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YESTERDAY AND TOMORROW

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The 1969-1970 academic year witnessed a decline in engineering enrollment according to the Engineering Manpower Commission of the Engineers Joint Council. The nation's engineering schools lost 9,500 full-time students. This is in spite of a 5% annual growth rate in the total number of first degrees awarded to male students in the United States.

The decline was most noticeable in full-time master's degree candidates, an 18% decrease from the previous year. Due to changes in draft deferments, engineering master's degree enrollments have dropped from 34,000 in 1967 to 20,000 in 1969. Doctoral degree candidates dropped approximately 10%. An increase in foreign graduate students, although substantial, accounted for only about 2% of the loss. Evening and part-time enrollments, however, did increase, especially in technology-type programs. This seems to indicate that students have a strong desire to work at their profession while studying for a degree, both at the undergraduate and graduate level.

Undergraduate enrollments have decreased, primarily in the first and second years. Evidence at hand indicates that 1971 will see a sharp decline in the number of freshman engineering students. The upperclass students undoubtedly feel that they have made their commitment and are going forward to complete their engineering education.

Many authorities feel that an engineering education is about the best preparation for life that is available to young people today. It forms a solid foundation upon which to build a career in law, architecture, public health, urban planning; to be brief, in our technological society, an engineering education is in itself the basis of a liberal education. the foundation of an engineering education is the training in logical thinking; the collection of the essential raw data, sifting and analyzing these data, and then formulating a possible solution. What better training does one want in order to plan his life and effectively execute his plan? It seems no exaggeration to say that an engineering education will be to the 70's what a liberal arts education was to the 50's. Engineering needs those who can see in the profession a means to a wider end, not merely an end in itself. For example, it is worth noting that today most graduate management business classes are made up of a large percentage of engineers. Engineering graduates have been known to enter the ministry and they have also become medical doctors.

The projected long-range needs for engineers and Civils in particular through the 1970's are expected to be substantially higher than can be met by the number of graduates being produced at the present enrollment levels. The present day major fluctuations in employment conditions for engineers must not be interpreted as an indication that engineering is fading away and is not to remain an attractive career choice. What are some of the reasons for this great change in the number of engineering students and what might be considered as means to reverse this downward trend in enrollment?

A recent report supported by funds from the Ford Foundation and submitted to HEW made several suggestions that might be worth considering. The report indicated that faculty members should be drawn not only from those who have spent their life in academic pursuit but also from persons with wide experience in society. This statement is also supported by the ASCE in its Guidelines for ECPD Inspectors. Today's students should be exposed to the practical aspects of engineering as well as the theoretical. All that now needs to be done is next to impossible, i.e., to convince the administrators of an engineering curriculum, deans in particular, of the wisdom of a faculty that consists of a few practical people and is not 100% research oriented. One large engineering school reports that the administrators refused to interview a candidate for a position on the Civil Engineering staff solely on the position that the man did not possess a Ph.D. degree. The candidate had an enviable record of 20 years of experience with considerable time as a project manager. It is rather ironic that today's engineering faculties are trying to teach young people how to make decisions in the engineering world that they, the faculty, have never been called upon to make for themselves.

Another point made in the report was that, at nearly all schools, students are expected to learn from reading assignments, attending classes, listening to lectures, conducting routine laboratory exercises, writing skeleton reports, and taking examinations. The report suggests that perhaps there were other ways to subject young minds to the learning process that would benefit students who are not attracted by the present method. A curriculum with a generous sprinkling of projects, work units to be completed at the student's own pace, seminars with student presentations and seminars with presentations by practicing engineers might be well received by today's embryo engineers. It would appear that the cooperative work plan of education might well be one of those ways – especially in engineering. Perhaps the part-time students referred to previously have already accepted this plan of education, i.e., a plan that combines classroom learning with practical applications, as one of those "other ways".

The report raised the question as to why only persons in the late teens and early twenties, for the most part, attended college. Could it be that this is one of the causes of the so-called "generation gap"? Colleges should be encouraged to

recruit older students to attend class with the youngsters. A work-study program would probably be necessary to enable the older student to finance his education. Since many of the part-time and evening students are usually older than most of the day students, it could conceivably be of great benefit if more of the day students had some of their classes scheduled with these evening students. The older student might discover "what's with" the younger set and bring about a "peace with dignity" between the older "degenerate" generation and the younger "progressive" generation.

