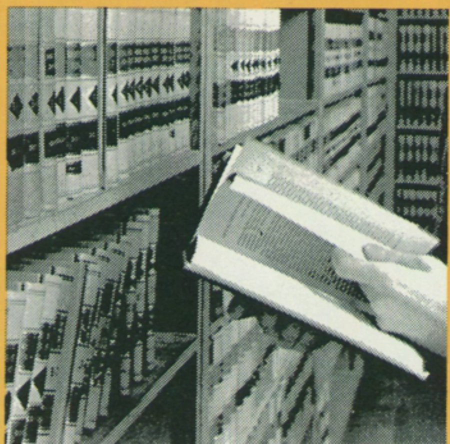
ENGINEERING

CORNELL QUARTERLY



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TRENDS
IN ENGINEERING
EDUCATION

IN THIS ISSUE

The expanding roles of engineers and accompanying changes in engineering curricula are discussed by Edmund T. Cranch, dean of the College of Engineering, in an interview with the editor of the *Quarterly*.

An increasing interest in undergraduate engineering education as preparation for graduate study in nonengineering professions is explored by Robert E. Gardner, director of the Engineering Advising and Counseling Center at Cornell.

By 1976 one out of six upperclass students in the College of Engineering may be a transfer from a two-year community college. The dramatic rise of the community college and its effect on higher education, particularly in engineering, is discussed by David C. Johnson, chairman of the College's Transfer Admissions Committee.

An innovative way of teaching a traditional aspect of engineering is depicted in a photo-essay on a new intensive course in civil and environmental engineering design.

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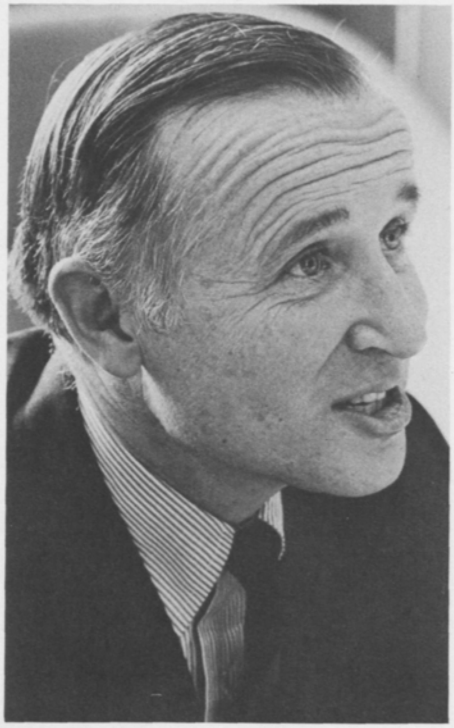

ENGINEERING TODAY

Some Views of Cornell's New Dean

A period in which engineers will expand the range of their activities and participate more visibly in economic planning, public affairs, and international development was projected by Edmund T. Cranch in a recent interview with the editor of the Quarterly. *Cranch, who became dean of the Cornell College of Engineering in December (see the Autumn 1972 issue of this magazine), also discussed ways in which he feels engineering schools can and must adapt their programs to meet changing conditions in society. Some questions and answers emerging from the interview may help give readers interested in the future of the College an idea of what the character of Dean Cranch's leadership is likely to be.*

What is the status of engineering as a profession today? Are the functions of engineers changing?

The engineering profession is by nature characterized by change because its role is to apply new techniques and materials in meeting the evolving needs of man. Thus, in our rapidly developing technological society the engineering profession has assumed an important role—one which has led to a heightened societal awareness of the impact of technological change. The innovative, adaptive, and planning roles of engineers have not changed appreciably, but engineers are now being called upon to perform these functions in an ever widening arena. For example, they are becoming heavily involved in issues of public planning and policy; and the resolution of these issues involves important questions of public safety, welfare, and finance. I believe that we will see in the years immediately ahead a more apparent movement of young engineers into work with a public-needs dimension. This is bound to be reflected in the professional organizations and education of engineers.

What kind of activity do you mean by "work with a public-needs dimension?"

There is a high probability that an engineer beginning his career, whether in industry or government, will become involved within a very short time in economic concerns. Alternatives are not only technological in nature, but almost always involve economic and social parameters. Such considerations are important from both the corporate and public points of view. If we want to do significant things—if we are to improve the quality of life for a much greater number of people—large amounts of capital must be committed and economic, social, and environmental consequences of great magnitude are often involved.

Committing large amounts of money and large segments of society to new ventures requires wise planning. It is easy to squander resources in programs that at the outset are not well planned. For instance, the implementation of a mass transportation system entails mat-

". . . expanding opportunities for engineers will exist beyond the basic and traditional categories."

ters such as land acquisition and environmental quality which affect many people; large-scale housing projects have extensive socio-economic ramifications. The time dimension of such projects is often significant, for once embarked upon, they are part of our system for long periods of time. Planning and policy determination are tremendously important at every level and in every aspect of technological and economic development.

How do you think this affects engineering students and engineering schools?

Those who are involved in the education of engineers must raise the consciousness of students to embrace both planning and technological considerations. Engineers are eminently equipped to participate in the decision-making functions I have cited because their analytical background enables them to evaluate technological and economic trade-offs from a knowledgeable position. But they must be willing and prepared to deal with other issues as well. Engineering students will to an increasing extent be exposed to the kind of integrating process required in solving the problems of the real world. We must provide students with the opportunity to study in areas that not only broaden their basic education but also provide, in a much more visible way, educational experiences that relate their studies to an integrated whole. It is this process of integration that will be recognized as an increasingly important part of the professional component of engineering education.

How do you think this kind of approach could be infused into the engineering curriculum at Cornell?

A natural way for engineering would be the case-study approach, which has been used successfully, for example, in business schools. At one time, some years ago, many disciplines did include the relationship of technical skills with economics and management, for example, but this was done in a much narrower sense than present circumstances require. We must now make another try. The basic difficulty is that, as a result of ever-increasing complexity and depth of understanding, we have divided our education into increasingly specialized units. Very little attention has been given to the interrelationships and interactions among specialties, so that we are now in a position of having virtually no educational experience or materials available for this mode of education.

I would like to see more of our faculty become involved in professional activities, through working or consulting in industry or governmental agencies, and thus make themselves familiar with the relationship between their field of expertise and the wider social context of its applications. Our staff should be encouraged to extract from such experiences material that has potential instructional value, and to convert it for educational purposes. Certainly this will not be an easy process, for it must be done without eroding the technological strength of the curriculum. The establishment of priorities is involved: we have been under pressure to increase the scientific content of our curriculum as well as provide the broadening component. Nevertheless, we must direct a certain fraction of

"*I would like to see more of our faculty become involved in professional activities . . .*"

our efforts in this new direction. The basic question is one of implementation. Should a separate unit be established to meet these needs, or should a broader consciousness be infused through the offerings and activities of the various schools and departments?

Are there constraints applied by government, industry, or professional societies on engineering education?

Engineering educational institutions are and must be guided by the nation's overall manpower needs, and as Andrew Schultz, Jr., has pointed out recently (in *ENGINEERING: Cornell Quarterly,* Vol. 7, No. 2, Summer 1972), a shortage in numbers of engineering graduates is a certainty in the immediate future. Historically, manpower predictions have not been very accurate as far as engineering is concerned, however. One difficulty is that they have usually been based on a narrow conception of the potential roles of engineers—assessments are made within defined categories that are no longer adequate.

It is estimated that about fifteen million new jobs will open up in the 1970s and that of these, thirteen million will be in the so-called service industries. The services needed by our society are shifting and changing and, in so far as engineering is concerned, job classifications can no longer be confined to the traditional categories. Clearly, engineers are going to be moving into these positions, in business, government, education, and industry. For example, we can look to such a critical area as energy production and see whole new areas of energy sources, modes of distribution, and management. Questions of environmental impact, societal cost, and equity must be investigated and resolved. Similar examples can be drawn from the field of health care and delivery, in which analysis and planning of complete systems will be a necessity. Engineers will be needed to work in areas, such as these, which have not been itemized in manpower reports under the traditional categories of engineering. Students should feel free and be encouraged to consider a wide range of activities not only in engineering *per se,* but in adjoining areas. Our engineering schools will best meet the overall needs of society if they prepare students for entry into a variety of new engineering-oriented pursuits, as well as the traditional specialties.

At the present time, the organization of the engineering profession into specialties does have a considerable influence on the character of engineering education, even though no monolithic organization, such as exists in medicine, controls both the profession and education for it. With respect to engineering, industry and government are

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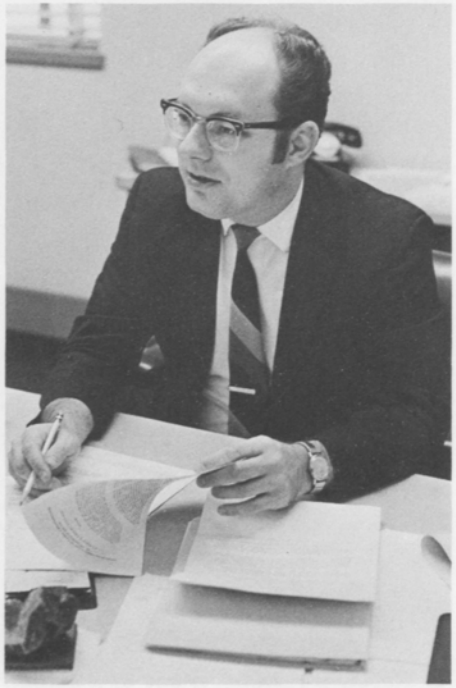

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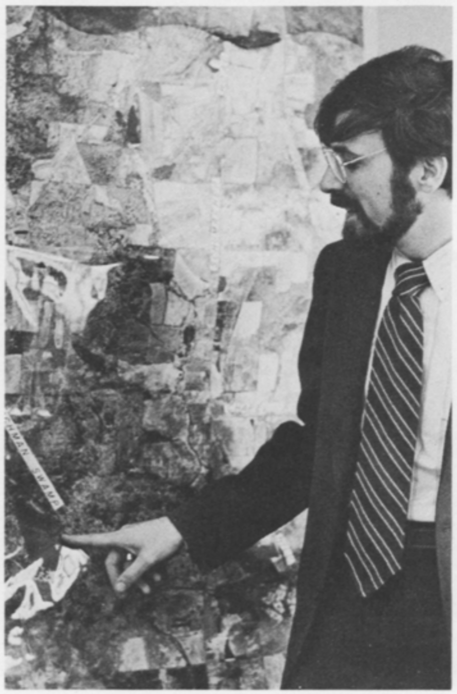

The expanding compass of engineering is evident in the activities and specialty fields of many College of Engineering faculty members, including those pictured here.

