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| AUTHOR | Galambos, Eva C. |
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ABSTRACT

Current issues in engineering education and supply and demand information on engineering personnel in the Southern region are summed up in this report. Highlights of the report include the following: (1) Although changes in national priorities make it difficult to forecast the demand for engineers, projections are in agreement that the national demand for bachelors of engineering will exceed the available supply. (2) The minimum annual national projection of demand for graduate engineers is 44,000. Yet with declining enrollments the expected annual supply in 1976 will be only 28,000, and will not reach 40,000 during the remainder of the decade. (3) For the Southern region the gap between available graduates and jobs will mirror the national imbalance. (4) At the Ph.D. level, however, it is expected that engineers will have difficulty in finding jobs that require training at that advanced level. (5) The current manpower situation has the following implications for the education of engineers: recruitment of women and minorities, integration of the engineering curriculum with social sciences, reduction or stabilization in the number of Ph.D. programs, and stress on continuing education for engineers by colleges and universities. (Author/PG)

# Engineering Needs In The South

Eva C. Galambos





Southern Regional Education Board
130 6th Street, N.W.
Atlanta, Georgia 30313
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# Highlights

- Although changes in national priorities make it difficult to forecast the demand for engineers, projections are in agreement that the national demand for bachelors of engineering will exceed the available supply.

- The minimum projection of demand nationally for graduate engineers annually is 44,000. Yet with declining enrollments the expected annual supply in 1976 is only 28,000, and will not reach 40,000 during the remainder of the decade.

- For the Southern region the gap between available graduates and jobs will mirror the national imbalance.

- At the Ph.D. level, however, it is expected that engineers will have difficulty in finding jobs that require training at that advanced level.

- The current manpower situation has the following implications for the education of engineers:

  Recruitment of women and minorities to help offset declining enrollments.

  Emphasis on the integration of the engineering curriculum with the social sciences.

  Emphasis in the curriculum on broadening the competency of the engineering graduate rather than on overspecialization in a narrow area.

  Careful study of the requirement to lengthen the course of preparation to qualify as a professional engineer.

  Retrenchment on the proliferation of bachelor of engineering technology programs in specific, narrow areas which prepare graduates to perform specialized technical tasks, but may not enable them to shift as technology and demand change their work.

  A hold-the-line policy, if not a reduction, in the number of programs at the Ph.D. level.

  Stress on the provision of continuing education for engineers by the colleges and universities. This need coincides with presently under-utilized resources in many engineering schools.

# Foreword

The SREB Manpower and Education program responds to twin responsibilities of education which have been clearly phrased in a statement of objectives by the National Commission on the Financing of Postsecondary Education:

> Postsecondary education should make available academic assistance and counseling that will enable each individual, according to his or her needs, capability and motivation, to achieve his or her educational objectives . . .
>
> Postsecondary education should offer programs of formal instruction and other learning opportunities . . .of sufficient diversity to be responsive to the changing needs of individuals and society.

This report capsulates within a few pages current issues in engineering education and sums up supply and demand information on engineering personnel in the Southern region. Under its developing Manpower and Education Program, partially supported by the Exxon Education Foundation, the Southern Regional Education Board will issue recurrent reports of a similar nature on selected fields in which new educational practices, shifting employment opportunities and other patterns of change become apparent. During the academic year 1972-73 the Board commissioned a number of exploratory "manpower and education needs" studies in several professional fields; this is a revised and compressed update of the report by Mario J. Goglia, *Education and Manpower in Engineering: A Status Report to the Southern Regional Education Board.*

Appreciation is expressed for a critical review of Dr. Galambos' report and for substantive and methodological suggestions by Dr. Goglia, vice chancellor for research, the University System of Georgia, as well as those of Dr. Thomas E. Stelson, vice president for research, Georgia Institute of Technology, and Dr. John K. Folger, executive director, Tennessee Higher Education Commission. Views expressed in the report are those of the SREB staff; commentary and corrections are invited.

Winfred L. Godwin
President

# Introduction

There are several constituencies to whom engineering manpower projections are important. First are policy makers who establish national goals, the pursuit of which may require engineering manpower. For example, the recently established national objective of reaching self sufficiency in energy resources by 1980 implies a strong input by scientists and engineers. Will enough of them be available, with the type of training that will be needed in these efforts? Safeguarding the environment for future generations, also entails technical applications of science or engineering. Again, will the necessary manpower be available?

Another audience for manpower projections is the academic world, which must plan ahead to prepare the engineers which society and the economic system will require. The public, in making a huge investment to finance education of professionals – especially in public institutions – deserves to know that these funds are used efficiently. Public subsidy of the education of more engineers than might be needed in various specialities or at different levels is obviously not efficient.

Finally, students who consider engineering as a prospective career are entitled to the best possible information available on what the long range employment opportunities will be. Manpower projections are especially important to the student whose choice of educational fields is influenced by the supply and demand situation in the future. Other students who make choices based on their own aptitudes and interests, regardless of demand for future services, are also entitled to the best possible knowledge on the risks they take.

