There and Back Again: An Academic’s Adventure in the ‘Real World’

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Abstract

In June of 2000, an adventurous academic with 12 years experience teaching in an industrial engineering program left the comfort of academia for the corporate world, returning just three years later with a new appreciation of the challenges and opportunities facing engineers in the workforce today. As manager of a group of human factors and usability professionals for a major manufacturer of consumer goods, this former academic witnessed first-hand the expectations placed on engineers in today’s consumer-oriented culture. Although strength in one’s chosen engineering field is critical, it is for better or worse a minimum requirement for the job and by no means a guarantor of success. The challenge for the returning academic – and the rest of us – is to develop effective strategies to prepare our students to be successful in all areas, and not just their technical field. This paper explores several of the skills critical to an engineer’s success and suggests ways in which we as engineering educators might help our students build those skills.

Introduction

For several years, engineering educators have been addressing the question of preparing engineering graduates for the complexities they will face in the marketplace. As defined by ABET, the criteria for accreditation are designed to "… foster the systematic pursuit of improvement in the quality of engineering education that satisfies the needs of constituencies in a dynamic and competitive environment." (ABET, 1) At the same time, a variety of institutions and individuals have developed innovative programs and instructional methods to encourage the development of specific skills and knowledge on the part of students to equip them for the competitive environment they will be entering. The purpose of this paper is to continue the discussion. The author, after several years in an academic environment, left to manage a diverse group of human factors and usability professionals at the headquarters of a major consumer products corporation. In this new role, the author interacted with corporate executives, working engineers and designers, and research and design consultants, and in the process gained a unique perspective on the challenges and opportunities facing businesses and engineering professionals today.

One of the first insights an academic might encounter when entering the corporate environment is that engineers don't engineer 'in a vacuum' - they are generally part of a larger organization that is facing competitive pressures and that must adapt quickly to new challenges and new opportunities. While this insight is not (or should not be) surprising, if we use it to shift our focus from the engineer to the business environment within which he or she will be working, perhaps we can gain some insight into the general skills needed to maintain a competitive edge. In fact, there seem to be three pervasive business pressures that are driving the current climate and will probably do so for many years to come. The first is of course the increasingly global marketplace that most if not all American businesses to some extent find themselves working within. Business is also under increasing pressure to engage in continuous and conspicuous customer-centered innovation to remain competitive. And, finally, the ever-changing business, political, cultural, and technological climate requires that business remains agile and adaptable.

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A successful engineer in this environment must possess, in addition to strong technical skills, a variety of non-traditional skills. These include the ability to compete in a global market, to engage in customer-centered innovation, and to adapt and grow to meet future needs in a dynamic business environment.

Skill #1: Succeeding in a Global Marketplace

Very few businesses today have the luxury of ignoring the global marketplace; all of the ‘big 3’ car manufacturers (and most other Fortune 500 firms) have global brands and the local grocery store serves fresh sushi. While the discussion of the global marketplace often focuses on issues of international competition and the export of jobs (including engineering jobs), the challenge of international competition goes hand in hand with the challenge of recognizing and exploiting increasing international opportunities. The same communication and transportation technologies that allow jobs to be exported also provide opportunities to compete in the wider global marketplace. The NSPE discusses the impact of the global economy on competitiveness in a position statement adopted in July of 2003, addressing in general terms the critical role of engineers at local, national, and global levels (NSPE, 2.)

Of course, competing in the wider global marketplace means dealing in a much more complex environment. Business must contend not only with international standards that may be different from current practices in the US, but also local laws, cultural mores, language barriers, and other differences, the subtleties of which cannot be clearly defined or articulated for the ‘outsider.’ It is within this context that engineers can increasingly expect to work, and understanding the subtle complexities of working in multicultural environments can in many cases be as important to success as technical expertise.