1. Pollution control has emerged as a prime concern in the research of professors in several departments. One is Joseph L. Rosson, professor of electrical engineering, who is working with students on the development of an electric car as an alternative to combustion-powered vehicles. This prototype, designed and built by electrical engineering students, won the Emissions Award at the 1972 Urban Vehicle Design Competition and has been in daily operation for the past year.

2. Research on the development of myoelectrically controlled prosthetic devices is directed by Donald L. Bartel, assistant professor of mechanical engineering.

3. Bioengineering of a different kind is a principal interest of Kenneth B. Bischoff, professor of chemical engineering, whose work includes the mathematical modeling of drug distribution in the body.

4. Environmental law is the specialty of Philip Bereano, assistant professor of environmental engineering, who holds degrees in chemical engineering, regional planning, and law.

Interdisciplinary research is conducted by members of all engineering departments at Cornell. Some of this activity is coordinated in University centers in which collaboration among professors and students from various Cornell units is facilitated, and some is developed independently.

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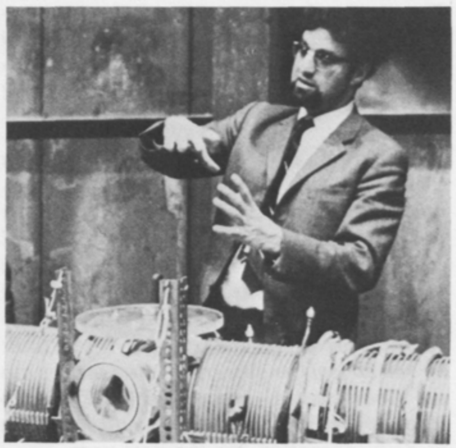

1. Among engineering professors active in the interdisciplinary Laboratory of Plasma Studies is Hans H. Fleischmann, who is using the laboratory's high-power electron beam to develop novel methods of plasma heating and containment.

2. Robert W. Balluffi is one of a number of professors in the Department of Materials Science and Engineering whose research is connected with Cornell's Materials Science Center, which provides extensive research and facilities support for various groups in the University. Balluffi and his associates are studying imperfections in solids by electron microscopy.

3. Biophysics is an interdisciplinary field in which several College of Engineering professors are working. Miriam M. Salpeter, who holds a dual appointment at Cornell in applied physics and in neurobiology and behavior, is studying the physiology of nerve cells using electron microscopic techniques.

4. The study of laser Raman scattering from biologically important molecules is a special research interest of biophysicist Aaron Lewis, new this year to the faculty of the School of Applied and Engineering Physics.

5. Research in atmospheric phenomena is a province of several engineering faculty members, including Neil M. Brice of the School of Electrical Engineering. Much of the work in this area makes use of data from the giant radar installation operated by Cornell in Puerto Rico.

6. Engineering activity in the geological sciences has increased rapidly in recent years, and a Department of Geological Sciences was incorporated into the College of Engineering in 1971. Professors Jack E. Oliver (left) and Bryan L. Isacks are directing research in seismology and its relation to the recently proposed theory of plate tectonics. The theory is providing an integrating basis for research in several disciplines, including geology, physics, and chemistry.

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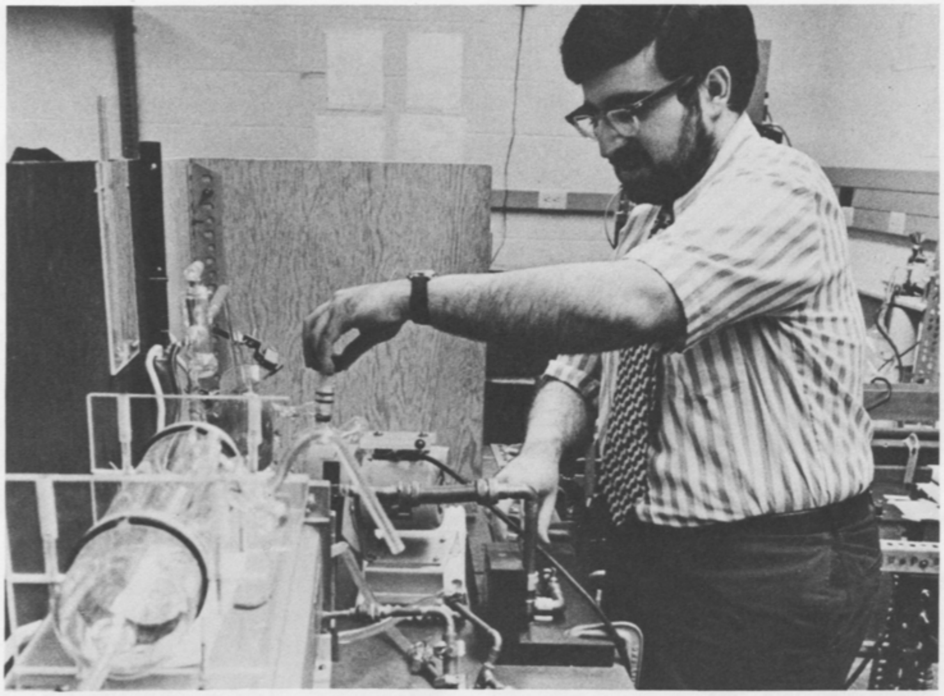

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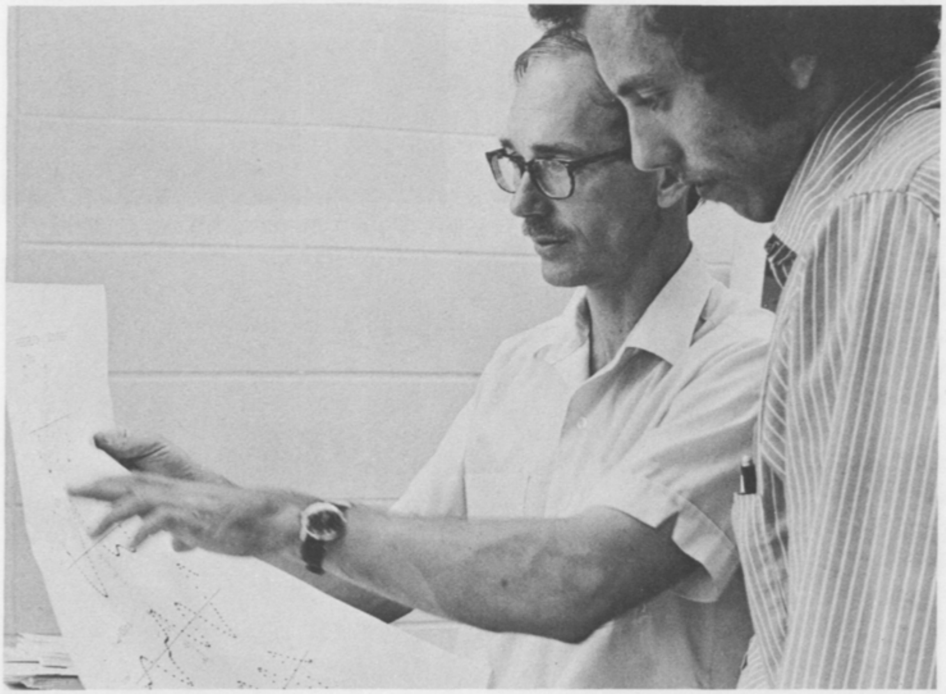

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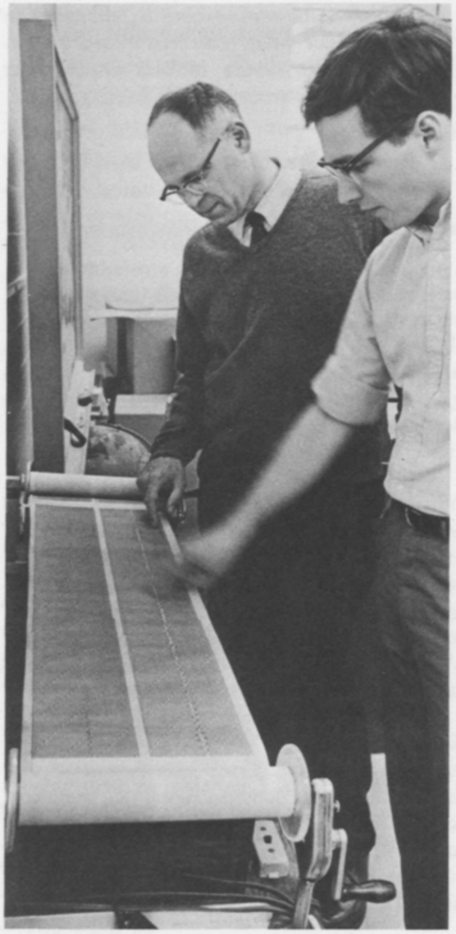

Environmental engineering is emerging as an important field. Current research activities of professors in this department at Cornell illustrate this development.

