The next stage in the boll weevil saga is for the USDA to evaluate its own three reports, on the biology, economics, and environmental impact of eradication, together with the Academy's critique. The department's decision is unlikely to be taken in an atmosphere of pure intellectual cogitation. Cotton growers, who are spending some $300 million a year on pest control but are suffering the same amount in pest damage, believe that they are facing a crisis.

Their opinions are not without influence in the USDA and Congress. "The growers will get together and use a blackjack on this report," predicts Davich. "If this report carries any real weight, we are not going to get into an eradication program for 5 to 10 years. But if the report falls flat on its face, we have a chance."

Budget constraints may rule out any immediate prospects for an eradication program, but the pressures to mount one will not go away. For one thing, Congress in 1973 passed a law directing the Secretary of Agriculture to eradicate the boll weevil as soon as suitable methods of doing so were at hand. As opponents of eradication wryly note, it is hard to imagine any congressman urging the repeal of the law. The scientific case for rooting out the weevil may be uncertain, but the technology is tempting, and the interests of the growers may yet prevail.—NICHOLAS WADE

# Engineering Education Under Stress

## *Undergraduate crush exacerbates shortage of faculty, resources; Iowa State avoids limits on admissions by extending time to degree*

*Ames, Iowa.* At Iowa State University (ISU), incoming students intent on majoring in high-demand specialties in engineering and computer science are warned that it may take them 5 years rather than 4 to complete their undergraduate work. The caveat is a clear local sign of what nationally is being called the crisis in engineering education.

As in other universities around the country the oversubscribed majors are electrical engineering, computer engineering, and mechanical engineering, with chemical and aeronautical engineering not far behind. At ISU the computer science department is lodged in the College of Sciences and Humanities rather than the College of Engineering, where it is in many universities, but the same overload conditions prevail.

Nationally, the "crisis" goes beyond crowding in undergraduate programs. In high-demand areas, faculty, particularly junior faculty are in short supply. Complaints about inadequate or obsolete equipment are endemic. Morale in many places is sinking.

Perhaps most significant, the ablest graduates with bachelor's and master's degrees are accepting job offers from industry on terms that universities cannot match. The result is a depletion of the ranks of graduate students on which research and teaching heavily depend.

Cutbacks in federal support of research and manpower training going back more than a decade have contributed to the problem. But the decline in status and rewards of engineering and computer science faculty compared to their counterparts in industry is a relatively new phenomenon. And there is serious concern about the current quality of engineering education and the longer term implications of a lost generation of faculty.

How are the universities dealing with the novel combination of feast and famine in engineering? What are the effects on students and faculty? To examine the crisis in terms of such practical problems as scheduling and staffing, it is necessary to focus on a specific institution. Iowa State provides an example of a technically oriented major institution with a big engineering school that this fall put fully into effect a scheme designed to maintain the quality of the engineering program while meeting the new conditions.

At ISU the trends are clear. Enrollment in engineering has virtually doubled from a low point in the 1970's to about 5375 (4815 undergraduates) this term. At ISU, the number of engineering students has increased from less than 13 percent in 1974 to more than 20 percent of the total enrollment of some 24,200 this term. Continuing the steady climb of recent years, electrical engineering rose from 671 majors last year to 745 this term, computer engineering from 370 to 440, and mechanical engineering from 631 to 673.

A key decision for any engineering school faced with current enrollment pressures is whether to limit admission to the oversubscribed specialties. At ISU, the decision was made at the top by the State Board of Regents, who set policy for Iowa's public universities. The regents have hewed to the line of its traditional policy that all Iowa high school graduates ranking in the top half of their class are eligible for admission. The alternatives are regarded as philosophically and politically unpalatable.

Working with this version of open admissions, the faculty had to devise a way to manage an overflow. In electrical and computer engineering the crunch comes in the sophomore year after students have made it through a basic engineering program. Majors are required to take a block of three entry-level courses for the "professional" engineering program. Admission to these courses is granted according to a set of firm criteria. First preference goes to qualified students earlier denied entrance. Candidates for the courses must have completed prerequisites satisfactorily and grade point averages also figure in selection. The real bottleneck is the laboratories for entry-level "professional" courses. ISU engineering faculty have long emphasized the importance of the laboratory part of the curriculum and they chose not to dilute the lab experience. This meant continuing to have lab sections of 12 students working in two-person teams. Electrical engineering department chairman J. O. Kopplin says that the faculty feels that students "need to use the instruments to know what's going on." Crowding more students into some labs could cause safety problems, but educational considerations were paramount in the decision to hold the line. Last year laboratories ran on a full schedule that included Saturday mornings. This year, half the seats in the labs go to students denied assignments earlier, so the number bumped is going up.

In the computer science department, chairman Robert M. Stewart, Jr., says that his department is also "falling further behind." The start of classes brought 300 new declared majors. The rate of growth in the department is indicated by the fact that computer science now has 700 majors, only about 100 of


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whom are seniors. The number of majors is, in fact, a poor gauge of the pressures on the department. Computer engineering majors in the College of Engineering—some 450 of them now—take a number of computer science courses in common with computer science majors. And the heavy demand from other departments of the university for computer instruction means that droves of students are turned away. Like engineering majors, prospective computer science majors are being told that it may take more than 4 years to finish.