An engineer who is successful in this environment is one who can contribute to the organization's ability to compete in the global marketplace. To do so, the engineer must not only be well versed in the fundamentals of his or her engineering specialty, but also conversant in international standards and able to research and apply specific standards for the country and region in which the organization is competing. It will also be useful for the engineer to understand the broader context in which given technologies might be applied. For example, if you visit a home in Italy, you will almost certainly find that the kitchen features a gas range and/or gas oven; occasionally there may be an electric cooktop, but very rarely will there be an electric oven. If you inquire about why this is so, you will learn that Italy imposes progressive energy tariffs (meaning households pay higher tariffs when they consume more electricity) and that there is a cap on the total electricity used at any one time. A consequence of this is that Italian households tend to favor non-electric cooking appliances. The successful engineer employed by a global manufacturer of household appliances is one who recognizes this type of constraint and devotes his or her skills to developing and improving technologies that improve cooking performance in this environment.

Beyond written standards and legal constraints, though, the engineer must also be aware of the cultural and social opportunities and constraints on the application of technology. Worldwide, history, tradition, and cultural expectations will affect how readily a given technology is accepted. For instance, microwave ovens are used much more extensively for cooking in Europe than in the US due mainly to the difference in history of microwave development and use in the two regions. At the same time, in some regions in Europe the microwave is often referred to as ‘the Devil,’ perhaps reflecting the importance of traditional cooking there. (See Johnston, 3, for a more thorough examination of the role of culture in engineering design.)

Educating engineers for the global marketplace

Of course, the first question might be, “do we need to educate engineers for the global marketplace?” This might also be followed by, “aren’t we already doing this?” The answer to the first seems obvious, as evidenced not only by the previous discussion but also by the mandates of ABET criterion 3, which specifically recognizes ‘global awareness’ as a critical skill for engineers (ABET, 1.) The answer to the second of course depends on the specific educational outcomes and criteria developed by each institution or program. Many schools, including Mercer University, have instituted formal programs working with schools around the world. These programs range from
study abroad programs to internet based international design labs (Silver, 4), and even to certificate programs in 'Global Engineering.'

There are several methods, both formal and informal (and with varying degrees of energy and time required of both faculty and students) for helping students develop an awareness and appreciation of the global marketplace they are about to enter. For example, an individual faculty member could raise awareness during class by:

- Identifying ‘global’ applications or concerns associated with particular topics (for example, how differences in anthropometric measures affect the design of car interiors in the US and Japan, the complexity of managing global project teams, etc.)

- Inviting international students to comment on potential cultural, political, or societal effects on engineering design (e.g., the effect of frequent power outages on the design of devices and systems, or how one might design a refrigerator for a culture in which refrigerators are typically kept outside regardless of weather.)

- Incorporating specific examples, homework problems, etc. that address global applications or concerns.

More formally,

- The faculty in each department might agree on specific courses in which global issues will be addressed as course objectives and/or specific topics.

- Course coordinators, instructors, and technical advisors for senior capstone design courses might work together to help students identify specific global applications and concerns relative to their projects. Again, this may be informal (discuss in class or during meetings with the instructor/advisor) or formal (a specific requirement for some or all project reports.) Such discussions might also be a part of earlier design projects.

At the school and curricular level,

- Certificate programs in global awareness might be developed that include coursework in world history, world religion, anthropology/sociology, modern languages, etc.;

- Specific course requirements in humanities/social science might focus on global awareness; and,

- Special incentives and additional opportunities might be developed to encourage greater participation in study abroad programs.

In addition, faculty can model global awareness to students if they:

- Participate in international conferences and colloquia;

- Mentor students during study abroad experiences;

- Participate in and lead international study programs; and,

- Cultivate partnerships with colleagues in other countries/cultures.

**Skill # 2: Customer-centered Innovation**

In the late 70’s and early 80’s, a frightening trend was seen in the automobile and electronic industries; product quality became a primary selling point and the source for quality was not American manufacturers but Japanese.
American industry spent the next two decades ‘catching up’ to Japanese manufacturers’ quality level, while American consumers have spent the time becoming used to higher and higher levels of quality in consumer goods. Now quality is the ‘entry fee’ for playing in the manufactured products game and a new differentiator is taking its place in the competition for customer interest. ‘Innovation’ is the new mantra for industry (and institutions, government agencies, even governments themselves!) and corporations and other institutions worldwide are continually seeking new products, new markets, and even new customer needs for which they can develop products and/or services.

