.5	10.5
Biology	1,343	55.3	32.0	12.6
Psychology	1,347	46.8	31.6	21.5
Humanities	8,680	43.4	36.4	20.1
Mathematics	1,310	41.7	38.7	19.5
ENGINEERING	5,030	32.8	45.9	21.2
Agriculture	698	25.2	29.0	45.7
Education	4,646	21.7	61.3	16.8
Business	7,151	16.8	42.4	40.7

Reference: Davis, J., Great Aspirations, Vol. 1, National Opinion Research Center, Report Number 9 (Chicago, March 1961), p. 539.

TABLE 2.

only about a third of the class was thinking of going on during the next year. One out of five was not thinking of going on at all. On the other hand, in a field like physics, 95 percent were certain of going on for graduate work.

As some evidence will be shown in the Interim Report of the Goals Study, in the undergraduate engineering population we are getting very good students, quite comparable to those in physics and the sciences, who could in fact go on for graduate work in greater numbers. Therefore, I would say, compared to the other fields, we have a natural resource that we are not developing.

In Figure 4, a general phenomenon is illustrated. This is a study done by Wolfle, and published in 1954. It shows an intelligence distribution calibrated in terms of the Army General Classification Tests, where 100 is the median for the total age group. You have progressively smaller curves moving to the right; higher scores, higher ability, but fewer of them going on to the next higher level of education. What one concludes from this is that, above each of the smaller curves, there is a reservoir of people with the same ability who did not go on to that particular level of education.

Figure 5 shows the similar situation with respect to doctorates, as reported in an article by Harmon in Science in 1961. It compares the Army General Classification Test score distribution for doctorates in all fields in 1958, compared to the total age group. At the median of the doctorate curve, which is an Army score of 130, for every 1,000 people at that level, there were only 12 who reached the doctorate. So I suggest again that we have a large natural resource still to be developed.

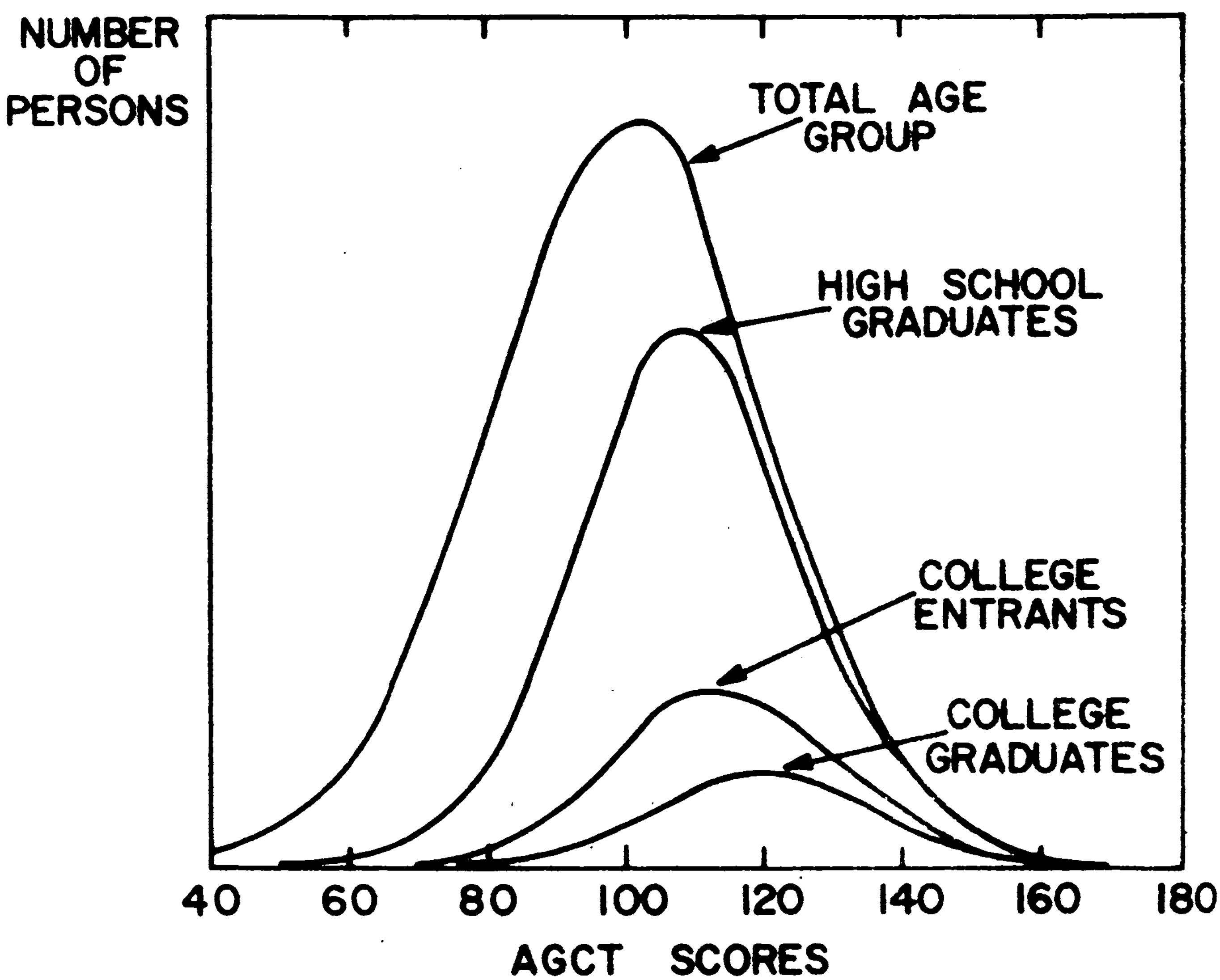


Figure 4. Distribution of Army General Classification Test scores for persons in a given age group who reach various educational levels.

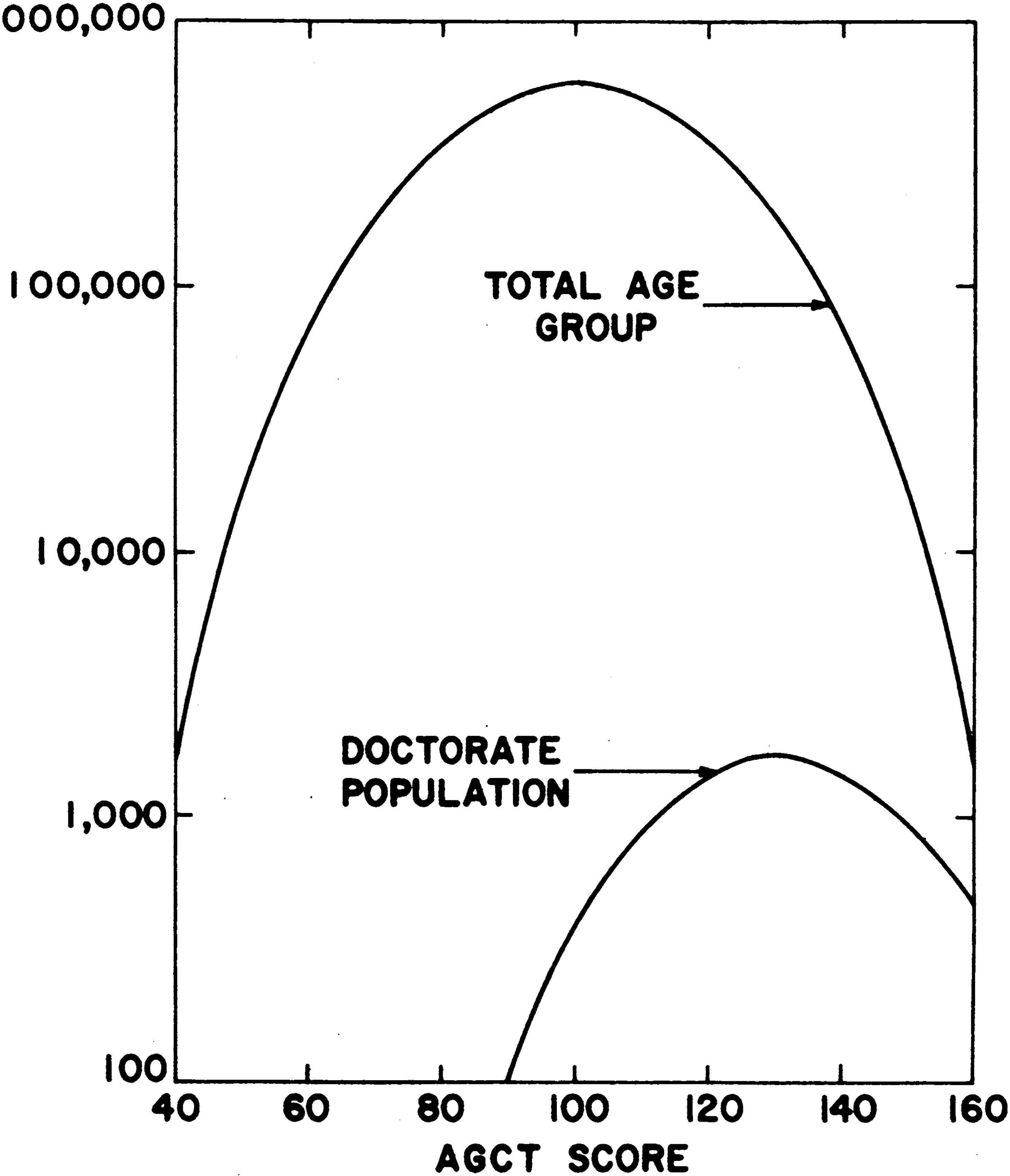


Figure 5. Distribution of Army General Classification Test Scores for 1958 Doctorate Population (Note log scale).

There is a need for adequate understanding by the National Academy, and for that matter by others, of this graduate enterprise and its implications for the future. I think the National Academy should evaluate the evidence when it becomes fully available in our Interim Report. You can look at what is presented here. I think that you have a choice of being only an observer of the passing scene, only observing change as it is occurring, or of being against the change, or being for it. I must report to you from the feedback of the educational community that its members are not at all unanimously for change. Some feel very concerned about the questions of standards. They seem to feel that as we have increased from ten percent of our bachelors going to master's degrees, as it was in 1950, up to 40 or 50 percent, that maybe we are lowering standards. Industry seems to express doubts about whether we need this many engineers with graduate degrees, whether by encouraging this kind of graduate education we may reduce total numbers coming into engineering.

There are others, of course, who are for the change. My recommendation is that this growing graduate enterprise is desirable, even important. It should continue with high standards and adequate support.

If you are for the growth, however, you must realize there are certain implications for government and for industry, mostly that they will be required to give increasing support to graduate education.

The graph in Figure 6 shows the growth in doctorate population in engineering, and the growth in research support related to that doctorate education, excluding the large central laboratories at

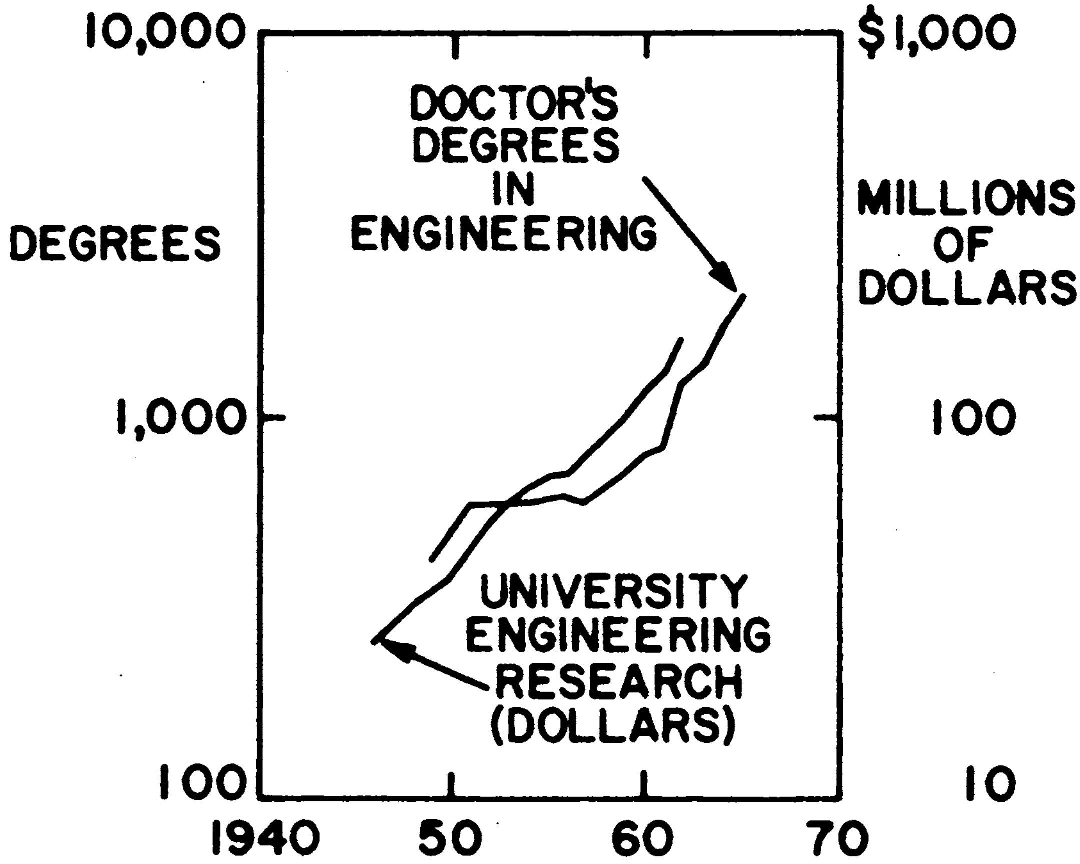


Figure 6. Comparison of annual university engineering research expenditures and doctor's degrees in engineering

several universities. It includes only research money going to the engineering colleges as such. You will see there is a closely parallel increase. Though coincidence does not necessarily indicate a causal relationship, I think these two curves are not entirely uncoupled. If we are to increase one, we are probably going to have to increase the other. There is no proof of this, of course. We can get by with less money. I can report, however, that the physical sciences are spending just as much per capita in their college research as we are in engineering. If you take the ratio of the two figures, it comes out to be $100,000 per degree. The life sciences are spending $150,000 per degree. This number need not frighten you, because if you divide it by the number of students who are in the pipeline compared to the ones coming out, there is a factor of five or six. If you take into consideration summer stipends for faculty, travel, and all the incidentals, the cost may come down to something more like $10,000-$20,000 per student per year, including his tuition, his stipends, and all of the indirect costs related thereto.

If you project, then, increasing research support as time progresses, you see that some large numbers of dollars are involved. It is not clear that these dollars will be forthcoming. They come from a variety of sources now, and Figure 7 shows the distribution of the support as of 1964. This is the actual support as reported by the engineering colleges themselves in our direct survey. You see that 79 percent of this support is coming from the Federal Government, only 7 percent from industry. We proposed in the Preliminary Report that industry do more, but we got some negative reaction on this: "The colleges are competing

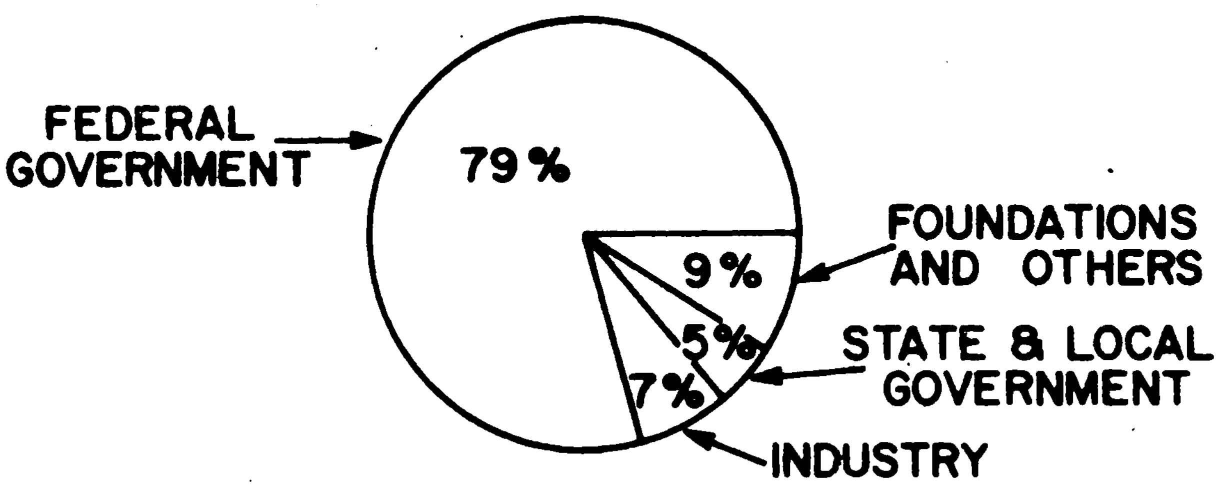


Figure 7. Sources of Support for Basic Research in the Engineering Schools.

with industry." "We don't have enough to spend ourselves." "Why should the colleges spend this much money?" At the same time we get complaints that the Federal Government is dominating the life on the campus, that the dissertations are too defense-oriented.

Actually the money that is coming to the campus from the Federal Government, from its diversity of agencies, is quite good money, and we are free to spend it. I call your attention, however, to the possibility, at least, that industry might provide additional support.

In any event, there certainly is a challenge if you do think that we need more engineers trained to higher levels--to assume higher responsibilities, technical and otherwise.

In conclusion I would say that I believe the National Academy should lend its support and its prestige to this national challenge which I believe is in front of us.

REMARKS ON THE GOALS STUDY OF THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

by

Eric A. Walker
Chairman, Goals of Engineering Education Committee

We now turn to a short discussion of the Goals Study of the American Society for Engineering Education. I must say that here again disaster has struck. George Hawkins was to be here and talk on the undergraduate part of the report. I got a call yesterday saying George had broken his arm, was in the hospital, and would not be here. That man has had more tough luck in the past three years than any man is justified in having. I feel responsible for some of it, having gotten him into this business of preparing the Goals Report.

Since he won't be able to speak about it, I am going to say a little covering his part, and leading up to the part that Dean Pettit will give you.

You know that I have said a number of times that I think that engineering education is the most studied kind of education in the world, not excepting medicine, which has just come out with a new report on graduate work in medicine. I think the biggest disaster that ever happened to engineering education was the Wickenden Report.* I don't know how many of you have really read that report. Everybody says he has. But there are two reports--the one that was actually issued, and a preliminary

---

* Report of the Investigation of Engineering Education, 1923-29, W. E. Wickenden, chairman. Volume 1 published 1930; volume 2 published 1934; Preliminary Report released November 1926. American Society for Engineering Education.

report that never saw the official light of day. The most remarkable one is the preliminary report because I think it says everything that has ever been said about engineering education, it suggests everything that has ever been suggested. It is a truly remarkable document. But I think this is the origin of most of our troubles.

You will remember that in 1920, law, divinity, and medicine were pretty firmly established as graduate studies. The question was: What should happen to engineering? The Wickenden report said that we need to have a broad scientific education to be engineers, something I have called a liberal science education, and yet we must be specialists in a discipline deep, narrow, professional. Ben Nead, my staff assistant, once suggested to me that the Wickenden Report produced a kind of schizophrenia among engineering educators that we have never quite gotten over. It has also given the profession a kind of schizophrenia, in that we are never sure whether we are professional or not.

Wickenden laid out this dilemma, and he identified it very clearly in his preliminary report. He called it the central question of engineering education. "In the wide scheme of liberal, technical and professional education," he asks, "what is the proper function and scope of the College of Engineering?" Is it a variant of the arts college, affording a somewhat different kind of general education, or is it a professional school in the strict sense, like schools of divinity, law, and medicine?

His answer is a clear indication of the situation as he saw it in the 1920's. Plainly, he says, it is an intermediate type. This was in his final report. "If the aims of the engineering college are less restrictive and definitive than those of the purely professional school, they are at the same time far more definite and concrete than those of the liberal arts college." In other words, he regarded engineering education as a unique kind of program in higher education in his day, something that was neither fish nor fowl, neither general nor professional, but somehow combining the characteristics of both. On the one hand, it was something more than a mere major in the arts and science program, such as a major in history or geology or physics or biology, but on the other hand, it could not be considered as training above and beyond a liberal education requiring real specialization and meriting true professional status.

It is perfectly obvious from his preliminary report that at one time Wickenden was much inclined to recommend that engineering education take the step and become graduate education, and it is a real exercise to think of what might have happened if he had recommended this at that time, and if the recommendations had been followed.