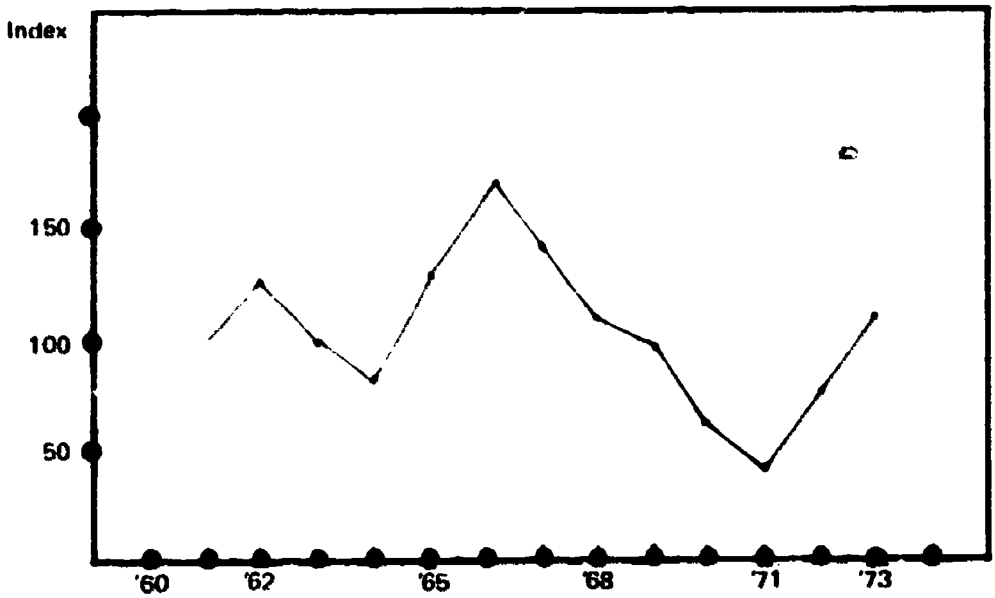
Admittedly, manpower projections in various fields and particularly in engineering, are beset with difficulties. Current assumptions on gross national product, values and priorities of society, and international events, all occurring well in the future, are crucial to the correctness of manpower demand projections, and yet these assumptions may not hold. The wide scope of possible assumptions indicates that a range of demand projections is necessary; a reasonable aim is that manpower supply should not exceed the top nor be less than the minimum of the range of demand projections. In the present state of art, manpower projections in engineering cannot be used for "fine tuning" in planning by educational institutions or students. However, these projections can serve as gross indicators on the need to either expand or retrench in various specialties and levels.

# Factors Influencing Demand

Changes in the demand for engineers occur frequently. The Deutsch Engineer/Scientist Demand Index shows two peaks in just a 12-year span from 1960 to 1972 (See Figure 1). These peaks coincide with those in a 20-year time series of employed engineers. In just 20 years there were five dips in the rate of growth of employed engineers; the frequency of these dips exceeds the frequency of general economic dips. Other variables, such as changes in national priorities to and from the military, space exploration, the environment, transportation systems, etc. affect the frequent up and down gyrations in demand for engineers.

**Figure 1**

**The Gyrations in the Demand for Engineers, United States**




Source: Deutsch, Shea & Evans, Engineer-Scientist Demand Index

The frequency and shortness of these cycles of demand for engineers mean that the corresponding response of student enrollments to current demand factors always lags. The basic preparation of an engineer requires four to five years. By the time reduced enrollment in response to a glut affects the labor market, the demand situation has changed again because of changed economic conditions and reordered priorities. Demand is suddenly strong and supply insufficient. This begins the cycle again by encouraging students and faculties, and enrollment swells - only to hit a different market by the time the current crop of students is ripe. Planning in reaction to short run fluctuations cannot overcome this cobweb effect. What is needed is a longer range outlook in manpower planning for engineering. Such an outlook would seek to determine the long term trend

through the troughs and peaks of shorter gyrations, and be more concerned with a supply that meets the long range demands rather than the vagaries of cyclical employment.

The extent to which engineers will be needed in the national economy depends on several major factors. Shifts of the economy away from the military and space exploration have negative impacts on engineering employment. Bezdek estimates 5% lower demand for engineers in 1980 if national priorities focus on social problems as opposed to renewed emphasis on military and defense expenditures.[1] A more service oriented economy, as contrasted to a "goods" economy, according to past trends, would mean less pressure for engineering graduates. In 1965 only 15% of all engineers were employed in the service sector of the economy while 54% were employed in durable and non-durable manufacturing. Government, which is another growth industry, also accounted for a lower percentage (15%) of engineering employment.[2]

There is some evidence that engineers may find a more important role in these sectors The problem of measuring output in service industries and of increasing productivity has involved engineers in recent years. For example, engineers are being called on to streamline hospital administration and to aid in the measure of output versus input in education. To the extent that the talents and orientation of engineers prove successful in these areas, they may increasingly find themselves dealing with service rather than goods output.

