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[Now Is The Time To Strategize The Future Of Engineering](#)

"If it works, it's obsolete." This quote from the late University of Toronto media professor Marshall McLuhan in the 1960s describes what electronics and computer engineers face every day.

Wayne Labs

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Short product life cycles. Fast turnarounds. A constant barrage of new information. A race to stay on top of technology while getting new products out the door. To win the race, America must lure college students into engineering. Otherwise, the nation could compromise its position as world leader in technology innovation as more baby boomers retire.

THE AGING WORKFORCE

What's important to older, experienced engineers? One answer dominates the list of responses to this question: staying on top of the barrage of information. With technology evolving at light speed, market forces demand an increasingly specialized engineering pool. Even within certain specialties and subspecialties, the pace of change makes adapting to new technologies a daunting challenge.

Compounding this is corporate reluctance to provide reimbursement, not just for formal continuing education, but for the technical literature, journals, seminars, etc. needed to keep up to date. An associated difficulty is the time squeeze. With reduced work forces, there just aren't enough hours in the day to filter new technologies and decide what subsets to focus on for optimal productivity gains.

What else is important? Engineers I interviewed agreed on the importance of working for companies that recognize the value of a lifetime of experience. Many companies view older engineers as less desirable and/or too expensive and seem to conclude that experience after a certain point doesn't seem to matter when compared to costs. Too many displaced senior engineers have discovered that for most companies, experience counts only if they have the "exact" experience a company needs—there's little commitment to reshaping solid basic skills to fit a specific job description.

Some companies are increasingly aware that experience is a valued commodity, and that recent grads—even those with advanced degrees—can't begin to offer the skills possessed by seasoned engineers. A study commissioned by the IEEE five years ago interviewed 139 supervisors (94% of whom actually manage the hiring process at their companies) about hiring practices. When asked to identify the specific characteristics they generally look for when hiring EEs, 35% called out technical skills/knowledge and 34% said experience. Supervisors also consider three attributes to be most

important in engineers: problem solving, teamwork, and communication skills. Older engineers (45 years and older) were rated stronger than younger engineers in problem-solving and communications skills. Supervisors saw no difference between the two groups in teamwork skills.

Older engineers searching for a position in today's job market find themselves competing with foreign engineers with temporary H-1B visas. To hire a foreign worker on an H-1B visa, the position must be a professional one that requires, at a minimum, a bachelor's degree in the field of specialization for entry into that position. The Immigration and Naturalization Service (INS) estimated that in 2000, approximately 78,000 workers came into the U.S. to fill IT jobs. According to Steve Richfield, high-tech consultant, these jobs pay about \$40,000 per year, about half the rate demanded by U.S. software engineers. Is there a desperate shortage of software engineers? The H-1B proponents think so, but Richfield suggests that there's only a shortage of willingness to employ available domestic engineers.

Another problem for the aging engineer is a "generation gap" within a company, where experienced over-50 engineering managers clash with younger, under-30 engineers. A real cultural difference can show up when younger engineers approach problem solving differently than senior management. Some companies have responded to these challenges by handling age differences as a diversity issue, much like race or gender.

RETIREMENTS SHRINK WORKFORCE

The retirement and replacement problem in the engineering population must be dealt with as the industry attempts to address markets of the future. Updated statistics from the National Science Board (NSB) paint a cautionary picture: Unless current retirement rates change significantly, the science and engineering (S&E) workforce in the U.S. will see a rapid decline in the engineering pool as the total number of retirements increases over the next two decades. More than half of those with S&E degrees are age 40 or older. This 40-44 age group is nearly four times as large as the 60-64 age group that's currently retiring. The shift of the 40-44 age group toward retirement is a red flag. Without changes in degree production, retirement behavior, or immigration, these figures imply that the S&E workforce will continue to grow, but at a slower pace, and its average age will increase over the next two decades.

There's no easy way to track engineers' retirements. Some individuals retire from one job and continue to work part time or even full time at another position, sometimes for the same employer. Others leave the workforce without a retired designation from a formal pension plan. By age 62, 50% of both S&E bachelor's and master's degree recipients no longer work full time. However, S&E doctorate holders don't reach the 50% mark until age 66 ([Fig. 1](#)). Thus, after age 55, full-time employment for PhDs remains significantly greater than for the other degrees.

