AC 2010-251: SOFT SKILLS FOR THE NEW ECONOMY: THEIR PLACE IN GRADUATE EDUCATION IN ENGINEERING AND ENGINEERING TECHNOLOGY

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Professional Skills for the New Economy: Their Place in Graduate Education in Engineering and Engineering Technology

Abstract

Much has been made in the media of the skills required for the new economy, and the role of professional or "soft" skills in getting and keeping a job. Technical skills alone are no longer sufficient to prepare graduates in engineering and engineering technology for a career. ABET and other accreditation standards acknowledge the role of these skills in engineering and engineering technology education at the undergraduate level, but what is the role of the so-called softer skills in graduate education? This paper will explore the definition of these non-technical skills, recent emphasis in the job market on soft skills for employees, the role of these skills in technical education, and provide some thoughts on how soft skills can be incorporated in graduate education in engineering and engineering technology.

Introduction

Recently, there has been significant discussion in the media on the skills required for the new economy, and the role of professional or soft skills in getting and keeping a job. In fact, according to one recent research report (discussed extensively below), only 31.5% of four year graduates enter the workforce with excellent professional skills.[1] While the research report discusses graduates of four-year institutions and their work skills, this author posits that any identified shortcomings in four-year education can be remedied not only by changing the education in undergraduate education, but also by addressing those employer needs at the graduate level. Without question, technical skills are required in technical professions, but those technical skills alone are no longer sufficient to prepare graduates in engineering and engineering technology for career success. Accreditation standards from such significant bodies as ABET and ATMAE acknowledge the role of professional skills in engineering and engineering technology education at the undergraduate level, but what about graduate education? Should graduate education include professional skills training? In this paper, the author will suggest a broad list of professional skills, explore some recent research from employers on these professional skills for employees, and provide some thoughts on the benefits of professional skills and how these skills can be incorporated in graduate education in engineering and engineering technology. For purposes of this paper, the author will use the terms soft skills, professional skills, and applied skills interchangeably.

Discussion

The "new economy" is frequently discussed in the media. For the purposes of this paper, the new economy encompasses the work world of Dan Pink's future, in which creativity, connection and design (often referred to as right brain skills) are as or more important than left brain skills (logic, analysis, and left brain skills).[2] Even if you do not subscribe

to Dan Pink's views of the current and future world of work, a review of the media sources indicates that the new economy is in general is global, technology driven, service oriented, and relies more on brain power than physical labor. Some use the term "global economy" to refer to a similar concept. Whichever term is used, professional skills have a large role to play.

"Soft skills"

If one were to ask educators in technical fields such as engineering or engineering technology what is meant by the term "soft skills", there would likely be some consensus on the list, but each educator asked would probably have a slightly different list. For many, the list of those "soft" or professional skills is derived from ABET accreditation standards.

Soft skills can be seen in the Technology Accreditation Criteria of ABET. For example, TAC/ABET Criterion 2[3] lists the eleven areas of expertise a graduate must possess upon program completion, known as the "a-k" criterion. Under this standard an engineering technology program must demonstrate that graduates have:

> a. an appropriate mastery of the knowledge, techniques, skills and modern tools of their disciplines,
> b. an ability to apply current knowledge and adapt to emerging applications of mathematics, science, engineering and technology,
> c. an ability to conduct, analyze and interpret experiments and apply experimental results to improve processes,
> d. an ability to apply creativity in the design of systems, components or processes appropriate to program objectives,
> e. an ability to function effectively on teams,
> f. an ability to identify, analyze and solve technical problems,
> g. an ability to communicate effectively,
> h. a recognition of the need for, and an ability to engage in lifelong learning,
> i. an ability to understand professional, ethical and social responsibilities,
> j. a respect for diversity and a knowledge of contemporary professional, societal and global issues, and
> k. a commitment to quality, timeliness, and continuous improvement.