A more technological or capital intensive economy, in both service and goods industries, also increases the demand for engineers There is every indication that our society will continue to be a capital intensive one, and to advance the use of machines and equipment to increase output. In the health industry, for example, computerization may be used in diagnosis and in patient records. Teaching aids in the form of technical apparatus are becoming more prevalent in education.

Present plans for federal funding of research and development expenditures to reach self sufficiency on energy resources might offset lower demand for engineers in the defense and space areas. This unforseen turnaround in federal funding illustrates the difficulty which manpower planners face even in postulating the various and conflicting assumptions on which to base projections. On balance, however, there is every indication that continuing use of technology to improve output in all sectors will provide long term continuing demand for more engineers, despite occasional up and down fluctuations in the long term rising trend.

## DEMAND PROJECTIONS FOR THE UNITED STATES

Unfortunately most present projections of demand do not extend beyond 1980. At the time they were made, they projected for a period 8 to 10 years in advance Today they are only six years hence, and to the extent that they are still valid, they are now short-run projections to the present prospective enrollees in engineering schools.

Projections of future demand are made on the basis of several variables. They include replacement and growth demands. Replacements include deaths, retirements, and transfers out of the profession. The growth component must be adjusted for the portion of engineering jobs that will be filled by non-engineering graduates. Some of these variables are subject to quite different outcomes depending upon the validity of the underlying assumptions.

The 1972 Manpower Report of the President assumes that the economic growth rate through 1980 will provide full employment. Under this assumption 48,000 engineering graduates per year would be required to meet projected replacement and growth demands [3] A somewhat lower projection was reached by Gloyna and Wissler in a 1972 assessment. Average annual replacement needs for graduate engineers are estimated by them at 24,000, with an additional 20,000 per year for the growth component.[4] The Fleckenstein Report projected a somewhat lower demand, yielding total engineering employment in 1980 below 1,350,000.[5] By comparison, 1980 requirements projected by the U.S. Department of Labor (Bulletin 1737) are for approximately 1,500,000 engineers.[6] This the Department translates into average annual openings for engineers ranging from 73,400 to 58,000. These openings, however, will not all be filled by engineering graduates. The Department's estimate on the required number of *engineering graduates* to fill these openings ranges from 48,000 to 45,000 annually. The degree to which non-graduates will fill openings is one of the assumptions most open to speculation.[7]

Despite the multiplicity of projections and their different methodologies, none of them projects less than a need for 44,000 graduates annually. The top of the range of these projectsions is 48,000.

## SUPPLY PROJECTIONS FOR THE UNITED STATES

Projections of the supply of engineers are made in the short run on the basis of freshman enrollments. The Engineering Manpower Commission has developed sophisticated measures on the relationships between enrollments at various levels of an engineer's educational preparation and the final annual number of engineers available. Factors to be considered in projecting the number of engineering graduates available for employment in engineering jobs include the proportion of foreign students who stay in the U.S. (and those who return to their own countries), and the percentage of graduates who enter some other field or profession. These adjustments depend upon imperfect knowledge and therefore are subject to error. Despite these difficulties, snort run validity is greater on the supply than on the demand side of the projections for engineering graduates.

Projections of college enrollments in all fields over the long run depend first on the number of college age students. The college age population will decline in the 1980's. The percentage of college age youths attending college also appears to be leveling off. This translates into lower annual increases in total college enrollments during the 1970's and actual declines in the 1980's. By 1990 the trend will reverse again, with an increasing number of 18 year olds, and accompanying rising enrollments.

Unless it is assumed that engineering can attract an increasing percentage of available college enrollees, the prospective leveling off and decline of college students indicates similar long run trends for engineering. One constraint on attracting a greater share of available students into engineering is the ability to perform the work. Brode believes that this constraint is operative, and that engineering degrees will saturate at 1.3% of twenty-two year-olds, as compared to the current 1.2% rate.[8]

The low proportion, historically, of women and minorities in engineering contradicts this prediction of a saturation level of qualified entrants. Stronger

efforts to recruit women and blacks to engineering schools currently present one opportunity to increase enrollments. Deliberate recruitment programs to tap the potential for engineering enrollments among minority groups have been successful in some areas, and might well be tried by other engineering schools.