You might ask why didn't he do it. I am now firmly convinced that he just didn't have guts enough to do it, that he put out the preliminary report and the flack started to rise, so the Committee retreated and abandoned this position in the final report. But he knew that this was not enough, that you just can't learn enough in the four-year engineering program. Indeed, his insistence on the need for additional education beyond the baccalaureate runs like a thread throughout his preliminary report, and culminates in a concrete proposal for what he terms "post-scholastic education." This is all in the preliminary report.

It is clear that by post-scholastic education, Wickenden meant neither formal graduate work nor what is generally thought of as continuing education. He was not concerned with the upgrading of an engineer's education in the sense of working for an advanced academic degree, at least for the majority of engineering graduates, nor did he mean updating, keeping abreast of new developments. What he had in mind was a broadening of baccalaureate interests and a knowledge aimed at qualifying the student for true professional status.

To accomplish this important aspect of the engineer's professional training, Wickenden proposed something that he called an organized stage of education beyond the baccaluareate, and he recommended that it be a formal, integrated program handled jointly by educators, industry, and the professional societies, that it be morally obligatory for engineering graduates, and that it be similar to the internship of the physician, that is, directly related to the achievement of a recognized professional development. I will quote him:

"To set up an adequate system of post scholastic training combining business training, specialized technical training, and related introductory experience, to integrate these elements into true professional novitiate equivalent to the internship of the physician, to relate such training to the award of professional degrees on the one hand, and to the terms of admission to the professional grades of membership in the engineering societies on the other, to make such training widely available to graduates on even terms and to make it morally obligatory upon them, would call for a large scale teamwork by the colleges, industries and other major professional organizations. If any such development is to come, it seems eminently desirable that the initiative should come from the colleges, and that they should provide in their own organization for the nucleus around which the needed organization may be created."

It is clear that Wickenden very definitely had in mind a scheme by which one could move from a college B. S. degree to a professional kind of degree--something which has been completely forgotten and completely neglected.

It was shortly after reading this preliminary report that we on the Goals of Engineering Education Committee started to put together the preliminary report of the Goals Study. As I read the preliminary report of the Goals Study, I could see it would have the impact on the engineering educational fraternity that a ball of putty would on the deck of a battleship. I said we have to do something to make this report more controversial, to make people listen to it, to make people talk about it.

The members of the committee decided that if they had any good ideas, even controversial ideas, they would put them into the report to sound out the engineering fraternity. The results went far beyond my expectations. I didn't expect to see the committee shot down. I expected to get some input or some impact, but not what we did get.

I have been very sorry for some of the things that happened to the Committee members in this exercise--to George Hawkins, who has been responsible for the undergraduate part of the study, and to Joseph Pettit, who has managed the graduate part--because I was the person who stood back and said, "Let's you and him have a fight." I enjoyed it perhaps a little more than I should. However, we are now in the process of writing a pre-final report that will issue not under the hammer of a schedule, as the last one did, but when we are ready to issue it. This may be December, January, February, somewhere along in there. It will be sent to all colleges, and then the Committee will take its own good time about receiving the feedback from anyone who wishes to comment on it before dressing up the final report.

ENGINEERING TECHNOLOGY EDUCATION

by

Merritt A. Williamson, P. E.
Vanderbilt University

I. INTRODUCTION

This paper presents background information which is particularly pertinent to the question "What Should the National Academy of Engineering do about Engineering Education?"

II. PLACE OF ENGINEERING TECHNOLOGY EDUCATION IN HIGHER EDUCATION

The engineering technician, because of his new and vital role in the American economy, is so closely related to the engineer that his education and training is of great importance to the engineer. As the whole field of engineering, science, and technology has advanced, the vital supporting role of the engineering technician has become more generally understood and appreciated. The concern of engineering educators is of long standing. The first study was published in 1931 by the Society for the Promotion of Engineering Education with funds provided by the Carnegie Corporation of New York and written by Wickenden and Spahr.[(1)] A Technical Institute Committee was established within The American Society for Engineering Education in 1941. Ten years later this became the Technical Institute Division of the Society. In 1960 a Technical Institute Council came into being to serve the administration in this field and this became the Technical Institute Administrative Council in 1966 while the Technical Institute Division continues to serve the academic and curriculum interests. The Engineers' Council for Professional Development initiated accreditation of Technical Institute programs in 1944. It was handled by a subcommittee of the Education and Accreditation Committee until 1964, when it was found necessary to establish a separate and parallel standing committee for this work.

The Technical Institute has always been considered as a post-secondary school field of study, more advanced and of a more engineering nature than the vocation schools. At present a distinction is drawn between the "engineering technician" and the "industrial technician." The former receiving an education oriented to a field rather than to a job. The distinctions are set forth in a paper by Schaefer and McCord appearing in the Technician Education Yearbook 1963-1964 (2) (pages 3-6).

At present the following types of institutions offer engineering technology curricula: (3)

A. Universities

1. Campus
2. Extension or non-campus
3. Regular courses
4. Refresher and upgrading courses
5. Home study courses

B. Colleges of technology and technical institutes

1. Mono-technical institutes and colleges

2. Polytechnical institutes and colleges

C. Junior and community colleges

D. Industry and commerce sponsored institutions and courses

E. Government and Military Agencies

F. Private proprietory schools

Programs may be of two, three or four years in duration beyond the high school 12th grade level and may lead to associate degree or to a baccalaureate degree. In some institutions the technology programs are the responsibility of the College of Engineering. In others a separate school or college has been organized. The subject matter is quite similar, but the programs are all designed to train first-class engineering technicians and not second-class engineers. There is a considerable difference.

III. DEFINITIONS AND TERMINOLOGY

A. The following are Engineers' Council for Professional Development definitions in effect for 1965-6.(4) (These are similar to the definitions given in the American Society for Engineering Education publication, "Characteristics of Excellence in Engineering Technician Education."(5)

1. Engineering Technology is that part of the engineering field which requires the application of scientific and

engineering knowledge and methods combined with technical skills in support of engineering activities; it lies in the occupational spectrum between the craftsman and the engineer at the end of the spectrum closest to the engineer.

(a) Engineering technology is identified as a part of the engineering field to indicate that it does not by any means encompass the entire field and also to differentiate it from other types of technology in areas such as medicine and the biological sciences. The engineering field is viewed as a continuum extending from the craftsman to the engineer. Engineering technology falls, in the continuum, between the craftsman and the engineer and closer to the engineer than to the craftsman.

(b) Engineering technology is concerned primarily with the application of established scientific and engineering knowledge and methods. Normally engineering technology is not concerned with the development of new principles and methods.

(c) Technical skills such as drafting are characteristic of engineering technology. Engineers graduated from scientifically oriented curricula may be expected to have acquired less of these skills than previously and the engineering technician will be expected to supply them.

(d) Engineering technology is concerned with the support of engineering activities whether or not the engineering technician is working under the immediate supervision of an engineer. It may well be that in a complex engineering activity he would work under the supervision of an engineer, a senior engineering technician, or a scientist.

2. An <u>engineering technician</u> is one whose education and experience qualify him to work in those areas of engineering which require the application of established scientific and engineering knowledge and methods, combined with technical skills, in the support of engineering or scientific activities toward the accomplishment of engineering objectives.

(a) ECPD does not wish to suggest job or position titles for use by employers. Position titles will vary from one company to another and would normally be functional titles. ECPD recommends, however, that the generic term of those in this field be engineering technicians.

(b) If the term engineering technician is restricted in its application to the upper portion of the range between the craftsman and the engineer, considerable future confusion can be avoided.

3. An engineering technology curriculum is a planned sequence of college-level courses, usually leading to an Associate or Bachelor's degree, designed to prepare students to work in the field of engineering technology.

(a) The term college-level in the definition of an engineering technology curriculum indicates the attitude with which the education is approached, the rigor, and the degree of achievement demanded.

(b) Although throughout this presentation the generic term engineering technology curriculum is used for convenience, there are many specific branches of engineering technology in which curricula are offered. Commonly encountered are such curriculum titles as mechanical engineering technology, electronic engineering technology, architectural engineering technology, chemical engineering technology, and civil engineering technology.

Revisions in the above definitions will be proposed at the October 5, 1966 Meeting of the Engineers' Council for Professional Development in Denver. Proposed changes are:

Replace 1 and 1(a) with the following:

1. Engineering technology is that part of the technological field which requires the application of scientific and engi-

neering knowledge and methods combined with technical skills in support of engineering activities.

(a) Engineering Technology is identified as a part of a continuum extending from the craftsman to the engineer. In this continuum, engineering technology is located between the craftsman and the engineer, closer to the engineer. The term engineering technology is used to differentiate it from other types of technology -- such as medicine and the biological sciences.

Replace 3 with the following:

3. An engineering technology curriculum is a planned sequence of college-level courses, leading to an associate or baccalaureate degree, designed to prepare students to work in the field of engineering technology.

The Institute for the Certification of Engineering Technicians adopted in July 1965 the following definition. This was subsequently approved by its sponsoring body, The National Society of Professional Engineers.(6)

"An engineering technician is one who, in support of and under the direction of professional engineers or scientists, can carry out in a responsible manner either proven techniques, which are common knowledge among those who are technically expert in a particular technology, or those techniques especially prescribed by professional engineers.

"Performance as an engineering technician requires the application of principles, methods, and techniques appropriate to a field of technology, combined with practical knowledge of the construction, application, properties, operation, and limitations of engineering systems, processes, structures, machinery, devices, or materials, and, as required, related manual crafts, instrumental mathematical or graphic skills.

"Under professional direction an engineering technician analyzes and solves technological problems, prepares formal reports on experiments, tests, and other similar projects or carries out functions such as drafting, surveying, technical sales, advising consumers, technical writing, teaching or training. An engineering technician need not have an education equivalent in type, scope, and rigor to that required of an engineer; however, he must have a more theoretical education with greater mathematical depth, and experience over a broader field than is required of skilled craftsmen who often work under his supervision."

There have been other pertinent definitions published by: The U.S. Office of Education, The President's Committee on Scientists and Engineers, U.S. Civil Service Commission, U. S. Department of Labor, and other organizations, but the definitions given above are the major ones that have been recognized and adopted by engineers and engineering educators.

The terms "technology" or "technician" should not be used without the adjective "engineering" since they are not limiting enough and describe various levels of work in many non-scientific and non-engineering areas. The terms engineering technology and engineering technician were first used - officially by ECPD in 1950 and 1953, respectively. The term "technologist" which is used abroad and in Canada to describe the higher grades of technician is not similarly used in this country as a rule. Rather, it is often used as a broad term embracing scientists and engineers; while, in the chemical industry it is reserved for high level (Ph.D.) scientists who are not in an administrative classification.

The term "Technical Institute" is the most generally used term to describe the institution offering education programs to prepare engineering technicians. It is also used to describe the level of such programs wherever they may be offered. The term Technical College appears to be growing in popularity as an alternative to Technical Institute for engineering technology as distinguished from industrial technology.

For a good discussion of terminology, see the recent book entitled, The Technical Institute written by Dr. Maurice Graney, Dean of the School of Engineering at the University of Dayton. (7)

IV. ACCREDITATION AND CERTIFICATION

As mentioned above, accrediting of Technical Institute Programs has been carried out by the Engineers' Council for Professional Development since 1944. In 1964 (because of the increasing importance of this area) a separate Engineering Technology Committee was formed which now conducts accreditation of these programs.

The National Commission on Accrediting, has for a long time recognized the Engineers' Council for Professional Development as the accrediting agency for engineering curriculums, but until a few years ago had never concerned itself with recognizing accreditation at the technical institute level. Approval of the Engineers' Council for Professional Development to act in this role has been requested, but has been deferred pending a much more inclusive study of the needs for specialized accreditation at the junior and community college levels. These institutions are generally opposed to accreditation by any group other than the regional associations and wish to avoid having any professional group accredit their programs. The National Commission on Accreditation is satisfied that there is a geniune social need to be served by accrediting engineering technology programs, and the Engineers' Council for Professional Development maintains that accreditation of such curricula should be done by qualified persons from the profession of engineering. This is a critical issue and a great disservice can be done to the engineering profession by preventing its having any influence on the education of the engineering technician through officially recognized competent accrediting procedures.

Accrediting criteria and procedures for engineering technology have been reviewed and the revisions given above are being submitted for approval at the October 1966 meeting of the ECPD in Denver. Procedures will cover accreditation tothe appropriate first degree in engineering technology - this may be either the associate or the baccalaureate degree. ECPD may also accredit non-degree programs under the prescribed standards. It is important to note that the jurisdiction of this committee is limited by field (engineering technology) and not by level of degree. This appears to be eminently sound since it should result in less confusion with the accreditation of baccalaureate level engineering programs.

Certification of engineering technicians is carried out by the Institute for the Certification of Engineering Technicians which is an examining body only and exists to perform the function of determining the competency of those who voluntarily apply for certification. Competency is determined through investigation -- including recommendations, endorsements, and examinations, as appropriate, -- of the applicant's work experience, character, and knowledge. As evidence of satisfactory attainment, the Institute grants and issues certificates in any of the three grades authorized, and also maintains a registry of holders of such certificates.

The Institute is sponsored by the National Society of Professional Engineers. Since engineering technicians are not professionals and do not assume professional responsibility independent of engineers, certification by a national examining agency was adopted rather than attempting to promote individual licensing arrangements in each state.

One of the purposes of certification was to provide an incentive for engineering technicians to increase their competence on the job by improving their qualifications. Educational improvement is encouraged, and the Institute plans, as soon as feasible, to require examination of each candidate for the middle grade except those who are graduates of a program accredited by the ECPD. The demand for various courses and home study programs should increase markedly in the future. As certification becomes more widely recognized, this should result in better educated technicians.

V. ORGANIZATIONS CONCERNED WITH ENGINEERING TECHNICIAN EDUCATION

The American Association of Junior Colleges
1785 Massachusetts Avenue, N.W.
Washington, D. C. 20036

American Society of Certified Engineering Technicians
2029 K Street, N.W.
Washington, D. C. 20036

American Society for Engineering Education
1346 Connecticut Ave., N.W.
Washington, D. C. 20036

American Technical Education Association, Inc.
22 Oakwood Place
Delmar, New York 12054

Engineers' Council for Professional Development
345 E. 47th Street
New York, N. Y. 10017

Institute for the Certification of Engineering Technicians
2029 K Street, N. W.
Washington, D. C. 20036

National Association of State Universities & Land-Grant Colleges
(Commission on Education for Engineering Profession)
1785 Massachusetts Avenue, N. W.
Washington, D. C. 20036

National Commission on Accrediting
1785 Massachusetts Avenue, N. W.
Washington, D. C. 20036

National Council of Technical Schools
1507 "M" Street, N. W.
Washington, D. C. 20035

VI. CURRENT CONCERNS

1. To prevent confusion with lower level industrial arts programs, recognition of accreditation is vital. Accreditation should be under the control of the engineering profession - not educationists.

2. Institutions should clearly label their programs so that no confusion will exist engineering programs and engineering technology programs. Engineering should be used as an adjective only, modifying the noun technology.

3. Where baccalaureate degree programs are offered in engineering technology, these should be clearly differentiable from baccalaureate degrees in engineering. The degree of Bachelor of Engineering Technology is recommended.

4. The Goals of Engineering Technology proposal has not yet been funded. This study is vital for the decade ahead.

5. There is a great scarcity of qualified teachers at the technical institute level. Experience in the field of technology is important and a great need exists for up-dating the educational background of practicing engineers who turn to teaching in Technical Colleges.

6. Terminology should be standardized as far as possible.

7. Curriculums should be continually upgraded as engineering curriculums are increased in theoretical content in order to avoid a "gap" in manpower possessing certain vitally needed abilities.

8. Many engineering technicians wish to obtain engineering degrees. How can a program be designed to allow this to take place with least lost time while still fulfilling the need for sound preparation of persons ready to go to work as engineering technicians?

VII. RECOMMENDATIONS TO N.A.E.

1. Recognize and maintain a concern for engineering technology and for engineering technicians by keeping informed and

endorsing the considered positions of other knowledgeable and directly responsible organizations (ECPD, NSPE, ICET, etc.)

2. Help in securing funding of the proposal on Goals of Engineering Technology. Although it is directed to engineering technology, the importance of this study to the engineering profession cannot be over-emphasized.

3. Help in securing funding for studies leading to examinations for engineering technician grade of certification in the Institute for Certification of Engineering Technicians.

4. Support programs for increasing the numbers and qualifications of teachers at the technical institute level.

5. Help in the promulgation of standardized technology as it is evolved.

6. Encourage the establishment of technician grade memberships in the technical societies to help tie the engineering technician closer to the engineer.

7. Encourage more widespread understanding of the role of the engineering technician in the technological manpower team.

VIII. ACKNOWLEDGEMENTS

Acknowledgement is made of valuable suggestions received from the following persons who reviewed this paper in draft form:

Kenneth C. Brigel
Supervisor, Research Technician
Laboratory Systems and Research Division
Honeywell, Incorporated
Minneapolis, Minn.
(Chairman, Board of Trustees, Institute for Certification of Engineering Technicians)

Walter M. Hartung, President
Academy of Aeronautics
LaGuardia Airport
Flushing, New York
(Immediate Past Chairman, Technical Institute Administration Council, American Society for Engineering Education)

Lawrence V. Johnson
Director of Engineering Extension Division
Georgia Institute of Technology
Atlanta, Georgia
(Chairman, Engineering Technology Committee, Engineers' Council for Professional Development)

Karl O. Werwath, President
Milwaukee School of Engineering
Milwaukee, Wisconsin
(Past Chairman, Technical Institute Council, American Society of Engineering Education)

IX. REFERENCES

1. A STUDY OF TECHNICAL INSTITUTES, The Society for Promotion of Engineering Education; February 1931
2. TECHNICIAN EDUCATION YEARBOOK 1963-1964, Prakken Publications Inc., Ann Arbor, Mich.
3. Proposal to the National Science Foundation entitled GOALS OF ENGINEERING TECHNOLOGY DATED NOVEMBER 19, 1965, submitted by The Technical Institute Council of the American Society for Engineering Education, Washington, D. C.
4. Engineers' Council for Professional Development, 33RD ANNUAL REPORT, September 30, 1965
5. CHARACTERISTICS OF EXCELLENCE IN ENGINEERING TECHNICIAN EDUCATION, American Society for Engineering Education, 1962

6. NEWSLETTER, Institute for the Certification of Engineering Technicians, Vol. 4, No. 1, May 1966

7. The Technical Institute - Maurice Graney, Center for Applied Research in Education (1964), New York, N. Y.

CONTINUING ENGINEERING EDUCATION

by Ernst Weber
Polytechnic Institute of Brooklyn

If we accept that at most half of the engineering graduates take up graduate study, that considerably less than half of the graduate students ever get advanced degrees, and that only ten percent of those with advanced degrees are really creatively contributing, we begin to recognize the scope of the problem of keeping our engineering manpower up-to-date in this rapidly advancing technological era. In fact, it is this small group of creative individuals that forces upon all the rest a continuing learning requirement. It is an equally small group of individuals that has accepted learning as a professional way of life and we hope that we can count a majority of at least these among our faculties.

As a fairly recent study by the National Science Foundation "Profiles in Manpower in Science and Technology" has shown, about 94% of the engineering manpower is employed in industry and government. If the employer's place is close to a university offering evening graduate programs, an opportunity to keep up-to-date in a formalized way exists. If the industrial employer has crystallized his long term objectives and realized the need for appropriately competent manpower, he will provide some opportunities for study in his own organization and, to a lesser extent, support a full-time study program in the form of fellowships. But the great majority of employed engineers, either for geographic reasons, or for lack of proper motivational incentives, will get detached from the flow of the modern concepts and methodologies of analysis and synthesis.

The question of the life span of an engineering degree has been raised often. Certainly, the curriculum at any particular reference time has knowledge content, gives tools for analysis and synthesis, and illustrates constructive use in problems of design. However, if the student, after graduation, does not continue to learn, the equipment he received in his undergraduate years will become dated. One might plot professional growth against years after graduation as in the self-explanatory Fig. 1. Industry, universities and engineering societies have the responsibility to provide ample opportunities for continuing engineering education at various levels, of varying intensity, in informal or formal courses, seminars or self-study programs.

Industry must consider its professional manpower as an asset, basically in short supply, that must be maintained at maximum proficiency as a matter of self-interest. Long range planning without the appropriate cultivation of the professional manpower to be ready for the new challenges will either fail or at least encounter difficult manning problems.

