COMING OFF THE DRAWING BOARD: BETTER ENGINEERS?

Curriculums shift so industry gets the sort of graduates it needs

As an Apple Computer Inc. engineer in the 1980s, Joe Wujek recruited dozens of engineering students—and didn't like what he saw. Science-heavy studies and narrow specialization had left the new prospects without the skills to design products that mix mechanical and electronic components. And intense classroom competition between individual students was poor preparation for Apple's team approach to engineering.

Today, at 60, Wujek is trying to bring a real-world flavor to academia. At the University of California at Berkeley, where he now teaches, Wujek assigns students practical problems, such as building an easy-to-program vcr. His design class last spring broke with a hoary rule that barred freshmen lacking prerequisite studies from taking courses alongside seniors. Now, he has senior "managers" learning management skills by overseeing the design work of freshmen "engineers."

And he has his students negotiate their grades with him—to prepare them for future salary wrangles.

MATH DIET. Groundbreaking moves such as Wujek's are leading the most dramatic change in engineering education since the late 1950s. Back then, U.S. schools responded to the Soviets' Sputnik launch by adopting a science-heavy curriculum. Ever since, engineering students typically have spent their first two years on a heavy diet of math, physics, and chemistry, then entered a specialty such as aerospace, chemical, mechanical, or electrical engineering. And the best students were often channeled into research careers. That alignment helped the U.S. build the rockets, solid fuels, and computers needed to land a man on the moon. And it helped propel the U.S. into the lead in new technologies—from computers to high-tech weaponry.

Now, however, the end of the cold war plus fierce global competition is redefining the nation's priorities. At the same time, the pervasive impact of electronics and other advances is blurring the differences between engineering specialties. To design electronics-laden cars and many other products, industry now wants engineers with both electrical and mechanical skills. Aware of such changes, one-third of the nation's 390 engineering schools are revamping their pro-
others have begun master's degree programs requiring the completion of design projects rather than the traditional research thesis. In September, Berkeley will start a four-year "mechatronics" program that merges traditionally separate mechanical and electrical engineering studies. Responding to a 1990 survey of 90 technology experts in industry and government, Massachusetts Institute of Technology's aerospace department revised its curriculum to combine structural and propulsion engineering with new courses in statistics and computer science tailored for engineering managers.

**TIMELY LESSONS.** In another key change, some schools have begun teaching math and science within engineering courses, rather than in separate first- and second-year classes. Carnegie Mellon University now teaches differential calculus as part of a new sophomore electrical engineering course. Officials insist that such changes aren't meant to de-emphasize math and science. Instead, this "just-in-time" approach means students learn calculus or chemistry in the context of engineering problems—rather than requiring them to recall the concepts from earlier courses. Administrators also hope it will help engineering schools—whose enrollments have dropped in the past decade by 13%, to 382,000—retain students who might switch majors out of frustration at having to take so many prerequisites before they can learn engineering.

Industry, meanwhile, is seizing what it views as an unusual chance to shape its future employees. "The people responsible for establishing curriculum are open to working with industry and educators to create courses that meet real-world needs," says Pat-

rick J. Carroll, Fermi Corp.'s director of corporate technology. He helped coach Stanford into developing programs that mix business school courses in management and budgeting with advanced engineering. And current and former executives from Boeing, Digital Equipment, Ford, and other companies are on campus, teaching such courses as spacecraft design at Stanford and manufacturing at MIT.

Four industry-academic consortia, funded by the National Science Foundation, are pushing the curriculum changes. Some 34 schools are involved, including MIT, Stanford, California Polytechnic State University, and Howard University. One NSF coalition brought together workstation maker Sun Microsystems Inc. with Cornell University. Last October, Sun's manager of engineering education, G. Jeffrey Arnst, suggested developing courses based on standard computer programs that combine civil, architectural, and structural engineering. "This is the technology the real world is using. It's the experience I want to see when a student graduates," says Arnst. Cornell civil engineering professor Anthony R. Ingraffea agrees that academia needs to "reintegrate" its overspecialized disciplines to give students the mix of skills industry seeks.

The main impediment to that has been the inertia of decades-old university practices and cultures. For instance, in order to mix seniors and first-year students—which the school had ruled out to keep freshmen from getting in over their heads—Berkeley's WuJek had to create two separate courses that meet in the same room at the same time. Challenging MIT's do-it-yourself-or-die philosophy, department head Earl M. Murman led his aerospace students to work together on homework as long as they acknowledg the collaboration. Stanley V. Jaskol-

ski, chief technology officer at Eaton Corp. in Cleveland, thinks this makes sense: "The major issue facing academia today is the need to produce stu-

dents who understand the technique for teaming to produce a product."

Even administrators are challenging longstanding rules of standardized engineering education. Last year, more than a dozen schools threatened to "vill draw from the Accreditation Board for Engineering & Technology (ABET), whose rules require that engineers students take specific number of math, science, and engineering courses. The schools wanted ABET to accept courses that blend these disciplines, says Carnegie Mellon engineering dean St.

phen W. Director. For example, CMU's new course that teaches calculus within engineering would count toward meeting math requirements under ABET's current rules. "We said this is our program. If you don't want to give credit, we'll do it anyway," says Direc- tor. Now, an ABET committee is consid-

ering overhauling the rules to allow more flexible curriculums.

**OLD HANDS.** The pressure for change is likely to grow stronger. Cost-cutting at competition mean industry can no longer afford to train freshly minted engineers in practical skills they didn't get in school. "Industry now expects the university to provide some kind of support when a student is doing design work and process technology," says Arden L. Bement Jr., former TRW vice-president for science and technol-
gy, who now teaches engineering at Purdue University. Moreover, some execu-
tives say the proposed curriculum changes don't go far enough. "Universi-
ties may take a group of six engineers and call it a team," says Frederick J.

Kovac, vice-president for technology business planning at Goodyear Tire & Rubber Co. "We think a team must be multifunctional," with marketing and fi-
nance students included, for instance.

The reform movement should gather force, too, as schools such as Berkeley, Cornell, Michigan, and others welcome a new group of students—practicing engineers from industry. Many schools are setting up programs designed to teach the latest advances to these pros, who typically take classes during work or after via videoconferencing systems. The engineers stay current, and their profes-
ses get feedback from the work world. That kind of contact with industry has also helped spark a curriculum revolu-
tion at business schools in recent years, notes Zemsky. "There's no going back to old patterns of how curricula are developed," he says. After all, the nation's competitiveness depends, in part, on the skill of tomorrow's engineers.

*By Gary McWilliams in Boston*