For faculty, the increasing numbers obviously have consequences. Teaching loads in terms of assigned classes have not been substantially increased. The normal load at ISU is 12 credit hours. For most faculty members this works out to teaching two classes and performing other duties to fulfill the obligation.

Class sizes, however, have risen sharply. Lecture classes that might have had enrollments of less than 30 in the mid-1970's may now have more than 70. Engineering faculty numbers have not been increased in proportion to the rise in enrollments. This means that the number of students each faculty member is expected to advise has grown. And scheduling has grown more complex and frustrating as students more frequently are shut out of classes. Larger classes and heavier advising loads are said to be making relations between teachers and students more impersonal.

The pattern is apparently now very common in engineering schools. Edwin C. Jones, Jr., an electrical engineering professor at ISU, whose participation in national professional activities gives him a broad perspective, says that there are widespread worries about the effects of current conditions on engineering teaching. In large classes recitation is impractical and teachers resort to straight lecturing. The tendency is not to collect homework. At ISU, faculty have resisted using machine-graded examinations now common elsewhere, but Jones thinks that professors teaching large classes will almost inevitably write exams to make grading them easier.

As student numbers have increased, university budget cuts have tended to reduce support services. Clerical staff dwindles, office supplies run short, and there is no money for equipment such as word processors that might permit the administrative load to be handled more effectively.

In engineering and computer science departments, the increases in undergraduate enrollments are not paralleled in graduate education. In electrical engineering, for example, the number of graduate students in the department peaked at about 100 in the late 1960's and in recent years has hovered between 50 and 60. The numbers would be even lower were it not for an influx of foreign students into graduate programs in all U.S. engineering schools in the 1970's. At ISU, about half the current graduate students in electrical engineering are on visas. Department chairman Kopplin notes that the foreign students are generally strong in research and do well in graduate work, but in many cases lack the fluency in English to serve as teaching assistants. The scarcity of teaching assistants adds to the faculty's task of bearing the undergraduate load.

The ebb of American students in graduate programs is in part ascribed to flagging federal support of manpower training. Federal fellowships which once attracted top American graduates are no longer available. Assistantships now require performance of specific duties which give graduate students less time for work on their degrees than was customary in the past. The ISU administration has sought to keep graduate stipends competitive at least with those paid with public institutions in neighboring states and have made them tenable for 12 months rather than 9 as in the past. But the full graduate stipend, now about $700 a month, pales in comparison to what industry currently offers a graduate with a bachelor's or master's degree in engineering or computer science.

In commenting on the paucity of American candidates for doctorates, computer sciences department chairman Stewart makes the telling point that in his field, "the Ph.D. is not perceived as cost effective." The computer scientist who stays in the university for his degree "will not make up the salary difference in the long run." Others say that in hot areas such as computer graphics and artificial intelligence, researchers in industry have the edge in working freedom and equipment, traditionally advantages offered by the university.

The same calculus operates at the faculty level, particularly with junior faculty. At ISU, assistant professors are paid in the low to mid twenties for an academic year. In high-demand specialties ISU must compete not only with industry but with other universities. Engineering currently has 10 positions unfilled, some of which have been open for 2 or 3 years. Consulting traditionally offers a means for engineers to supplement their incomes. Opportunities are in some degree affected by nearness to industry and ISU, as one administrator put it, is "in the middle of a cornfield." From the recruiting standpoint, however, there are compensations. Two recent additions to the engineering faculty, for example, were glad to leave urban areas and come to Ames where schools are good and housing costs moderate by current standards.

Current constraints on university budgets make it difficult to compete in the new manpower market. ISU last year had an experience of a kind increasingly familiar to Midwest universities when a drop in state revenues caused "recision" of 4.6 percent in its operating budget. The cuts fell heaviest on building and instrumentation budgets, sharply affecting growth areas like engineering and computer science. This year there was some relief in the form of significant salary increases and a substantial raise in tuition, which the university was for the first time allowed to keep and apply to academic activities. The university administration also did what it could to give divisions with rising enrollments a budgetary dividend. But there is agreement that in the budget context of universities like ISU a major reallocation of resources is unlikely.

Faculty and administrators at ISU say expectations about state financing have changed. In future, it will be necessary for those working in engineering and computer science to take much more responsibility for acquiring equipment and even new buildings. Dean of engineering R. R. Boylan concurs, saying, "It is quite clear to us that we will need to find a supplement to state money to survive." This means forging new links with alumni and convincing industry that its own interests are served by helping to fund the departments that provide the people and ideas industry needs.

The same sort of initiative is seen as necessary in recruiting graduate students, particularly doctoral students. Universities have cooperated with industry in providing graduate training, often part time, for their employees. Now, says Boylan, industry must be convinced that it is just as important for universities to produce the academics of the future.

This year, an ISU experiment in matching numbers to resources in engineering and computer science is under way. But what if the queuing system produces an increasing backlog, making entering students feel that they face an infinite regress? If that should happen, say faculty and administrators, it would then be necessary to consider—traditions and politics notwithstanding—ISU's own version of limits to growth.

—JOHN WALSH