Universities must provide in addition to the traditional undergraduate and graduate degree programs, a third dimension of academic activity, namely continuing engineering study programs of the variety responding to the needs in their industrial environment. In the planning, consultations between industry and universities will increase the effectiveness of the programs for the benefit of the students.

Engineering societies should perhaps most appropriately concentrate upon the great variety of self-study programs. The direct commun ications channels to the individual members should call attention to the need for and professional responsibility of keeping up-to-date.

The great emphasis upon continuing engineering studies stems from the fact that since the turn of the century the rate of scientific discoveries and resulting technological applications has been increasing. One can possibly portray this acceleration as shown in Fig. 2. An engineering degree received in 1900 might have carried the individual with progressive company experience well into the 1920's at which time additional professional studies became necessary. Arbitrarily one might define the half-life of the degree as 35 years, or in other words: 35 years after graduation at least half of the problems encountered by the individual required new knowledge, tools and techniques, so that serious up-dating had become necessary to be technically proficient. By 1930 this half-life had reduced to about 20 years and by 1960 had shrunk to 10 years, a fact that most of us can attest from personal experience.

It is this accelerated pace of change that has prompted the concern of the Engineers' Council for Professional Development, the Engineers Joint Council, the American Society for Engineering Education, and the National Society for Professional Engineers to appoint the Joint Advisory Committee on Continuing Engineering Studies in March of 1964 for the express purpose to formulate recommendations for national action. The Committee has rendered its report at the Annual meeting of the Engineers' Council for Professional Development in Florida, January 1966, with these general recommendations:

1. A national agency of high prestige and unquestioned technical competence such as the National Academy of Engineering, should immediately assume the leadership for a comprehensive and coordinated effort to deal with the national problem of continuing engineering studies utilizing, of course, pertinent existing endeavors in this area.

2. The problems of continuing engineering studies are so complex and the potential benefits so great that individuals and groups of exceptional technical competence must be called upon to assist in the development of suitable programs.

3. A central agency should be identified at an early date for the development and maintenance of a reference list of course material and for making available basic materials for continuing engineering studies.

A number of specific recommendations for implementation are also given in the report published by ECPD and available for one dollar at headquarters.

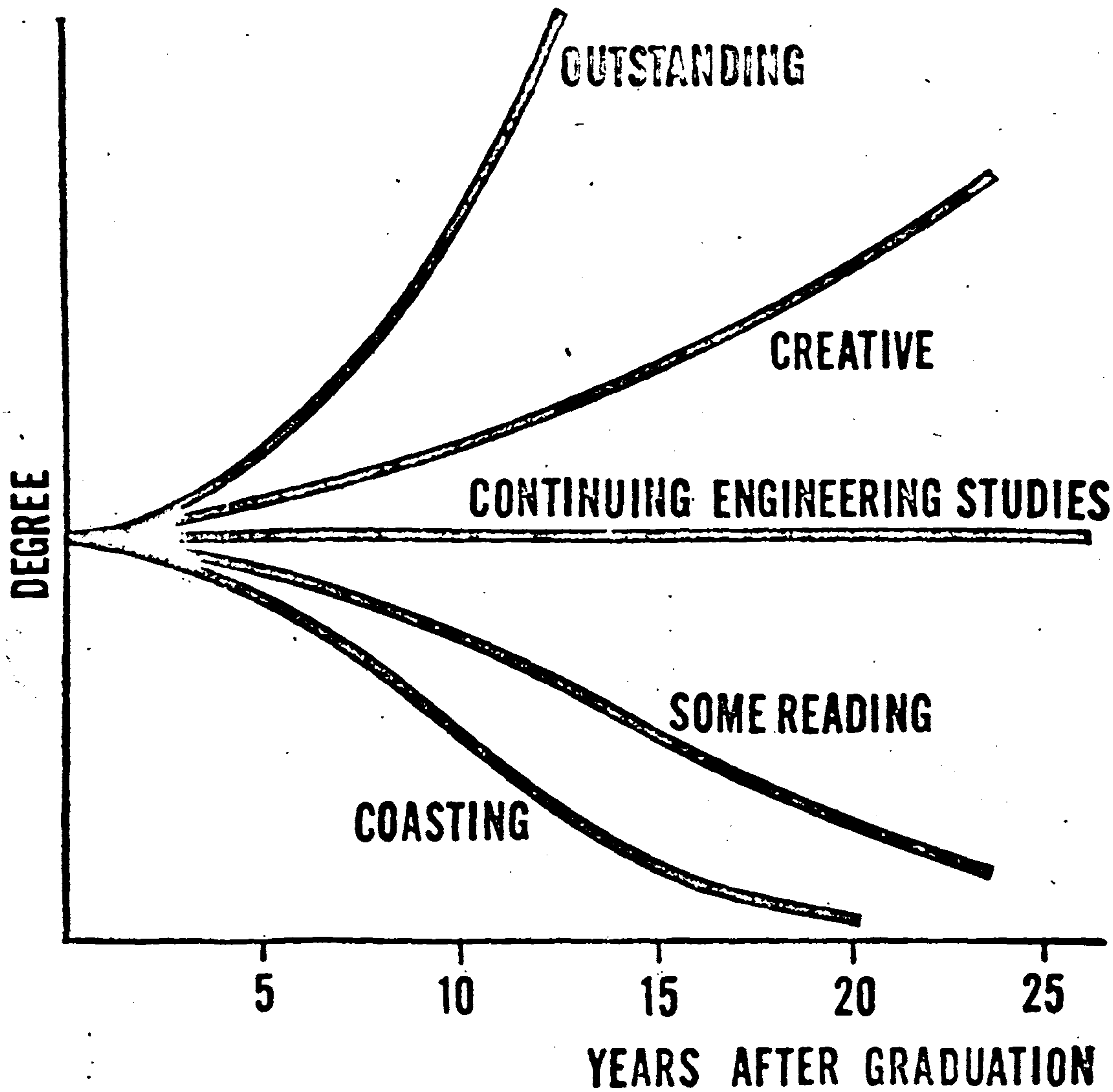


FIG. 1 PROFESSIONAL GROWTH OF INDIVIDUALS AFTER GRADUATION

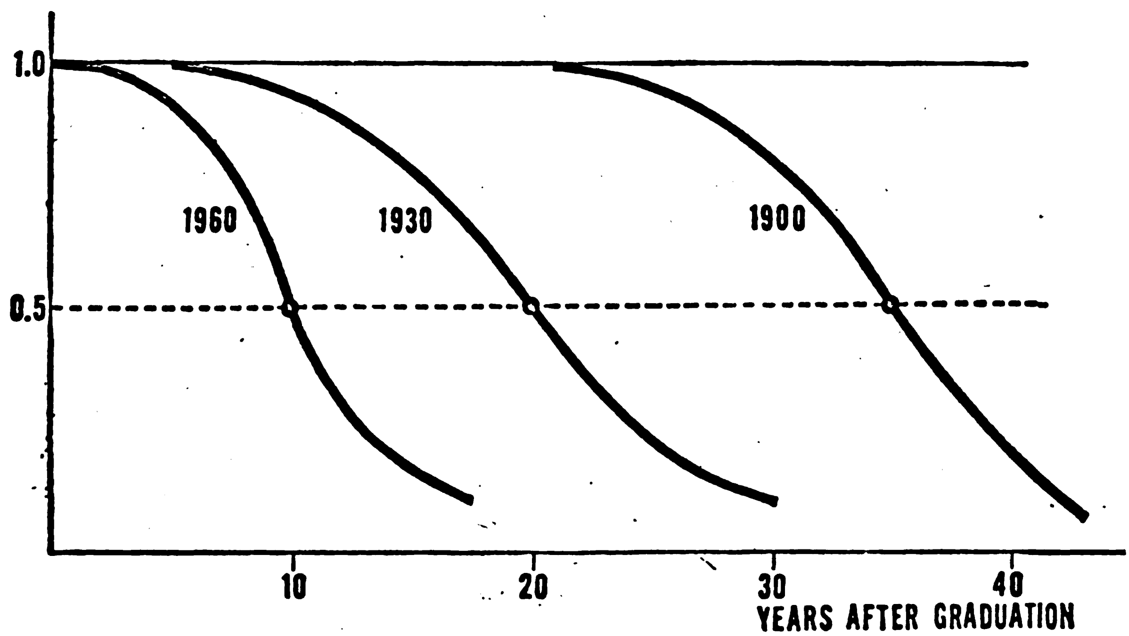


FIG.2 ADEQUACY OF "GRADUATION KNOWLEDGE" AFTER GRADUATION

WHAT ARE THE PROFESSIONAL ENGINEERING SOCIETIES DOING ABOUT ENGINEERING EDUCATION?

Engineers Joint Council

by

Clarence H. Linder
Vice President (retired), General Electric Company
President, Engineers Joint Council

If you examine the charters of the engineering societies, you will find that most of them, especially the older societies, have three items of importance in their charter. First, the responsibility of the society for the dissemination of technical information; second, an interest in education; and third, an interest in the professional status of engineers. The second item, "education", I have always interpreted to mean an interest in formal education.

The discipline-oriented engineering societies have made and are still making significant contributions to education. The published documents of the societies and the meeting structures have made a basic and significant contribution to engineering education, not only formal education, but also to the continuing education of the members of the engineering community. The meetings and publications programs of the engineering societies have been a primary process by which many people in academic life have related to the reality of engineering in industry and government. This has been a very vital function and is still of great importance.

Presently, the societies are faced with the reality of the recent and tremendous movement of scientific research results into technology; of the ever increasing technical mobility of the engineer (the majority of engineers today are not working in the discipline of their formal training); of the many emerging interfaces between disciplines; and also, of an ever-widening scope and depth of engineering activity. These developments and many others have a very significant effect on what the engineering societies can and should do.

All of these influences contribute to the need for a new look at the engineering society contribution in literature and in meetings. Many societies are presently undergoing a reappraisal of their literature and meeting structures.

The Annual Meeting of Engineers Joint Council on the 17th and 18th of January, is going to be devoted to the question: "To what extent are the discipline-oriented engineering societies' publications serving the needs of their membership?" It is hoped that the issues can be sharply defined and that suggestions and encouragement can be given to the engineering societies to give leadership to satisfying current needs.

Many of the societies are responding to the need for a new look at the engineering societies contribution to continuing education. Some are modifying their publications and meetings structures and some are going beyond their traditional pattern of meetings and publications to establish what they designate as continuing education courses. It is my belief that the engineering societies must continue to examine very critically what they are doing in publications and meetings especially in light of the identifiable needs of their members for continuing education.

Engineers Joint Council has had support by the Charles F. Kettering Foundation in the amount of $65,000 for study and experiment in continuing education. A committee chaired by Professor Garrelts of Columbia University, has been taking a look at continuing education. Recommendations are now being formulated for active participation by EJC. Engineers Joint Council's contributions are now considered to be desirable in those areas where there may be redundancy between the various discipline-oriented societies, or possibly where there is need for a mission-oriented course structure. In addition, Engineers Joint Council in an experiment supported by the Kettering Foundation has established a Clearinghouse which is receiving reports of current continuing education activities from the academic community, from societies, from entrepreneurs, and from industries. The inputs to this Clearinghouse are developing rapidly and it is now possible to discern a pattern of development of continuing education offerings.

In contrast to the indirect contribution of the engineering societies to engineering education, the discipline-oriented engineering societies have not given significant leadership in questions of policy, of curriculum, and of change to formal engineering education. The engineering societies have rather tended to react to changes in formal engineering education. It would appear that our predecessors intended that the societies take some initiative and leadership in formal education and there is probably room for much more than has been evidenced. Recently, Engineers Joint Council asked certain people to cooperate in making an assessment of "The Preliminary Report, Goals of Engineering Education." The assessment, now available, represents an attempt to make a creative contribution to the study effort leading to the final Goals Report.

WHAT IS THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION DOING ABOUT ENGINEERING EDUCATION?

by

George D. Lobingier
Westinghouse Electric Corporation
(Immediate Past President, ASEE)

ASEE has a constituency of 12,000 individual members who are engineering teachers, administrators, and industry people, more than 320 technical institute, college, and university members, and 220 industrial company members. The Society is responsive to this membership, to the engineering profession, to employers of engineering graduates, and to government and the needs of the country, at times with more success than at others. Often it speaks with leadership and a reasonable degree of authority. In all its affairs it strives to advance engineering education as an important discipline in the higher education system.

Like all organizations with large constituencies, it suffers at times from inertia and tradition; like its sister societies, it has to rely for much of its work on the part-time effort of its dedicated members. As I read the objectives of ASEE, the Society is currently concerned with:

1. The investigation of bodies of knowledge which appear to be applicable to engineering courses and curricula.
2. The investigation and suggesting of means to implement the use of such knowledge in the teaching of engineering.

3. The opportunity for engineering faculty members, administrators, and practicing engineering graduates to increase their capabilities and knowledge.
4. The availability of advice and counsel to institutions which seek to increase their participation and effectiveness in engineering education.
5. The providing of a forum for exchange of information and viewpoints in matters of engineering education.
6. The assessment of requirements for engineering education to prepare talented people of high potential to meet the demands which a society, dependent upon technology among its other characteristics, will make for its self-preservation and advancement.

With these objectives in mind, working groups in ASEE are presently engaged in, or have in prospect, the following projects:

1. A Committee on Design in Engineering, headed by Dr. B. R. Teare, surveying and assessing design instruction and suggesting various means to integrate the subject matter in the curriculum.
2. A Committee on Ocean Engineering, which is just getting started.
3. An active Committee on Environmental Engineering & Science, under Dr. A. F. Gaudy, Jr., Oklahoma State University, paying particular attention to the interdisciplinary aspects of the subject.
4. A project in Programmed Learning, under the Educational Methods Division, exploring the application of modern technical devices to the teaching of engineering, programming experimental courses

to test such means of instruction, and training engineering instructors to program engineering courses. Funded at $200,000 by the Ford Foundation and several industries.

5. A curriculum study in Industrial Engineering, related to the "Goals of Engineering Education" project. Funded by the NSF at about $17,000.
6. A joint committee, with the Commission on Engineering Education, on computers in engineering education.
7. A project, funded by OCD at $500,000, for a series of summer institutes and short topical conferences for engineering and architectural teachers, and a new fellowship program for graduate students. The Association of Collegiate Schools of Architecture is a co-sponsor.
8. A second successful and continuing faculty development program in the NASA series of Summer Institutes for Engineering Teachers. Under the direction of the Society's Space Committee, five universities have contracted for these Summer Institutes, to be jointly carried out with NASA laboratories. Funded at $475,000 by NASA.
9. A contract with the AEC for short conferences on advanced and newly developed topics significant to nuclear engineering instruction. A National Nuclear Lectureship program and a Faculty Internship with Industry pilot project are new features of this contract. Funded at $73,000.
10. A Faculty Interchange Program, with five predominantly Negro colleges of engineering and a like number of other colleges of engineering. Funded by industry at about $60,000 at present.

11. In an early stage, a larger and more involved institutional development program between established engineering colleges and institutions which are desirous of increasing their participation in engineering education.
12. A continuing Visiting Engineer Program, supported by NSF, enabling a school to have a distinguished engineer or engineering teacher visit its campus for one or two days at very little expense to the school. Funded by NSF.
13. A Continuing Engineering Studies Division, actively working with industry in updating engineers through services of the engineering colleges. It is apparent that engineering schools will be called upon to play an important role, along with professional societies. The first national meeting and conference will be held in Chicago during December of this year.
14. The "Goals of Engineering Education" project, with which everyone is familiar. An interim report is to be released in early 1967.

This listing of current projects is not to suggest a limit to ASEE's work, nor to suggest that there are no additional areas of concern. There are plenty of gaps and wide-open spaces. For instance, President Roy has only recently assigned a number of Recommendations from the 1966 Woods Hole Conference on Creative Engineering Education to various groups within the Society for task force attention.

I believe ASEE must vigorously push for a greater participation in engineering education by other disciplines outside of engineering. There is more need than formerly for the cross-disciplinary curriculum. In their daily practice, engineering graduates have many close work relationships with equally talented people, educated in different areas of knowledge than engineering. That recognition of this fact is occurring is evidenced by a proposal from a group in ASEE for a study of the Role of the Humanities and Social Sciences in the Education of Engineers.

Remaining is the troublesome difficulty of gaining greater acceptance for engineering and engineering education by the knowledgeable public. ASEE's beginning effort in this respect, through a PR program as an integral part of the Society, was unfortunately thwarted last year when plans had to be temporarily dropped for financial reasons.

ASEE believes that it can be and should be the spokesman for engineering education. Perhaps it has not as yet reached this status, but it is dedicated to this concept. We seek the advice and counsel of all those agencies and individuals who can contribute to the advancement of engineering education and to the preparation of the technical manpower resources of the country.

WHAT IS THE NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS DOING ABOUT ENGINEERING EDUCATION?

by

J. Neils Thompson, P. E.
Professor of Civil Engineering
The University of Texas
(Immediate Past President NSPE)

In continuing education, NSPE's concern is for the non-engineering aspects of an engineer's activities and responsibilities. For example, we are concerned with linking the engineering practice ladder and the engineering management ladder closer together for the benefit of the profession, as well as for the employer of engineers. Continuing education in engineering studies is a must to keep one's knowledge reservoir up to date with the rapidly changing technology. But at the same time there are many non-engineering aspects that are important to an engineer's effectiveness, whether he is on the management ladder, the engineering practice ladder or is straddling the two. A committee is actively studying how to develop a program to serve the engineer in these areas.

We are involved in two distinct programs. One is with the Encyclopedia Britannica and the other with the Office of Civil Defense. Many of the problems confronting an engineer, particularly in the management area, are in the fields in which he has had no formal education.

<u>NSPE-PEI Survey</u>

In 1965, a rigorously pre-tested questionnaire was mailed to 5,000 members of the National Society of Professional Engineers. Of these, 2,528 (approximately 50%) usable questionnaires were returned within a two-week, cut-off date. Another 400 were received later, but were not counted in the analysis. I think this was an amazing return.

From this survey,* we have realized the contribution NSPE can make to the profession. To make the results of this survey as meaningful as possible to as many engineering employers as could be covered in a study of this type, eleven questions were developed principally to elicit background information from respondents. The first question placed respondents into one of eleven possible employment classifications based on the major field of their current employers. These classifications were as follows: manufacturing, communications, research and development, distribution, public utility, government (federal, state, and local), education, consulting, construction, transportation, and other (including petroleum, chemical, food processing, laundry, systems engineering, plant maintenance and engineering, service laboratory, testing, promotion, design, and manufacturer's representative). Chart I graphically shows the distribution with major classifications being manufacturing, government, and consulting. Chart 2 shows the major area of work effort with executive management, design and research and development being the major efforts.

ASEE Survey

The ASEE Survey, which has been reported and commented on in this meeting, provides some findings that have been helpful to NSPE. I should like to emphasize several points from the survey.

Advanced engineering studies from an individual's viewpoint appear to be important, but emphasis depends upon the type of industry in which the engineer is employed.