1. Planning for the use and development of natural resources is facilitated by techniques, including air-photo interpretation, developed in faculty-directed research projects in geophysical engineering. A current contracted project, for example, is helping Puerto Rican planners apply land classification and resources inventory methods. Professor Ta Liang, shown with Cornell staff members, is serving as a consultant.

2. Working in the area of public systems planning and analysis is Professor Walter R. Lynn, who has a major interest in the administration of public health programs. In one project he is developing computer procedures for predicting the probability and course of an epidemic; he is shown sending and receiving data at a typewriter terminal of Cornell's computer facility.

3. Alonzo Wm. Lawrence is directing research in the area of water quality control technology and environmental protection. Here he confers with a graduate student on analytical techniques for the determination of heavy metals in natural waters.

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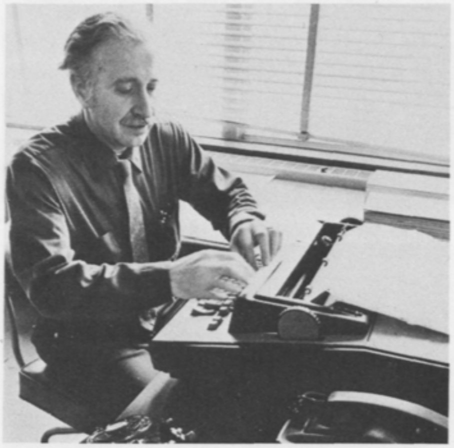

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Associate deans of the College of Engineering confer with Dean Edmund T. Cranch. Left to right are A. Richard Seebass, whose main concern is with research and graduate education; John F. McManus, who is in charge of financial and personnel matters; Cranch; and Malcolm S. Burton, whose area of responsibility is undergraduate education.

structured around the established specialties, so that although schools have been broadening the educational base, students do tend to confront, upon graduation, a "channeled" job market in which openings are quite naturally classified in terms of required special expertise. As I have suggested, however, I believe that expanding opportunities for engineers will exist beyond the basic and traditional categories.

You have recently been involved, at Cornell, in the Program on Policies for Science and Technology in Developing Nations. Would you like to comment on international aspects of engineering?

To an increasing extent, the United States is no longer self-sufficient in either a resource or economic sense, for we are inextricably involved with all of mankind. The entire world community is changing rapidly. I believe we are now experiencing a period of transition from societies based on the concept of nationalism to a system in which the interactions among groups will be dominant. The importance of world trade and its political consequences is brought home to us every day.

Clearly, the world of engineering sees this changing situation through a widespread interchange and flow of technological information, and also through an awareness of the importance of technology in international business enterprises. This is another realm in which engineers must cope with nontechnological factors, including economic, cultural, and geographic considerations.

They must also be prepared to confront a rising level of technical as well as economic competition from other nations. The United States will be confronted with a succession of technological equals—Japan is an obvious example—and because of differences in economic levels, some of these nations will be able to compete successfully with us. Engineering educators must recognize the international ramifications of the profession and help raise the level of students' consciousness of them so that they will be prepared for careers having an international component.

The emerging world of engineering will be different in many ways from the traditional one. Engineering schools and, indeed, all components of the profession must adapt to the changing attitudes of man and his society.

Edmund T. Cranch became dean of the College of Engineering last December after serving as an associate dean for almost six years and as a member of the theoretical and applied mechanics faculty for almost twenty-three. He was educated at Cornell, also, earning the B.M.E. degree in 1945 and the Ph.D. in 1951.

During his years in administration, Dean Cranch has continued an active teaching interest in the fields of mechanics and engineering mathematics, and has maintained a research program in his specialty areas of wave propagation in solids and the dynamics of shells. He also has an extensive record of service as an industrial consultant.

He is a member of a number of engineering societies, including the American Society of Mechanical Engineers, the American Society for Testing and Materials, the Society for Experimental Stress Analysis, the American Society for Engineering Education, Sigma Xi, and Tau Beta Pi.

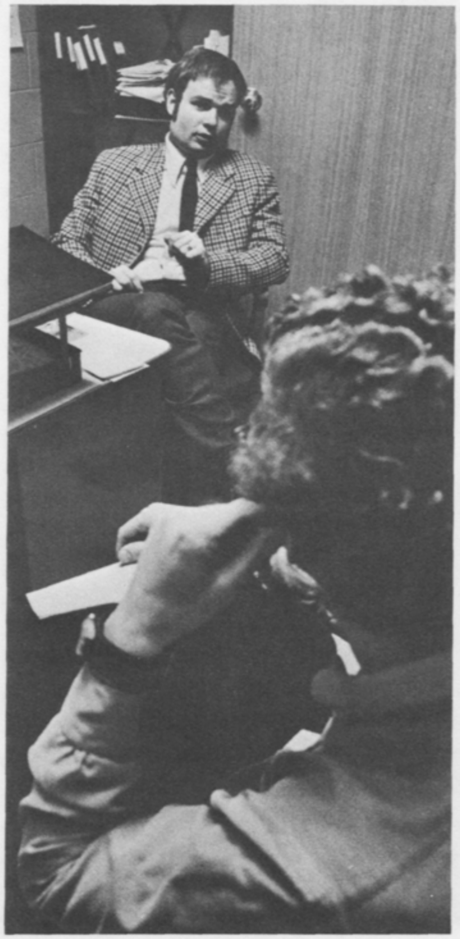
WIDENING THE PROFESSIONAL SPECTRUM

by Robert E. Gardner

Like many of his peers, Bill Brown had arrived for his admission interview fifteen minutes early, and was now sitting outside my office, well groomed and polished, nervously waiting. As I glanced down the interview information sheet, nothing unusual appeared until I reached the line, "What vocation(s) are you considering?" Bill had responded, "Medicine, Law, Business."

A year ago any of these goals would have struck me as very unusual, but now that familiarity had produced acceptance, I was really taken aback only by the fact that Bill had mentioned all three as goals, without so much as a nod to a single "engineering" field. In this respect, Bill is an extreme case. More frequently students emphasize "professional" and "engineering" alternatives equally.

The idea of engineering students who don't plan to become engineers may seem shocking to those who have not been in close contact with engineering education the past few years, although it is not an entirely new phenomenon. Actually, Bill is in part a member of a group with some historical tradition



in the College, in part a reflection of recent changes that have taken place in society and in education, and in part a forerunner in advance of a wave portending future shock. It matters little if Bill's plans strike one as unusual, for, like it or not, Bill is electing to enter one of the more rapidly growing areas in engineering education.

While I was busy interviewing Bill, Professor Andrew Schultz, Jr., then dean of the College, was drafting an article for *Engineering Education* on engineering and the professions. In his paper the dean traced the evolution of undergraduate curricula over the past decade toward flexible, basic programs of study, and concluded that ". . . it is no longer necessary to surmise that an undergraduate engineering education is an excellent foundation for many of the professional activities demanded by our society." Almost all of us in engineering education would agree, because it certainly appears that undergraduate engineering education provides all the ingredients necessary for preparing students to enter a variety of professions.

"Interest in law and medicine among beginning engineering students seems to be entering the takeoff stage."

What makes the situation crucial at the present time is that students in the class of 1976 and aspirants to the class of 1977 are suddenly hearing the dean's message loud and clear, forcing us to carefully evaluate our programs to make sure we can produce what we have promised. There are serious overtones to the evaluation, because it is not at all clear that the admissions personnel of the respective graduate schools are tuned in—and they may hold the key to the aspirations of students enrolling at the undergraduate level now. What are the prospects for students entering the College who want to have the option of pursuing a profession other than engineering?

BUSINESS—THE LEADING NONENGINEERING CHOICE

The historical development of student interest in nonengineering preprofessional education within the College is perhaps best revealed by the *Confidential Placement Reports* of the College, though these reports did not include information on fields other than engineering until 1964.

A bar graph (see Figure 1) based on the reported plans of graduates during the years 1965 to 1972 shows that business and public administration was the most significant area of interest outside engineering. The number of individuals who intended to undertake graduate study in law or medicine, the most generally recognized professional areas, was small and relatively constant. Even if it is supposed that the number of students who actually entered these fields is double that shown—which seems reasonable, since the Reports are based on a 50% response—one cannot escape the conclusion that during the past seven years undergraduate engineering education has been used as a principal route to nonengineering professional graduate work in one area only: business and public administration.

LAW AND MEDICINE AS CAREER OPTIONS

At first glance, the absence of growth in the number of engineering students preparing for careers in law and medicine seems incongruous, for these fields have been the fastest growing areas of undergraduate interest for a decade. The number of individuals applying each year to medical schools has nearly doubled in this period, and the total number of applications they have filed has more than tripled (see Figure 2). An even more phenomenal upsurge of interest has been directed to graduate study in law. At Cornell the number of applications to the law school has almost tripled within the past *five* years (see Figure 3), and other law schools have experienced similar increases. Yet the intentions of engineering graduates at Cornell have not mirrored these dramatic growth patterns. Why?