According to the U.S. Department of Labor, Bureau of Labor Statistics (February 2004 Monthly Labor Review), two areas related to electronics engineering can look forward to significant growth. Computer-system analysts, who numbered 468,000 in 2002, are expected to increase by 39% to 653,000 in 2012. Software application engineers numbered 394,000 in 2002, but that number is expected to balloon 46% to reach 573,000 in 2012. Other fast-growing computer-related fields include computer-support specialists; computer software engineers, systems software; network and computer systems administrators; and network systems and data communication analysts.

ARE ENGINEERING ENROLLMENTS DECLINING?

It depends on who you ask. The NSB reports that from a 1983 peak of about 441,000 students,

undergraduate engineering enrollment declined to about 361,000 in 1999 (an 18% drop), and then rebounded to 421,000 in 2002 ([Fig. 2](#)). However, that latter figure is still 20,000 shy of the 1983 peak.

Despite the rebound, the Committee for Economic Development (CED) says the percentage of college students seeking degrees in science and engineering is still falling. Its 1985-2000 statistics show BSEE degrees earned dropping 25% over the period from 23,668 in 1985 to 17,672 in 2000. All engineering fields, not counting computer science, saw a decline of 23% from 77,572 degrees in 1985 to 59,536 in 2000. Lower CED stats may reflect the fact that not all enrolled students finish a degree.

But the engineering schools with which I spoke saw a steady or improving trend. In academic year 2002-2003, student enrollment at MIT, for example, was 10,317, compared to 10,204 in 2001-2002. There were 4178 undergraduates (4220 the previous year) and 6139 graduate students (5984 the previous year).

This upward enrollment trend was corroborated by Dr. Zaki Bassiouni, dean of the College of Engineering at Louisiana State University (LSU), Baton Rouge. While LSU's engineering enrollment has been fairly consistent, its freshman numbers show an upward trend. And for the entire department, undergrad enrollment has jumped about 250 over the last five years. Recent enrollment at the California Institute of Technology, Pasadena, has also been steady, with no indication of future declines.

Pennsylvania has a competitive engineering school market with Drexel University, the University of Pennsylvania's School of Engineering & Applied Science, Villanova's College of Engineering, all in Philadelphia; Lehigh University in Bethlehem; Penn State, University Park; and Carnegie Mellon University's College of Engineering, Pittsburgh. Drexel, Lehigh, and Carnegie Mellon University's College of Engineering are pleased to report that there's no evidence of decreasing engineering enrollments at their respective institutions. Their concern, however, is the barely increasing pool of engineering talent nationwide and what this ultimately means to U.S. technology leadership. Drexel's associate dean of engineering, Dr. Mun Choi, states that while Drexel's enrollment has been stable, national engineering enrollment seems to be falling off in fields that were considered hot just four or five years ago, such as computer science, information technology, and computer engineering.

Will these slight increases in enrollment be sufficient to replace the engineering population lost through retirement? Dr. El-Aasser, Lehigh's dean of engineering, suggests that if the percentage of women increased to the same proportion in society, we would be on track with a more appropriate number of engineering students. A study by the American Association of Engineering Societies/ Engineering Workforce Commission's (EWC) Engineering & Technology Enrollments, Fall, 2001, placed the total number of engineering freshmen at 106,825 (19,509 were women), a 4.9% increase over 2000. Computer engineering was the largest discipline at a total of 22,576 (almost 4000 women), mechanical was second at about 13,800, and EE came in third at about 13,000 students.

RETAINING EEs POSES CHALLENGE TO SCHOOLS

For Dr. G. Kemble Bennett, PhD, PE, vice chancellor, and dean of engineering at Dwight Look College of Engineering at Texas A&M University, the challenge isn't decreasing enrollment, but retaining the engineering students who do enroll. "We really haven't seen a downturn in the

enrollment of engineering students," he says. "The university has a cap on the number of engineering students we can admit, and even in a program as large as ours we consistently turn away qualified applicants. However, that doesn't mean there isn't a drop in the national averages."