Engineering since its beginnings has always been thought of as a creative profession. The early works of engineers or master builders as they were called, such as the ancient temples, bridges, aqueducts, medieval churches and early skyscrapers, represent a continuing sequence of creative acquisitions. These early civil engineering achievements were followed by the more recent attainments in mechanical, electrical, chemical, aeronautical, nuclear and space achievements of great brilliance. To me, these accomplishments are only indicative of the bright future that lies ahead. Unfortunately, very recent past history indicates that many activities of engineers are not thought of as being areas of great brilliance by all, especially by some students. These students, at least the more radical ones, somehow see engineering, and to some extent the physical sciences, as being heavily corrupted with the so-called false values of the "Establishment". These students feel that engineers have been enslaved by the military, the polluters, and the exploiters.

Perhaps this image as seen by the young is a correct one to those who do not know much about engineering and whose minds can understand little about conditions outside their own narrow area of involvement. In the first place, due to the professional ethics that frown upon self-laudatory statements, unlike politicians, few engineers are known to the public to have taken an active role in public life and in defending the public good. Although a change is now taking place, in the past the professional societies have not generally made public their opinions on controversial issues of a technological nature and of social importance. This has left many young people a little cold. They want to be part of an active and progressive group that is concerned with the world in which they would like to live.

A more logical explanation of the student's anti-science and anti-technology feeling might be the fact that most of these students are less than 25 years old. They have had a short life span and direct experience with a limited number of things. This would suggest that many, expecially non-engineering students, do not have an understanding of how incredibly complex and interdependent modern civilization is. They cannot comprehend the major catastrophy millions of human beings would face if our food production, transportation systems or power failed for a few days. The way in which things have been done, and are

being done, has not changed much in their lifetime. They have had TV, the automobile, radio, airplanes, etc. They have had all of these things and they have had no other basis with which to make comparison; and they are not happy. It may be excusable if the youth questions the society that we live in and the goals that we appear to have set for ourselves, but the older generation is somewhat frightened because our memories extend back to what things were like without the products of today's technology. Older people see a need and the young see a need. I believe that it is the same need. This need is to change things and bring technology under control so that it becomes a real servant of human beings. We know that this has to be a gradual process, one that is now going on and one in which every move does not bring about disruption and complications to the next move. The youth, in their inexperience, think that it can be done very rapidly and very radically – after all, very complicated problems are almost instantly solved at the end of the TV programs in order to leave some time for the commercial.

Another possibility for explaining young people's attitude toward engineering is a little frightening. One hears little of any dissent or criticism of the engineering discipline in the totalitarian countries. In fact, engineers are held in great esteem in these countries, and it is a great honor for any young person to be chosen to study engineering. Our country, and the other free nations of the world, depend to a considerable extent upon engineering achievements to maintain strength, leadership and freedom in the world. What an easy matter it would be for an unfriendly foreign power to saturate this country with silver tongued agitators that could easily sway young minds to believe that our industrial complex is in reality nothing more than a scheme to enrich a few while systematically poisoning and enslaving the remaining members of our society. The young and inexperienced minds might well believe the distorted views of these imports and begin the destruction of our democracy by sabotaging the one thing that has made this country the great nation that it is: namely, the U.S. educational system. We all know the trouble that has been prevalent on our college campuses and is now plaguing the high schools. All wars are not necessarily fought with guns, planes and tanks on the battlefields. Psychological warfare seems to be replacing old-time warfare. The A-bomb has assured the nations of the world that everyone will be losers in the next armed conflict between major powers.

A look at history will tell us that Galileo had trouble with the problem of anti-technology. R. A. Millikan was worrying in the 1920's about the anti-science movement at that time and suggested a holiday on new science so that society could catch up to the developments of science. It would appear then that the engineer has been under periodic attack in past, so why should today be different?

A long and costly depression and World War II with its one-sided industrial productivity was followed by a great boom-time in which the people demanded the products that they had long gone without. Unfortunately in our haste to get back to modern living with its multitude of improved products, we overlooked many of the byproducts of this industrial explosion – water pollution, noise pollution, air pollution, ecological exploitations, and the fact that we could build cars faster than we could build roads. We also inadvertently produced the greatest love affair the world has ever known – man's love for his automobile. The production of cars within the economic reach of large numbers of people justified mass production. The enthusiastic response of the public gave rise to new industrial enterprises and transformed the landscape and our living habits to a remarkable degree. However, it is fairly clear that someone needs reminding that the industrial explosion was provided by the demands made by the general public.