The reasons are not obscure: (1) None of the students who reported matriculated in the College's present, more flexible curriculum. (2) In the past, students who planned to study law or medicine after completing their undergraduate education did not apply to the College of Engineering. (3) Students who did enroll in the College of Engineering and subsequently decided to study law or medicine were at a slight disadvantage because of their late de-

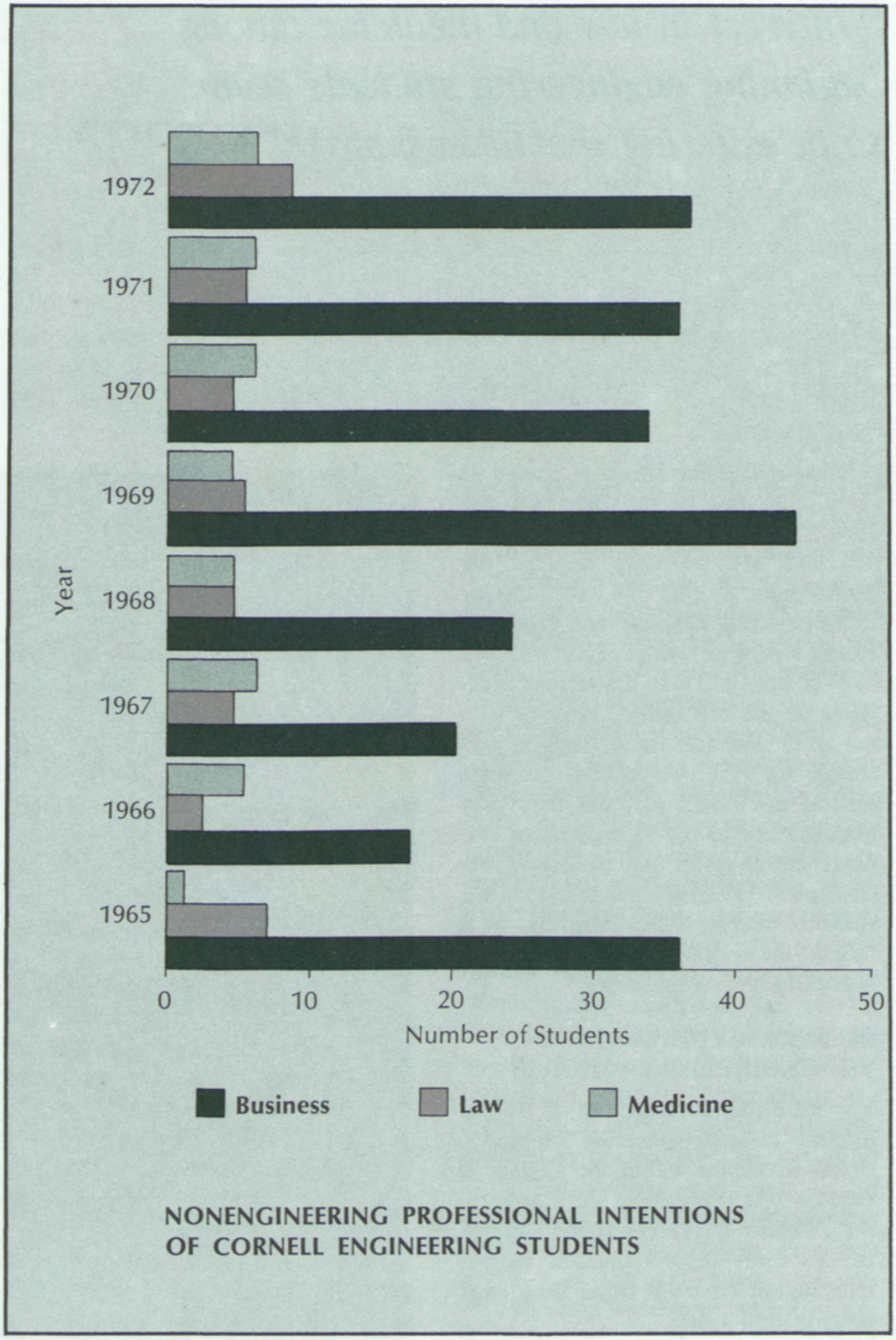


Figure 1. In recent years the dominant nonengineering professional field that College of Engineering graduates have planned to enter is business and public administration. Present indications are that law and medicine are now experiencing a marked growth in interest among students in the College. The data shown are from the Confidential Placement Reports of the College, and represent information obtained from about half the number of students in each graduating class.

cision. As a result of these factors, it has been primarily the College of Arts and Sciences that has educated the Cornell students who later entered these graduate fields.

But times are changing. Interest in law and medicine among beginning engineering students seems to be entering the takeoff stage. This year, for the first time, a sizeable number of incoming freshmen indicated their intention of preparing for graduate school in these areas; in the past, such decisions were not made until the junior or senior year. Last fall there were nearly a dozen matriculants who expressed the hope of pursuing graduate study in law. Last year sixteen seniors registered with Cornell's Premedical Advisory Committee with the intention of applying to medical schools; this number may be compared with a projected figure of perhaps three times that many for the class of 1976, this year's freshmen.

FLEXIBILITY IN THE NEW CURRICULUM

What is responsible for the broader interests of freshmen entering the College of Engineering? Recently—just three years ago—the College incorporated at the visible freshman and sophomore level a new flexible curriculum, which for the first time brought students to view engineering as a solid choice for preprofessional training in nonengineering fields. This new curriculum introduced a natural or social science elective course each semester of the freshman year, and offered a wider choice of sophomore-year engineering sciences. It cleared the way for the adaptation of an engineering program to meet the requirements for graduate professional study.

At the same time, the new curriculum has raised the expectations of students interested in preprofessional education, and created an unmistakable break with the past. Unlike their predecessors, current underclassmen do not expect to suffer the old problems inherent in making a late decision within a rather rigid engineering curriculum; rather, they expect a curriculum that will allow them to prepare themselves with minimum inconvenience and with maximum emphasis on their areas of interest.

ADAPTABILITY OF THE PRESENT CURRICULUM

Can the new curriculum produce what these students expect of it? Can they elect the courses they need?

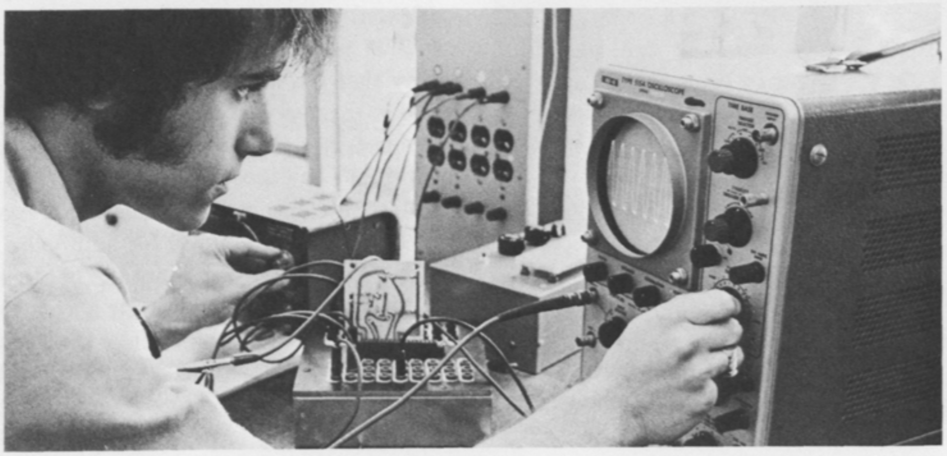
There is no problem for undergraduates who wish to prepare for graduate study in business or public administration. The necessary behavioral sciences may be taken during the first two years in the Division of Basic Studies as natural or social science electives, and the required educational breadth may be obtained through the choice of liberal electives throughout the undergraduate years. These electives can include a course or two in economics, but business and law courses are excluded as liberal electives for engineering students. Concern is frequently voiced about this apparent shortcoming, but actually these courses are not necessary or even recommended at the undergraduate level.

As upperclassmen, students preparing for advanced study in business and public administration may choose any one of a number of appropriate engineering fields as their specialty. The one most frequently selected is industrial engineering and operations research, primarily because the mathematical and analytical skills emphasized in that field are similar to those called for in the first year of graduate work and so constitute the best general preparation. Particularly perceptive students have used their upperclass field program as a foundation for a specific marketable specialty: students interested in hospital administration, for example, have selected electrical engineering and taken electives in medically oriented courses.

It is not possible to state categorically that the new engineering curriculum is appropriate preparation for law, because in terms of curricula there is no "best" or "most appropriate" preparation for law school. There are no specific courses required for admission. The essential element is not the content of the courses studied, but the way they are presented. Engineering students interested in preparing for law would do well to select elective courses that emphasize logic, require oral presentation of written material, and incorporate critical commentary by members of the class. Such courses are offered usually by the College of Arts and Sciences and the School of Industrial and Labor Relations, though more recently by the College of Engineering also.

Prelaw undergraduates in the College of Engineering have ample opportunity to fit appropriate choices into their schedules for there are available eight liberal studies electives, two natural or social science electives, and two free electives. Moreover, the number of electives is sufficient to allow students to obtain a broad foundation and still specialize in several areas; many prelaw students have concentrated on government, history, labor relations, economics, or assessment of technology. Depending on the area of law that interests an individual, a degree of specialization at the upperclass level is possible. Students in the College may use mechanical engineering as a background for patent law, or civil and environmental engineering as preparation for environmental law.