Innovation is of course nothing new (since the first cave person decided to call the first round thing he invented a ‘wheel’, we have been innovating), but today’s innovation is customer-centered, rather than purely technology centered and is above all deliberate. In other words, companies are trying to understand and target specific customer needs and develop innovative solutions. This is true whether the customer in question is the ‘average’ consumer, an industry, or a government. If a company is going to compete on an ‘innovation’ footing, that company must go far deeper than market research and RFPs and truly understand the latent unmet (or inadequately met) needs of the customer. The success of the Palm Pilot, for example, didn’t come about because of technology, but because the developers of the Palm made themselves intimately familiar with the needs, habits, and practices of the typical business person and developed a device which met those needs and fit in with their standard practices.

Successfully innovative companies are also able to develop creative technological and non-technological solutions to meet customer needs. They are able to work within their core competencies and also to push the boundaries of their traditional business. At 3M, for example, they know they are succeeding at innovation if they are “making middle managers and supervisors uncomfortable” (3M Corporation, 5, pg. 49.) At Whirlpool, innovation team members were encouraged to look beyond the company’s core competencies in creating product and service ideas such as Inspired Chef™ (now unfortunately out of business) and Gladiator Garage Works™.

Another key factor in the success of innovation initiatives is a dynamic blend of perspectives, areas of expertise, and backgrounds that comes from well-functioning interdisciplinary teams. For example, Cagan and Vogel (6) advocate the integration of engineers and designers in product development teams and have developed specific methods for new product development based on the integration of style and technology and firmly grounded in an understanding of consumer needs and social, technological, and economic trends. In practice, successful innovation and product development teams are multidisciplinary (engineering, design, marketing, etc.) and are based not only on sound methodologies (like those advocated by Cagan and Vogel), but also on an openness and respect for the unique strengths and perspectives each member brings to the team.

A successful engineer in an organization focused on innovation will possess, in addition to technical competence, certain skills and traits not normally addressed in engineering school. These include but are not limited to: 1) an ability to define and articulate customer, organizational, and/or societal needs; 2) an awareness and understanding of a variety of technological, social, and global trends that may or may not be directly related to his or her core competencies; 3) an openness (even eagerness) to exploring new and even ‘outlandish’ ideas; and, 4) controlled creativity.

The challenge for both the engineer and the organization is to embed or institutionalize innovation in the culture of the organization. Fortunately for us, there are ‘tools’ available to help both the organization and the individual to develop and use the necessary skills to manage innovation. We can consider these ‘creativity tools’ as another part of the engineer’s toolbox and, like traditional analytical tools, they can be used as necessary and appropriate.

**Educating engineers for customer-centered innovation**

In general, engineering programs emphasize design throughout the curriculum (beginning, at Mercer, with a Freshman Design course) and focus on teaching good design methodology, thereby laying the groundwork laid for developing innovation skills in engineering students. Innovation, however, is more than sound design methodology; it involves the ability to research, identify, and understand critical latent needs, as well as an ability to think creatively as well as analytically. Luckily, these skills can be developed with the right set of tools.
To help students develop an ability to identify latent and unmet needs, we can:

- Teach research and interview skills throughout the curriculum, beginning with freshman design and including ‘refreshers’ in all courses with open-ended design problems. This should include specific methods for performing library, internet, and other types of research, as well as interview and analysis techniques to identify client needs (which are often vague even for the client.)

- Encourage students to participate in courses and extracurricular activities that focus on understanding and meeting the needs of individuals and communities.

- Teach specific methods for analyzing and synthesizing research results and require students to use these methods when identifying specific need(s) or design problems.

To encourage the development of creativity in students, we can:

- Teach effective brainstorming methods, such as DeBono’s ‘Six Thinking Hats.’ (DeBono, 7)

- Teach specific creative problem solving methods.

- Encourage both individual and group work that requires creativity for a successful solution.

- Because the exchange of different viewpoints helps to foster creativity, encourage multi-disciplinary learning opportunities. These opportunities could include interdisciplinary courses, multidisciplinary senior design projects, or simply assigning students to multidisciplinary groups to complete group assignments in core courses.

- Develop and encourage opportunities for students to work with students and/or professionals in traditionally 'creative' fields such as art, music, architecture, etc.