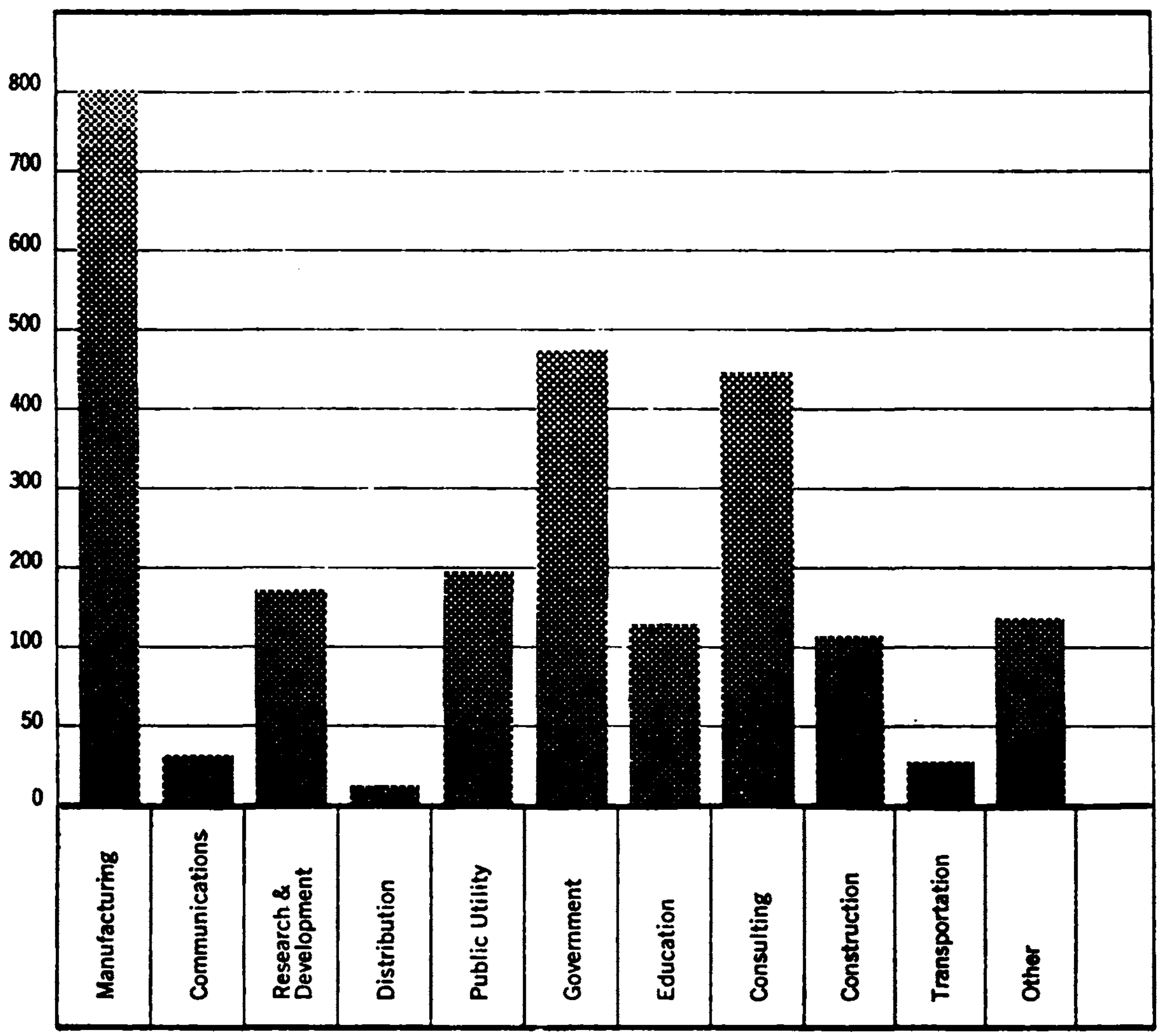
An indication of interest in continuing studies by employed engineers was gleaned from ASEE Survey Question 39, which asked if one had his education to do over again, would he go on to graduate work.

15% - No, would not go on to graduate work.
35% - Yes, would take an engineering graduate program.
33% - Yes, would take an industrial management or business program.
10% - Yes, would take a mathematics or physical science program.
7% - Yes, other.

---

* Professional Engineers in Industry Survey Report, Continuing Education of Professional Engineers. National Society of Professional Engineers, March 1966, No. 1431.

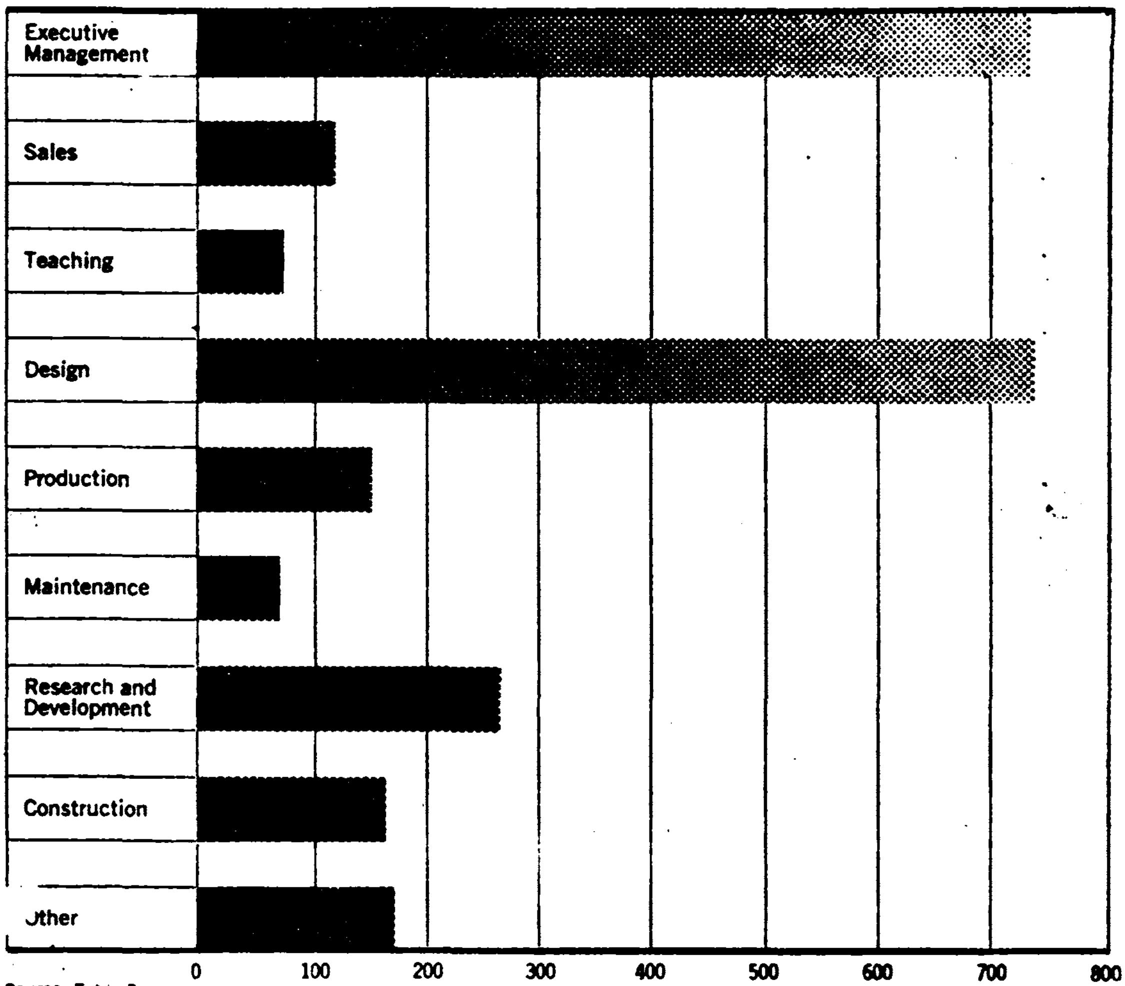
CHART 1
MAJOR FIELD OF EMPLOYER



Source: Table 1

CHART 2

MAJOR AREA OF WORK EFFORT



Source: Table 2

However, there was considerable variation by industries, with 36.8% in the construction organizations indicating they would not take graduate work as compared to 8.2% in aircraft, missiles and spacecraft organizations. Those that would take an engineering graduate program varied from 26.2% in miscellaneous manufacturing to 46.9% in Federal Government agencies. Industrial management or business programs were selected by 16.9% in state and local government agencies, as compared to 61.1% in communications, electrical, gas, transportation, etc.

In Question 43, in the ASEE Survey, the respondents were asked to make a choice of an engineering graduate program. Of those in communication, electrical, gas, transportation, etc., 11.0% wanted design or research oriented programs, while 85.7% wanted management oriented programs. On the other hand, those in non-manufacturing wanted 67.6% in design or research oriented programs as compared to only 27.0% in management oriented programs. The total group distribution was 41% for design or research oriented programs as compared to 56% preferring management oriented.

Participation in Continuing Education

The extent of participation in continuing education programs was amazing as gleaned from the NSPE Survey. In the five-year period 1960-1965, 884, or 35% of the respondents indicated that they had completed continuing education programs organized and conducted by colleges or universities (see Table I). Engineers employed in the field of research and development had the highest percentage of participation with 98 out of 172, or 57%, taking college or university conducted programs. Engineers in education followed with 43%, while 39% of the respondents in the field of distribution indicated completion of college or university conducted programs during the same period. Respondents in the fields of manufacturing, public utilities and government each recorded a 35% participation. Engineers whose employers are in the field of transportation reported the lowest percentage of participation with only 24% indicating completion of college or university conducted programs.

As shown in Table II, 951, or 67% of the 1,412 engineers who took any formally organized continuing education programs, completed 3,801 technical programs in the five-year period 1960-1965. Managerial programs followed with 547, or 38% of the 1,412, completing a total of 1,776 management

Table I. **Extent of Participation in Continuing Education Programs (1960-1965)**

Major Field of Employer	Number of Respondents	College or University Programs		Company Programs		Society Programs	
		Number of Participants	Percentage	Number of Participants	Percentage	Number of Participants	Percentage
Manufacturing	801	283	35%	341	43%	127	16%
Communications	33	10	30%	20	60%	5	15%
Research and Development	172	98	57%	88	51%	24	14%
Distribution	18	7	39%	7	39%	1	6%
Public Utility	197	69	35%	77	39%	33	17%
Government	474	165	35%	192	40%	56	12%
Education	121	52	43%	23	43%	16	13%
Consulting	445	120	27%	67	14%	68	14%
Construction	109	30	27%	22	27%	10	9%
Transportation	29	7	24%	12	41%	4	14%
Other	129	43	33%	51	39%	17	13%
TOTAL	2,528	884	35%	900	36%	361	14%

Table II. **Type and Number of Continuing Education Programs Taken (1960-1965)**

Major Field Of Employer	Respondents Taking Any Programs	Technical			Managerial			Personal Development		
		Number of Responses	%	Number of Programs	Number of Responses	%	Number of Programs	Number of Responses	%	Number of Programs
Manufacturing	488	316	64%	1,134	207	42%	673	123	25%	216
Communications	22	17	77%	50	11	50%	22	7	31%	20
Research & Development	130	99	76%	493	50	38%	173	34	26%	102
Distribution	12	6	50%	13	4	33%	27	2	16%	2
Public Utility	112	62	55%	162	58	51%	163	36	32%	111
Government	277	198	71%	886	113	40%	465	55	19%	116
Education	65	45	69%	201	10	15%	12	10	15%	20
Consulting	174	125	71%	500	43	24%	91	21	12%	58
Construction	44	27	61%	88	17	38%	25	5	11%	13
Transportation	15	4	26%	11	6	40%	18	2	13%	23
Other	73	52	71%	263	28	38%	107	18	18%	60
TOTAL	1,412	951	67%	3,801	547	38%	1,776	313	22%	741

* Percentage figures based on number of respondents taking any continuing education programs.

related programs. Personal Development programs were completed by 313, or 22% of the 1,412 respondents, in 741 programs.

Supervisors attended and completed twice as many technical programs as managerial (see Table III). The ratio of technical programs over personal development was much greater--2,099 to 419, or almost exactly five to one.

Table III. **Type of Programs Taken by Supervisors**

Major Field of Employer	Participation by Supervisors	Type and Number of Programs Attended *		
		Technical	Managerial	Personal Development
Manufacturing	310	572	347	122
Communications	15	29	15	19
Research & Development	67	243	88	32
Distribution	10	13	27	2
Public Utility	86	114	116	88
Government	203	476	297	84
Education	49	161	11	17
Consulting	154	318	72	19
Construction	39	81	21	11
Transportation	12	7	15	1
Other	49	85	41	24
TOTAL	996	2,099	1,050	419

* Figures refer to number of programs taken only.

The ECPD Study

The ECPD study* which has been reported and commented on here provided some findings which have been helpful to NSPE. Practicing engineers within industry represent a broad spectrum of employment, talent, education, and disciplines and thus their needs differ. Some disciplines require highly specialized training and special talents; others require a broad education of many talents. Work or project assignments for practicing engineers vary with a multiplicity commensurate with the number of engineers involved. Any approach taken to define the continuing engineering requirements of the practicing engineer must follow an individual approach rather than a "group" or "Institutional" one.

The results from ASEE Survey Question No. 43 concerning graduate programs give credence to this conclusion, as shown in Table IV.

Table IV.

	Would not take	Eng'r.	Ind. Mgt. or Bus.	Phys. Sc. or Math.	Other
Construction	36.8	26.3	29.8	1.8	5.3
Engr. & Arch. Ser.	24.7	34.8	28.1	6.7	5.6
Chem. Pet. Rubber & All	14.8	29.5	39.3	7.8	8.6
Prim. & Fab. Metals, Ord.	13.7	32.6	28.4	13.7	11.6
Machinery	9.4	40.6	33.3	11.5	5.2
Elect. Equip.	11.9	35.3	35.3	11.9	5.8
Aircraft Missiles Spacecraft	8.2	45.5	20.0	16.5	9.8
Misc. Manuf.	14.1	26.2	46.4	7.3	6.0
Comm. Elect. Gas, San. Ser. Transp.	15.6	18.9	61.1	2.2	2.2
Other Non-Man.	5.0	45.0	20.0	22.5	7.5
Fed. Govt.	17.3	46.9	23.5	7.1	5.1
State & Local Govt.	29.7	40.7	16.9	2.5	10.2

---

* A Report of the Joint Advisory Committee on Continuing Engineering Studies. Engineers' Council for Professional Development, September 16, 1965.

Of those that would take engineering graduate programs, which are one form of continuing engineering studies, the respondents indicated significant differences in interest as reflected in Table V.

Table V.

	Design Oriented	Research Oriented	Management Oriented	Other
Construction	14.8	5.6	74.1	5.6
Engr. & Arch Ser.	34.1	12.5	50.0	3.4
Chem. Pet. Rubber & All	12.3	22.0	61.4	4.2
Prim. & Fab. Metals, Ord	12.0	29.3	54.3	4.3
Machinery	20.8	21.9	52.1	5.2
Elect. Equip.	21.3	29.2	47.9	1.6
Aircraft, Missiles, Space craft	20.6	35.6	38.1	5.7
Misc. Manuf.	10.7	12.8	74.8	1.7
Comm. Elect. Gas, San. Ser. Transp.	7.7	3.3	85.7	3.3
Other Non-Manf.	8.1	59.5	27.0	5.4
Fed. Govt.	15.3	30.6	53.1	1.0
State & Local Govt.	37.7	12.3	48.2	1.8

Alternatives in Continuing Education

One of the recommendations of the ECPD Joint Committee was that a continuing engineering studies program must have a sufficient number of alternatives in order for each engineer to select and integrate what is useful and needed by him.

They gave some examples of an engineer's needs:

1. To know how to learn new subject matter quickly and efficiently. The ASEE Survey (70j) showed that 79% agreed that short courses on modern technology would be sufficient for keeping "up-to-date" as opposed to advanced degree work.

2. To have published information, research results and new developments gathered, evaluated, summarized, and made available to practicing engineers.

3. To be aware of the related rapid knowledge and information changes affecting a profession. In the ASEE Survey (70c), 73% agreed that formal instruction in modern technology is necessary for keeping "up-to-date."

4. To know how to do simple or rudimentary research.

5. To learn new skills for handling problems using information process machines.

6. To identify and understand the knowledge of interface disciplines as it borders one's own profession. The ASEE Survey (70k) indicated approximately 51% agreed to this need.

7. To know how to set up criterion or standards and what techniques or measures can be employed for measuring against these standards.

8. To do work that will challenge technical competence.

9. To know how to plan and organize.

10. To be recognized as advancing in status within a company equivalent to that of members of management. This was particularly important to those with BS or MS degrees because 60.4% of those respondents in the ASEE Survey (70h) indicated a need for emphasis on management training, whereas only 29.1% of those with PhD's agreed.

11. To be recognized as a member of a profession.

12. To pursue independent interests with due recognition for achievements.

13. To know how to work cooperatively and understandingly with others.

Personal Costs Incurred

The NSPE-PEI Survey revealed some interesting information on who carried the costs, which is shown in Chart 3. Over 60% of the costs incurred in participating in any formally organized continuing education programs were at the personal expense of the respondents. Consulting engineers bore the highest financial burden, paying just over 78% out-of-pocket costs for their participation in continuing education programs. Engineers employed in the construction field followed close behind with almost 75% of the costs incurred for continuing education programs being at their own personal expense. Engineers employed in the field of communications paid the least to participate in continuing education programs-41%.

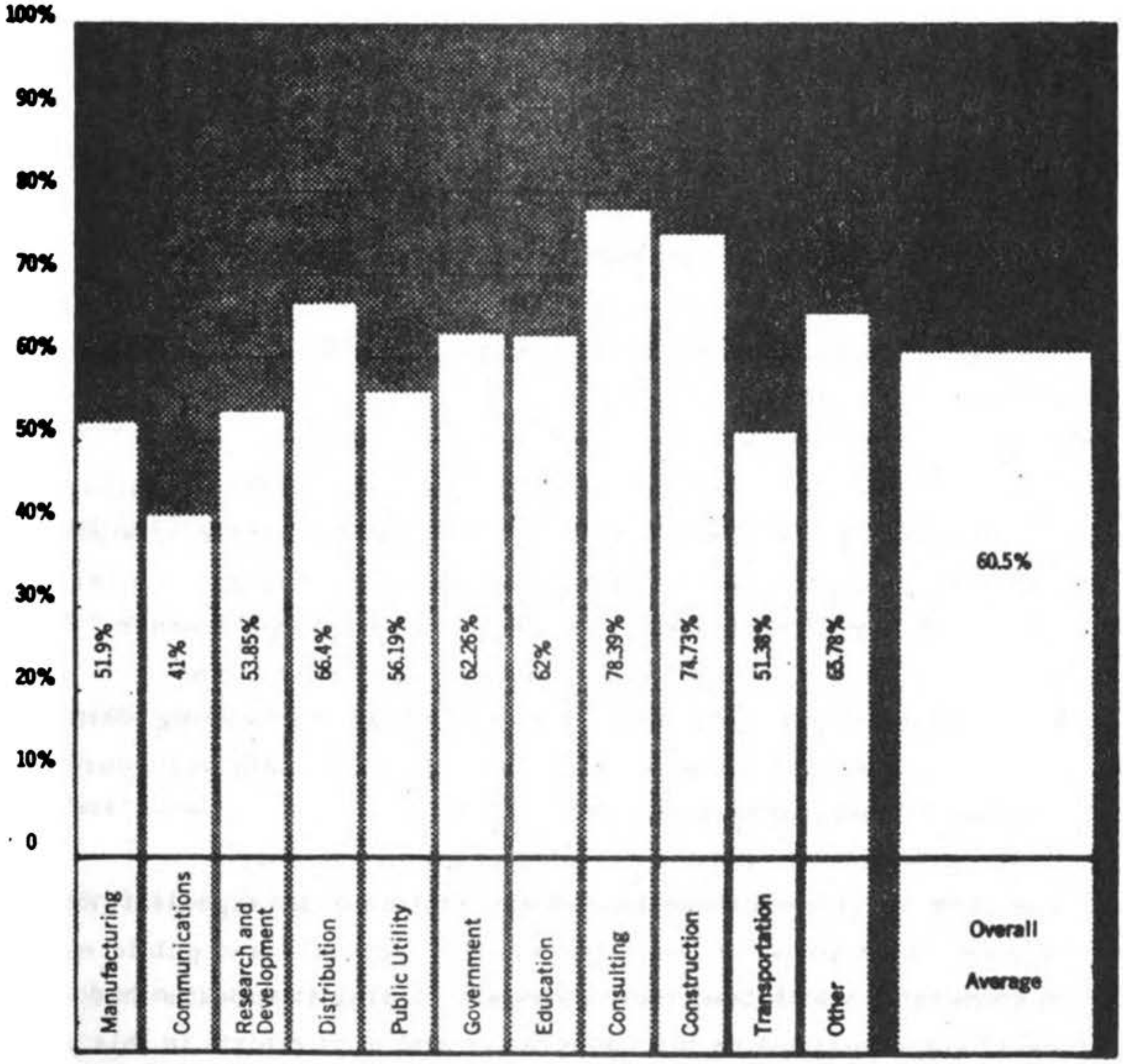
Objectives

Another important recommendation from the ECPD Study was that programs of continuing engineering studies should be established with deliberate objectives. For example, such objectives might be:

1. To indoctrinate and orient young graduating engineers with the attitudes, skills, and habits of mind necessary to adjust and adapt to continuous change, growth, and self-renewal as required in industry.

Chart 3.

AVERAGE PERCENTAGE OF RESPONDENT'S PERSONAL EXPENSE FOR CONTINUING EDUCATION PROGRAMS



Source: Question 17 of Survey

2. To institute a program of enlightenment, caution and concern of the effects the rapid technological and scientific changes are having on acquired skills and knowledge in one's profession.