Dr. Mary C. Juhas, assistant dean of the College of Engineering at Ohio State University, Columbus, agrees. Part of the problem, as she sees it, is the rigorous engineering curriculum—especially the mathematics courses, as well as "gatekeeper classes" that include chemistry and physics, both of which involve laboratory courses and demand a great deal of time.

How can colleges retain their engineering majors? Incoming freshmen who have a genuine interest in engineering as an eventual career path can be dissuaded by a low grade in math or science, especially if they were accustomed to maintaining a strong academic record in high school. In addition, students may not know if they really want to major in engineering, and the fact is, they just don't see much engineering in their first few years of study.

When Lehigh's Dr. El-Aasser realized that freshmen needed to get the big picture without waiting for junior-year engineering courses, he suggested inverting the "education pyramid." In response, the engineering college designed a three-credit course where freshmen participate in two five-week projects in teams of five to six students. Each project has at least one engineering challenge based on theoretical concepts with deliverables at the end. Students have the opportunity to pick an area of interest, and the faculty assigns a second project that forces students to move beyond their "comfort zones."

Another direct approach was implemented at Drexel about 12 years ago to decrease the weed-out rate and keep students interested in engineering. Now, all courses in physics, math, and chemistry are taught with an engineering perspective. Theoretical foundations are supported with real-world engineering applications, giving students a chance to make the correlation. Working in teams of five, students are assigned projects as their first engineering course.

"Engineering is a team sport," says Motorola CTO's chief strategist, Charlie Backof. "Unfortunately, colleges tend to teach it as an individual sport." He states that while design classes are typically the only courses that bring multidisciplinary teams of students together to solve a problem, far too many colleges fail to offer these classes until the senior year. He recommends that schools begin these classes earlier in the program and require a series of them across the full undergraduate program, rather than a single event at the end.

Texas A&M starts team projects in the freshman engineering year and requires senior-year projects that teach prospective engineers that not everything is math- and science-based. For example, national policies and business aspects of marketing, packaging, and timing are integral parts of the production process. Senior engineering students find themselves interacting with business majors and people from the Bush School of Government who are studying policy. If the project is energy-related, an awareness of government energy policies is critical to its success. This multidiscipline effort teaches students across a wide spectrum of majors to realize that just coming up with the best scientific solution may not necessarily bring a project to fruition.

For over four decades, a hallmark of Drexel's engineering curriculum has been its mandatory co-op program. Typically, students spend 18 months working in engineering companies in three cycles of six months each, getting paid, but more importantly, being treated as junior engineers with

responsibilities. They acquire professionalism and organizational skills and learn to develop presentations to sell their ideas. This is a tremendous asset for students when they look for a job. Employers find that these grads come to work ready to work.

Further recommendations come from LSU's Dr. Bassiouni, who suggests using student leaders and recent grads to reach out to new students. He recommends introducing freshmen to both academic and social programs with an engineering slant, such as engineering olympics. In addition, schools should offer tutoring services and supplemental instruction to help students succeed in engineering courses. Several schools have engineering councils, which often serve as a liaison among the administration, other societies, and engineering students. Councils serve a social purpose while also increasing engineering awareness among students.

WHAT CAN SECONDARY SCHOOLS DO?

John Kennedy, senior R&D engineer at Lumenis Inc., Santa Clara, Calif., attributes his early interest in electronics to his parents' support and encouragement. "My father had numerous pieces of war surplus electronics he let me play around with," he says. "Then I was given one of those electronic lab kits with various projects when I was about 11 or 12 years old." Kennedy's experience is typical of many engineers. Homes that foster creativity and independent thinking are essential in raising children who will be tomorrow's leaders in technology and design.

But parental involvement can only go so far. Schools must get students interested in science and how things work at an early age, because by high school, it's often too late. Middle-school courses that offer hands-on experience and explain what engineering is all about are essential, as are science teachers who actually understand the relationship between science and engineering. Teachers need the practical experience that engineering requires to relate it to the kids.

One way to develop qualified teachers is to bring them in for engineering training. Drexel has a National Science Foundation-sponsored program called Research Experience for Teachers. Each year, the Philadelphia School District brings in about 40 teachers who receive a stipend of \$5000 to work with Drexel's faculty and graduate students on cutting-edge research in such fields as information technology, wireless communications, biotechnology, tissue engineering, drug delivery, nanotechnology, and carbon nanotubes. Students find these topics exciting, but teachers often lack the confidence to talk to students about cutting-edge subjects. This continuing education and research program gives teachers both the confidence and enthusiasm to approach their students.