In addition, faculty could model a focus on creativity and innovation by:

- Participating in innovative and/or interdisciplinary projects and actively publicizing these efforts among students.

- Engaging students in developing innovative research projects.

- Experimenting with alternative and innovative methods in the classroom, lab, on assignments, etc. and explicitly informing students that they are trying an innovative approach. Encourage students to honestly evaluate the methods and results.

**Skill #3: Adaptability**

In order to effectively innovate and successfully compete in a global marketplace, engineers will need to cultivate ‘adaptability,’ or the ability to recognize and respond appropriately to global, political, technological, and market trends (Ames, 9.) Although this particular skill has always been critical for ongoing success, the pace of change today has become so great that a new field of ‘change management’ has developed just to help organizations respond to new challenges and opportunities. Successful change management, or adaptability, requires a proactive and thoughtful response to a robust understanding of the current situation and future trends. Successful development and application of this skill requires an engineer to develop social, political, and critical thinking skills equal to the traditional technical skills we normally associate with the field. (Beder, 8.)
Necessary skills to compete in a highly adaptive environment include the ability to research and understand trends in relevant business, political, social, and technological arenas. The ability to understand and/or define current and future business strategy with respect to those trends is also critical. Finally, managing the transition from the current to the future strategy entails significant problem solving skill and individual adaptability.

An engineer in this environment must similarly be able to identify and understand relevant trends that signal a need for change. He or she must have the skills and knowledge necessary to view these trends from a variety of perspectives and identify potential opportunities for change. Once these opportunities are defined, the successfully adaptable engineer will be willing and able to seek out new knowledge and skills, whether in service to the current employer/industry or in preparation for a career in new industries.

**Educating ‘adaptable’ engineers**

Teaching 'adaptability' is probably one of the more difficult issues to confront. From one perspective, one might acknowledge that knowledge breeds adaptability and focus on those skills and techniques that foster a commitment to lifelong learning. In addition, though, the type of adaptability we would wish to foster is applied in the context of global awareness and customer focused innovation, so many of the specific skills we would like to promote with respect to those areas would be applicable here, as well. For example,

- The ability to research and synthesize information regarding global issues and customer needs will also be useful in identifying and evaluating trends affecting one’s business environment and career.
- Creative problem solving skills are critical to successfully respond to changes in business environments.
- Collaborating with students and professionals in other engineering and non-engineering fields increases awareness of other fields, as well as knowledge of other approaches and opportunities for business and career.

Some specific methods to promote adaptability in engineering students might include:

- Develop interdisciplinary courses (such as “Mechatronics” or “Human Factors of Machine Design”) and require students to approach problem solutions from a perspective other than their own (for example, the ISE students in the “HF of Machine Design” are responsible for a portion of the machine design work and the ME students are responsible for a portion of the human factors design and evaluation.)
- Encourage or require multidisciplinary teams for senior design. Of course, this may require extra effort to work with outside clients to develop realistic multidisciplinary projects or a decision to ‘create’ projects in-house that adequately address the requirements of all disciplines.
- Define and offer true independent study courses that require students to identify their own learning needs, learn the material independently, and apply what they have learned to an open-ended problem.
- Within ‘traditional’ courses, develop open-ended assignments that require the same type of independent definition of learning needs, learning, and application, but on a smaller scale.
- Faculty might also be encouraged to explore research and learning opportunities outside of their own discipline and to actively publicize their efforts.
Looking Ahead

The hallmark of a 'good engineer' has always been technical expertise. In today's dynamic and competitive environment, however, technical expertise is now a necessary but not sufficient requirement for career success. A variety of skills, three of which have been discussed in this paper, will be required in order for an engineer to succeed in today's marketplace. The challenge for engineering educators is to understand these skills and develop programs and instructional methods that encourage and support engineering students to develop them. The intent of this paper is to continue the discussion in that direction. As we look ahead to continued growth and adaptation, ongoing discussion among educators, industry, and other constituencies will be critical. In essence, engineering education must foster the skills in itself that it seeks to instill in its students. We must learn to 'think globally,' to be both customer-centric (i.e., student-oriented and responsive to the needs of our constituencies) and innovative, and to be adaptable in our methods and perspective.

References


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