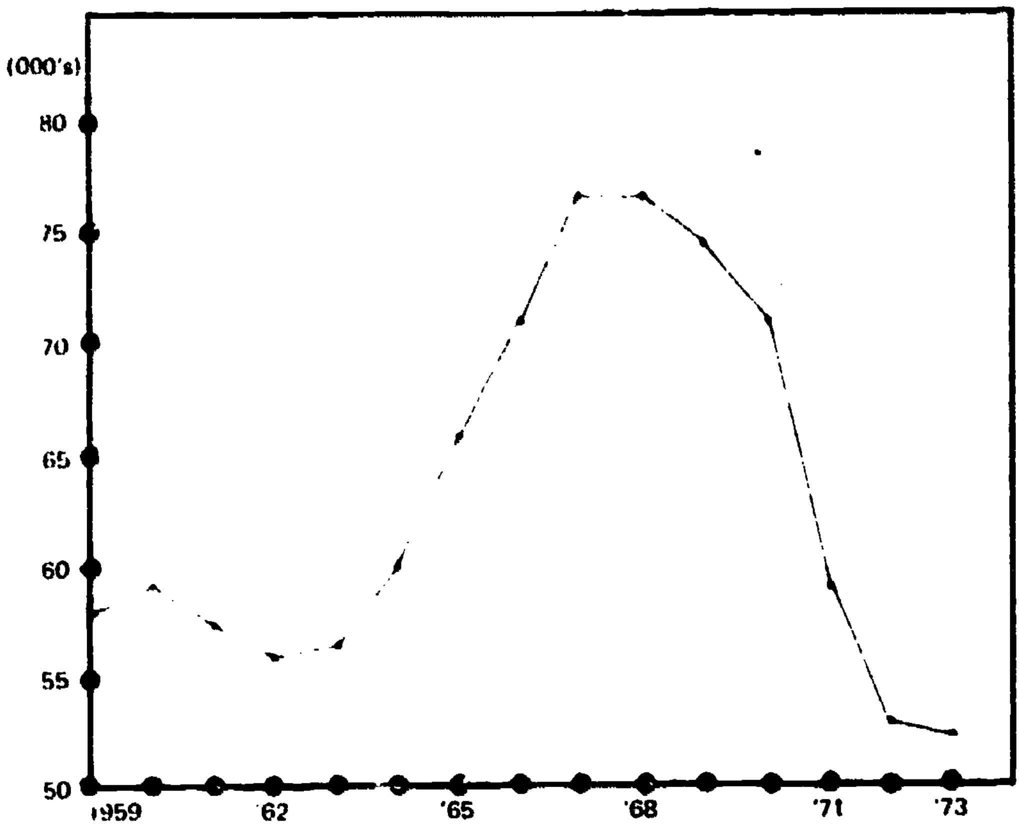
Besides "ability" constraints as a determinant of engineering enrollment, there is the grave problem of assessing the orientation of youth in the long run. Who predicted in the 1950's the disenchantment of youth with the applications of technology and of science in the 1960's? Who in the 1970's has insight into what will "turn on" the generation of the 1980's?

Short run projections of engineering graduates during the remainder of the 1970's all point to a gap between available supply and projected demands. In 1972 the Engineering Manpower Commission projected the number of new engineers who would be available for employment through 1982. The annual total ranges from a high of 40,000 in 1972 to a low of 28,000 in 1976. The annual total then gradually climbs to 37,000 in 1982. This annual total includes entrants into the job market from all levels of engineering education and is predicated on an output of bachelor of engineering graduates of 44,560 in 1972-73.[9] Unfortunately, the degree output in that year was lower by 1,000, suggesting that projected degree output and therefore available engineers might also be overestimated for the remainder of the 1970's.

# Supply and Demand Relationship

**Figure 2**

**Engineering Freshman Enrollments, United States**




Freshman enrollments in engineering schools in the U.S. have declined since 1968, with particularly sharp declines in 1971 (See Figure 2). The 1973 enrollment drop seems to be easing. The drop during recent years reflects the combined short run reaction of students to publicity on unemployment of aerospace engineers in 1970-71, as well as the longer trend shift of student interests. The short run reaction may already be spent. However, even if engineering enrollment has bottomed out, the projections on the annual supply of new engineers available for employment through 1982 (ranging from 28,000 to 40,000) falls far short of all projections for estimated annual demand. No projection as outlined in the previous section on demand foresees a need for less than 44,000 to 48,000 graduate engineers annually. The present estimates of available new entrants through 1982, all below 40,000, result in a serious gap of available trained manpower in engineering (See Figure 3).

## THE SOUTHERN REGION

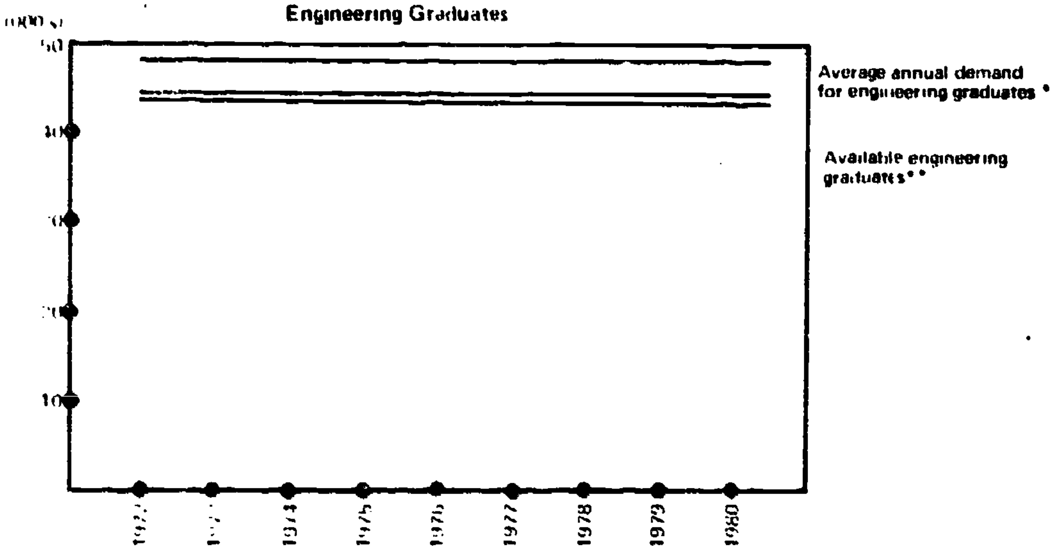
Average annual openings for engineers through 1975 have been calculated by

