November 2006

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Available at: https://digitalcommons.uri.edu/ojgee/vol1/iss1/2
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Cover Page Footnote
This article is based on the author's keynote address given on November 11, 2005 at the 8th Annual Colloquium on International Engineering Education held at the Georgia Tech Hotel and Conference Center in Atlanta, Georgia.

This article is available in Online Journal for Global Engineering Education: https://digitalcommons.uri.edu/ojgee/vol1/iss1/2
Engineering the Future: Staying Competitive in the Global Economy

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ABSTRACT
Maintaining and bolstering America's position as an innovation and technology leader requires aggressive, progressive and creative curricular changes in engineering education. Preparing future engineers in the Age of Globalization requires additional skill sets beyond traditional technical capabilities, skill sets drawn from the humanities, social sciences and, above all, foreign languages. The author discusses how Siemens Corporation has been navigating the opportunities and pitfalls presented by globalization by seeking out and developing "Renaissance Engineers."

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Introduction
The launch of the Online Journal for Global Engineering Education (OJGEE), dedicated as it is to encouraging exchange between practitioners, educators, and students of global engineering, could not be more timely or important in light of the increasingly complex global economy. The changing dynamics of a borderless, 24/7, and increasingly politicized and "flat" world means that to succeed in business, we need to work smarter and faster in addition to acquiring new skill sets and a better understanding of geographic differences. For engineers in particular, the opportunities this changing world presents are very exciting. That is why I am eager to use this new platform to share with colleagues from the various disciplines and professions at work in these efforts a few ideas about how we can together take a more global approach to engineering education in America. If we want to succeed – if we want to retain America's position as an innovation and technology leader—we must get aggressive, progressive and creative with our curricula so that engineers and scientists have the tools and capabilities to compete in the global marketplace.

So how do we better prepare our future engineers? This is not an idle question, nor is it one merely of concern to academia or the job placement office. Science and engineering have traditionally been the driving forces behind discovery and innovation. The ability to innovate and create the next big thing drives our $12 trillion economy and keeps America on top as the world’s technology leader. More and more we realize that our domestic security and stability, our culture and society, our freedom and democracy are all connected to our economic growth and our ability to innovate.

Crossroads
I would submit that we are at a crossroads right now in America. We are currently in what Dr. Shirley Jackson of the venerable Rensselaer Polytechnic Institute calls the “quiet crisis.” Our preeminence in science and engineering is being challenged by the rise of China, India and other emerging markets that are taking full advantage of the new rules of the global economy (Freeman). Consider just a few of the trends in education (Figure 1):

- **PhDs in Science and Engineering:** The U.S. has a smaller share than Asia and Europe (89,000 degrees of 114,000 are awarded outside U.S.)
- **Undergraduate Science and Engineering degrees:** In 2000, Asia and Europe accounted for more than 2 million degrees versus 500,000 in North America. China alone matriculates 400,000 engineers annually versus the 70,000 in the U.S. In fact, the U.S. rate is down 20 percent since 1985.
- **High School:** U.S. high school students ranked 23rd in science and 28th in mathematics out of 41 countries (OECD study)
- **Elementary School:** American 4th graders score above average compared to their international peers, but their scores decline by the 8th grade.
Globalization is clearly altering the world’s economic and technological topography. The economies of China and India are catching up in the production of quality goods and services. The challenge to the competitive positions of the U.S. is a very real one. The perception of a U.S. decline is keeping some very important people up at night. In Tom Friedman’s book on globalization, *The World is Flat*, Bill Gates makes the following point: Thirty years ago, if you had to choose between being born a genius in Mumbai or Shanghai or an average person in Poughkeepsie, you would have chosen Poughkeepsie because your chances of living a prosperous and fulfilled life were much greater there. "Now," Gates says, "I would rather be a genius born in China than an average guy born in Poughkeepsie" (194).

Siemens, for example, is seizing that opportunity by taking a global approach to innovation in order to stay competitive. We do this in a number of ways by investing in trendsetting technologies and key growth regions like the U.S. and leveraging best practices – wherever they may be. Globalization has made innovation a more collaborative process and what this means for our future engineers who want to stay competitive and marketable in the global economy cannot be understated nor left unexamined.

Siemens has been in business for more than 150 years; we are the largest engineering company in Europe. We have a broad portfolio of businesses that contribute to the growth and development of many aspects of the global infrastructure. We are a leader in everything from healthcare technologies, transportation, and energy to lighting, industrial automation and water technologies (Figure 3).

From the earliest days of the company, Siemens had an international orientation and sought growth in foreign markets. Our external focus has intensified in the last decade as you can see from Figure 4. Europe is our largest single region, but the high growth markets of the U.S. and Asia are increasing in importance for us. Our intensified focus on these growth markets goes even a multinational company. My point is this: globalization is as much an *opportunity* for Americans as it is a threat. Certainly, the United States will have to make adjustments – China and India are here to stay and will continue to grow and win market share (Figure 2). But companies and individuals who take a global approach to their business and their skills should have what it takes to be competitive and to prosper.