Middle and high schools need to be innovative in exploring ways to network with local companies to introduce young people to engineering. If students understand more about the various engineering disciplines at an early age, even as early as elementary school, they'll be more inclined to consider engineering as a career.

To interest elementary and middle school students in engineering, ROBOLAB, a joint effort of Tufts University, National Instruments (NI), and LEGO Company, offers students hands-on experience with engineering and robotics concepts ([Fig. 3](#)). Local contests give kids the opportunity to show off their inventions and programming skills. (For more information, go to www.ni.com/company/robolab_how.htm.) Future City (www.futurecity.org), sponsored by National Engineers Week, is another great example of a successful community-based program that introduces kids to engineering via the popular Sims software packages ([Fig. 4](#)).

HOT DISCIPLINES ATTRACT NEW STUDENTS

While standard-fare engineering disciplines (electrical, mechanical, chemical) won't go away anytime soon, new disciplines promise to be hot in the future and will merge with older ones to create new specialties.

Dr. Pradeep Khosla, dean of Carnegie Mellon University's College of Engineering, believes that the whole industry around VLSI technology will be hot, simply because our ability to put more transistors on a chip is growing faster than our ability to design them. He predicts that the areas of magnetic storage and computer security will see significant growth, as will IT, electrical and computer engineering (ECE), and computer science.

Another hot field is anything bio-related, such as drug discovery, drug design, discovering new molecules, and building new materials. This involves not only biomedical engineering, but also chemical engineering, materials science, and bio- and environmental-related engineering technologies.

Biomedical engineering is a perfect example of how traditional disciplines like electrical engineering are marrying with new, more exotic disciplines and jobs. One growth area is cell communication, in which EEs use signal-processing techniques to analyze the electrical impulses cells use to communicate with one another. Engineers work with cardiologists to study the heart and analyze materials and mechanics as they relate to the human body. Also, engineers in mechanical and electrical fields are major players in the health-care industry as they design and make new devices. Some of the newer technologies, such as nanotechnology and biotechnology, have seen many advances. There are whole new fields opening up at the micro and molecular levels.

According to Dr. Jay Lee, director of the NSF Industry/University Cooperative Research Center for Intelligent Maintenance Systems, University of Wisconsin-Milwaukee, there are four hot disciplines, or initiatives, for the future: information technology, biotechnology, nanotechnology, and peril or security technologies. Among these, the key discipline is information-systems engineering, which in a broad sense covers software development, electronics, functional design, system integration, maintenance design, and smart network systems. These areas are hard to define in terms of IE, EE, chemical, mechanical, bio, or other areas. But employers will assume applicants have this kind of knowledge and seek out engineers with system-level understanding.

Lee also notes a distinct change in the traditional physics, chemistry, calculus triad that has been de rigueur for college freshmen over the last three decades. Three courses form a longer-term foundation for everything else: mathematics, physics, and statistics.

With a math and physics foundation, engineers can train for almost anything, while statistics have become more important in our Internet-rich environment, where engineers must deal with data coming from everywhere. Ten years ago, before the Internet, spreadsheets and simple analysis bar and pie charts were enough. Now the data comes in real time, and those charts no longer suffice. Today, engineers often have to develop a stochastic process model or a variance diagram or a six-sigma process. Six-sigma is becoming a fundamental business tool, and it's based on statistics.

ENGINEERING AS A CAREER CHOICE?

When all is said and done, would engineers recommend their field? The answers to this question offer insights into recent trends in education as well as trends in corporate America.

Richard Metro, director of Technical Services for CookTek, Chicago, Ill., expresses frustration with recent engineering grads who don't seem to know what is expected of them in the real world. Of the grads he has observed applying for entry-level positions, many don't even know how to draw simple circuit diagrams or explain how a basic power supply works.

Metro states that too many schools focus on theory alone, suggesting that universities today focus more on "Blue Sky" technologies and gloss over the basics. With the lack of real-world internships, students are left to focus on projects that really have no application when they enter the business world. He recommends that universities focus on hands-on classes in addition to their lectures. Would he recommend engineering? The answer is a qualified yes. "In order for the U.S. to survive and prosper, we need a talented pool of highly trained engineers," he says.