12 states in the Southern Region according to the methods suggested by the U.S. Department of Labor in Bulletin 1606.[10] SREB has applied the method for Virginia and West Virginia where the states themselves had not made such occupational projections available. Total average annual openings for the period to 1975 for the 14 states of the Region total 14,700. This takes into account growth and replacement demands. However, as is true for the national projections, not all these openings will be filled by graduate engineers. If 25% of all openings are filled by non-engineering graduates or non college graduates, these average annual openings would be translated into an effective demand for graduate engineers of approximately 11,000.

Figure 3

Demand & Supply Projections

Engineering Graduates




*Demand projections range from a low of 44,000 to a high of 48,000 openings per year
**Engineers Joint Council, *Engineering Manpower Highlights*, March 1973, p. 4

The output of bachelor degrees in engineering for the South in 1970-71 was 11,646. Assuming that the same relationship holds in the South as the Engineers Joint Council postulates nationally between annual output of bachelors and the number of graduate engineers at all levels available for employment (87%),[11] then the current Southern state projections of demand exceed the available oncoming supply. These state projections yield a current gap of approximately 10%. This gap will tend to worsen in the 1975-80 period if Southern engineering enrollments follow the same paths as national enrollment projections. The South's growing role in many economic activities, as it continues to reach towards national averages in income and employment distribution, will also exert pressure on the demand for engineers, and tend to intensify the gap in supply.

## SUPPLY AND DEMAND FOR Ph.D.'S IN ENGINEERING

The relationship between supply and demand for engineers at the doctoral level requires special comment. Over 50% of all Ph.D.'s in engineering have been employed in the higher education of prospective engineers. Declining college enrollment through the 1980's indicates no new demand for Ph.D.'s in engineering in that area except for replacement of current faculty.

Research and development (R&D), the other area in which employment of graduate engineers is concentrated, is highly dependent on the vagaries of government funding. R & D funding, both in private industry and government, rose in 1972, resulting in a 3% increase of engineers and scientists in that area.

R & D funding should rise in the ensuing years in response to increased research in the field of energy. The Atomic Energy Commission Report on the Nation's Future Energy Needs recommends funding of approximately $2 billion annually through 1979, which compares with $640 million spent for R & D in his area in 1973.

Cartter estimates that "a better than 9% annual growth rate (compounded) in non-academic employment" would be needed to employ the projected growth of doctoral degrees produced in all fields. Except in brief periods of time, and for some sub-specialties, we have never experienced such an overall growth rate for doctoral scientists and engineers in the past." He predicts an average growth in employment of science and engineering doctorates in R & D type activities of about 5% annually.[12]

The number of Ph.D.'s degrees awarded in engineering in 1973 declined 5% from the previous year, as compared to a 1.7% decline for bachelor's and master's degrees. This is the first year of decline in the output of Ph.D.'s. Responding in part to the abundant publicity on the surplus of Ph.D.'s in various areas, and also to the cutbacks in federal funding for advanced study, 1971 enrollments in advanced programs in engineering were 14% below those of 1970. Despite this drop, there were still 3,587 Ph.D.'s awarded in engineering last year. The total projected addition of Ph.D.'s in private industry from 1968 to 1980, according to a 1968 survey of firms, is only 7,300.[13] In 1968 the total number of engineering Ph.D.'s in the U.S. was only 20,000[14] so that even 2,000 new Ph.D.'s per year would increase the supply 10% relative to that base period. Therefore, the declining enrollment in advanced engineering programs indicates a healthy adjustment relative to projected demands.

## Ph.D.'S IN ENGINEERING IN THE SOUTH

Output of Ph.D.'s in the South has increased faster than for the nation as a whole. In 1971 Southern output was 83% above 1966, while for the U.S. it had risen 58% during the same period. Southern institutions in 1970-71 produced 23.1% of all bachelor of engineering degrees, 17.3% of master's and 17.6% of doctoral degrees.[15] To the extent that the South continues to "catch up" in the role it plays nationally in R & D, the demand for advanced engineering degrees in the South relative to basic degrees may be expected to rise. However the market for Ph.D.'s in all fields is a national one, so that increased Southern demand for engineers in research and development may be expected to be met by the overall supply of engineering Ph.D.'s in the United States. Moreover the

fairly low output of degrees per program in the South (4.4 at the Ph.D. level versus 5.7 nationally) indicates that there may already be too many Ph.D. programs in the Southern states, from the standpoint of efficiency in output.