3. To provide efficient and convenient methods of gathering, evaluating, summarizing, and distributing published information, research studies, and new product dvelopments.

4. To provide formalized and approved institutional engineering renewal programs that selected individuals may attend for updating.

5. To provide opportunities for the development and use of basic research skills and tools for handling large amounts of data, aggregates, samples, and populations.

6. To provide efficient self-instructional, self-renewal, and self-learning techniques, opportunities, and devices for the individual practicing engineer who wishes to pursue his educational requirements at a pace and time workable to his situation.

NSPE's Effort

NSPE's effort will be to help complement the efforts of the technical societies and engineering colleges by working in the non-engineering studies area. There is adequate evidence of need and demand on the part of a large segment of the engineering profession. NSPE, more so than any other engineering society, is in the position of contributing to studies in:

1. Engineering management with emphasis on the engineering team;

2. Engineering economics with emphasis on critical path procedures, costs, statistics, finance, securities, etc;

3. Engineering feasibility and sociological implications;

4. Engineering-science know-how interpretation to management; and,

5. Engineering approaches to letter writing, reports, and public speaking.

From conferences with book publishers and others, it appears that there are some excellent opportunities for cooperative and joint efforts in this phase of continuing education for engineers.

What Is the Engineers' Council for Professional Development Doing About Engineering Education ?

by

L. E. Grinter
University of Florida
President, Engineers' Council for Professional Development

The question raised as to the desirability of the National Academy of Engineering attempting to influence engineering education raises the broader question of the most desirable subdivisions and interrelationships within the total profession of engineering. Engineering is essentially unique in having an entire society, the ASEE, devoting its total energies to the study and improvement of the education of engineers. No other profession seems to have had an equal interest, tangibly represented by published literature, in its own education. No other profession seems to have been so ready to analyze, criticize, and revise its educational curricula and procedures. Each decade has produced a near revolution in engineering education as evidenced by the obsolescence of textbooks even more than by the titles and descriptions of courses and curricula.

The interposition of ECPD between the colleges and the technical societies in the mid nineteen thirties appears to have been an attempt to avoid the biases of professionally dominated accreditation and the weaknesses of a college or university dominated system. I believe that experience has demonstrated not only the wisdom but the necessity for this organizational pattern even though it increased by one the multiplicity of agencies related to engineering education.

For many years the technical societies showed relatively little interest in the work of ECPD or in the education of engineers. Each society has its education committee, but it could not be said that they influenced engineering education significantly. The main influences upon engineering education might be placed in this order: (1) industrial developments based upon university research such as nuclear technology, solid state devices, and rocketry; (2) the continuing work of ASEE having its influence upon thousands of faculty members; (3) the major ECPD-ASEE studies that have repeatedly produced shock effects upon engineering education.

Within recent years the public's sharp increase in interest in higher education has been reflected in the technical engineering societies, in NSPE, EJC, CEE and in AEC, NASA, NSF and other Federal agencies and industries.

The concerns and attempts at action are so divergent that engineering education instead of being strengthened might conceivably be pulled apart at the seams or at the interfaces between professional groups and interests. It is possible to have overinterest as well as under-interest in education when such interests are expressed in action programs. For example, every town seems prepared to express its sharp concern that its state has not as yet provided it with a degree program in engineering, which it believes is essential to the attraction of an industrial payroll.

Along with a greatly enhanced interest in engineering education of technical societies, government agencies, and industry, there seems to have developed a lack of willingness to delegate the solution of certain problems of the profession including education to designated agencies. The acceptance of the necessity for such delegation of responsibility is a mark of true professionalism. For example, one can hardly visualize multiple agencies of the medical profession, let alone government and industry, attempting to influence the direction of the basic education of physicians.

The National Academy of Engineering has as its main function the study, recommendation and, if necessary, action upon problems of major national import. There seems to be no reason to classify engineering education as a critical national problem today. In a national emergency when the requirements for engineers and technicians might double or triple, the National Academy of Engineering would logically be the central agency for coordinating the effort of engineering education to serve the Federal need. However, under evolutionary rather than revolutionary conditions the entire engineering profession would be strengthened by a strong resolution to delegate its educational responsibilities to ASEE and ECPD. Other agencies of the engineering profession along with government and industry should continue to provide the essential service of criticism which is so strong a tradition in engineering education.

WHAT IS THE NATIONAL ACADEMY OF SCIENCES DOING ABOUT ENGINEERING EDUCATION?

by

M. H. Trytten
Director of the Office of Scientific Personnel
National Academy of Sciences

May I say first that Dr. Seitz asked me to express his regret at not being with you, and asked me to take his place here. I shall be brief because the activities of the Office of Scientific Personnel, which is the part of the Research Council dealing with education and manpower matters, lies somewhat outside what I think seems to be the mainstream of thought in this meeting.

I shall, however, give you some brief overview of the activities of the Office, because in fact they do relate to education, all of them, and in all of them, engineering is one part of the complex served.

Our major activities are in the general field of fellowships, where we administer quite a number of programs, including the selection of the National Science Foundation recipients. This is a rather large activity in itself. Last year we dealt with approximately 15,000 applications for fellowships in the graduate and post doctoral area. Besides that, the senior part of the Fulbright Program is administered under a contract with the Department of State by the National Academy of Sciences.

We have additionally, however, some programs that I think are less well known, and have a certain significance in our estimation.

I would like to refer to those briefly. These are programs we call associateships. They are in every respect a parallel to a post doctoral appointment, with one exception : the individual works at a designated laboratory to which he applies through us for such a program. This was started at the Bureau of Standards and proved so successful that some 20 federal laboratories now have programs of that kind administered through us in all of the different fields of their activities and the different fields of sciences, covering practically all of them, including engineering. Perhaps the field of engineering is particularly involved in such aerospace activities as that in connection with the California Institute of Technology at the Jet Propulsion Laboratory.

Outside of this area, we do quite a bit of research on manpower matters, and this has been largely related, of course, to the graduate and post doctoral area. We have as a base for this research certain data banks that are unique in the United States, and extremely fruitful for continued research. One of them is a repository of information on all people who have attained a doctorate in the United States in any field, covering a period now of 45 years. We have the results up to 1965 practically all in the files.

This contains a great deal of information, and is the basis for quite a bit of research.

The other areas in which we have data banks is a cumulative index of everyone who has applied for any one of these fellowship programs. There is a high degree of qualitative information involved in this, which is also useful for various kinds of research; there is a segregated file of people on whom we have substantial quality information.

Just briefly, what kind of studies do we carry out? I shall only mention a few of them. Perhaps the newest, and one that I think you may be interested in, is a study of post doctorate education. This is just being inaugurated this fall, and has been called for by so many different interests that it appears to be a much needed study. We know that on some campuses the post doctorate population now is actually greater than that of the resident faculty. This has created many, many administrative problems in relationships on the campus, the need for organizational structures on the campus to deal with this problem, and so on.

We intend to make a study of that through an office located at MIT. That part of the study dealing with the more personal aspects, the values concerned for the individual, the eventual disposition of these individuals, where they go, what kind of work they go into, and so on, will be carried out in our Washington office.

We have carried out a number of studies in this respect. One of them I shall mention is the career pattern study which we carried out under National Institutes of Health auspices or support, which covers a fairly large sample of persons over a period of some 35 years, to determine how as a function of time our society uses this kind of person. We have a special study of engineering doctorates of a somewhat similar pattern. It is intended to run until 1970 and will involve periodic followups of the doctoral graduates of a given period of several years, in order to get some idea of the functions individuals perform after a post doctorate experience. These studies ought to be useful for the engineering profession when they come out, as indeed the career pattern study will be useful for other areas.

We are carrying out also at the present time a study of the fellowship programs of the National Institutes of Health to help evaluate these programs. The study is just getting started.

This will give you a brief overview of the kinds of work that we have been doing. You will note that it does not include the kind of thought that you are dealing with today, that is, the specific curricular matters, the nature of the curriculum, and that sort of thing. There is a very good reason for that, especially in the sciences, in that so much of this is being done by the professional societies, notably and most conspicuously at the secondary school level with such groups as the Physical Science Study Committee. In addition, there is now a fairly strong movement in such agencies as the American Association of Physics Teachers and others who are moving into the college area with substantial studies of the curriculum and its nature and suitability.

WHAT IS THE GOVERNMENT DOING ABOUT ENGINEERING EDUCATION?

by

R. Louis Bright
Associate Commissioner for Research
Office of Education, Department of Health, Education, and Welfare

An earlier speaker has already referred to some of the activities of the Atomic Energy Commission and of the National Aeronautics and Space Administration. These agencies, as most of you in academic circles know, support a variety of educational programs--doctoral and postdoctoral fellowships, faculty seminars and appointments, some hardware development--all related to each agency's area of major concern. Most of these programs involve or have definite implications for engineering.

Right now, the Office of Education may seem really to be doing very little directly and specifically related to engineering education, but this in no way reflects a lack of interest. Today I would like to do more than describe what the Office is doing; I would like to talk about what we ought to be doing, what we would like to be doing, particularly insofar as the Bureau of Research is concerned.

In the Bureau of Research our major goal is the improvement of the quality and effectiveness of education. Many people think the Bureau is primarily concerned with elementary and secondary education; in the past this may have been true. However, the present legislation does not restrict Bureau activities to any particular educational level and we hope to balance the distribution of funds somewhat more evenly than has been the case in the past. Right now, we are involved not only in efforts to improve what goes on in the elementary and secondary schools; we are also concerned with preschool learning, postsecondary and continuing education, technical and vocational training, the entire gamut of education from child to adult. Whatever we can do to improve the effectiveness of education in general should also increase the potential effectiveness of specialized programs, such as engineering.

When we speak of support for research and related activities to improve the quality and effectiveness of education, we include, of course, projects and programs concerned with the improvement of course content. But we are convinced very strongly that technology has a great deal to offer curriculum development--that in a great many situations where the newer media can present material more effectively, chalk and blackboard are rather obsolete as methods of teaching. In fact, the capabilities of the newer media not only enable us to improve the way teaching and learning take place. Use of newer media considerably expands what can be taught in the schools. For example, a picture of a machine in operation communicates far more than a verbal description of that machine's operation; visual presentations of customs in remote geographic areas communicate far more than other descriptions of those customs. Furthermore, to the extent that the machines carry the instructional burden, the teacher is free for more important things.

In other words, modern technology gives us alternatives we didn't have a generation ago and it is up to research and development to help us devise programs and practices which benefit from these advancements. With the funds that the Bureau of Research has available, however, we simply can't justify supporting the development of a curriculum by one particular individual or for use in only one institution, while the rest of education sticks to what has long been the status quo. To provide for the pressing widescale needs for educational improvement and at the same time assure that we are on relatively firm ground, we would much rather support comprehensive--rather than piecemeal--curriculum development activities that involve a reasonable cross-section of highly competent people from many disciplines. In the course of their efforts to determine what is needed in the way of curricular content, the curriculum developers would, in many cases, confer with those who will later employ the products of schools--for example, with representatives of industry and the professions. Such an interchange between curriculum developers and potential employers could help to determine what the educational objectives of a particular kind of program should be. It would also make it easier to implement the program, not with the techniques of the past--the program is not going to be used in the past--but with the techniques of the present and the future.

Education must always be future oriented--for two reasons. First of all, today's learning should have some value in tomorrow's world. And second, by the time you establish curricular objectives, develop the curriculum, and put it into reasonable use at all, six years or so have probably passed. After the curriculum has been in use for about ten years, even if the initial development was future oriented, it will be overdue for revision, unless there has been continuous adaptation and updating in the meantime. In fact, at the rate new knowledge and new technology are developing, education is literally forced to turn to new media and new teaching-learning techniques in order to make the necessary continuous adaptations.

If we are to develop a program that takes full advantage of the effectiveness of modern media and modern techniques, it will probably cost somewhere in the neighborhood of ten to twenty thousand dollars just to prepare the amount of material that a student will go through in one hour of instruction. This includes the cost of all the steps from establishing objectives through preparing material, testing it, revising it, and so on. Multiply this by the number of hours of instruction for which materials are needed and you have some idea of the magnitude of curriculum development cost. When you are talking about spending this much money, it does not make economic sense to develop materials for isolated cases. There isn't time--or money--to experiment haphazardly. Comprehensive curriculum development activities make sense only if the programs are going to be widely used when they are completed. You can see why we value the opinions of the professional associations; whether they are on the instructional side of the continuum as teachers or on the consumer side as potential employers, they can help us determine the kind of future-oriented programs we need to work toward.

I might mention that when I speak of using modern techniques, I don't mean for people to pick out a particular technique--say computerized instruction, or educational TV, or programmed materials--and try to develop a particular course to fit the technique, as if the technique were more important than the content. Media are simply tools of instruction, and even the best of tools may be useless when they are used on poor material or in the hands of unskilled artisans. We feel strongly that the choice of the media or the mixture of the media depends on what you are trying to do. Instead of starting out with a preconceived idea about developing a computerized course in something or other, we must begin with a careful definition of the objectives of the course in terms of the observable behavior of the students. Only then can we decide what combination of media achieves this in the optimum manner.

A very open question here--concerning an area in which there has been very little work done up to the present time--is: What is the role of the professor in a system which uses modern instructional technology to the maximum extent feasible? First, I think we should define just what technology can do. I suppose it follows that the professor should do those things that technology can't do. But, simple as this answer may sound, we have little objective evidence to go on in redesigning our programs to make use of technology and in retraining or reorienting our teachers to use it. Here again is a challenge to educational research and related activities.

I can see that the whole question of the place of educational technology has considerable application in a number of situations that have been mentioned at this meeting. For example, I feel rather strongly that we need to remedy the almost total lack of any engineering component in the secondary schools. Also, I think some of the new approaches to education would make a great contribution in the community colleges, many of which are new enough not to be hampered by tradition and most of which have a practical school-community orientation amenable to a relatively pragmatic approach to learning.

Perhaps I tend, for the sake of argument, to pick up the gauntlet that was thrown down here a few moments ago and ask, "Is it possible for every community to give a first-class degree-granting program in education?" I am not sure that the answer is an immediate, "No." I think it requires further study. If students in the community colleges can learn faster and better with some of the new techniques, they may be more inclined to go on for degrees--if the degree programs are equally challenging. So, you see, the rapid spread of community colleges and the transfer of students in the junior year into the major universities may get a sort of shot in the arm from programs that are future oriented and capitalize on effective educational technology. Also, the continuing education of adults can benefit by the same kinds of instructional improvements.

If I were to summarize in a single sentence one of the major goals of the Bureau of Research, it would be this: We would like to develop curricula which have modern high-quality content, which make appropriate use of the capabilities of educational technology, and which engender a future-oriented approach to continuous and self-renewing learning. This challenge is constantly before us in selecting research activities to be supported out of available funds. To the extent we succeed, we shall be making a major contribution to improvement of all of education--including the education of engineers.

What is the National Science Foundation Doing about Engineering Education?

by

John M. Ide
Director, Division of Engineering
National Science Foundation

I should start this brief summary by reminding you of the objectives for which the National Science Foundation was established. The act passed by Congress in 1950 directed the Foundation to

"Develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences; initiate and support basic scientific research in the mathematical, physical, medical, biological, engineering, and other sciences by making contracts or other arrangements-----for the conduct of such basic scientific research and to appraise the impact of such research upon industrial development and upon the general welfare; to award scholarships and graduate fellowships"; and to perform other related tasks.

From the very outset, the Foundation has consistently emphasized two objectives—support of research and support of education in the sciences and engineering. The scale on which NSF activities have been performed has consistently grown from small beginnings to the present overall budget level of just under a half-billion dollars annually. The NSF budget accounts for about 10-15% of the total Federal outlay for comparable activities in all fields of science and engineering.

My topic today is—What is NSF Doing about Engineering Education? This is not quite so easy to answer as it may seem. First there is the distinction between research and education, which we can make only in a rough sort of way. Then there is the point that, up to the college level, the education of the scientist and the engineer is substantially the same. For example, everyone who will eventually seek an engineering degree must study the fundamentals of mathematics, and some combination of the physical sciences. The Foundation has spent many millions during the last decade in thorough revisions of curricula and rewriting of textbooks in physics, chemistry,and mathematics at the pre-college level. I refer here to the "new math" and to the parallel efforts in the basic sciences. These efforts have strengthened the common stem of the tree of scientific knowledge. Engineering education has, of course, benefited in the process.

The educational portion of the NSF organization is not divided by disciplines or by branches of science. It is arranged by educational level. There are three divisions—Pre-College Education in Science, Undergraduate Education in Science, and Graduate Education in Science. In the first of these, engineering as such currently enters only into one curriculum project. This deals with the presentation of Engineering Concepts to high school students, and the project has reached the final phase of try-out and evaluation in selected schools. A text has been produced, "The Man-Made World," which covers Logic and Computers, Measurement and Models, and Energy Control and Design.

Engineering enters much more strongly into the work of the two divisions which cover undergraduate and graduate education.

Support has been provided for a relatively large number of projects in the field of engineering. There have been influential conferences and reports on desirable directions for curriculum development in such areas as technical institutes, chemical engineering, ceramic engineering, civil engineering, sanitary engineering, and theoretical and applied mechanics. A major reexamination of the "Goals of Engineering Education" at all levels, funded by the Foundation, is being sponsored by the American Society for Engineering Education.

The Commission on Engineering Education, also supported by NSF, has made a thorough study of potentialities of the case method in teaching design. As a result, case writing projects are now under way at Stanford and Cornell Universities. The Commission, urging that more engineering educators find ways to bring realistic experience with design into their own classroom, organized summer 1965 workshops on engineering design at six leading institutions.

Leadership for engineering films has been provided by the National Committee on Films in Fluid Mechanics, and a comparable project is being undertaken by the National Committee for Electrical Engineering Films.

Illustrative of course development projects is the work of the Semiconductor Electronics Education Committee. Representatives of a score of universities and a number of industrial organizations are cooperating in the development of a teaching program which demonstrates introductory semiconductor physics, principles of semiconductor devices, and important features of circuit design employing semiconductors. A series of seven textbooks went through two trial editions; final editions are being published this year, together with four films.

I would estimate that in recent years about $2.5 M annually has been spent by the Foundation on special studies, course content improvement, teachers' institutes, and undergraduate research participation—all specifically in engineering.

This brings us, working up the educational ladder, to the provision of fellowships and traineeships for graduate study in engineering. The budget for these—in engineering only—last year, was $12.2 M, and the number of individual students who benefited was 2289, divided as follows:

Graduate Fellowships	273	Academic Year 1965-66
Cooperative Graduate Fellowships	296	
Graduate Traineeships	1720	
Total	2289	

By Engineering discipline, the distribution of traineeships in 65-66 was:

Electrical	337
Chemical	243
Mechanical	230
Civil	188
Electronics	109
Mechanics	105
Aeronautical	94
Nuclear	73
Metallurgical	73
All Other	268
Total	1720

A very large fraction of the eligible graduate schools received traineeships. In 1966, with full science coverage, 193 of the 200 eligible graduate schools are involved.

Engineering has recently become a heavy beneficiary of the total support available for the fellowship-traineeship kind of assistance, receiving 40.6%

of the total FY 64, and 38.1% in FY 65. This percentage will decline as all fields of science come to participate more fully in traineeships, but in any case it can be said that engineering will continue to get its fair share of the funds available for this purpose.

Science Faculty Fellowships are available to engineering faculty who teach primarily at the undergraduate level. These awards provide opportunities to teachers to refresh their knowledge in their fields of specialization, or to continue their formal education, usually to the Ph.D. Engineers have found this program particularly helpful. For example, from 1957 through 1963, 40% of the awards were offered to engineering faculty—a much higher percentage than in any of the other major fields supported.

Graduate training programs in certain institutions, both at the Master's and Ph.D. level, have been strengthened by support provided by a Graduate Education Development Project grant. Two very substantial grants extending over a three year period are enabling two engineering schools* to introduce improvements toward enhancing the quality of graduate training. Both of these grants are in the neighborhood of $300,000 each and provide funds for faculty development, upgrading of courses, visiting professors, and other items for developing a quality graduate program.

Advanced educational opportunities for engineers are offered by the Advanced Science Seminar Program. During the past year two Advanced

*Duke University (GE-2558)
*University of Alabama (GZ-245)

Seminars in engineering have received support from the Foundation, a seminar in energetics in metallurgical phenomena held in the West** and an institute on advanced control to be held in the South***. These seminars are attended by faculty, graduate students (pre- and postdoctoral) and industrial engineers.