David Haas, senior firmware engineer for NBS Technologies, Toronto, Canada (office in Paramus, N.J.), has worked for four employers in 22 years and left two due to downsizing or bankruptcy. Of the latter two, one was a real proponent for career development of its employees. In his experience, the problem with many engineering jobs is that some companies view their product marketing and management groups much more highly than their engineering departments, whose work could simply be outsourced to save money. Would he recommend engineering? A qualified yes is in order. Haas says that one of the toughest challenges is discovering what companies make the best employers—those that place a value on engineering and internalize the technology to gain a competitive advantage.

John Wylie, senior service technician, Dr. Schleuniger Pharmatron, Manchester, N.H., mentioned that when his great-grandfather and grandfather were engineers for Ingersoll-Rand, the company valued their expertise. Today in many corporations, engineers are pressured to hurry up and short-cut everything in the rush to market. Wylie believes that there's no future in engineering if employees feel trapped in high-pressure, impersonalized work environments. He also notes that colleges don't always prepare students for the real world. Labs and conditions are set up for ideal environments, and from his own experience, electronics courses had little or no instruction on how to troubleshoot unknown circuits.

Alan Kopnicky was dissatisfied while working for others so he started his own company. Kopnicky, president of PLC2GO Inc., Oberlin, Ohio, states that if colleges do their job, students will graduate knowing how to apply the research skills necessary to stay up to date. Colleges should consider teaching students how to work with people and how to use the tools—analyzers, emulators, scopes—of key importance. Kopnicky recommends engineering, but cautions engineers to make sure they don't pigeonhole themselves into just one or two areas of experience—keep reading and learning.

What irks Oceaneering International Inc. (Houston, Texas) systems architect Richard Mustakos? It's similar to the H-1B issue, and that's foreign graduate students who come here and do research but don't stay and become American citizens. "The problem is that we are not supporting immigrants. We are supporting transients who are taking the information back to their home countries," he says. "This is bad. We lose a strategic advantage when we fund basic research for other countries." Would he recommend engineering to others? "It is a challenging and interesting field, it is high paying, and you can contribute to society. I recommend it."

CORPORATIONS AND ENGINEERING JOBS

At the moment, the future of engineering looks a bit brighter than it looked a few years ago. Starting

salaries are improving, and most companies have career paths that will allow engineers to advance into engineering management positions or engineering sales—where there are often big rewards.

According to the National Association of Colleges and Employers (NACE, Bethlehem, Pa.) Salary Survey, there is evidence that salaries may be more attractive to 2003-2004 college graduates. For computer science grads, the average offer jumped 7.5% over last year to \$50,007. More than one-third of these offers were for software design and development positions, with an average offer of \$54,467. Positions in information sciences and systems saw an increase of 10.7% to \$44,075. The average starting salary for EE grads increased by 0.4% to \$50,761, and mechanical engineering grads' salaries edged up 0.8% to \$49,056. At the same time, chemical engineering grads' starting salaries fell by 0.3% to \$52,038, and computer engineering graduates' average offer fell by 0.2% to \$52,573. Compare these salaries to accounting majors at \$42,155; economics/finance, \$40,718; marketing, \$35,680; liberal arts, \$29,119; and communications at \$28,388.

Known for hiring the best young talent out of college, Microsoft's hirings for fiscal year 2004 include 4000 to 5000 new employees (60% in the U.S.), mostly in research and development and technical sales. R&D expenditures to enhance security for customers, improve software quality, and advance innovations are set for \$6.8 billion. When making hiring decisions, Microsoft screens for core competencies while using behavior-based interviewing to evaluate a person's creativity and problem-solving ability—qualities required of all Microsoft employees.

Pamela Ferrell, manager of Bringing in Really Cool Talent, discussed the engineering disciplines Texas Instruments (TI) is hiring now, as well as the new engineering disciplines the company will be hiring in the future. "The main positions are in six functional areas (design, product/test, process, systems, software, and program management). Within these groups, there is a huge focus on all types of wireless and broadband skills, along with RF and mixed signal. We are finding many of these skills in the U.S., with the candidates representing a mixture of U.S. citizens and engineers here in the U.S. on work visas," she says.