# Implications For Education of Engineers

What are the implications of the supply and demand projections for the educational process of engineers?

How can the educational system best protect the engineer from the consequences of shifting national priorities? What does the continuing growth of the service and government sectors imply for the education of the engineer? What do the characteristics associated with unemployed engineers imply in terms of the educational institutions? What are the requirements of the jobs to be done by engineers relative to the length and content of their professional education?

## INTERDISCIPLINARY EDUCATION

The frequent gyrations in the demand for engineers imply that engineers must be adaptable as one industry gains with respect to another. Unemployment of aerospace engineers in recent years has illustrated the problem of a narrow specialization that suffers in comparison with broader specialities such as mechanical and electrical engineering, which are applicable in numerous industries. The advantages of proficiency in a specialized narrow area in any of the engineering subspecialties needs to be weighed against the risk that this specialization holds in terms of applicability to various industries and engineering problems.

The problem of providing a broader scope in engineering education has received a great deal of attention in recent years. The incentive to do so has come from two directions: (1) the more narrow the specialization, the more restricted are the employment possibilities in terms of shifting demands, and (2) the narrower the orientation of the educational process, the more difficult it is for engineering schools to have appeal for the young people of today who are so keenly interested in social issues. Several innovative programs have been developed that tend to broaden the engineering curriculum. Some are established across the traditional engineering specialties, and concentrate instead on a problem area. For example the energy engineering curriculum in one institution entails courses in the following traditional engineering specialties: aerospace, ceramic, chemical, civil, electrical, science and mechanics, industrial & systems and mechanical and nuclear engineering. This approach provides interdisciplinary integration among engineering specialties, and focuses on problem areas in which students are interested. A different approach is to provide more integration with nonengineering departments within a college or university. At the University of Maryland a BS in Engineering, with an "Applied Science" option, is designed so that it appeals to prospective medical, law and business administration students.

An innovation at the Georgia Institute of Technology to attract students who might have otherwise been reluctant to enter engineering is to establish dual degree programs with liberal arts colleges. Students who wish to obtain broad knowledge and general culture may do so in liberal arts colleges for approximately three years, and then complete their engineering courses at Georgia Tech for an additional two years. This has opened the door to the recruitment of many students (including women and blacks) who might otherwise not have considered engineering.

Reorganization of the engineering structure at Southern Methodist Institute of Technology (SMI) also stresses the integration of various sub-specialties. The entire engineering school is organized under three divisions: civil-mechanical engineering, computer science and operations research, and electrical engineering. Curricula in various areas, such as public and societal systems, or biomedical engineering are provided by faculties in the various divisions.

In an effort to attract more students, and especially those with interests in social issues, several colleges have developed new programs. SMI has instituted two new degrees the Bachelor of Applied Science and the Bachelor of Science in Engineering without designation of an area. These programs are designed so that students can direct their technical and scientific curriculum to socially important problems. The Environmental Systems Program, which is organized within the Bachelor of Applied Science degree, has had strong response in its first year. The curriculum deals with social, political and biological considerations, as well as with scientific principles and practical engineering applications. SMI in its 1972 Annual Report notes that the program should be equally attractive to students with scientific interests as well as those who wish to channel their feelings of social concern into positive and constructive action."

## THE LENGTH OF THE EDUCATIONAL REQUIREMENT

Not only is integration of various disciplines an issue in the education of a professional engineer, but also the length of his education. The Engineers Commission for Professional Development, which for many years has nad the responsibility of accrediting undergraduate programs in engineering, has embarked on a policy of accrediting two types of degrees: the "basic degree," which essentially is the bachelor of engineering degree, and the "advanced" degree, which requires an additional year of mathematical, scientific and technical course work. Although this move in one sense is simply to extend accreditation to advanced programs for which there was no previous accreditation possibility, in another sense it can be interpreted as the first step towards requiring an advanced degree for credentialing a professional engineer.

Accrediting "advanced" degrees does not yet have unanimous support among engineering educators and practitioners. Since adoption of the advanced accreditation policy in 1972, ECPD has accredited 24 programs. Those who approve of the tendency to lengthen the educational requirement for engineers point to the increasingly sophisticated technology which must be mastered by each succeeding class of engineers. They also point out that even before the "advanced" accrediting system was initiated, 40% of all engineering students continued with graduate education. Yet there was no accrediting agency for the programs in which they enrolled.

Those who oppose accreditation at the advanced level question whether the pressure originates because engineers wish to strengthen their professional status, or whether the requirements of industry, where most engineers are employed, are really such as to demand longer educational preparation. The possible oversupply of Ph.D.'s in engineering, who tend to bump those with less training when employment at their own level is not available, is also an obstacle to raising the educational requirements for the professional engineer. Similarly, if the supply of engineering graduates will not suffice, as projected for the foreseeable

future, this might not be the most opportune time to further reduce the supply of available graduates by lengthening their educational requirements. Although a sellers' market presents the best time to tighten requirements from the sellers' viewpoint, this may not coincide with the public interest.