This brings us to the support which NSF provides for research in engineering. We recognize that research and education at the graduate level are the two sides of the same coin. Our view is that the research support strengthens the engineering schools at the graduate level and thus makes the schools more attractive to all students who attend them.

Engineering research now rates division status in the Foundation on a par with divisions for the mathematical and physical sciences, the environmental sciences, biological and medical sciences, and the social sciences. This group of divisions reports to the Associate Director for Research.

University research in Engineering has been supported by the Science Foundation from the earliest days of the organization, beginning with 3 grants ($42,000) in 1952. From this small beginning there has been steady growth over the years to our current annual level of about 500 grants, for nearly $20 M, in about 100 different schools of engineering. On the average, we make one grant for each three research proposals made to us.

**University of Denver (GZ-233)
***University of Florida (GZ-263)

All of our grant money goes to universities - - none of it to industry or to non-profit institutions.

The scope of engineering research supported by us as well as the number of dollars spent has steadily broadened as programs have grown in size.

Initially the grants for research support were pretty well limited to work in the accepted engineering sciences. These include, for example, mechanics of fluids and solids, thermodynamics, transfer processes, electrical theory, and the nature and properties of materials. The major fraction of our grants are still in these classical areas.

In recent years, however, it has become obvious that we need a broader definition of engineering research appropriate for support by us.

To meet the trends in engineering proposals, the National Science Board, which sets policy for the Foundation, in mid-1962 adopted a resolution broadening the definition of supportable work to include "intellectual pursuits at educational institutions intended to advance significantly the basic engineering capabilities of the country." The resolution further specified that "such work must be of a true scientific nature and not routine engineering practice, and must meet the usual NSF standards of originality and excellence."

Equipped with this broadened definition of acceptable engineering research, we have noted a growing trend toward the making of grants in systems analysis, computer applications, biomedical engineering, transportation studies, and earthquake engineering. We would actually welcome the opportunity to support more research of high quality on engineering problems relevant to the civil economy. There is obviously going to be an increasing need for engineers with research experience in these newer areas.

I have thus far not commented on the grants made by the Foundation to strengthen institutions as a whole, and those which combine with matching money from the universities to build buildings for teaching and research. The amount of money going into institutional grants for the benefit of engineering is of the order of $5-8 M per year. The largest portion of this is in the program which we refer to as Science Development - - the so-called "Center of Excellence" program. Several of these grants have involved major funding for strengthening selected engineering schools. Examples include Case Institute, Rice University, Polytechnic Institute of Brooklyn, and the University of Colorado.

Summing up, the National Science Foundation has been putting $45 to $50 millions annually into well-rounded programs of grants for research and education in engineering schools and colleges. These run the gamut from institutional grants of various kinds, through curriculum studies, fellowships and traineeships for advanced study, to research support in virtually all fields of engineering.

Finally I would like to offer my personal opinion as to what the Academy of Engineering should do about engineering education. Wholly new programs should hardly be needed. Better funding of existing programs, however, would go far to improve the health and status of engineering education. For these programs to meet the needs, a better share of Federal assistance funds may have to be obtained.

This can best be achieved, in my opinion, by broad-scale studies of potential contributions of engineering research to the national welfare.

The various fields of science are well advanced on such studies, with NAS reports appearing in rapid order on the research needs of astronomy, physics, chemistry, plant science, etc.

Similar or parallel studies devoted to the disciplines of engineering, sponsored by this Academy, would greatly clarify the proper claims of engineering research to support in the highly competitive world in which we find ourselves. Without some such stimulus, it will be difficult to sustain the growth now manifest in our schools of engineering.

WHAT IS THE COMMISSION ON ENGINEERING EDUCATION DOING ABOUT ENGINEERING EDUCATION ?

by

Newman A. Hall
Executive Director

Educational developments today call for the concern and attention of engineers. The educational establishment in this country represents one of the more complex and consequential systems in our society. While this system is one involving primarily the behavior and capabilities of people, it is increasingly evident that technology and engineering have an extraordinary opportunity to serve society in giving attention to the problems our educational system presents. In fact it is very fitting to identify this as a system which as a whole is as worthy of attention by engineers as any which society is bringing to our attention.

It was in this spirit of concern regarding education as an engineering system that the Commission on Engineering Education was founded some five years ago. If engineers are the creators and innovators of systems that serve society, it should be possible for them to examine and serve their own educational system in the same spirit. Certainly engineering education, if a system, should be the beneficiary of the development and creative talent of the engineer.

The Commission on Engineering Education was established in the fall of 1961 and incorporated in 1963 in Washington, D.C., as a nonprofit educational research and development organization. Policy and overall direction is established by a Board of Directors of nineteen individuals. Of these Directors, almost half (William Everitt, Nathan M. Newmark, W. H. Pickering, Gordon S. Brown, John G. Truxal, John R. Whinnery, Edward E. David, Jr., Walter R. Hibbard) are members of the National Academy of Engineering. The Commission itself consists of present and past members of the Board and chairmen of advisory committees appointed by the Board. Directors are elected by the Commission at its annual meeting for a three-year term. In order to maintain desirable and appropriate liaison, the individuals currently holding office as president of the Engineers' Council for Professional Development and of the American Society for Engineering Education are ex officio Directors. Current officers and members of the executive committee are: Chairman, John Whinnery; Vice-Chairman, Edward D. David; Secretary-Treasurer, Fred Lindvall; Paul Chenea and W. L. Everitt.

The Commission came into being to a large extent as a result of concerns for educational development within the National Science Foundation. Our operations accordingly partake of many of the same objectives of the several college commissions in the sciences supported by NSF. Ours, however, is the only one which has been separately incorporated and our concerns and objectives are in general broader than the other Commissions. A little over one-half of the financial support for the Commission since its inception has come from the National Science Foundation. The remainder has come from private foundations and industry.

Operations of the Commission are administered by the Executive Director. Staff has been kept at a minimum although projects being carried forward by the Commission are requiring the addition of staff to handle details. Also, it is probable that there will be further individuals brought in to the central office to assist in planning of major activities in which the Commission may become involved. Most of the exploratory studies are carried on by advisory committees selected from industry and the educational community. To the extent that it is possible, individual members of committees are selected on the basis of the exceptional talent they can bring to bear on the educational and engineering problems under review.

The outstanding characteristic of the Commission is its receptivity to creative ideas most likely to improve engineering education or to provide engineering contributions to educational systems. It endeavors to develop and implement these ideas within its own organizational framework, or encourage the promising contributions of other individuals, institutions, or professional societies. The major emphasis of activity is in the development of educational resources. These may take any one of several forms, such as institutional development, faculty advancement, improved educational techniques, or new approaches to the understanding of engineering. Given the opportunity to experiment constructively and the resources of information and method to conduct such experimentation, engineering schools and the educational system more generally will be able to meet the demands of greater enrollments and a much broader scope of educational content requirements. The development of resources that will be effective and appropriately take advantage of current technology is not only a substantial educational task but calls upon real engineering talent as well. It is the intent of the Commission to bring together the skills and understanding of the engineer and educator in the most effective manner to insure that the needed development is undertaken. Wherever possible such activity should be undertaken by other institutions and establishments. However, when other possibilities are impractical or unavailable, the Commission is sufficiently flexible to undertake the effort itself.

Rather than catalog the entire current program of the Commission, a description of several of our key activities will adequately illustrate the spirit of our endeavors. First of all is our BUILD program at the Universities of Colorado and Illinois. Supported by an $800,000 four-year grant to the Commission, BUILD intends through paired collaboration to help one school achieve self-sustaining excellence and to help the other reassess and reinforce its position of achieved eminence in engineering education. Much attention has been given in recent years to the need for stimulating the attainment of excellence in those engineering schools which are rapidly moving to the position of contributing substantially to the output of graduate students in engineering and, accordingly, influencing significantly the complexion of leadership in engineering. The BUILD program represents an effort to contribute to meeting this need by stimulating the overall advance of this group of engineering schools by pairing two institutions, one which has well-established resources in administration, faculty,and facilities, and the other which is in the process of developing such resources. By intimate interaction on all levels of education operation, both institutions will benefit, and the developing institution will move along more rapidly.

Within the past several months an evaluation study of the BUILD program has been conducted for the Commission by Richard Bolt of Bolt, Beranek and Newman associates. This study reports that the objectives are being very well realized and recommends that as a successful experiment, it should be extended to other appropriate pairs of institutions.

A second general area of Commission activity pertains to equipment and facility resources. Typical has been our concern with educational films, laboratory equipment and methods of instruction, and computer facilities and programming. In these and similar cases it is apparent that there has been a dominant tendency to rely on adaptation of available resources rather than the much more appropriate course of designing the facilities or methods specifically to meet educational objectives in an optimum manner. For example, in a limited number of our leading engineering schools there is very extensive use of computing facilities in the educational program. This has been made possible by the exceptional efforts of the faculty in building effective problem-oriented approaches to programming languages so that students and faculty can make use of the computer in advanced analysis and design. Such specialized languages, however, have been developed on an uncoordinated basis in general so their applicability is restricted essentially to the institutions where they originated. The ultimate resolution of the restrictions which this situation as well as other difficulties impose in making the computer a fully integrated element in the educational program awaits a systematic large-scale coordinated effort. This is currently receiving attention by a joint committee of the Commission and the American Society for Engineering Education.

A third area which has been studied at length by the Commission is the interaction between industry and the engineering schools. This is, of course, a very old problem with many ramifications. There are very well established procedures of communication which provide much information and many useful experiences for engineering faculty. However, there is a chronic tendency for engineering schools to move away from activities that relate constructively to industry needs and for industry to accept the student output of the schools without exerting any other responsible initiative. The very important

Relations-With-Industry activity of ASEE represents one approach to this concern; recent studies by EJC and ECPD on continuing education, another. The Ford Foundation with its industrial residency program, has shown on a very small scale the great value of a discriminatingly planned interaction with industry. There still remains, however, the task of working systematically with industrial management in developing an acceptance of meaningful and appropriate responsibility for engineering education. Current exploratory studies of the Commission are seeking a better understanding of the intrinsic pattern of feasible acceptance of responsibility by industry for engineering education and its advancement. It is clear that in this area there is much to be gained by coordinated planning. The means for accomplishing this most effectively at the present and in the immediate future need much better definition.

Among the more rapidly developing of the Commission's programs is the Engineering Concepts Curriculm Project. This activity under the joint direction of E. E. David and John Truxal - members of NAE - represents the first expression of the engineering profession in high school curriculum reform. At a time when technological accomplishment is the most consequential factor influencing the nature and evolution of our society and economy, we feel that there should be an adequate and appropriate plan for a course which would provide a basis for appreciation of the unique contribution of the engineer. Much attention has been given in the last few years to the new math and the new science in our secondary schools. There is no question that this reorientation of courses providing fundamental appreciations and understanding is greatly needed. Nevertheless, to provide a glimpse of technology only through the eyes of science is as circumscribing as it would be to try to understand modern economics by studying classical philosophy. To be sure, the engineer operates in an environment where scientific knowledge is an essential ingredient in his background, but economics, human relations, political pressures, and the whole structure of existing technology are just as essential ingredients. The basic concepts of the engineer are not those of science, nor are his methods of analysis and synthesis. The engineer has introduced into our whole approach the problems of society whether they be technical, political, economic, or other, a method of logical synthesis coupled with astute judgment that while vital for technological success has demonstrated a comparable effectiveness in other domains. It is not without significance that the degital computer which epitomizes the logic of the engineer has become such a pervasive factor everywhere we turn.

It is with this viewpoint that the Commission has developed a course with a text entitled THE MAN-MADE WORLD that is already being received with enthusiasm by high schools across the country. Initially this course comprises a limited selection of engineering concepts : logic and logical design, including an appreciation of the computer not as a calculating device, but as a means of logical synthesis of almost limitless capacity; analytical and experimental modeling, as a basis for selecting and discriminating analysis and synthesis, involving concepts of dynamics, stability, feedback, etc.; and feasibility and optimization involving constraints imposed by energy, dynamics, and materials. By examining situations and phenomena that occur in the day-to-day technological environment of the student and samples available in the laboratory, the students are provided with an immediate appreciation of the relevance of these engineering concepts and methods to the whole of the contemporary world.

The course is designed for the normal college-bound student, not necessarily for the potential engineering or science major. It is our conviction that a well-organized introduction to engineering concepts should be one of the most desirable elements of the basic education of any well-informed citizen.

Our effort so far represents only a beginning. The approach we are taking possesses a great deal of flexibility and diverse potentialities. We believe it is one of the more exciting means whereby the interests of engineering may be served. We can expect our role in society to be appreciated and supported only when society understands how and why the engineer reasons as he does.

These activities of the Commission on Engineering Education, we believe, exemplify the most enlightened approach of the engineer to educational problems. The opportunity is extraordinary and relatively untouched. On the occasion when the Academy of Engineering is exploring possibilities of engineering activity in education, we welcome the privilege of being able to report on what can be done in a spirit of discriminating initiative that is equally appropriate for NAE.

WHAT IS INDUSTRY DOING ABOUT ENGINEERING EDUCATION?

by

Gerald A. Rosselot
Vice-President of Engineering
Bendix Corporation

When I was in grade school, we had a little debating society in the sixth grade, and someone once offered for debate the question "Are girls or boys the more important in this world?"

The girls won this. They were smarter in that instance. They refused to debate the question or take a side. They simply said that you could not prove that boys were the more important.

I feel inclined to take this position on questions regarding industry's relation to education, and education's relation to industry. Industry is a customer, one of the major customers for the output of our educational system, whether it may be the university or elsewhere. We are a supplier of funds and quite a few times of people. We ourselves came from the university. The only conclusion we can draw is that we are part of a very active and expanding-in-bandwidth, dynamic system.

In regard to the question, What is industry doing about engineering education? each of the speakers so far has discussed and commented on part of what industry is doing. Let us look for a moment--and I am sure I am not telling you anything new--at what is happening to industry at the present time without going into statistics. We are moving, as has been indicated, at an astounding rate as a dynamic, automated industrial society. We are highly innovative. We have to be innovative in all of our activities.

Industry is quite interested in the problem of education and in industry's part in the educational system, its interfacing with this dynamic system. I believe industry is stepping up its participation quite a bit more than it did twenty years ago. You are familiar with the funding that is going on. Industry began establishing many years ago scholarships, fellowships, grants for research, and unrestricted grants in educational institutions.

With engineers moving into top management at an increasing rate, engineering has become more and more a part of the corporate management, and not nearly as much of a necessary evil as it used to be. If we remember not too many years back, engineering was strictly an overhead item the companies wished they could do away with, but they couldn't. That is still true in a few companies but with most of them it is no longer the case. We are most emphatically interested in communicating with the educational system on an industry-community education basis.

This week, the Industrial Research Institute, which was born of the National Research Council, had its autumn meeting. Several hundred companies send their directors of research and engineering as representatives to this meeting. Forty percent of the program this year and last year was devoted to discussions of engineering education problems and education problems in general. This will no doubt continue. What we are searching for in these discussions is more familiarity with the university and its problems. We do it by having guests and quite a few people from universities talk to us and meet with us and become acquainted with us.

At the moment we are looking at the teacher problem. Is there any way we can help you? How can we solve it? There is interest in sabbaticals, exchanges, much stronger interest in summer employment, even the possibility of early retirement of professionals who would then go into education in the smaller colleges that have a very difficult time today getting science and mathematics teachers. Whether this will be done on a large scale, no one knows yet. It has to be tried and looked at. We do know that in industry quite a few people retire three or four times. I think we have one or two people here who I know have retired three times and are still going like a house afire.

We are involved in many supporting activities that have already been mentioned. In regard to professional societies, we are interested in increasing the professional system, the professionalism of our employees. We make grants both of a selfish and unselfish kind. We establish company institutions for upgrading. We are using educational people and assistance wherever we can get it. Foundations and gap-fillers, if you will, are being established to meet the problems in areas where the political system has not been able to keep up with it. Some of you of course are familiar with the Foundation for the Advancement of Graduate Study in Engineering in New Jersey as one example.

Trends, diversification, and change in companies bring about, of course, the need for rapid and greater change in our relationships with universities. Industry is looking more and more at the problem of specific grants to specific universities, not spreading its funds as widely as it did before, but concentrating them more and more. This is a tendency and it is a change brought about by the increase in fund sources.

The same kind of thing applies all over the map in our relationships with educational institutions and the community.

We see changes in the university, of course, and other speakers have brought them out. We have had a broad interest in the programs of education, your goals in engineering, and our interfaces with them. A number of our people are studying these matters continuously.

It is difficult to pinpoint exactly what industry is doing for engineering education. It is difficult to find out how much industry is doing. The statistics do not show it. Industry makes unrestricted grants to universities, for example, but what percentage of such grants gets down to the engineering department or the engineering school? Probably less than 10 percent.

We hope that the Academy of Engineering may be able to look into some of this, and we certainly hope that the Academy will help us sort out some of the problems that are looming up in the future. Industry has the same problem that education has. It requires an initial training of fifteen years. Industry must plan today for its scientific management of the future. This is a big step and it will require more and more the systems approach in business as well as in education.

What, If Anything, Should the National Academy of Engineering Do About Engineering Education ?

MR. WALKER: Let me pause for a moment and try to pull together what we've been doing. We have talked about what is going on in engineering education. As I see it, we have drawn up a sort of map of the situation, and I am surprised, as I am sure many of you are, at the number of things that are going on, and the number of different people who are doing these things. The ASEE, ECPD, EJC, the professional societies, the Commission on Engineering Education, the Federal Government, industry, are all in the act, and I believe properly so.

What we would like to focus on for the remainder of our time is really two problems. First, what needs to be done that is not being done? This is not an easy question to answer, because you might say that if anything really needed to be done, certainly somebody by now would have stepped up and started to do it. The next question that arises is: What can the NAE do uniquely, what is only the NAE able to do, or what can it do better than anyone else can do? We have already had one answer to this--which I admired for its clarity--coming from L. E. Grinter, who said, "I think that the NAE ought not to get into this racket, that most of the work in engineering education ought to be done by the ASEE and the ECPD."

I am sure that there will be different opinions, and to insure that there are, we have asked several people to get a discussion going. And if you are picking someone to start any discussion, you do well to pick J. Herbert Hollomon, Assistant Secretary of Commerce for Science and Technology, U. S. Department of Commerce.

MR. HOLLOMON: I would like to make a few comments, and then ask a few questions.

First, a general comment with respect to goals. The ASEE Goals Report has set a series of goals for engineering education during the next decade. These have caused controversy and discussion, and I for one am pleased that they have. I am confident that the recommendations which will finally evolve will be of significance. However, I find something very seriously missing in the Goals Report. I see no reflection in the reports as to the purposes to which engineering education itself should be put. By this I mean, what are the future directions in which the society will inevitably move--in fact, is now moving, and how then shall engineering education reflect the changing characteristics of the public and the private need?

Let me be explicit. At the present time, approximately 75 percent, give or take a little, of all engineers graduated with one or more degrees, are hired directly or indirectly for the public sector of the economy, either in the government, or in industries which contract for or serve the government, either federal or local. If that use of manpower continues, then obviously engineering education must reflect the changing requirements of that public demand.

In addition, the society faces a series of complex problems which might be called, for the lack of a better word, public sector problems. We have changed in this nation from one which I characterize as a rarified gas--in which the particles seldom interacted with each other--to a society resembling a condensed system. What is really important in this condensed system, our society, is not the behavior of the individual particles so much as their interaction with one another. The products in the society, the services rendered to it, will be less and less importantly products which are bought by individuals, and more and more importantly those which are bought by public and private institutions. Examples already evident are the sale of technology for school systems, the design of buildings, the design of cities and the renovation of the downtown sections of the cities, and the design of medical treatment facilities to serve the interests not only of a single hospital but a hospital-welfare complex. In all those cases, the product is not sold to an individual buyer, you or me, but is sold to a city, or a municipality, or a reconstruction district, or a state, or some other public body.

The same is true of air pollution control systems. The same is true of traffic safety control systems. The same is true of water pollution control systems. These are all characterized by the fact that the product or service that is rendered is not sold to an individual, but rather is sold in a complex interacting society, and the purchaser is a public, either local or state or national, institution. Increasingly, that is the trend of an obviously complicated system of society.

From the social as well as the economic standpoint, something new has to be added. First, industry has to be created that can design, develop, manufacture, and sell such systems to a new customer. A market has to be created, and industrial institutions which can fill that market have to grow.