With the focus on systems-on-a-chip (SoCs), TI has more openings now in embedded software, systems, and integration than ever before—again with an emphasis in power management, wireless technology, and broadband. When it comes to hiring, TI sets its standards high for new engineers. Typically, TI seeks master's and PhD degrees in analog and mixed-signal technologies along with multiple internships. When hiring undergrads, the company typically selects students from very specific universities where the curriculum and professors are known entities.

However, seasoned engineers are welcome to apply. TI's technical selection criteria is very specific to the business unit they will support—and very specific to the product they will be working on. Engineers need more than technical skills. They require, for example, high energy, initiative, and the ability to be a team player, make decisions, and communicate effectively.

When asked about current hiring trends, Motorola CTO's Backof said the jobs he's filling now tend to be "up the stack." That is, they're away from the hardware and associated with the applications, networking, and human interface. Web programming is dramatically affecting all networked devices, including cell phones and public safety radios. Java and its variants are becoming a popular programming environment for a wide range of applications. Motorola can find people with these skills inside and outside the U.S. Unfortunately, at present, there are more qualified people than jobs.

What jobs may not be around for so long? Says Backof, "Generally, hardware-oriented jobs are decreasing. The march of Moore's law has commoditized much of the middle ground between silicon design and solution design, so the only places where differentiation is happening are in leading edge semiconductors, and in systems design."

According to Dr. Waguih Ishak, director of Photonics & Electronics Research Labs, Agilent Technologies, Palo Alto, Calif., Agilent hires all disciplines of engineering, and specifically EE, computer engineering, IE, and ME. More recently, bio-engineering became an important discipline because of the growth in research and development in life sciences. Agilent, a 1999 spinoff of Hewlett-Packard, has several ongoing award programs for engineers who contribute innovative solutions to problems that result in products with significant revenues. Examples include the prestigious Barney Oliver Award, named after the first director of Agilent Central Research Labs, along with monetary awards, promotion awards, and patent awards for patentable inventions.

RECRUITING FOR THE FUTURE

Mark Finger, vice president of Human Resources at NI, Austin, Texas, is keenly aware of potential shortages of engineers. "Once the baby boomers are through the system, it will be the first time where the next generation is actually smaller than the retiring generation. We've got to find ways to get people into engineering, to enjoy it, and have it as a true career path," he says.

The college co-op and intern programs discussed earlier have revolutionized hiring practices across the industry. NI, for example, has about 135 co-op or intern college students this summer, as well as co-ops year round. Its goal is to fill 25% of its engineering openings from these programs drawn from about 25 schools. Students gain valuable work experience as they check out NI and participate in its culture. From NI's perspective, the internship is a 12- to 24-week job interview. By the end of the program, NI knows these kids very well. It has been hiring interns for 23 years and, according to Finger, "success leads to success."

At General Electric, Fairfield, Conn., 65% of entry-level hires come from the pool of interns and co-op students. These programs create a "getting to know you" situation that allows management to identify a good fit between the student and the company in terms of retention and quality. According to Steve Canale, manager of Recruiting & Staffing Services, the objective for both co-ops and interns is essentially the same—to identify long-term, potential full-time hires.

And where might some of these new hires work? Biotechnology is one of the new engineering disciplines that GE is staffing along with nanotechnology, which finds its home at the Global Research Center in Schenectady, N.Y. And the core disciplines remain in demand: mechanical, electrical, industrial, and a distant fourth, chemical engineering.

Extreme Blue, IBM's intern program, combines talent and cutting-edge technology to foster innovation. Says Jane Harper, IBM director, University Talent Programs, "Since 2002, college interns in this program have filed over 170 patent disclosures, created solutions for key clients, and have helped bring to market the next generation of IBM products."

Unlike other intern programs that relegate a student to work on outdated technology, Extreme Blue allows interns to work on leading technology that helps grow their skills and makes them more attractive candidates in the technology field. Interns in this high-performance environment get to work with hot technology like Linux, grid computing, autonomic computing, and Web services. The

Extreme Blue teams are like mini-businesses that create a solution for a client while being mentored by IBM engineers. More than 4500 students vied for the 175 summer internships this year. Through this program and other intern programs, IBM will have almost 2000 interns in the U.S. this year.