John Alden, executive secretary of the Engineering Manpower Commission, points out that jobs "which nominally call for engineers are increasingly being found to require less educational preparation than is provided by prevalent engineering curricula. As engineering educators seek to 'upgrade' the academic content and degree level of their programs, they are reducing the spectrum of the job market covered by their graduates."[16]

The deans of engineering of the Big Ten Conference schools issued a statement in November, 1973 in opposition to accreditation of advanced degrees. They base their opposition on a reluctance to impose rigid criteria on advanced degree programs which might inhibit the extensive interaction which their programs have developed with many disciplines.[17]

## BACHELOR OF ENGINEERING TECHNOLOGY

In addition to the issue of lengthening the educational requirements for the professional engineer, the engineering educational system also faces the problem of whether to expand the bachelor of engineering technology programs. The technology programs do not include the same stress on the fundamentals of science, math and technology as the traditional engineering degrees. They are designed to provide manpower for middle level management jobs, often with entry at the foreman's level. They are jobs essentially devoted to the *production* process, as contrasted to design, planning and administrative functions. The content of the bachelor of engineering program stresses creativity towards new technology, while the technologist is more concerned with the continuous functioning of existing technology. The increase in the number of ECPD accredited institutions and curricula has been more rapid for engineering technology degrees than for bachelor of engineering degrees. This rise has been even more evident in the South.

**Percent Increases in Bachelor of Engineering and Bachelor of Engineering Technology Programs in Accredited Institutions**

| Percent Increase | Accredited Institutions | | Accredited Programs | |
|---|---|---|---|---|
| 1967-72 | U.S. | South | U.S. | South |
| Bachelor of Engineering | 35% | 32% | 24% | 25% |
| Bachelor of Engineering Technology | 82% | 186% | 92% | 225% |

Source: ECPD Annual Reports

The increase in the number of *accredited* institutions and curricula for technologists, as shown above, does not include the concurrent development of many additional nonaccredited programs. Proliferation of numerous narrow technology degrees will produce individuals suited for immediate jobs in industry, but may not enable them to meet the inevitable shifts to new job require-

ments inherent in a dynamic world. Although industry traditionally has a tendency to seek from educational institutions graduates who are narrowly prepared to immediately perform special tasks, such education of students may not be in the long run interests either of students or employers. Employers who sacrifice some immediate efficiency because the student's preparation was relatively broad, or non-specific to unique applications, may gain in the long run - if this preparation permits the young engineer to handle new applications and to adapt to changing technology.

Demand for engineering technology graduates may be expected to continue strong, especially as long as bachelors of engineering are in short supply. The employment of engineering technologists when there is an insufficient supply of bachelors of engineering may exert pressure to modify the curriculum of the technology programs in the direction of the traditional programs. Such a move would produce graduates from technology programs who are better substitutes for non-available bachelors of engineering. To the extent that this might occur, the distinction between engineering technologists and engineers will become blurred. On the other hand, if the curricula of the two types of degrees do not become more similar, and if engineering graduates should become more plentiful in the late 1970's and early 1980's, the latter would constrict employment opportunities for the technologists.

## NUMBER OF ENGINEERING PROGRAMS IN THE SOUTH

Degree output of engineers at various levels, by Southern educational institutions relative to output nationally, offers guidance to educational planners in meeting the demand for engineering graduates in the future. The average number of degrees produced per program is one indicator of the efficiency of engineering programs. Where program output is well below the national averages, there may be a need to consolidate programs or at least to discourage development of new ones.

**Average Number of Degrees Per Engineering Program, 1970-71**

| | United States | Southern States |
|---|---|---|
| Bachelor's | 33.3 | 28.7 |
| Master's | 14.3 | 10.3 |
| Ph.D. | 5.7 | 4.4 |

Source SREB, *Degree Output in the South, 1970-71*

At all levels the Southern states, in their various engineering programs, produced fewer degrees than the national average. The variation between Southern and national degree output varies by engineering specialties. Output in the South is higher for bachelor's degrees in the following specialties: industrial management, bioengineering, textile engineering, engineering physics, nuclear engineering, engineering mechanics, naval and ocean engineering. At the master's level, the South is higher for textile, environmental-sanitary and "other" specialties. At the Ph.D. level the South is higher in petroleum, nuclear and environmental-sanitary engineering. The specialties in which degree output in the South is below the national averages, at all levels, by far exceed the itemized specialties in which Southern institutions are more productive. A 1971 analysis prepared for the

Coordinating Council of Higher Education in Louisiana on the future needs of engineering education in the state, resulted in a recommendation that programs leading to the bachelor of engineering degree should be maintained in only five of the 13 public institutions. The recommendations included discontinuing several bachelor's programs, and "pre-engineering" curricula, although technology offerings were suggested to replace some existing programs.