I have said on a number of other occasions that we ought to have industries in this country that build cities, not redevelop areas, not suburbs, but cities, and we ought to have educational institutions in engineering which anticipate the needs of city-builders. To put it bluntly, I see little in the Goals Report that reflects the current and growing requirements of the nation or of the world for engineering talent. I see little that relates such social requirements back into the requirements of the educational system.

Now, as to specific questions, with some preambles. The first I will direct to Dean Grinter. I presume that he would accept the observation of the Goals Report that there is an increasing trend towards graduate education in America, and that this is an expensive business. A rough cost is $100,000 per Ph.D. If you believe the extrapolations, graduate Ph.D. education is growing at the rate of between 10 and 15 percent per year, which means that in 1975, considering no increased complexity of engineering education, we will require an additional $1,000,000,000 support of graduate research and education in engineering in America. Whether the money comes from government or industry, a political process will be involved in raising that amount of money. I should like to ask Dean Grinter whether he believes that ASEE or ECPD is ready to instigate, develop, guide, and lead the political process that will be absolutely essential to raise that kind of money? That is three times the size of the present National Science Foundation budget. This in the face of the fact that the budgets for research and development and education of NASA, AEC, and DOD will actually be declining during the same period. This raises the additional question as to whether or not the engineering fraternity wishes to have the support for engineering education to come wholly or nearly wholly from mission-oriented agencies. In brief, the question is, who will lead the political process necessary to obtain vast sums of money for the engineering profession?

There is another question I would ask of those participating. My estimate of the requirements by 1975, or in the next several years, for computers for engineering education alone is of the order of half a billion dollars.

Are we ready to seek the funds, and if so, how are we to go about it, and what is the public policy? Who will fund them? Will they be capitalized, and how will they be upgraded, and who will train the programmers, and who will reflect that back on the undergraduate education of engineers? Will we be able to introduce that into the high school system at an appropriate rate?

These are the kinds of relevant questions that come to my mind when I consider hat should the National Academy of Engineering do?

MR. WALKER: The next discussant is Chauncey Starr, President of Atomics International, North American Aviation. He is soon to become a Dean of Engineering at the University of California, Los Angeles.

MR. STARR: I am still a member of industry. I won't be involved in engineering education until January 1st, so I can perhaps talk a little more objectively. Herb Hollomon's comments are cogent and very much to the point. I will amplify them from a slightly different point of view.

The National Academy of Engineering membership, by its process of selection, contains engineers who because of their accomplishments have some familiarity with the operation of organizations that get things done for the public. Therefore, they have background in how to utilize the resources the universities make available. They are familiar with the functional operations in organizations and with the qualities of engineering leadership that make things happen. They are familiar with the flexibility that organizations require in technical areas. They are familiar with how to anticipate the changing environment.

These are all qualities that define what the customer of the engineering schools is concerned with. To meet these various broad qualifications that industry wants in engineers, the schools have to turn out a variety of engineering talent. The variety runs all the way from the engineering technician discussed this morning, to the group that can handle design by computers and other highly professional but very definitive types of technical performance, to the creative leader in producing engineering products and engineering systems for use by the public.

To cover this spread, the engineering schools are going to have to produce a much greater breadth and insight in their engineering graduates. The history of technology is an example of such broadening studies. Sociology and social institutions, psychology, the motivation of people and groups, and political institutions are other examples. Anyone who has lived in Washington, or anyone who has tried to get anything done on a broad scale publicly, must understand political institutions and their realities. The problems that are sometimes handled in business schools under management science are also necessary background to create a full utility of engineering talents. This is quite at the other end of the spectrum from design by computers, for example.

How the experience that the members of the National Academy of Engineering have can be brought to bear on engineering education is an important question, but one I don't have an answer to. I do believe that there is a role that the National Academy of Engineering might play, provided the engineering educational institutions could play the associated role of utilizing the information. The experience is there. How one gets it incorporated, I don't know.

MR. WALKER: Next is Edward E. David, Jr., Executive Director, Communications System, Research Division, Bell Telephone Laboratories.

MR. DAVID: In listening to what has been said this morning, it seems to me that the National Academy of Engineering is not in a good position to tell the universities what they should teach or what their curriculum should contain. We are, I think, in a position to speak to issues at the interfaces between engineering education, the government, and industry. Those interfaces can be rather abrasive. There are issues a-plenty to be found there. I can't name all of them for you, but some come to mind rather easily, and they may serve to remind you of others.

First, with respect to the interface between universities and government, there have been a number of studies done by the Congress indicating that government support of research in the universities has had a very definite influence on education, and particularly on engineering education. I am thinking of the Reuss Report, which I believe was entitled, "The Effect of Government Support on Education."[1]

Perhaps the major point that comes out of that study is that Congress found in the universities a number of people who had their doubts about the effects of government support on the universities. Some effects were felt to be not entirely good, and in particular the emphasis on research as opposed to teaching had perhaps gone too far. I hear from some of my friends in the universities similar opinions. This is a question of degree, not of absolutes. I certainly would not subscribe to the view that there has been too much research support.

On the other hand, a question to which NAE could address itself is how can the person who is only a fine teacher in the university be given the credits he needs to prosper in a research oriented university? It seems to me this is a rather important point.

The Daddario Committee[2] in Congress has spoken recently to the interface between the government and engineering. The viewpoint of that Committee has pleased a number of people in the engineering fraternity. The Daddario Committee has said in effect that applied science, particularly engineering research aimed at the needs of society, are very important and should be supported. Out of the Committee's deliberations has come a proposed bill to revamp the charter

---

1 "Conflicts Between the Federal Research Programs and the Nation's Goals for Higher Education," issued October 1965 by the Subcommittee on Research and Technical Programs, House Committee on Government Operations.

2 Subcommittee on Science, Research, and Development, House Committee on Science and Astronautics. Emilion Daddario, chairman.

of the National Science Foundation, so that such efforts can be supported under National Science Foundation grants. I think the NAE might very well ask itself what it would like to see supported if the Daddario bill finally passes.*

There are a number of questions that have been raised here already about major facilities for engineering education that, because of their size, need government support. Computers are a very good example, and one that has already been mentioned. However, in creating the computer resources necessary for engineering education, software is often overlooked, at least on the surface. One must ask who is going to prepare the software if engineering education is suddenly given much computer hardware.

With respect to the interface between industry and the universities, I find many people in industry asking themselves how limited support from industry can compete in any way with the massive support from government. I think the NAE might very well answer this question for industry by pointing out how incisive support from industry can greatly influence and benefit the universities.

Finally, with respect to the ASEE Goals Report, it seems to me the primary question that has been asked here, and one to which NAE might address itself, is how can a parallel ladder for professional education on the graduate level be created? Such education should parallel today's academic education.

Overall, using someone's term here today, I certainly agree that engineering education exhibits a certain amount of schizophrenia rooted in the differences between science and professional engineering

* Reintroduced in Congress February 1967 as HR5404

skills. Perhaps NAE ought to be the psychiatrist for engineering education.

MR. WALKER: The last discussant is John R. Whinnery, Professor of Electrical Engineering, University of California, Berkeley.

MR. WHINNERY: Before asking my leading question, I would first observe that the presentations today have shown us the amount of work going on in engineering education and make clear that the Academy cannot do the whole job. It is also clear that the problem is an important one so that the Academy cannot completely ignore it. Anything that is done should of course be unique to the special membership of the body and consistent with the overall goals of the NAE. I am also sure that we cannot rush into the matter only on the basis of these brief presentations. Thus I presume that our comments should be largely useful to the Projects Committee in its consideration of a possible NAE program in this subject.

With this preliminery, I see three possible approaches, not necessarily mutually exclusive. One is to give support to a program or a specific project already started by another group. An example of the latter possibility is that of the highschool level program described by Dr. David, Dr. Truxal, and Dr. Hall. Proper motivation at the high school level to go into engineering has long been recognized as an important problem by the profession, and it seems critical now because of the recent decrease in high school science enrollments.

A second approach is to attempt to find a project to be carried out primarily by this group. Of the suggestions made this morning, that of continuing education is certainly important to the membership. A second intriguing idea is that of helping to "engineer" the technological aids to education, such as computers and television, that are becoming so important. Either of these tasks would be sizable ones.

Finally there is one matter that the NAE should certainly consider. That is the matter of advising government and industry, and all the potential sources of support for engineering education, of the finances needed for continuing growth of engineering education, and the proper forms of distribution of funds. This was a subject raised by Dean Pettit, Dr. Ide, and Dr. Hollomon, and seems clearly within the objectives of the Academy.

Put in the form of a question, I would then ask if any of these alternatives are desirable ones?

DISCUSSION

MR. WALKER: I received a long and thoughtful letter this morning that raises a point that is not quite new. In fact, Herb Hollomon said almost the same thing. I won't read this letter to you because it is too long, but I will give you its essence. The writer, Benjamin Edelman of Western Electric Company, feels it is high time that engineers do something about the process of education in general, not just engineering education, but the whole process of education itself. He goes on to point out that in times of national stress, in case of war or depressions, we find mechanisms for training people--he does not say educating them--but training them very quickly to do specific jobs. He points out the success that was achieved in training programs during the war. He says that this achievement came about largely because we threw out all of the old ways of doing things and found new ones. He suggests that something should be done at the present time about getting engineering principles into education in general, that this is something that has been neglected. He feels that the NAE ought to do something about it. Certainly we will turn this suggestion over to the Projects Committee to put into the hopper along with the ideas being presented here.

I want now to generalize the discussion and ask for volunteers to comment, recognizing once again that what we are trying to do is to point out what needs to be done that has not been done, and what the NAE might do about these things, if indeed it should do anything.

The first volunteer is Charles Susskind, who is the Assistant Dean of the College of Engineering at the University of California, Berkeley.

MR. SUSSKIND: What are various groups doing specifically about the topics under discussion, and what might the National Academy do to help in such fields as continuing education? At the University of California we have given much thought to this problem, even though our Engineering Master Plan Study for the rest of the century, which many here may have seen (a graph of the projected UC contribution to the engineering work force appears on the title page of the current issue of the Journal of Engineering Education), gives relatively short shrift to continuing education.

I agree with the conclusion of the Joint Advisory Committee, which Ernst Weber and others cited this morning, that engineering colleges should recognize continuing engineering studies as part of their commitments. But if that recommendation is to be realized, if it is to become anything more than a pious hope, we must upgrade the prestige of such studies, not only with the students, but also with the professors. There _are_ institutions, especially in metropolitan environments, where regular faculty members teach external students, mostly in courses given for degree credits. But in many cases, on campuses where regular undergraduate and graduate instruction is the bulk of the program, virtually an entirely different faculty teaches evening courses, off-campus extension courses, and other components of continuing education.

Our experience at Berkeley has shown that few professors will volunteer for such programs, but there is an exception. Short courses on specific topics, such as oceanographic engineering, the engineering of earthquake-proof structures, the problems of on-line computing, and other topics that are at the very frontier of engineering practice, have attracted top faculty members in droves. We have worked out two formats that I should like to bring to your attention.

The first is a course of several lectures, each given by a different lecturer on three or four successive evenings in different locations--say, Berkeley, Los Angeles, and San Diego. Each audience then hears one lecture per week for ten weeks in a row. The other format has been even more successful: a series of all-day Friday and Saturday meetings, given on several successive weekends. This

Friday-Saturday format insures the interest of the student and of his employer both, since the employer usually pays for the course and gives the man the Friday off, but the student has to contribute his own free Saturday. Under such an arrangement, incidentally, the fee can be sufficiently high to permit payments to faculty members generous enough to attract the best ones, which may be why the format has been successful.

I want to emphasize that these are not credit courses. We must carefully separate this type of program from courses given for degree credit. Credit courses will be better able to take care of themselves, and will be, so to speak, with us regardless of outside support. Not so these short courses, which I think are really more important.

What I should like to see the National Academy do is to find a way to put its prestige behind such efforts, perhaps by some informal means of rating or even accrediting these programs, circularizing the potential "customers," keeping a register and information exchange about courses to be given, and so on. I feel that this is a subject on which some higher constituted authority is necessary to give it the necessary prestige, that colleges and employers cannot do the job by themselves to the extent that will be needed in the future.

I shall mention another area in which the National Academy can help engineering education. I echo Dr. Hollomon's sentiments that the engineering education establishment cannot "go it alone." NAE can help by going beyond a study, or even a continuing study such as Dr. Whinnery suggests, to become a sort of lobby or pressure group in regard to Washington agencies that support research at engineering colleges. This is an area in which the American Association of State Universities and Land Grant Colleges has been quite active, but that Association of course covers only certain institutions and does not limit its activities to engineering. Setting up visiting committees, perhaps even employing permanent staff members of the Academy who could appear before Congressional committees and in the Executive Branch offices that discuss such topics as the mix of support for research and development, basic versus applied, or science versus engineering, etc., is a prime activity in which NAE should engage, and one engineering colleges would greatly appreciate.

MR. WALKER: Thomas Kavanagh, of the firm Praeger-Kavanagh-Waterbury, Engineers-Architects, New York.

MR. KAVANAGH: I think the Academy has already done something tangible in meeting its obligations toward the public and toward the profession by calling together this particular meeting on this subject, with participants from academic, industrial, governmental, consulting and practicing areas.

We have had many expressions of opinion from the speakers. Unfortunately not all of their points have been touched on in the discussions. Several worthwhile studies were mentioned. I have read most of the documentation on the Goals Report, and have contributed to other studies. I think some of these other studies, particularly the one by the EJC, should be read by everybody here, because it does delve a little more into the general policy picture with respect to goals of engineering and their relationship (as Dr. Hollomon mentioned) to the national goals and the changing nature of technology at the present time. I have a feeling, however, that what seems to be expected of the Academy is that it should itself come out with some kind of a goals statement on education.

I personally don't think this is necessary. Perhaps if that feeling exists, the people who hold this view may overlook the fact that most of the projects that we in the Academy have had presented to us thus far (at least from my observation) involve a broad systems approach to major public policy, major public engineering decisions. In this broad concept itself, we are going to be concerned with a true systems procedure wherein we will set up objectives, examine information retrieval problems, manpower problems, and <u>education</u> problems.

As an example of this, I might cite a case of one committee at present functioning in the Academy, the Committee on Ocean Engineering. The Committee on Ocean Engineering is approaching its task very broadly to include all of the facets relating to ocean engineering; ocean engineering <u>education</u> certainly is one of these.

What I am pointing out is that in its broad policy approach aimed at keeping abreast of our changing technology, the National Academy of Engineering will automatically consider in every one of its projects the problems of engineering education and its changing requirements.

<u>MORRIS HOOVEN</u> (Consulting Engineer, Public Service and Electric Gas Company of New Jersey): I have a very specific and direct objective to set before the Project Committee. I get the words describing it from our first discusser, Dr. Hollomon, who asked, "Why not set a goal for the goals?" I think the point was made that

the Goals of Engineering Education is an excellent production but that it does not set the goal of the profession. It sets well the goals toward which engineering education should progress. That is perfect, fine, but we have our larger duty to the profession. It seems to me that this is a duty of the Academy.

For background, let me go back exactly eleven years to a session similar to this one, held for EJC and ECPD to discuss the Grinter Report, The Evaluation of Engineering Education.* In the discussion of that report it was determined and agreed to by that group, which included many of you here today, that we should go beyond engineering education and set up some idea of where our profession as a whole is headed. This initiated the project called Survey of the Profession.

We have gone eleven years since that discussion, sometimes with progress, sometimes without it, and I will not go through the dreary detail of its history. I will tell you, however, that at this moment we are approaching the end of one of its important phases. The survey of the engineering profession by the Bureau of the Census for the National Science Foundation is now scheduled for completion by the first half of 1967. Its title is American Scientists and Engineers: Employment Conditions 1960-62. When this is available, we will have knowledge of how many people there are in the profession of engineering, and what the engineers are doing. From there we can perhaps go on, as other speakers have said today, to determine where we should aim our young people and our continuing education people in their programs to serve the public in their profession. That

* The Report of the Committee on the Evauluation of Engineering Education. L. E. Grinter, Chairman; American Society for Engineering Education, 1955.

determination would be by the creation--you are all familiar with the studies which have recommended this--by the creation of a Hoover type of commission which would take the results of the ECPD - EJC survey-study, analyze these results, and then determine where we as a profession will go, or perhaps should go, from here.

So I repeat my questions. Why not have the Academy consider setting up this Commission to set up the goal of the profession? Or a goal for the Goals?

ARTHUR BRONWELL (Dean of Engineering, University of Connecticut): It is in the nature of a profession to see itself in its own image. Therein lies its strength, but also its weakness. Engineering education has been evaluating itself in its own image for the past half century, and the Goals Report in many respects is a re-focus on the same image. This image deals largely with the expanding roles of the physical sciences, mathematics, and engineering. The humanities and social sciences have been regarded as peripheral fields that run the whole spectrum from the erudite cultural realms of literature, music, and the fine arts to the functionally useful realms of economics, sociology, and administration. Because they embrace an enormously large and amorphous cosmos of knowledge, it has been difficult to prescribe any clear-cut objectives. Should the engineering student savor delicacies from the smorgasbord of the esthetic cultures or should he pursue a functionally structured program? There are advocates of both viewpoints with equally valid arguments, hence this sector of education in the engineering curriculum has remained relatively undefined, other than the fact that it must have built-in elements of quality.

We look upon the world of technology as being an extremely complex world, and one which is central to the advancement of industry, of our economy, and of our way of life--and so it is. But there are other worlds that are just as essential to the development of industry, of our economy, and of our way of life. The worlds of economics, of sociology, of political science, and of finance and administration are likewise intricate worlds that are growing ever more complex, and they too have dominant roles to play in advancing our civilization.

To a large extent, the education of the engineer deals with non-human systems--that is, with the application of scientific laws in the creation of physical systems, along with the necessary economics to enable the engineer to make intelligent judgment decisions. Much of engineering education is microscopic in scale, for that is the scale on which physical laws are discovered and understood.

In contrast, these other worlds of which I speak deal with large-scale problems involving all of the imprecise intangibles of macroscopic, multi-variable systems. They involve complex economic, social, political, and human elements. Not infrequently engineering educators look with disdain upon such realms of educational endeavor because these realms do not have the precise analytical character of engineering. But I submit that students pursuing education in these other worlds of economics, psychology, social and political sciences, may be much closer to the corporate president's chair than are the engineers. The reason is obvious--these non-engineering students are dealing with the kinds of fundamental knowledge and the methodologies of analysis that top administration is called upon to deal with. We may well be deceiving ourselves if we assume that the engineer is better qualified to assume leadership roles in corporate or public enterprise because of his mastery of the "scientific method." The problems of corporate and public leadership require a far broader comprehension of knowledge, a far different outlook, and the development of quite different analytical skills than are ordinarily experienced in engineering.

If we are to educate our engineers for positions of leadership, in my estimation we can no longer ignore these interdisciplinary aspects of education. They are quite definitely not peripheral; they are central to the educational needs of many engineers. As the engineer moves into large-scale applications of his engineering, he inevitably becomes confronted more and more with the interdisciplinary character of his work, and here not infrequently he finds that his engineering education, knowledge, and experiences fail him. He is now dealing with problems involving not only engineering knowledge, but also with social, political, financial, and human factors often inter-related in extremely complex packages.

What I am trying to say is that the Goals Report fails to come to grips forcefully and effectively with the impact these extremely important interdisciplinary domains of knowledge have upon engineering and engineering education. We have been repeatedly studying in great detail the contours of the visible portion of the iceberg above the surface of the ocean, whereas we ought to be studying in much greater detail the enormously larger interdisciplinary portions that are submerged yet support the visible portion.

There are other interdisciplinary areas that are becoming exceedingly important in a quite different sense. The confluences of engineering with the life sciences, the marine sciences, and the environmental sciences are so conspicuous and so promising that we can no longer consider these as peripheral interests. Increasingly they are becoming of central importance to engineering education. Yet, in my estimation, the Goals Report, in its adherence to orthodoxy, does not deal effectively with these emerging domains that embody many of the dominant engineering challenges of the future. The impact of interdisciplinary fields upon engineering raises extremely complex issues and any attempt to oversimplify them or to find categorical solutions can lead only to self-deception. I fear that our studies of engineering education have been bogged down by the dead weight of orthodoxy far too long, and that now we need a truly liberal movement in engineering education--a movement that will take hold centrally and imaginatively with these much larger issues that have thus far eluded us and that have been largely ignored in the Goals Report.

MICHAEL F. X. GIGLIOTTI(President, Junior Engineering Technical Society): Dr. Hollomon's sweeping view and some of the other comments have encouraged me to bring up the topic of pre-college career guidance in general.