CHARTING A COURSE TO THE FUTURE

According to Richard Boring, director of systems development at Borett Automation Technologies, Torrance, Calif., "While the future for engineering is very exciting, it now almost requires a master's degree. I would recommend that all engineering students take four years of physics and two years in a particular engineering master's degree curriculum. The future is full of exciting, thinking, seeing, hearing, moving machines of all sizes. Fusion or its equivalent is coming for unprecedented worldwide availability of energy. All the engineering disciplines are combining into an exciting micromachine technology that will address biotech concerns as well as myriad numbers of safety, military, transportation, and maintenance tasks. Engineering design is going to be more fun than ever with all the design implementation tools the future has to offer."

But Boring predicts trouble for many companies that don't understand the paradigm shift in the electronics industry influenced by the global economy and engineering design discipline. The majority of the industry upper management does not understand "engineering economics" (PV, PMT, FV, AMORT) and the importance of an up-front product design cycle that doesn't belong to any one department. Too many companies, large and small, are using complex software tools rather than a design methodology that involves management, interdepartmental, and peer design reviews.

Rather than being a victim of a company's poor management, engineers may need to take the freelance (1099) route. Says Boring, "I think 1099 work is the new paradigm for future engineers. My recommendation that colleges place an emphasis on 'engineering economy' is partially based on that assumption. I also think the new 1099 paradigm calls for dynamic networks of independent engineering disciplines forming into integrated product development entities with each engineering network node partaking in a percentage of the new product profitability according to a predefined/negotiated profit sharing structure."

If self-employment seems daunting, David Winter, electronic engineering manager, Henny Penny Corp., Eaton, Ohio, has some tips for choosing an employer. He recommends that job seekers look for a smaller niche company with a good track record of product innovation and market expansion. They should also consider specializing in a field like analog or high frequency design to avoid being merely a commodity EE in a big company. This is probably good advice for any profession or field, as making yourself valuable to your employer is becoming increasingly important.

INNOVATION IN THE U.S.

"I worry about the funding for basic research," says Richard Mustakos. "Things like the Apollo program were exciting, not just from a national pride and achievement point of view, but because of the output of basic research required to support it. Basic research is an expensive, risky, and unpopular thing. Most companies don't really do it unless they are in special areas (e.g., semiconductors) or are government funded, in which case some of their funding is earmarked for R&D."

However, research conducted by a small company can really pay off. Says Lucent Technologies (Murray Hill, N.J.) hardware engineering manager Roger Membreno, "A small company that puts 10% to 20% of its revenue into R&D has a better chance of working on a new product that might

make it 'big.' Take Ascend. I started working there in 1994. The company had gone public with a video-conference product. They had captured 99% of the global market, but it had little if any growth. One of the company founders saw that the Internet was the next big thing and pushed (and kicked) all of R&D to work on a remote-access server. It went from 60 employees in 1994 to over 2000 employees in 1999. Revenues got as high as \$2.3 billion. (That's over \$1 million per employee. Not even Cisco does this!)"

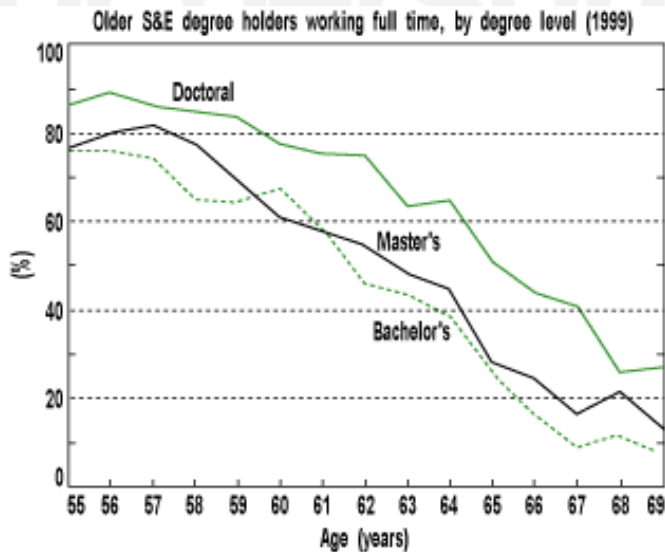
Peter Hausman, principal systems engineer at Sierra Nevada Corp., Sparks, Nev., sees engineering as a rewarding field but cautions that it's definitely not for everyone. Over the years, he's met people who chose engineering as a good job but didn't have the analytical mind to do the work well. He's known engineers who graduated as A students but couldn't solve a real problem if they tripped over the solution. To Hausman, these people were generally lost and confused about where their career was going.