Students who are considering graduate study in medicine have an entirely different problem because they must meet extensive entrance requirements. The present engineering core curriculum provides more than enough physics and mathematics, and includes sufficient liberal studies electives to meet the English and foreign language requirements and sufficient science electives to meet the chemistry requirements. Fitting enough chemistry into the underclass schedule means, however, that only one semester of biology can be included, and then in subsequent years the student runs into problems of



Business, law, and medicine are the leading nonengineering fields of interest to students in the College of Engineering.

Top: Conrad Kenley, a junior, is planning to enter Cornell's Graduate School of Business and Public Administration after he completes his engineering education in operations research. He is hoping to organize an engineering-based business enterprise.

Center: Carl Ferrentino, a senior in environmental engineering, has applied for admission to law school. He will probably specialize in environmental law.

Bottom: Taking a premedical course in the College of Engineering is Norman Marcus, a junior enrolled in the Field Program in Electrical Engineering. He hopes to work in biomedical engineering, perhaps designing electronically operated prosthetic devices.

course prerequisites in trying to fulfil his biology requirements. The net result is that premedical students now face minor curricular problems not encountered by those headed for law or business. This situation is in the process of being remedied, however.

Overall, then, the new curriculum has created an opportunity for premed and prelaw students similar to the one that was always present for students interested in business and public administration: the principal requirements for entry into the professional school can be met within the prescribed curriculum. More importantly, this has been done without forcing students to seriously compromise either their engineering education or their professional goals. This is not to say that the current curriculum is designed to allow one to have his cake and eat it too. By no means is this true, as there are trade-offs to be made all along the way.

Nevertheless, it is now possible for a student to arrange a course of study that will enable him to choose among a number of possibilities for further study. He can, for example, simultaneously meet the requirements for medical school, study bioengineering with an emphasis on, perhaps, electrical or mechanical engineering, and prepare for traditional graduate study in either of these traditional engineering fields.

THE PROSPECTS FOR ENGINEERING GRADUATES

The next question is, how have engineering graduates fared in applying for admission to professional schools?

For engineers interested in business and public administration, success has been good to excellent. Especially at Cornell the prospects for engineers appear bright, according to George Ridenour, director of admissions and student affairs in the Graduate School of Business and Public Administration, partly because historically engineers have made up a substantial portion of the entering class (see Figure 4). Engineering graduates appear to be valued for their analytical training and familiarity with technology: experience has shown that it is normally easier to orient a person with quantitative training to behavioral modes of thought than to accomplish the reverse.

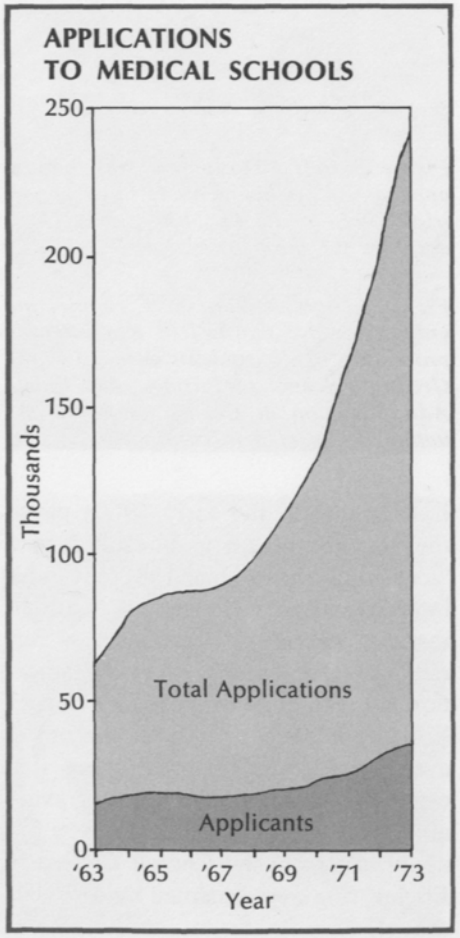


Figure 2. National figures show that over the past decade the number of applicants to medical schools has nearly doubled and the total number of applications they filed has more than tripled. (This year the average number of applications per individual is seven.) A comparable increase on the part of engineering students has not yet occurred, although indications are that this situation is changing rapidly.

The Cornell School of Business and Public Administration is particularly interested in engineering graduates as candidates for degrees in the areas of public administration and of hospital and health administration. The reason is that engineers can elect a course of study that is especially relevant to these areas while they are undergraduates. For example, a student with an undergraduate major in civil engineering and specific course work in transportation systems followed by graduate study in public administration has a desirable background that commands a very attractive salary. Similarly, a student in electrical engineering or operations research who has had course work in biology or bioengineering would be an excellent candidate for graduate work in hospital and health administration, and would have several different paths open after completing graduate study. It is, in fact, possible for Cornell engineering students to apply for a special program that permits matriculation in the business school at the end of the junior year. These students simultane-

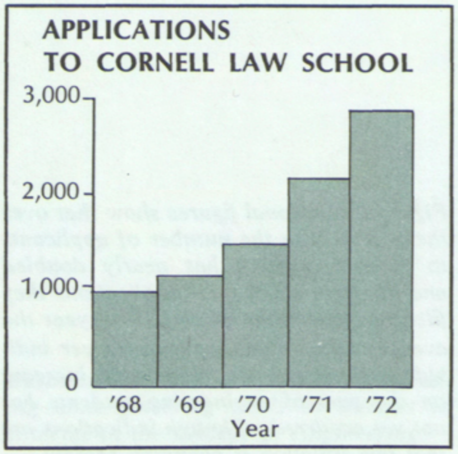
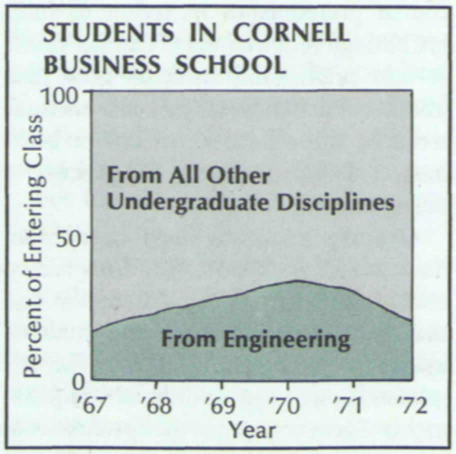


Figure 3 (left). Throughout the nation, applications to law schools have almost tripled within the last five years. These data are for the Cornell Law School.

Figure 4 (right). Historically, engineering graduates have constituted a substantial proportion of the students enrolled in the Graduate School of Business and Public Administration at Cornell, and this situation is expected to continue.



ously complete their baccalaureate degree work and begin graduate studies.

The situation for engineering students who intend to enter law school is considerably different, largely because of different admissions criteria. One criterion is performance on the Law School Admission Test, the so-called "law boards," which is required by the majority of law schools. Available results of this examination indicate that Cornell engineering students have done at least as well as those from other colleges of the University. This is not surprising, since the examination measures abilities and aptitudes rather than knowledge of specific areas.

The question that remains is whether able engineering graduates have an equal chance in the competition for law school admission. Responses from those who should know—the admissions personnel—vary depending on the institutions they represent. J. David Cullings, director of the Prelaw Advisory Committee at Cornell, feels that the good performance of a relatively few first-rate engineering graduates accepted "experimentally" by the Cornell Law School in the early 1960s paved the way for others and resulted in a "loosening" by the late 1960s. It is his impression that if engineering is not already a generally accepted prelaw curriculum, it soon will be. A rough indication may be that whereas the Cornell Law School admitted about one out of every twenty applicants last year, it is estimated (exact figures are not available) that at least two out of every five applicants from the Cornell College of Engineering were accepted by some law school.

Such figures may not cause a stampede to the College of Engineering by freshmen intending to go to law school, but it can be concluded that an undergraduate engineering education will certainly not hurt a candidate's chances for law school acceptance if he has the ability. Indeed, it might prove to be an asset; for example, if the volume of environmental legislation continues to grow, undergraduate studies in environmental engineering would provide a valuable background for a law specialty in that area.

Earlier the point was made that preparing for medical school differs considerably from preparing for law or business because of the large amount of required undergraduate course work. Before the Cornell College of Engineering instituted its "new" curriculum three years ago, it was extremely difficult for engineering students to fit the prerequisites into their schedules, and those who were successful in gaining admittance to medical school often did so not because they were engineers, but in spite of that fact. It may be that there will be a time lag before the value of engineering education is recognized by medical school admissions personnel.

One advantage of using an engineering curriculum as preparation for medical study is that an engineering graduate has other viable alternatives should he not be accepted by a medical school. As an example, a recent Cornell electrical engineering student who failed to gain admission to a medical school was admitted to a top-notch program in hospital administration and health care delivery—a program designed especially for engineers.