Only about half of the eleven criteria apply to technical mastery: all others cover "soft skills" (i.e., creativity, communication, teamwork, problem-solving, life-long learning, and appreciation for diversity).

Similarly, the Association of Technology, Management and Applied Engineering (ATMAE, formerly known as NAIT)[4] also considers non-technical skills or professional skills. In its standards for baccalaureate accreditation, industrial work experience is considered. In the 2009 Accreditation Handbook, 6.3.10 covers Industrial Experience.[5] "Each program of study shall include appropriate industrial experience such as industrial

tours, work-study options/cooperative education, and/or senior seminars focusing on problem-solving activities related to industry. *Industrial experiences shall be designed to provide an understanding of the industrial environment and what industry expects of students upon employment." (emphasis added)*

Both of these major accrediting bodies recognize the importance of students' preparation for the work world, and strive to give them preparation for it.

Soft skills, or professional skills, are commonly understood to include those skills which professionals must possess in addition to their technical skills in order to be effective in the workplace. While there is no definitive list of professional skills (outside the commonly recognized ABET accreditation standards), a review of academic literature, accreditation standards, and popular media reveals a list which variously includes: effective oral communication and presentation skills; effective written communication; creativity and/or creative problem solving; interpersonal skills; ability to work effectively on a team; time management and planning; conflict resolution; ethical decision-making; the importance of continuing self-education or life-long learning; an appreciation for diversity; an understanding of the profession's place in a larger context (global/societal/professional issues); professionalism; work ethic; and leadership. The list of applied skills from the research report *2009 Ill-Prepared US Workforce* discussed below generally falls within this list of professional skills.

Table 1: Suggested List of Professional Skills for Engineering/Engineering Technology Education

- effective oral communication and presentation skills
- effective written communication
- creativity and/or creative problem solving
- interpersonal skills
- ability to work effectively on a team
- time management and planning
- conflict resolution
- ethical decision-making
- the importance of continuing self-education
- an appreciation for diversity,
- an understanding of the profession's place in a larger context (global/societal/professional issues),
- professionalism
- work ethic
- leadership

For this paper, applied skills, soft skills and professional skills will be used interchangeably.

Employers' View of What the Workforce Needs

In 2009 a research report on *The ILL-Prepared U.S. Workforce (Exploring the Challenges of Employer-Provided Workplace Readiness Training)* was released by a

consortium of organizations, including SHRM (Society for Human Resource Management), ASTD (American Society for Training & Development), The Conference Board, and Corporate Voices for Working Families.[6] The report was directed at exploring the need for workforce readiness training in corporations that were hiring poorly prepared employees. The report raised the issue of whether employer-delivered workforce readiness training was the most effective way to address the gap in skills of poorly prepared entrants in the workforce. The survey results analyzed were directed at three levels, high school, two-year college, and four-year college. For purposes of this discussion, the results for four-year college (the typical applicants to graduate school), would be most relevant. As noted above, while the results may be very useful for undergraduate programs who wish to improve the employability of their graduates, it may also be relevant to graduate schools who wish to ensure their graduates do not retain the shortcomings or deficiencies of the four-year graduates noted by employers.

The survey results were obtained from 217 participants (employer respondents), who commented on three types of training: workforce readiness (remedial), job-specific, and career development training. The survey was intended to explore the need for workforce readiness training among the three groups, any gaps in training in responding employers, and whether such employer-delivered training was effective.

Responding employers were grouped into four categories or industry clusters: manufacturing, financial services, non-financial services, and education/government/other non-profits.[7]

The report gives some interesting insights into employers' evaluation of the professional skills of employees in a number of fields. On overall preparedness of new workforce entrants, 17.4% of the responding employers reported that four-year college graduates were deficiently prepared.[8] About one third (31.5%) of the employers responding found the levels of preparation "excellent" in four-year college graduates, and 51.1% of four-year college graduates were deemed adequate in preparation.[9]