*Figure 1*

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*Figure 2*

Well, I’m here to tell you that the demise of the average guy in Poughkeepsie is greatly exaggerated! It would be a mistake to count him out. The same is true for the graduate from an international engineering program or even a multinational company. My point is this: globalization is as much an *opportunity* for Americans as it is a threat. Certainly, the United States will have to make adjustments – China and India are here to stay and will continue to grow and win market share (Figure 2). But companies and individuals who take a global approach to their business and their skills should have what it takes to be competitive and to prosper.

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hand in hand with the rise of globalization. At Siemens, we understood the challenges and opportunities of globalization early on. Why? Because our survival and growth depended on it.

Siemens operates in 192 countries and has over 430,000 employees (Figure 5). Waiting for regional competition to develop or for other global companies to enter attractive growing markets was not an option. Therefore, we have been investing in international markets to stay one step ahead of our competitors. And investing in the U.S. has been a linchpin of this strategy.

Importantly, more than 26,000 of our 70,000 American employees work in manufacturing. In a tangible way, then, Siemens has contributed to strengthening the manufacturing base of the U.S. Of course, one of the criticisms of globalization is that jobs are being outsourced from high wage to low wage countries. Some of that is indeed happening. But on the other hand, globalization is fueling the rise of the middle class in quickly developing countries. In both China and India, for example, these markets will be very big in a few years. As their standard of living rises, residents of both countries (and others) will be able to buy more goods and services from the United States, keeping our economy strong and Americans employed.

Some hard lessons regarding globalization remain to be learned, just as Siemens discovered when it entered the U.S. telecommunications market. Initially, we set up a distribution company in the southeast and tried to import technologies from other regions. The idea was inherently flawed. We did not understand the U.S. market and the venture failed. We tried again, this time with U.S. engineers and managers who could better define and predict the market. Our results were much more successful this second time around. This experience demonstrated the need for local know-how at many levels, including customer research,
engineering, distribution, marketing and sales. It told us that business is not so simple – that sometimes you have to ‘home grow’ it. The ability of Siemens to transfer skills and technologies into and out of our U.S. businesses also taught us that innovation is borderless.

Case in point: the U.S. region is the headquarters of eleven global business units. These Centers of Competence, as we call them, have the P&L responsibility for major growth drivers of the company, ranging from our automotive business in Huntsville to lighting products at Sylvania to Medical’s Ultrasound Division and our water technologies business. So Siemens takes globalization one step further by empowering regional business units to manage – and export - products and services that can be adapted for markets around the globe.

But relentless globalization has also changed the ways in which we innovate. Innovation is now a global, borderless process. To stay on top, U.S. and European companies must tap global networks of innovation. When we think of an inventor, it is usually the classical image of the lone genius operating in a garage or small lab—Werner von Siemens tinkering in his lab in Berlin or Thomas Edison in Menlo Park, New Jersey. Or 20th Century tech titans George Westinghouse, Bill Hewlett, Bob Packard or, more recently, Steve Jobs. The individual genius of these men working alone and following their muse gave rise to companies that are still with us today. At Siemens, the current head of corporate technology, Dr. Claus Weyrich, divides the corporate Research and Development into four historical phases leading up to our current era of globalization. The first phase after World War Two was basically a pure research push that can be characterized as “technology for technology’s sake.” By the mid-1970s, it was clear that market forces had started to influence the R&D effort and we coordinated more closely with our groups. In the third phase running from the 1980s to mid-90s, processes became more important as research needed to result more quickly in marketable products. We are currently in the fourth phase, one that is marked by globalization and a razor sharp focus on the needs of our customers and our customers’ customers.

Put another way, business requirements are now firmly driving innovation in the global economy. And this has fundamentally changed the way we at Siemens go about the business of innovation. We have turned 180 degrees from the lone genius working in the garage to a global collaborative model. One example of this model can be found in the area of medical imaging technology, in which Siemens is a world leader. Name a type of sophisticated diagnostic equipment and chances are we probably make it: ultrasounds, MRI, CT scanners and so on. These systems run on sophisticated software. A few years ago we had the idea of developing a common user interface for these systems—so we created a system called Syngo. Syngo was designed to minimize eye movement and mouse clicks, making the software easy to use and improving productivity. Syngo can integrate all processes of medical imaging, from data acquisition and processing to archiving. The development team that worked on this system spanned our medical headquarters in Germany, our U.S. subsidiary in Pennsylvania, my department in Princeton, and offices in Bangalore, India. Syngo was under development for ten years across three continents and all twenty-four time zones.

The collaboration involved in developing Syngo continues every day at Siemens. We have R&D centers in Germany, the U.S., China, India, and Russia, and 45,000 people collaborating in a network of innovation around the world. Siemens also supports R&D into disruptive technologies in our technology incubator in Berkeley, the Technology-to-Business Center. Last year we opened a second Technology-to-Business Center in China. Globally, we are adding jobs in R&D and innovation.

Customers increasingly require solutions that integrate numerous complex technologies on a global basis. This is prompting companies to work more closely together. These types of partnerships have therefore become even more important for Siemens. For example, healthcare providers worldwide are seeking to lower costs while improving patient treatment. Siemens and SAP announced earlier this year that they would jointly develop healthcare IT solutions that will help to streamline workflow, improve administration and lower costs. Siemens also has a global strategic alliance with Microsoft to develop a variety of integrated communications solutions for global companies.