The importance of the present com-

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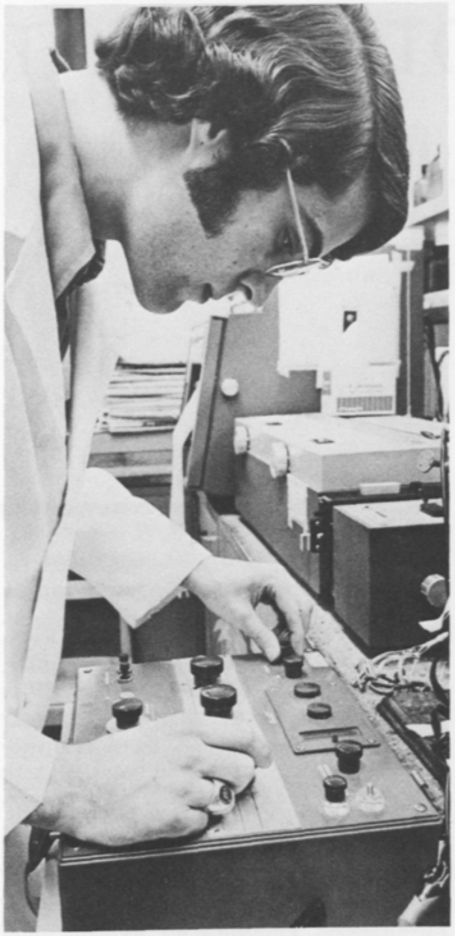

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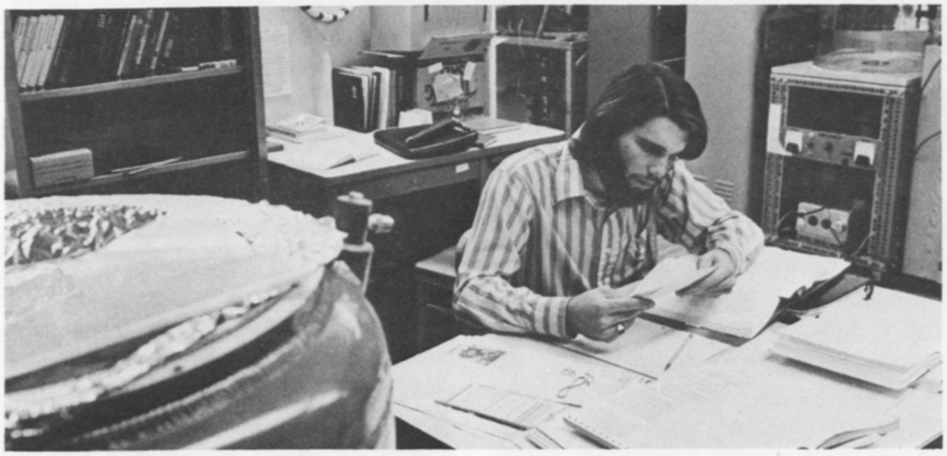

Interest in nonengineering or interdisciplinary fields is an increasingly significant trend in undergraduate engineering education.

1. Jerry Tobler, a senior, plans to do graduate work in biochemistry. Rather than specializing in a particular engineering discipline, Tobler arranged an individual upperclass College Program that permits the curricular flexibility he needs.

2. Sherri Koenig, a senior in industrial engineering and operations research, is applying for admission to the Ph.D. program in operations research, a relatively new specialty that is interdisciplinary in nature. The analysis and design of operational systems, applications of probability and statistics, and information processing are among the functions of operations research, and disciplines that may be involved include mathematics, computer science, business and public administration, and city and regional planning.

3. Bill Dobbs, a freshman, plans to concentrate on anthropology as well as structural engineering. After graduation, he hopes to participate in the development of South American countries—where he spent much of his childhood—perhaps in the building of culturally and structurally suitable housing. He finds his hobby of photography a useful skill in projects such as the field study of a housing project in Mexico that he conducted last summer.

4. A career in physics is the goal of Steven Beckwith, a junior majoring in applied and engineering physics. He would like to do research or teaching, but feels that his engineering background will prepare him well for an alternate career in industry after he completes a Ph.D. degree in physics.

mitment of the College to the philosophy of "keeping the options open" cannot be overemphasized. The response of the College to the demand for premedical training, for example, has not been to start a rigorous separate premedical program with either a direct pipeline to an established medical school or an alluring six-year total package. Such an arrangement would force students to make a "hard" decision when they entered at the freshman level, and this can be an unfortunate thing for those who subsequently fail to handle certain rigorous courses or have a change of heart. Moreover, such an approach is not attractive to the great majority of students who are undecided. For these students, the prospect of making a wrong choice and backing up to pursue a different course of study is discouraging. It is much preferable if decisions can be made in a progressive fashion as experience grows. To be sure, the luxury of maintaining options has its cost as well: the student may be obliged to take more course work and work harder than his peers who are single-minded about their goals.

For a variety of reasons, the College has a valuable asset in its ability to offer preprofessional training within an engineering curriculum. Graduates can acquire a unique background while maintaining the option of pursuing a profession other than engineering if they so desire. It is healthy to have persons with an engineering point of view in all professions, and for this reason too engineering students should be encouraged to consider other professional alternatives.

The problem of facilitating preprofessional education within an engineering school is essentially one of formulating a flexible curriculum that allows students to participate in the engineering course and still have sufficient elective choices available at appropriate times so that they can acquire the prerequisites for admission to a nonengineering graduate program. Considered in this light, the encouragement of preprofessional education may be one of the healthiest challenges the College has yet encountered, because it forces us to ponder what undergraduate engineering education is really all about.

Robert F. Gardner, director of the Engineering Advising and Counseling Center, assistant to the dean, and lecturer in engineering, writes about needs and trends in engineering education from the vantage of daily experience in working with students on their curricular and career-planning problems.

The Center, now in its third year of operation, helps coordinate the efforts of individual faculty advisers, provides career information, publishes an informational handbook and periodic newsletters for freshmen, and offers counseling on many kinds of student problems by a staff that includes College seniors.

This spring Gardner is teaching two half-semester sections of the freshman course in Engineering Perspectives. These "mini courses" are Technological Innovation and Social Change, and Creativity in Science and Engineering.

Gardner joined the College staff in 1971 after completing his Ph.D. studies at Cornell in the history of science. He received his undergraduate education at Linfield College, earning the B.A. degree in chemistry in 1966. He is a member of the American Historical Association and the History of Science Society.

TRANSFER TO CORNELL: A NEW ROUTE TO ENGINEERING

by David C. Johnson

Within the past three years, a new kind of undergraduate engineer has begun to appear at Cornell. Typically, his age is around twenty-four, he may be married and have a family, he has had several years of experience in the armed forces or in general employment, and he knows where he wants to go from here: to a professional job in an established field of engineering. He is a transfer student from a two-year community college, and he represents a significant development in higher education at Cornell and throughout the nation.

Since the fall of 1969, when the College of Engineering began an active program to recruit community college graduates as upperclass engineering students, their number at Cornell has increased to almost one hundred in the current academic year, and plans call for the matriculation of one hundred new transfers annually by 1976. Moreover, the basic commitment of the College to encourage the enrollment of community college graduates has been backed up by the allocation of engineering scholarship funds specifically for transfer students. The education of community college graduates at the Cornell College of Engineering is evidently here to stay for some time to come.

What are the reasons for the dramatic rise of community colleges, and what effects are they likely to have on our society and our universities? What is the present and future relationship between the new publicly supported two-year colleges and the more traditional public and private institutions, including Cornell? What are the potentials of the transfer student at Cornell and in the engineering profession? These are among the questions that concern us in the Office of Engineering Admissions, and others interested in the future of engineering education.

THE DRAMATIC GROWTH OF TWO-YEAR COLLEGES

America is rapidly approaching the realization of a national goal: to make higher education accessible to every qualified student. Since World War II, college enrollments have steadily increased, and although the population of college-age Americans has reportedly crested, the percentage of those who enroll in collegiate programs is still rising. Without a doubt, the most dramatic growth has been experienced by state-supported educational systems, including two-year community colleges.

National enrollment figures released by the United States Office of Education reveal that total enrollment in two-year institutions rose 5.4% between the fall of 1971 and the fall of 1972, while total undergraduate enrollment in universities and four-year schools dropped almost 2% over the same period. This means that with the start of classes this past September, public two-year colleges were making room for 135,000 more freshmen than were enrolled one year earlier, while at the same time the country's senior institutions were reporting 175,000 unfilled freshman class openings.

What accounts for the increasing popularity of community colleges? Certainly geographic accessibility, curricular flexibility, and virtual open-door admissions are contributing factors. Even more important are the financial advantages. To the student, the ability to complete a full academic year of study for normally less than $800 while living at home and often while holding a part-time job means a financial saving simply not possible at either state or private four-year institutions.

There are benefits also for the community and for the state. The funding formula for most community colleges requires that costs be shared equally by the state and by the sponsoring local governmental unit. This arrangement has a twofold advantage. The state educational dollar may be spread over a broader base of the population through the support of schools that typically have no expensive research programs or dormitory facilities. And the fact that local money is being spent obliges a community college to be responsive to the educational and vocational needs of the local constituency.

THE TRANSFER ROUTE TO FOUR-YEAR COLLEGES

Another important aspect of the rise of two-year colleges is the fact that in addition to offering vocational training, they generally serve the second purpose of providing access to baccalaureate programs in four-year institutions. It is conservatively estimated that at least 500,000 students sought transfer admission to four-year schools last fall, and that at least half of this group were from two-year colleges. Community colleges have been successful in this role largely because the transfer phenomenon has received the recognition of the educational community and of state legislatures. Many states have redesigned their educational programs to accommodate two-year college systems; and some states, including Florida, Illinois, Texas, and New York, are creating "upper level" colleges that will enroll only juniors, seniors, and graduate students, and that will guarantee transfer admission to two-year college graduates who satisfy program requirements.

CORNELL ENGINEERING AND THE TWO-YEAR COLLEGE

Transfer programs offered by a community college may include, in addition to liberal arts subjects, a preengineering or engineering science curriculum that a graduate with a good record may use as the basis of continuing study at a recognized engineering school.