Workforce training provided by employers was only moderately successful.[10] About half of the employer respondents offered some workforce readiness training to new employees.[11] The responding employers who did offer training were asked to rate how well they developed new employees who were rated below the excellent level.[12] Specifically, they were asked how well their training programs developed workers from "deficient" to "adequate" skill/expertise, and from "adequate" to "excellent" skill/expertise.[13]

For comparison purposes, while 82.6% of four-year college graduates were rated either adequate or excellent, 78.3% were either adequate or excellent for two-year graduates, and 66.2% of high school graduates were adequate or excellent. The true level of difference was in the proportion of those workforce entrants who were rated deficient in skills: For four-year students, only 17.4% were deficient, rising to 21.7% deficient for two-year college students, and up to 33.9% deficient for high school graduates.[14]

Skills that needed additional training according to the employers included both applied skills (see Table 2) and basic skills. Skills which were listed as high need included Creativity/Innovation, Ethics/Social Responsibility, Professionalism/Work Ethic, Lifelong Learning/Self Direction, and Critical Thinking/Problem Solving.

Table 2. Applied Skills rated by responding employers[15]

- Creativity/Innovation
- Ethics/Social Responsibility
- Professionalism/Work Ethic
- Lifelong Learning/Self Direction
- Critical Thinking/Problem Solving
- Written Communications
- Diversity
- Oral Communications
- Teamwork/Collaboration
- Information Technology application
- Leadership

(It is interesting to note that some employers rated some of these same skills as low need, yet still offered training (surplus of training effort).)

In basic skills, reading comprehension and writing in English were both rated as high need. Many employers who indicated a high need for training in Mathematics did not provide it.

According to the report, some in the education field are examining how education might fill the gap between what workers need and the deficient levels of certain critical skills they now have.[16] In meeting their requirements for a well-prepared workforce, employers are exploring formal training programs such as the ones surveyed above, as well as informal training and newer technology techniques such as wikis, blogs and podcasts. Some types of informal training opportunities for readiness include the company intranet, email, mentoring and coaching, self learning modules, and the newer technologies including wikis, podcasts and social networking.[17]

Since employers have identified these training gaps in workforce readiness, one of the natural places to look for help has been at the schools. According to the authors of the report, at least two issues exist in this area: education is not often focused on workplace readiness, and businesses are not clear in what they expect from education—is it basic skills, or applied skills?[18]

For those interested in further information in this area, this report built on the *2006 Are They Really Ready to Work* report.[19] Skills which were found important to employers in that project were professionalism, teamwork, oral communication, ethics and social responsibility, and reading comprehension, and employers noted significant deficiencies in written communication, leadership and professionalism even at the four-year college

level. Projected skills for the next five years (from 2006) included foreign language (globalization), critical thinking and creativity/innovation.

While focused on employers' evaluations of employer-delivered workforce readiness training, the research report is valuable for the light it sheds on the gaps in skills which employers find in workforce entrants, including those entering with workforce with a four-year college degree. It is also valuable for the information it provides on how employers rate the work skills which new employees need: the list of applied skills has substantial overlap with the soft skills in accreditation standards for ABET for example, and is reflective of other sources of soft or professional skills. The new economy and current world of work requires many skills, and specifically the applied or professional skills which began this discussion.

What relevance does this information have for graduate education?

Taking it as a given that master's level and higher graduates are looking for advanced or higher positions in their field, most graduate students will benefit from practice in professional skills. Looking at the report discussed above, the four-year graduate entering the workforce may have deficient (17.4%) or only adequate (51.1%) applied skills. In order to make graduate students more employable, it would follow that a graduate program could serve the purpose of raising the deficient to at least adequate, and the large percentage of adequate into the excellent category.