Many of the world’s most innovative companies have been following this collaborative model for a while now—Microsoft, Cisco, GE, Dell, and IBM, to name a few. The implications for future engineers, scientists and researchers are clear. American graduates in science and engineering in particular must become accustomed to collaborative work across cultures, traditions, and languages in order to stay relevant in the coming years.

To succeed in this new environment, new skills will be needed (Figure 7), skills that go beyond the traditional technical capabilities. Being technically proficient will still be important, of course, but in an environment that emphasizes cross-border collaboration, one needs to
augment analytical left-brain abilities with creative right-brain skills. A list of what the engineer of the 21st Century will need to succeed would look something like this:

- Good communication skills, including multiple languages
- The ability to work in teams
- Cross-cultural sensitivity and knowledge; social awareness
- Capacity to handle complex systems
- Business acumen and sense of entrepreneurship

Figure 7

To see how and why these “softer skills” have become so important, one need only take a look at another collaborative R&D effort currently underway at Siemens. Called the Global Studio Project, it involves teams from the U.S., Brazil, Germany, India, and Ireland in the practical study of diverse scientific, technical and cultural questions involved in managing a global software development team. The idea is to develop techniques to improve the efficiency, productivity and effectiveness of such development teams. These teams need not only first-rate software development and engineering skills; they also require a good understanding of cultural differences in order to be able to function smoothly in a complex social setting. It goes without saying that language skills are also critical for success.

Engineers will need these skills because their employers—and I hope it will be Siemens—have to meet a series of challenges in the globalized economy, some of which I have already touched on. Market globalization and a global value chain will require both broad global market knowledge as well as local market savvy (Figure 8). Siemens has twelve business areas and it is increasingly important to our business that we drive cross-divisional synergies. We look for talented people who can work in these virtual teams to win these big projects. Siemens also grows through acquisitions. Quickly integrating these teams is of importance to us—communication, teamwork and similar skills are key here.

Dr. Shirley Jackson of Rensselaer provides a great term for the future science and engineering worker: The “Renaissance Engineer.” To develop all of the skills just enumerated, the curriculum for engineering students will need to encompass much more than technical courses. These students will need a large dose of liberal arts, including humanities, social sciences and, perhaps above all, foreign languages. Programs like the International Engineering Program (IEP) at the University of Rhode Island (URI) are regularly adding new languages to their offerings; in the case of URI’s IEP, Chinese is currently being added to its existing curriculum of German, French and Spanish. That is a welcome development for a company like Siemens. These are the types of programs, themselves models of successful collaboration across varying constituencies, which will ensure success for its graduates and for the U.S. role in technology and innovation.

Siemens and forward-thinking companies like it encourage these broader skills in internal management review process. We call it the T-shaped profile, encompassing both general capabilities and specific skills. Siemens is looking for engineers who can speak foreign languages and who have a diversity of industry experience under their belt. At the same time, the ideal candidates have a solid combination of management or team-oriented skills. Personal characteristics and

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Published by DigitalCommons@URI, 2006
attitude also count a lot—optimistic problem-solvers are always welcome. The net is this: We are looking for engineers and other skilled employees who tap equally into their left and right brain abilities.

It is vital to Siemens that we develop these skills early on, preferably while the prospective employee is still in school. This is why Siemens was an early and active supporter of the international engineering programs at places like University of Rhode Island and Georgia Tech, as well as some of our other partner universities such as Virginia Tech. Among the programs we sponsor is an international internship that gives students exposure to global business issues and helps them nurture the capabilities crucial for success in a the global collaborative work environment. Siemens is also an enthusiastic supporter of science and engineering education at the K-12 level. In fact, we recently created a new national program—Siemens Science Day—to boost interest in science at the elementary school level. Nearly 1,000 people turned out for our Science Day at Polytechnic University in New York last month. At the high school level, we encourage the best and the brightest to pursue research projects that could win the prestigious Siemens Westinghouse Competition in Math, Science and Technology.

Looking ahead, it is difficult to foresee with any certainty where the forces of globalization will take us. According to Harvard economist Richard Freeman, the U.S. will have to share some of its technological leadership with China and India in the not too distant future. I agree with Freeman’s assessment that the net effect of this competition will be good for the U.S. and the world; the spread of modern technologies and science will raise incomes, boost global productivity, create new processes and lower costs. It will also lead to a more evenly distributed economic development around the world which will be beneficial for global political and economic stability.

Even as we evolve to a world with multiple centers of technological excellence, the U.S. is in the best position to lead this transformation. One of the key reasons is a strong system of higher education and a growing tradition of cooperation between the university and the private sector. Together, we can turn economic uncertainty into scientific possibilities. Let us embrace the new rules that reward collaboration. Together, let us refocus on our tradition of developing and nurturing the best engineers and scientists and let us reignite a passion for invention and innovation. As computer pioneer Alan Kay once said – The best way to predict the future is to invent it.

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