The word "resources" has been used here today in many ways. In the Junior Engineering Technical Society, we are concerned with one of the more basic resources--the high aptitude, technically inclined human being who has yet to make his career decision. This is raw ore. It is unmined. It has not been refined or alloyed or made into the shape that it will finally take for contributing to our social order. JETS, Dr. Hall's engineering concepts curriculum, the guidance activities of the many technical societies in the field, all have been working in this area, somewhat like prospectors, sometimes like wildcat oil well drillers. All of this sometimes hinders rather than helps.

This is a problem of growing national import. Some of the charts shown here today show that we are not utilizing the high aptitude human being who could go on to a college degree.

Consider the confusion in the mind of the uncommitted, undecided high school student, particularly the one with the high aptitudes and the technical orientation, as he tries to make a career decision. He faces the need to make a very basic, almost irrevocable choice.

I think there is a challenge here for the NAE and there is a challenge here for all of us. Could we find some way to allow him to defer this choice to a more mature and appropriate time when he has gained some experience? Could we do this by providing in some way a common entrance vestibule to all of the scientific, technical, medical, and engineering formal education programs? Could the NAE by working with other national groups on such a public problem turn attention toward the need for a common study, which has been referred to here twice today, on something like "the goals of scientific, technical, medical, engineering education." The study should not be confined to just one facet of this problem, because the basic human resource is the same for all of these technically oriented professional fields. We are all after that same kid.

Could we do this especially for the guidance of the rapidly growing broad-gauge junior college and community college educational programs?

LT. COL. WILLIAM V. MCGUINNESS, JR. (Office of the Chief of Engineers, U.S. Army): I am speaking as an individual.

The question is, What should the National Academy do and what should others do about engineering education? My proposed answer for your consideration is that the National Academy might use its prestige, insight, and experience to anticipate and illuminate the engineering environment of the future, and leave to ASEE, ECPD, and others the job of developing the engineering educational goals to meet that environment.

JOHN GAMMELL (Coordinator, Professional Placement, Allis Chalmers Company): I would suggest that perhaps NAE doesn't really have to do anything. It just has to observe what is going on, pick out the good things, and accentuate them a little bit through the use of its high prestige. I have noticed that our young men coming into industry are sharp and they seem to know what to do about continuing their education without our telling them. They have observed that while their education is good in technological matters, this is not quite enough. The gap between knowing how to do things and getting them done is broadening. Observing this, they go out and take all sorts of courses to help them learn how to get things done. The Master of Business Administration on top of a four-year engineering degree is often their answer for fitting themselves to get things done.

I have also noticed there is a great desire on the part of engineers to apply scientific knowledge to ordinary matters. A few years ago the highly scientific people seemed to apply their skills in the labs mostly to the far-out projects. Now we have a tremendous increase in the demand for industrial engineers, and we want them to apply their skills in the shops to matters of everyday importance. I have noticed one question becoming of increasing concern: What is an engineer? As we get into the problem of five-year and four-year degrees and perhaps fewer years in the case of technical institutes, we would like to know who is an engineer. I would suggest that people should not usurp this title by accident or individual purpose. Some group should establish what it is. Education does it to some extent, through certification by certain types of schools. Certainly licensing does it to some extent. And what is the other facet? It is experience. How much experience, and what is it worth in terms of equivalent education? Giving some value to experience might help get around the problems accompanying the notion that the four-year man is not really an engineer. I would submit that he is an engineer if he has enough appropriate experience, but how much is "enough"?

CHARLES F. SAVAGE (Manager, Professional Relations, General Electric Corporation): I suggest to the Academy that it might observe the spectrum of "customers"--the major groups of customers--of engineering educational institutions.

A previous speaker noted that the potential customers for engineering education were the young people in secondary schools. Many mechanisms, such as JETS, are already at work in this area giving guidance and other services to this group. Additional activity might be desirable, but the situation is not desperate.

The customers of the educational institutions are being served while in college by a system which is dynamic. The needs of this customer are being studied constantly by ASEE, i.e., the Goals Study, and a host of other organizations. Presumably these activities result in a state of dynamic stability that at least reasonably fills the needs.

But as I listened today, I heard Dr. Weber note that the half-life of an engineer is ten years. I heard the president of NSPE say its survey of "Continuing Education" showed that only 30 percent of college graduates went on with continuing education.

Thus, putting two and two together, I come up with the conclusion that 70 percent of the immediate past customers of the educational institutions are in a state of dynamic deterioration and in 10 years will be obsolete!

I suggest to the Academy it might well examine this area of need. This 70 percent represents potential customers for educational institutions. A concept of life-time education might be a very challenging one to supply to the profession. How to motivate the 70 percent to take advantage of the output of the educational system is the problem. The Academy might look to the behavioral scientists to study what it takes to bring graduates back to the classroom.

The activities and endeavors to assist the 30 percent who do go on with continuing education are many and manifold. These activities might be brought into better focus if applied to a larger base of students.

To serve the whole spectrum of customer needs for engineering education is to advance the whole profession.

CARL CHAMBERS (Professor of Electrical Engineering, University of Pennsylvania): I would like to be very specific in making a recommendation to the National Academy of Engineering. It is that the Academy of Engineering endeavor to make it clear to the profession and to the people at large what is an engineer. I would venture to say that even if we went to most of the faculty members of engineering throughout the country that they would say that Eric Walker, if he ever was, is no longer an engineer, that is is now a University president.

It seems to me that the National Academy of Engineering is a body with prestige and it should use this prestige for the purpose of making a clarifying statement on what we mean by being an engineer as a career throughout life. I feel this would be a very important contribution, because it is a unique thing that the National Academy of Engineering could do. It is true that a formal short definition has been reached by compromise through the Offices of the ECPD, but the meaning of that is sufficiently ambiguous that everybody who was a part to it found no objection to it, and left it subject to all kinds of interpretation. It is the interpretation of this definition of engineering that I think NAE could contribute. Were this done, it would mean that the educator would have coming to him students who look forward to becoming that kind of a person in engineering, and he would design his program to suit.

MYRON TRIBUS (Dean of Engineering, Dartmouth College): It is a rare privilege to be asked to give advice to an organization so select that it is having difficulty finding 200 members out of a population of 200 million. I find it difficult also to anticipate much help from a group that asks, "Should we look into perhaps, maybe finding out how we might somehow help?"

This is an era in which we often see organizations governed by "management without leadership." In education we are in a period where we are seeing a great deal of this "management without leadership." There are few schools in the United States that will even maintain the fiction of having an institutional purpose and claim any integrity of that purpose.

The size of our educational enterprises and the manner in which they are now being managed, makes it extremely difficult even for men of ability to have much of an influence in the educational process. Under these circumstances, it is most important that external agencies of integrity and repute make statements that help those battling within the educational world to carry out needed educational reforms.

The problems we face, as has been said before, must be looked upon as "systems" problems, but we must not forget they are also social and motivational problems. One of the great weaknesses in recent studies of engineering education has been that they have been conducted by engineers. The medical profession, by contrast, appointed a commission consisting of ten or eleven people of which only one was an M.D.--the rest were lawyers, sociologists, historians, and so on--to look at the problems of medical education. Engineers should do likewise. It is well known that very few people in engineering education are really doing anything avant garde. With this spirit it is very difficult to exert changes.

The records show students are still not showing up in large numbers. Since most professors are trained as engineers and are the products of the system, with its obvious deficiencies in social science studies, they come to these motivational problems not really knowing what to do about them. In meetings they talk about something else. I think the Academy might very well help in this regard if it wishes to exert leadership.

I would point out that there are educational reforms going on elsewhere in the world, and these reforms might very well be studied. Perhaps the Academy could send someone to look at other places, and find the men who are doing the dynamic things in whatever country they may reside and bring them to this country to show what can be done.

For example, I will call your attention to the educational reforms at Nancy in France under M. Schwartz, in which, for example, the work week has been cut to 40 hours and it is prescribed that the student have at least 20 hours in each week to work on things of a personal nature. The school has recruited men from industry who come in and teach as members of the staff after first going through an educational program in which they learn how to teach within the system. The school has adopted the practice of giving anonymous examinations so that instructors can find out what the students are learning without putting the students on the firing line. All of the students are required to design apparatus for the research departments, so that the students can learn how to design and meet needs. The school has proclaimed that it is setting the pattern for a new educational experience in France, an educational experience that will be a guide for the liberal arts part of the educational world.

When Archie Higdon visited us on his round to engineering schools, we asked him, "Archie, what is going on that is significant in engineering education around the United States? We want to know where we ought to go and see things that are really worth looking at and learning about." Archie could not give us more than three or four names out of 200 schools.

This is why I think something needs to be done. It needs to be done by people who will exert leadership, and if the Academy can fill out its ranks and decide that it wants to lead, it will. The motto is: Leadership belongs to those who exert it.

WILLIAM P. KIMBALL (Assistant Secretary - Education, American Society of Civil Engineers): For a good many years, more than I wish to admit, I was at Dartmouth, and I was engaged in engineering education. A little over a month ago, I moved to New York City and I took a position with the American Society of Civil Engineers as Assistant Secretary for Education. This I did because I was convinced that the so-called discipline-oriented professional societies have a real opportunity to make important contributions of a positive and progressive nature to engineering education.

Somewhat more significant than my own belief in this is the fact that the American Society of Civil Engineers has recognized this opportunity by the creation of a post for a man to spend full time on engineering education. I know that there are other discipline-oriented professional societies. I know that they have people on their staffs who are working on engineering education but I am told by my own employing society that it is the first one to put a man full time on this assignment. I simply want to urge the National Academy of Engineering and other organizations interested in engineering education not to overlook the resource of the discipline-oriented professional societies that can be positive and helpful.

LEONARD M. RODNEY (Public Works Associate, University of Pittsburgh): I am very concerned about the role of engineers in our society. I think that engineers are capable of providing significant leadership and making substantial contributions to the solution of the major problems confronting our nation. I believe that they can do this because of their aptitudes in problem-solving, their experience in using a systematic approach, and their highly developed analytic skills. Unfortunately, I have seen a number of indications that others are trying to remove engineers from these positions of leadership, and to deprive them of opportunities to participate in the decision-making process. Let me give you some examples of what is happening in my own field of civil engineering.

Recently, the California Department of Water Resources, which is headed by a non-engineer, obtained permission from the state Personnel Board to change the title of the regional directors from District Engineer to District Director. Why? Because then the engineering registration requirement could be dropped, which would permit the employment of non-engineers in these decision-making positions.

Also in California, there is a serious effort to eliminate the civil engineering requirement for the positions of County Road Commissioners.

A few days ago, I was speaking to former Governor George Clyde of Utah, one of the few engineers who has held high political office, about these events, and he was concerned about them and the similar events that are taking place in Utah.

Influential magazines are questioning engineers' ability to provide leadership on major projects that help shape the lives of the citizens of our nation. Just last night, I picked up Life magazine, and it had an article entitled "A City's Splendid Plan Hurt by Myopia" on its editorial page. The article discussed the Bay Area Rapid Transit (BART) System that is being developed in the San Francisco region. This is an engineering system that has attracted world-wide attention as a potential model for the solution of metropolitan transportation problems. If I read just a couple of excerpts, you will see whose "myopia" they were talking about.

> "Last month BART's two widely recognized architectural consultants resigned. They complained that the views of BART's architects and urban planners had been ignored by myopic engineers too concerned with efficiency, indifferent to esthetic values and to the impact of the system on the areas it will serve."

At another point:

> "...unfortunately [because of engineers' myopia] BART will probably not fulfill its real potential, not simply a solution to a traffic problem, but a force to reshape and improve and beautify the whole area."

In short, they are saying that engineers do not deal with the total environment, and that they tend to look only at the physical engineering aspects of the total problem.

This interpretation of the engineer's approach to problems does contain an element of truth, and I think that this is a definite problem for our profession. We must start thinking more broadly if we are going to continue to hold positions of leadership, and if we want to enhance the reputation of engineering. Otherwise we will see the profession degraded by nationally circulated magazine editorials focusing on the myopia of engineers.

To achieve a position of greater leadership and enhanced reputation, the profession needs new educational programs. I would like to suggest that there are few existing programs designed to train engineers for their leadership responsibilities in our increasingly complex society. Most engineering schools are not equipped to do this, and the Master of Business Administration programs usually are not directly related to the engineer's background or his needs. What we need are new and fully integrated programs that bring together engineering and the other disciplines and concepts the engineer needs in order to be able to make significant contributions to the solutions of the major problems in our society. These programs should be heavily focused on how the concepts of economics, sociology, psychology, urban planning, operations research, and systems analysis can be effectively incorporated in the design and operation of engineering systems. There are programs of this nature on the drawing boards, and you will be hearing about some in the immediate future.

I would like to see the National Academy of Engineering put its support and prestige behind the development of programs of this type, so that once again engineers can provide the necessary guidance and leadership for our nation.

JOHN CALHOUN (Vice-President, Texas A and M University; representing American Institute of Mining, Metallurgical, and Petroleum Engineers): I think most of us are looking to the National Academy of Engineering to be a dominant force in public affairs--to speak for engineering and engineers. I think it is very important, therefore, that the first jobs the Academy undertakes should be the right jobs. This gives me some concern when I see the Academy directing itself to the subject of engineering education.

It isn't that engineering education is not an important area. It is a very important one, and as has been indicated, a very complex one. However, it is not a subject within engineering. As has already been pointed out, engineering education is education, and, in this sense, engineering is only a modifier.

I think the Academy would be better advised to address itself to the subject of engineering directly. If engineering education comes in peripherally, this is fine. But the Academy is young, and as has been indicated, there is a limit to its resources.

My feeling is that the Academy could do much more in the long run for engineering education if it would direct its attention to the role of the engineer in society, the kinds of jobs the engineer will be called upon to do, the kinds of decisions he will be called upon to make, the places where his influence is and can be felt, and the kinds of people he will have to deal with or should be dealing with. From this analysis of what the engineer can be and should be, there can be digested and pulled out a set of guidelines that can be given to the educators as a base toward which their efforts should be directed.

Such guidelines will then put the engineering educator in the position to enable him to do the job he ought to be doing, which is to carry on his educational program within the context of the university, rather than within the context of the profession. The engineering education we know today has made and is making a contribution to education as a whole, which is broader than its contribution made directly to the engineering profession. The engineering educator cannot change his mode of operation or the things he does without taking into consideration the total picture as to where he fits within the academic community.

So my point is this--I would like to see the Academy spend its time on the problems that will help identify the engineer and his place, and let the American Society for Engineering Education pick up the ball specifically on engineering education matters. If ASEE can identify some public issue that the Academy can help out on, then ASEE should call on the Academy for assistance.

E. W. COMINGS (Dean of Engineering, University of Delaware): When Dr. Walker sent me an invitation some time ago to attend this august meeting, I wrote out four or five pages of comments. I find now that these have to do more with the goals of engineering education than specifically with the question that has been asked here. Incidentally, there are some copies of my comments available if you are interested in them.

As to the question, "What should the National Academy do?" it would seem to me that if the Academy is to meet its function in advising the Congress and government, it must be concerned with some of the major problems facing the country. These, as we all know, involve an interrelation between industry and urban problems, education at all levels, and the problems of the minorities. I think we are coming to find as we discuss these problems more and more that they constitute one large system. The parts are not as independent as we would like to think they are. In this technological age, engineering education is a key factor in this system. I am afraid we have not looked at it as being as much of a factor as it is, and possibly it has not been playing as important a part in this system as it should be playing.

The NAE cannot adequately discharge its function unless it takes this key factor into consideration. I don't mean by this that it must duplicate the activities of ASEE or ECPD. It should not. Nevertheless, it must discharge its responsibility in engineering education, and therefore satisfy itself that these other bodies are adequately providing for engineering education in the broader sense.

It seems to me that asking the engineering educator to cater to a well-defined, self-contained profession of engineering is really no longer compatible with meeting also the varied demands for a broadened education that are presented to engineering educators. This really means that either professionalism or education, one or the other, must play a secondary role. Either we must place our main emphasis on the profession or our main emphasis on doing the whole job that engineering education might do.

The facts and the trends presented to us are indisputable. The great trend toward graduate education is with us and I think many of us have worked rather hard to bring this about. There should not be any great dispute here. We really don't need the pressure from a Goals Report to accelerate graduate education. The fact that an 11 and 12 percent annual increase is occurring in the number of master's and doctor's degrees granted seems evidence that there is and will be a marked increase in the number of engineers well prepared at the higher educational levels.

However, the present technological age is, I think, also calling for well educated and maybe well trained people at all levels. There is a demand for more graduate level and post-graduate level engineers. There is also a demand for technicians. In addition, it would seem desirable that lawyers, businessmen, and politicans should be better informed as to the role of engineering and technology in the world. We have heard of the emphasis being placed through the engineering concepts program on reaching the students in the high schools. Engineering educators should share the responsibility of attracting high school students into engineering education.

I think the real question we are facing is: What is to be the scope of the interests of engineering educators, and how much of the various challenges will the engineering educator accept?

One other point has to do with the attempt to make an analogy between engineering and the other professions, specifically the medical profession. No one is going to question the idea that a woman cannot be half pregnant. Neither can an individual be a half-trained doctor. It is an all or nothing situation. It might be possible for an individual to be a half-trained medical doctor, but it is not really acceptable. A man who is not well prepared to be a medical doctor certainly deserves the term "quack" and he does not deserve the confidence of his patients.

On the other hand, when we apply this same sort of all or nothing criterion to engineering education, I think we come up with a different answer. The student who has gone halfway through an engineering education is prepared to make certain contributions to the work that engineers do. He does not deserve to be called a quack. There is more of a continuum in engineering education than there is in medical education. Furthermore, medical doctors are not taught by medical practitioners until the graduate program. Engineering students are taught by engineers and engineering educators in the undergraduate years. The engineering educator is making a contribution to this kind of broad liberal science education. Thus, there are many ways in which engineering education differs markedly and appreciably from medical education. I think it would be well to seek these differences out and identify them, seek out the strengths of engineering education, rather than downgrade it or bring it into poor comparison by using an analogy that is not really appropriate.

HAROLD B. GOTAAS (Dean of Engineering, Northwestern University): As we all know, engineering education and the engineering profession have a great many serious needs for improvement. We have heard about many of them today. I believe that the National Academy can have a unique and important role in engineering education and professional leadership because of the prestige of its membership and its distinguished character. That role cannot be such that it would deal with all of these detailed problems. Other organizations, ASEE, ECPD, etc., are going to have to carry on many of the developments.

But the position of leadership and placing its prestige into a catalytic role is most important. The leadership role of at least needling and getting consideration and action on such areas as Dr. Hollomon discussed, such interfaces as Dr. David mentioned, is most important for engineering education and the progress of the engineering profession. NAE leadership and support will help other organizations to be more effective.

However, the Academy cannot, it seems to me, have the manpower, energy, and resources to handle all the detailed studies that are necessary to progress. When it sees a need, it can help initiate activity concerning any one of the multitude of areas, whether it be continuing education or the status of the profession. The other organizations can carry forward some of the studies with the blessing of the National Academy of Engineering. Its support of recommendations it believes to be sound will help the profession to accept them more rapidly.

In summary, the primary role of the National Academy of Engineering in engineering education is that of being the number one leadership group and a very high quality catalyst. The position of the Academy in the field of engineering and engineering education will help facilitate greater interest and agreement among engineering faculties and the profession as a whole in connection with important problems of engineering education.

CONCLUSION

MR. WALKER: I think this discussion has been very helpful to members of the Academy, but it would be very difficult to summarize it effectively. I would say I detect two schools of thought here.

One school of thought seems to say that the National Academy has a goal but it is not specifically that of doing something about engineering education, that our goal should be rather to define the larger aims of engineering--what the profession ought to be and where it ought to go, and how it ought to get there.

The other school of thought says, I think, that there is still a great deal to be done in the field of engineering education, and that the Academy ought to do something about it, ought to try to pull things together, and ought to play an active part. Luckily the decision is not one that I am going to make. This task has been assigned to the Project Committee of the Academy, which I think will take all that has been said into consideration and will come up with a recommendation for a policy statement--at least for the present--on the extent of the Academy's concern in the field of engineering education. I hope that when that statement has been formulated it will be published for all of you to see.

ACTION OF THE COUNCIL

NATIONAL ACADEMY OF ENGINEERING

March 27, 1967

The Council made the policy decision that the Academy take a leadership role with respect to the broad questions affecting engineering education in the United States.