Ernest Weber, President of ECPD in 1969-1970, noted that technological leadership was taken, only a short while ago, as the measure for the ranking of nations. But times have changed, he noted, and now technology is the "scapegoat of society for all the ills that we cannot cope with." It seems only natural that people resent and even hate those to whom they have become indebted. Mr. Weber warns, "It is an axiom that the mere existence of man pollutes the environment. The combination of venture capital and the almost insatiable desires of society exploit technology; the decisions are essentially society's own responsibility." The automobile is a classic example of this.

Many would have us believe that our industries and our cars are using up the earth's oxygen so that eventually we will suffocate. NSF has recently compared samples of air from 78 sites around the world with samples taken 61 years ago. Their findings indicate that we have the same amount of oxygen today as we had 61 years ago – 20.95%. New York's Department of Air Resources reports that there has been a steady decrease in air pollutants since 1965. New York City air is much cleaner today than it was 100 years ago in the soft coal burning era that produced smog one could cut with a knife. This improvement is the result of engineering design of power plants and more stringent specifications for fuel. This was reported in a recent talk by the editor of Look magazine before a meeting of business managers. Undoubtedly, he was referring to the oxides of sulfur only as it is rather difficult to believe that the pollutants due to automobile emission in New York City have decreased in the last 5 years.

Prior to the industrialization of America, our lakes and streams were crystal clear. However, these clear rivers and lakes were the source of the worst cholera, yellow fever and typhoid fever epidemics the world has ever known. Today, our waterways are not as pretty as they used to be but they are not as deadly. The water we drink is the safest in the world – thanks to engineering. We are making

progress in improving the appearance of our streams but it will take time. After all, it took time to disfigure the streams. The recent sewage plant operation strike in England caused the dumping of raw sewage into the well-known streams in England, and now that the short strike is over the best estimate is that it will take 7 years to return the streams to their previous normal condition. This illustration indicates the havoc that can be wrought in a short time; and as our streams and lakes have been used for dumping areas for years, it will take considerable time to clean them up.

Our young friends and our old friends must be made aware of the great strides that industry and municipalities are making in the effort to clean up our lakes and streams. The task would be made much easier if the young (and many of the older people) would conserve some of the energy they consume in demonstrations and put it to work in more fruitful ways, such as increased studying to better prepare themselves to go out into the real world of professional work, and an increased willingness to work a little harder to hasten this clean-up process. It is work that is going to solve our problems, not endless jawboning and demonstrations.

Industry is admitting its history, but as I have pointed out before, the community also shares in the responsibility for today's environmental problems. It is we as consumers, who have demanded higher standards of living and have been willing to finance this living standard, but now we find that the price is more than money, due to the open cycle system we have encouraged our industry to develop. Up until a few years ago, the public had been apathetic despite warnings from a few people that we were headed for trouble.

Today, however, people are concerned and often angry about the pollution problems. These aroused people are attempting to do something about it. They should be encouraged as we need a basic reassertion of concern and pride among the people in this country in areas of pollution control, as well as in other areas such as corruption in government (a form of pollution), apathy on the part of workers, and a growing disregard for law and order.

Many ask the question, "What is clean air?" To a resident in a remote area, a find day in a metropolitan area might be viewed as horrifying. His judgment would be based upon appearance. A physician would, on the other hand, judge the air based upon any potential health hazards. The ordinary citizen might well view the problem from the standpoint of costs. All this points up to the fact that many of our environmental problems involve many criteria and contingencies and are always relative matters. Our educational curriculums should be programmed to include all matters concerned with the means of solving problems, not just a hard, cold, ruthless mathematical type of solution that may or may not arouse the interest of the students.

Engineering educators have been criticized for being narrow professionals. Credit for being a good professional seems to be lacking. Engineering has been defined as "the application of science for the good of mankind" – please note "the *application* of science for the good of mankind". One might also want to consider this expression: "Scientists learn what is – engineers create what never was." Thus engineers might be considered as professional users of knowledge, who take the scientists' principles and apply them to some purpose in imaginative and innovative ways. Today the engineering practiced and taught by many college engineering departments is quite far afield from its applications. The research in engineering schools has been more involved in science than in engineering. This trend was fostered by government research money that was distributed to fundamental research or to applied work of a military nature just after World War II and more specifically after Sputnik I. In order for a faculty member to obtain a promotion and tenure it was necessary to get a suitable share of the government funds for his department. To convince the government of his capabilities, the faculty member began to develop his interest in science and to stress science to his classroom contacts and in his research efforts. New faculty members were added to staffs if they had a strong scientific background. Engineering experience was not a requirement. This situation is still somewhat the same, although a change is gradually taking place; but this change is not taking place fast enough.