Several deans of engineering schools in Southern colleges and universities in 1972 revealed serious underutilization. The somewhat brighter picture of recent enrollments (although they were still declining) may gradually alleviate the overcapacity problem. However, the proliferation of programs at various levels, the low output relative to national averages, and attendant effects on the quality of the programs may point to consolidation of some offerings.

## CONTINUING EDUCATION FOR ENGINEERS

The explosion of available information and the rapid transformation of technology conspire to make an engineer obsolete more rapidly than many other professionals unless continuing education is consistently pursued. Dr. T.E. Stelson, vice president for research at the Georgia Institute of Technology, estimates that the average engineer should spend one third of his time in renewal, but that at the present time only 50% of all engineers spend as much as two weeks annually in some kind of refresher course or training program. The burden of renewing the profession is a huge item on the engineering educational agenda which is largely unmet. Older engineers, who were furthest away in time from educational programs, had the greatest tendency to be unemployed in the "engineering recession" of 1970-71.

In its final report on the Goals of Engineering Education, the American Society for Engineering Education placed great emphasis on the role that engineering schools have in the process of continuing education. "The Goals study recommends that engineering schools recognize more fully the place of continuing studies as a distinct category in the spectrum of engineering education, and that wherever possible they provide additional leadership in the planning and offering of programs of continuing studies as part of normal institutional activity. It is also recommended that engineering schools cooperate to a much greater extent with industry, government, and the engineering societies in programs of continuing engineering studies in order to achieve maximum benefit for the students and optimum utilization of teaching resources. Finally, it is recommended that employers facilitate in every possible way employee participation in programs of continuing engineering studies."[18]

These recommendations were issued in 1968. Since then the engineering schools have experienced sharp drops in enrollments of students in the traditional baccalaureate and graduate programs. The excess capacity of engineering education resources would have provided an excellent opportunity to marshal these resources for an intensive effort to meet the continuing education needs of the engineering profession. Such a move would be in keeping with the Carnegie Commission's findings that, in the future, individuals will increasingly avail themselves of formal education at various stages of their lives and careers, and that colleges and universities must adapt themselves to serve this continuum of educational needs if they are to be responsive to the needs of society.

# Summary

Making projections of manpower requirements for engineers is frought with difficulties because the demand for engineers is more volatile than for many other professions. The demand for engineers is dependent on shifting private and public spending priorities of the nation which often cannot be predicted.

Despite the difficulties inherent in making projections for engineering demand, there is fairly substantial agreement that average annual demand for graduate engineers in the early 1980's will exceed available engineering graduates, nationally and in the South. Concerted recruitment effort among women and minorities presents a viable alternative for reversal of declining enrollments in engineering. Other possible adjustments to close the gap between available engineering graduates and jobs is a renewal of interest by students in engineering curricula. However, if the number of engineering graduates is insufficient, employers will have no choice except to "downgrade" jobs and hire engineers with less than a bachelor's degree.

Although engineers with baccalaureate degrees are much in demand, prospects for engineering Ph.D.'s are dimmer. Moreover, the average output of degrees per Ph.D. program in the South is almost 25% below the national average, suggesting that there is presently no need for new doctoral programs.

The manpower situation has several implications relating to the education of engineers. Overspecialization in the educational preparation of an engineer tends to narrow his options in a rapidly changing world of work, and may alienate some young people who wish to integrate an engineering curriculum with their concern over social issues. Reorganization of overspecialized engineering curricula and integration of technical and scientific work with liberal arts offerings are two major trends in engineering education that reflect positive response to engineering manpower problems.

Another issue in engineering education relating to manpower utilization deals with the problem of advanced degrees. The increasingly sophisticated technology to be mastered by succeeding generations of engineers suggests that their training should be lengthened. At a time when the supply of engineers does not appear to be sufficient however, a move towards requiring an advanced degree for an engineering professional does not seem practical from a manpower standpoint. Also there is no real evidence that most of the jobs for engineers in industry and government require persons with "upgraded" education.

At the other end of the engineering educational spectrum is the bachelor of engineering technology degree. There has been a widespread expansion of institutions offering this degree in a growing assortment of specialized areas. There is a danger that graduates of very narrow technology programs will lack the flexibility to adjust to inevitable technological shifts in job markets. The proliferation of institutions offering four-year programs in engineering technology in the South has exceeded the pace in the rest of the nation. Also, the lower output of engineering programs at all levels in the South, relative to national averages, concurrent with declining enrollments, indicates that some programs might be cominbed in the interest of maintaining quality and preventing cost escalation.

The lower output of engineering degrees per program in the South at all levels, and the currently reported underutilization of engineering schools' re-

sources offer the opportunity of more emphasis on a nontraditional role for these institutions. to provide more continuing education of engineers. Rapidly changing technology poses a greater risk of obsolescence among engineers than for most other professions. There would seem to be no better time for engineering schools to focus on expansion of continuing education than while they experience excess capacity in undergraduate programs.

# Footnotes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