In the early years there were problems in effecting transfer because of the lack of similarity between preengineering curricula and the underclass programs of established four-year schools. In response, the New York State Department of Education challenged all schools in the state to develop a common basic engineering curriculum that would facilitate the transfer of students without significant loss of time or academic credit. A task force to make recommendations was assembled in 1968. Cornell's representatives were headed by William H. Erickson, then an associate dean of the College, and included several faculty members who served on subcommittees responsible for the evaluation and recommendation of courses in mathematics, physics, chemistry, and the engineering sciences. A curriculum proposal, two years in the drafting, was unanimously approved at a joint meet-

UNDERCLASS ENGINEERING CURRICULA AT CORNELL AND AT COMMUNITY COLLEGES IN NEW YORK STATE

Subjects	Minimum Number of Semester Courses: Cornell	Community Colleges
Mathematics	4	4
Physics	3	3
Chemistry	1	2
Humanities/Social Science	6	4
Mechanics I (Statics)	–	1
Technical Electives*	4	3
Other Engineering Courses (Graphics, Computers, etc.)	2	3
	20 (66 credit hours)	20 (70-72 credit hours)

* Suggested technical electives for the Engineering Science curriculum at two-year colleges are: Mechanics II (Dynamics), Circuits (Electrical), Strength of Materials, Thermodynamics, and Materials Science. At Cornell the technical electives are chosen from a variety of sophomore Engineering Core Sciences.

ing of engineering deans in the spring of 1971, and was subsequently ratified by the state Department of Education. This standardized Engineering Science Curriculum is now available at most community colleges in New York State.

Actually, Cornell had anticipated by a year the adoption of the standardized curriculum. In 1970-71 the College of Engineering had introduced a revised Basic Studies program for freshmen and sophomores, which the recommended preengineering curriculum resembles (see the chart).

CORNELL'S EXPERIENCE WITH TRANSFER STUDENTS

Cornell's recent interest in the two-year college reflects the University's recognition that many talented students are choosing to initiate their studies at less costly institutions. Moreover, there is an advantage to the University in that the matriculation of new students at the junior-year level helps keep enrollments in upperclass courses at appropriate and economical levels. Especially in engineering, significant attrition occurs during the freshman and sophomore years and as a result upperclass courses may be underenrolled.

The College of Engineering implemented its decision to encourage the entrance of qualified two-year college students through a series of visits by Office of Admissions personnel to community colleges in New York and contiguous states. The purpose was to publicize Cornell's interest and also the availability of financial assistance for transfer students. Contacts were established with transfer counselors and special efforts were made to communicate with the community college faculty members who were responsible for the preengineering programs. These faculty contacts proved to be very important to the Cornell effort, for the lack of centralized counseling activities at most community colleges results in considerable guidance on the part of the faculty.

The visits to community colleges revealed some interesting facts. It became apparent that Cornell was one of the last engineering schools in New York State to take an active interest in community college students.

A second fact that emerged from the visits was that the general reputation Cornell enjoys as a large, highly selective, and expensive institution frightened away many qualified students. In the first year, visits to community colleges were largely ineffective in allaying these fears, and so the College sponsored "Community College Days" in an effort to bring interested, qualified students and faculty members of these colleges to the Cornell campus for a first-hand experience. The College has sponsored this program each fall since 1970, and attendance has risen substantially each year. The three-day program typically starts on Sunday evening and concludes by noon on the following Tuesday. During their stay, the visitors are free to attend engineering classes of interest, inspect the College facilities, meet with current Cornell undergraduates and professors, and generally acquire a "feel" for Cornell education. We believe that "Community College Days" have been instrumental in demonstrating the accessibility of Cornell engineering.

These efforts have been very successful in increasing the College's enrollment of transfer students. In 1970-71 seventeen students from community colleges entered Cornell; in 1972-73 ninety-five are enrolled. Fifty-five new community college graduates joined the College this past fall, and by 1976 the number of new transfers is expected to rise to one hundred each year. Such an input would almost totally offset the attrition experienced at the underclass level at Cornell.

THE SUCCESSFUL TRANSFER: A PREDICTIVE MODEL

Since the fall term of 1970, the College of Engineering has maintained performance records for each transfer student in an effort to identify significant factors contributing to success or failure at Cornell. With few exceptions, the typical first-term transfer student experiences a considerable drop in earned grade-point average (GPA) from that achieved at the two-year school. The mean drop in GPA has been 0.51, which is equivalent to one-half of a letter grade. Generally, this decline is followed by some improvement.

Anticipating this downward shift,

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These three transfer students at the College of Engineering are typical of the nearly one hundred enrolled this year.

1. Larry Dannenberg enrolled as a sophomore in the fall of 1971 after four and one-half years of active duty with the United States Army and then a year's study in the engineering science program at Rockland Community College, Suffern, New York. This year, as a junior, he entered the Field Program in Civil and Environmental Engineering and is specializing in structures. He was selected as one of five advisory aides at the College's Engineering Advising and Counseling Center, and has responsibility for assisting other veterans and transfer students from two-year colleges.

2. Joseph Krieger entered Cornell as a junior transfer student from the Agricultural and Technical College at Farmingdale, a two-year school of the State University of New York system, and he is now enrolled in the fifth-year Master of Engineering (Civil) degree program. He is specializing in aerial photographic interpretation and is carrying out a master's project on the location of preglacial buried channels by remote sensing techniques—information that is potentially useful in finding sand and gravel deposits and ground-water supplies. Krieger has augmented his studies with short-term jobs on sponsored projects related to his specialty.

3. Arthur Harris entered the engineering science program at Bronx Community College in 1969, but had to leave after a year and a half for financial reasons. After working for an air-conditioning firm in New York City for a year, he visited Cornell, was interviewed by College admissions officers, and matriculated in January, 1972, as a second-term sophomore. A participant in the Engineering Cooperative Program, Harris spent the fall term this year on assignment with the Raytheon Corporation, working in sonar research. He is now a junior in electrical engineering.

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the College sets admissions standards that require a minimum two-year college average of 2.70, equivalent to the letter grade of B−. At the present time, this required average is the most selective index reported by any engineering school in New York State; in fact, several schools admit any Engineering Science graduate. We feel, though, that selectivity in admissions is a safeguard to the student as well as to the school: The junior-level transfer—unlike his freshman counterpart—has only two years at the engineering college in which to prepare himself for graduate work or employment, and if his record during those two years is poor, so too will be his employment opportunities.

It is apparent that the measures of achievement and potential used in assessing freshman applicants—academic standing in the high-school class and standardized test data—are of questionable value in predicting success or failure for the transfer student. The vast majority of the current transfers in the College were, at best, modestly successful at the high-school level, and their Scholastic Aptitude Test (SAT) scores run considerably below those of Cornell's freshman engineers. On the other hand, motivational factors—which are not found to be significant in predicting the academic success of freshmen—appear to be highly important for transfer students.

In fact, motivation and maturity seem to be the keys to success for the two-year college graduates. They have made a firm commitment to engineering at a level (the two-year college) where educational changes may be accommodated without penalty. Furthermore, they have, typically, a mature insight into the nature of engineering—both educationally and professionally—as a result of academic exposure at the community college and, frequently, military or job experience.

A recent national study conducted by Warren W. Willingham of the Educational Testing Service corroborates the Cornell experience with transfer students. The study shows that while first-semester transfers suffer a rather marked drop in grades, at least three-fourths of them do earn the baccalaureate degree within two years of their enrollment at the senior institution. Perhaps these findings are finally providing some real ammunition for the proponents of the "late bloomer—" the student who needs a year or two of exposure to college or work before he is willing or able to produce in a competitive academic environment.

THE GOAL OF A DIVERSE STUDENT POPULATION

During the past decade, Cornell has shared with most institutions the desire to enroll a student body that represents all factions of contemporary society. Realizing this objective has been particularly difficult for established, traditional universities accustomed to meeting the educational and personal needs of a relatively elite clientele. In contrast, the community college was first designed to accommodate the needs of students of modest financial and educational backgrounds, and its students have tended to represent a wider cross section of the population. It quickly became the school for the masses.

The community college appears to meet the needs of many kinds of people. With its modest tuition charges, it is often the only school that returning veterans can afford on the G.I. Bill. It often becomes a training center for career people who want to upgrade their skills. Because of its virtual open-door admissions, the two-year school provides a second chance for those students whose educational opportunities are limited because of marginal achievement in high school. Most importantly, the community college provides an environment in which students can define uncertain interests; it provides an important link in the educational chain for those contemporary adolescents who initially reject the pressure inherent in a more traditional collegiate setting.

CAREER GOALS OF TRANSFER STUDENTS

Two-year college graduates now enrolled in Cornell engineering include all these student types. As a general group, transfer students have added two salient dimensions to the undergraduate student body: maturity and career motivation. Of the ninety-five transfers now at the College, only one-third enrolled in community college directly from high school; most of them had spent at least a year in the armed forces or in general employment. Regardless of age, they are characterized by strong engineering career goals. Almost all of them—as compared to only 50 to 60% of the freshmen at the College—plan to become practicing engineers. Many of the transfer students have specific interests in such specialities as structures, electronics, and mechanical systems and design, and most of them select the more traditional, design-oriented upperclass fields of civil, electrical, or mechanical engineering.

At the time of matriculation at Cornell, few transfer students indicate any definite plans for the future other than to obtain appropriate employment. Any decision to pursue graduate study is commonly deferred until the senior year, and the usual choice is the one-year professional master of engineering degree program. So far, few have expressed any interest in using engineering as a springboard into other fields, but this situation is expected to change as community colleges enroll students of greater affluence and educational background.

THE OUTLOOK FOR TRANSFER TO CORNELL

It is apparent that community college graduates will have greater representation on the Cornell campus in the very near future. A special University committee for the study of long-range financial planning (a group headed by engineering dean Edmund T. Cranch) recently recommended that undergraduate enrollment be increased by 2,000 students, and it is reasonable to assume that such growth would be taken up largely by transfer students. Cornell's three statutory divisions—Agriculture and Life Sciences, Human Ecology, and Industrial and Labor Relations—are currently working under a legislative mandate designed to facilitate the transfer of students from state-supported two-year colleges.