SUMMING UP

The future of engineering is not just in statistics, grades, and job descriptions. Colleges must continue to develop programs that provide real-world engineering connections. Courses in the freshman year must include engineering experiences or find a way to incorporate engineering practicality in the traditional freshman courses. Internships and co-op programs are essential to prepare students for immediate placement. Professors should have real-world experience and research connections. Colleges and universities, as well as elementary and secondary schools, must develop programs in cooperation with industry.

With all of the new technologies coming on board, the future of engineering will be challenging, rewarding, and global in scope. We are no longer isolated. Engineers from around the world both compete against each other for jobs and work together on projects in a way never before possible. And as engineers of all disciplines address problems in any one part of the world, their solutions will affect us all. For example, with the fast-growing automobile industry in China, the need to produce energy-efficient cars to minimize the impact on world oil supplies will create a ripple effect through the global automobile marketplace. Whether it's environment, energy, transportation, communication, lifestyle, or our health, engineers—especially electrical engineers—have a role to play in our future.

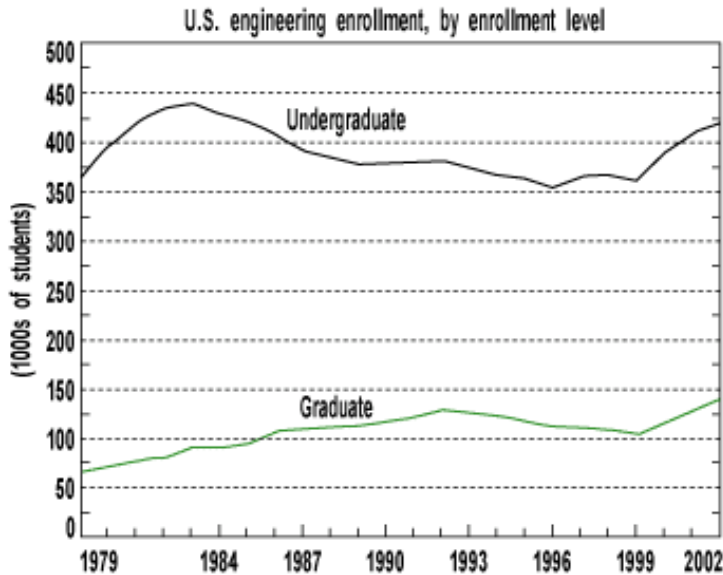
Figure 1



Source: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1999
 Science & Engineering Indicators – 2004

1. After age 55, full-time employment for PhDs is much higher than those with other degrees. In fact, 50% of science and engineering BS and MS degreed engineers no longer work full time by the age 62.

Figure 2



Note: Enrollment data includes full- and part-time students.

Source: Engineering Workforce Commission, *Engineering Technology Enrollments, 2002-2003*
 Science & Engineering Indicators – 2004

2. Though undergraduate engineering enrollment rebounded to 421,000 in 2002, it's still 20,000 off from the 1983 peak year for such enrollment.

Figure 3




3. A joint effort of LEGO Company, National Instruments, and Tufts University, ROBOLAB lets kids from grades K-12 get familiar with engineering. With the ROBOLAB system, students write programs on a computer and then transfer these programs to a programmable LEGO brick, the RCX. The system contains motors, gears, and sensors that can make the robots turn, rotate, reverse directions, start and stop, respond to their environment, and execute other robotic functions controlled by the ROBOLAB software.

Figure 4



4. Shown are the National Champions for the 2004 Future City Competition, sponsored by National Engineers Week. The victors hail from Riverview Junior/Senior High School, Oakmont, Pa. (left to right: Cara Hartz, Natalie French, teacher Brian Ludwig, Allison Garda) (Photo credit: Ben Zweig/DCEventphoto)

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