The Engineering curriculum naturally enough reflected the attitude and skill of the faculty with its emphasis on engineering science and mathematics. A curriculum such as this may be desirable and appropriate to sophisticated technology, but it has led to the neglect of application and design. It produced a program that was dull and lacking in contact with potential applications of subject matter. The course challenged the mathematically gifted student but failed to match the expectations of many who chose engineering instead of science because they expected to do something useful. This state of affairs soon produced disenchantment, loss of motivation, and a feeling of helplessness in the face of the future engineering situations that the students felt they would face. To compound matters, it was felt by many engineering educators that it was absolutely necessary that engineering students carry from 1/5 to 1/4 of their total classes in areas of the humanities. Unfortunately, there was little connection between the humanities courses and engineering courses taken by engineering students. In the student's mind the engineering curriculum seemed isolated since the two disciplines did not appear relevant to each other and there was not any order to the humanities. The further removed from engineering a humanities course was, the better the course it was; at least that was the way it seemed to many.

Student lack of interest, along with outside pressures, has recently caused many engineering schools to reevaluate their programs, both educational and research. Drastic changes are taking place; the core of specifically required courses has been reduced, more engineering electives made available in the upperclass years, and courses with humanistic and social content added. There has been a renewed emphasis in research on applied work and work of a social value. In Civil Engineering, this has been primarily in Environmental Engineering and in Transportation Engineering. The students apparently are feeling the wind of these changes as the Civil Engineering enrollment at Northeastern University is continuing the upward swing that started 10 years ago. Other schools are reporting a recent renewed interest in Civil Engineering. I might add that although we did make changes in our curriculum during the science fad, we managed to hold on to a "basic engineering with application" type of curriculum. In our recently revised curriculum, care has been taken not to load the curriculum with the learning of skills which will be outdated or taken over by machines or computers.

Today's engineering curriculums are designed to be concerned with human values and the solution of society's ills. It is vital to the success of this new curriculum that the teachers relate engineering to society in the classroom, and communicate an enthusiasm for engineering as a practical and useful profession. This may mean that many instructors will have to revise their attitude toward encouraging students to learn. A strong individualistic appeal must be made to the young people to point out that an engineering education is one of the best means to equip them to be able to help their fellow man. Students will come back to engineering when it can be shown that the engineering profession is indeed contributing to society's welfare.

Having credited the engineer for his triumphs, we might well ask to what extent is the engineer at fault when technology fails? The fault may be less than the critics claim, but more than the engineer realizes. Engineers, in concentrating on producing miracles, assumed the public had some realization that such miracles are not always beneficial to everyone. More often than not, a price has to be paid. Engineers can be accused of not making this part clear; and the public, in their zeal to take advantage of the miracle, usually forgets it.

One must not forget that approximately 10% of the working population are engineers and scientists. The remaining 90% probably have absolutely no knowledge, and many have no willingness to know, what the art and science of engineering really is. Without science and engineering, their life would be a miserable one, as we know from our study of living conditions in the past; and they would clamor for every bit of comfort, even though there is a price attached to it.

Historically, the men and women who have shaped this country, directed it,

governed it, and handled its political, social, and financial affairs, have been trained, for the most part, as lawyers and businessmen. These leaders have rarely been trained as engineers or scientists. They probably know less about engineering than the engineer knew of liberal arts, humanities, and social sciences.

Today, one can see far enough into our uneasy future to know that we must include engineers and scientists in our leadership in order to assure a proper solution to most of the problems of today and tomorrow. As a species, man will probably survive. This survival problem might be stated in quite another way: Any young man or woman who decides to become an engineer can know that his career will lead not just to satisfying work, but to a role in changing the world by transforming technological knowledge into human renewal and by assuring survival. The solution to our social and environmental problems will come only through more science and technology, and *not through restrictive action.* The best hope for wiser use of technological power rests in the hands of young men and women now thinking about how they will use their years of achievement.

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