The College of Engineering, having

"It is clear that the tax-supported community college has become a permanent and vital educational resource."

developed strong ties with many two-year schools, now hopes to expand its interaction with them. Developments may include formal agreements with certain community colleges, guaranteeing transfer for engineering science graduates with prescribed credentials. The College may offer an informal community college referral service to freshman candidates who are not admitted to Cornell, in the hope that they might gain transfer admission after a successful experience in a two-year college. The College is presently working with several New York State community colleges to develop a cooperative effort to increase the enrollment in engineering of minority-group students. Such a program would seek to identify interested but educationally disadvantaged minority students, and place them in a remedial/engineering science program at the two-year college with the assurance that those who are successful will have the opportunity to continue their studies at Cornell. Both schools would share in the provision of support services such as recruitment, financial aid, and counseling.

A recent development has been a proposal by the faculty of the School of Electrical Engineering at Cornell to prepare a "packaged" version of its introductory circuit analysis course for use at community colleges which cannot offer such a course themselves. The course would be coordinated by Cornell professors operating through community college instructors who would follow a recommended course outline and administer examinations provided and graded by Cornell. It is expected that this introductory electrical engineering course will be the first of several Cornell engineering courses to be made available in "packaged" form.

In a report prepared for Governor Rockefeller this past fall, the New York State Board of Regents estimated that by the fall of 1974 collegiate enrollment within the state will increase by at least 120,000 students, with the largest growth expected at the two-year college level. It is clear that the tax-supported community college has become a permanent and vital educational resource. Anticipating this growth, the College of Engineering has moved effectively to assure its ability to work cooperatively with the two-year college system.

David C. Johnson, associate director of engineering admissions and chairman of the Transfer Admissions Committee of the Cornell College of Engineering, has been largely responsible for the development of the program for transfer students.

He has been a member of the admissions staff since 1969. Previously he served for two years as assistant director of admissions at Ohio Wesleyan University.

Johnson was graduated from DePauw University in 1967 with a major in English and a minor in economics. Since coming to Cornell, he has undertaken graduate studies in the areas of guidance and student personnel administration.

He is a member of the National Association of College Admissions Counselors, the American Association of College Registrars and Admissions Officers, the New York State Personnel and Guidance Association, the American Personnel and Guidance Association, and the American Association of Junior and Community Colleges.

VANTAGE

A New Format for Teaching Engineering Design

Intersession may be a lax period in some parts of the University, but at the School of Civil and Environmental Engineering last January some thirty Master of Engineering degree candidates designed a bridge and a regional water supply system.

The activity was part of a newly revised Master of Engineering (Civil) degree program that features an intensive three-week course in engineering design. During the time between the regular fall and spring terms, students in this program participate in full-time work on large-scale engineering problems based on actual situations. They work under the supervision of regular faculty members and visiting consulting engineers.

The purpose of the new program is to heighten the effectiveness of the students' instruction in design, according to Professor Dwight A. Sangrey, who is chairman of the School's Graduate Professional Program Committee. They spend about the same total amount of time on the design project that has always been required for the degree, but they do so in a concentrated way.

The students this year were divided into two main groups, one in the area of structural and soil engineering, and one in environmental engineering. Each group consisted of a dozen or so teams assigned to particular aspects of the overall problem. The consulting engineers spent several days on campus working with the students and returned later, during the spring term, for a presentation of the completed designs.

The project for the structural engineering group, headed by Professor Richard N. White, was to design a bridge for a crossing of Milwaukee Harbor. The consulting engineer was Gerald Fox, a principal partner of Howard, Needles, Tammen and Bergendoff, consulting engineers of New York, who designed the actual bridge, now under construction, for the site. The environmental engineering group, headed by Professor Vaughn C. Behn, worked on the updating of a design for a water supply system to serve the geographical area in which the Cornell campus is situated. Serving as professional consultant on this project was Arthur Adams, principal engineer with

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Greeley and Hansen Engineers of Chicago. Both Fox and Adams are Cornell engineering graduates.

The "new" M. Eng. (Civil) format for teaching engineering design may remind some graduates and faculty members of the summer surveying camps that used to be held twenty or more years ago. The innovative aspect of the current program, Professor Sangrey says, is that experience in the basic engineering function of design is acquired in work on a "real life" problem under professional supervision.

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Intensive work on Master of Engineering (Civil) design projects was carried out during a special three-week session between semesters.

1. Brian Grinter (at center), student project leader for the bridge design project, confers with Professor Richard N. White. Student teams were set up to design such components as the piled foundation, the pier structure, the bridge deck, and the tower and cable structure. Other groups studied loading due to wind and traffic, and designed approach ways and a highway underpass.

2. Consultant Gerald Fox analyzes design codes with student team members.

3. Professor Vaughn C. Behn, faculty adviser for the project to design a water supply system for Tompkins County, discusses chemical treatment processes with Robert Morehouse (at center) and Robert Lyon.

4. Hydraulic aspects of the water supply system are discussed by (left to right) John Puzauskas, Robert Taylor, and Paul Lewis. Other teams worked on an underwater intake structure, a plant facility, a distribution network, an economic analysis, and a study of projected population growth and water use. The final design will be presented to local authorities now involved in the planning of such a water supply system for the county.

1. Gerald Fox discusses a small-scale model for a cable-stayed bridge with (left to right) James Reid, Victor Bochicchio, and Brian Grinter. Of the several models built, this is the one the group selected for the final design.

2. Individual students sometimes worked on several project teams, each of which was responsible for a specific part of the overall design. Michael Collins (left) and Steven Schleede confer on the foundation design.

3. The group that designed the bridge piers was primarily concerned with the esthetics of the total structure, and consulted Cornell architecture professors as well as engineering specialists. Team members included (left to right) Charles Griffes, Carl Rentschler, Satish Vij, and Steven Knauss.

4. Finally, Schleede describes the design at a final presentation climaxing the entire project. The bridge design group accomplished the equivalent of three man-years of effort and feel that they have designed a bridge that would be up-to-date, economical, and visually pleasing.

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FACULTY PUBLICATIONS

The following publications and conference papers by faculty members and graduate students of the Cornell College of Engineering were published or presented during August, September, and October 1972. Earlier publications inadvertently omitted from previous listings are included here with the date in parentheses. The names of Cornell personnel are in italics.

■ AGRICULTURAL ENGINEERING

Ko, H.-S., and *Levine, G.* 1972. On Farm Irrigation and the Off-Farm System of Water Delivery in the Chianan Irrigation Association, Taiwan, Republic of China. Paper read at ADC/RTN Seminar on the Management of Irrigation Systems for the Farm Level, 16–18 October 1972, at Cornell University, Ithaca, New York.

Loehr, R. C. 1972. Agricultural Waste Control Legislation in the United States. Paper presented to officials of the Ministry of Social Affairs and Public Health, The Netherlands, 25 September 1972, at The Hague, The Netherlands.

———. 1972. Animal Waste Management—Needs and Approaches. Paper read at Farm Waste Disposal Conference sponsored by the Agriculture Research Council of Great Britain, 14 September 1972, in Glasgow, Scotland.

Parchomchuk, P., and *Cooke, J. R.* 1972. Vibratory fruit harvesting: an experimental analysis of fruit-stem dynamics. *Transactions of ASAE* 15(4):598–603.

■ APPLIED AND ENGINEERING PHYSICS

Abermann, R., and *Salpeter, M. M.* 1972. High resolution shadowing of DNA. In *30th annual proceedings of the Electron Society of America*, ed. C. J. Arceneaux, pp. 310–1. Baton Rouge: Claitor.

Abermann, R., *Salpeter, M. M.*, and Bachmann, L. 1972. High resolution shadowing. Chapter 5 in *Principles and techniques of electron microscopy*, ed. M. J. Hayat. New York: Van Nostrand Reinhold.

Brinckmann, H. F., Fromm, W. D., Heiser, C., Rotter, H., *Clark, D. D.*, Hansen, N. J. S., and Pedersen, J. 1972. Nuclear isomers in ^{113}Sn, ^{111}Sn, ^{117}Te, and ^{115}Te. *Nuclear Physics* A193:236–46.

Buhrman, R. A., *Halperin, W. P.*, and *Webb, W. W.* 1972. Thermodynamic Fluctuations in "Zero-Dimensional" Superconductors. Paper read at 13th International Conference on Low Temperature Physics, 20–25 August 1972, in Boulder, Colorado.

Claassen, J. H., and *Webb, W. W.* 1972. Fluctuation-Induced Diamagnetism in Bulk Al and Al Alloys above the Superconducting Transition Temperature. Paper read at 13th International Conference on Low Temperature Physics, 20–25 August 1972, in Boulder, Colorado.

Diederich, M. E. (1972). An Audio-Tutorial Course in Physics for Engineering and Physics Majors. Paper read at Summer Meeting of the American Association of Physics Teachers, 22–24 June 1972, in Albany, New York.

———. (1972). The context of inquiry in physics. *American Journal of Physics* 40:449–57.

———. 1972. Materials to facilitate the use of discussion in science teaching. *Journal of General Education* XXIV(3):184–7.

Dolan, G. J., and *Silcox, J.* 1972. Transition to the Mixed State in Lead Films at 4.2K. Paper read at 13th International Conference on Low Temperature Physics, 20–25 August 1972, in Boulder, Colorado.

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