This author would posit that the higher the position in the field, the greater the role professional skills play in the job position. A review of the typical types of positions that an institution's graduates take upon graduation can be referenced with the skills required for those positions using federal database employment information such as the Occupational Outlook Handbook (available at www.bls.gov/OCO) and O*Net OnLine at http://online.onetcenter.org/ . The Occupational Supply Demand System is also helpful in listing the education and skills required for particular professions.[20] In those resources, positions in the relevant professions and occupations are analyzed and identified by skills required to obtain and keep those positions. Professional skills such as communication, critical thinking and problem solving are commonly listed for leadership or management positions in almost any technical or engineering field, which correlates with the research report discussed above. For mechanical engineering technologists, for example, skills listed for the position include reading comprehension, active listening, coordination, judgment and decision-making, time management, active learning and complex problem solving, in addition to mathematics, equipment selection and troubleshooting.[21] Engineering Managers' skills are listed, in addition to knowledge and abilities, are listed as active listening, reading comprehension, speaking, writing, complex problems solving, coordination, critical thinking, judgment and decision making, management of personnel resources, and monitoring.[22] Many of these skills such as management of personnel and coordination will require additional applied or professional skills. Graduates who have excellent professional/applied skills in addition to their technical or basic skills and knowledge will be more employable, and will enhance the reputation of the institution of higher learning in graduating highly qualified individuals.

The Master of Science in Technology at our institution can be used as an example. The degree program has particular objectives. The degree objectives listed below are from the application for state approval to offer the degree.

> "This program is designed for students with both technical and non-technical backgrounds and will provide the knowledge and skills required for its graduates to function effectively in a technical environment and *to accept increasing responsibility in technical leadership positions*. (Emphasis added.) The program permits specialization in an area of modern technology applicable to each student's working environment or area of interest. Emphasis is placed on preparing students for technical leadership positions in business and industry, faculty positions in technology and engineering technology at community college and university levels, or to continue for a PhD in technology or a closely related field at Purdue or another university.
>
> The program outcomes for the graduates, consistent with the existing University engineering technology programs, are:

- Ability to develop research concepts and practical applications of research methodologies in technical environments and analyze, evaluate and synthesize research
- Ability to communicate effectively and employ constructive professional and interpersonal skills
- Ability to function effectively in one or more of the technology disciplines
- An ability to function on multidisciplinary teams
- Ability to continue for a PhD program in technology or a related field."

This would indicate that master's level graduates in the MS in Technology program would be educated in or given the opportunity to practice such professional skills as effective communication, professional and interpersonal skills, and teamwork.

Since the MS in Technology program is only two years old at this point, the School is just beginning to collect and assess its success in meeting its goals and outcomes. Graduates of the program are asked to respond to a survey assessing the program's success in meeting these objectives.

Incorporating professional skills development in graduate education

Professional or soft skills can be incorporated in graduate education in a number of ways. Skills practice can be incorporated within technical classes by encouraging professional experience or internship (experiential education), and by including courses on professional practice or professional skills within the plan of study.

Several techniques for incorporating professional skills can be used within a class. Work at the graduate level is often done through extensive written reports or papers, which are excellent for enhancing basic communication skills, and also critical thinking and analysis. Many master's programs require either a thesis or directed project, which both

require extensive writing and analysis skills, and may also require creativity and innovation. Presentations of class topics, research papers, etc. can also be incorporated as assignments within a class to enhance oral communication/presentation skills. Group projects can be assigned and geared to enhance teamwork skills (even though students often object to group projects). Graduate students can be asked to help design a framework for team projects to help them understand and evaluate issues that arise in professional teams. Case studies can help with analysis, critical thinking, and creative problem solving skills. Of course, this places the burden on individual faculty to investigate and design appropriate assignments or case studies to develop these skills, and to determine how best to assess the skills.

Internships at the graduate level

Experiential education such as internships and industry projects are available at the graduate level. A graduate degree program may offer internships, or individual courses may contain projects for industry. Directed projects in programs which allow/require directed projects are often focused on work with particular technical industry employers. These types of experiences allow students to obtain some real world work experiences to enhance both their professional and technical skills. This can be a double-edged sword though: industry employers who work with graduate students may expect them to have a level of professionalism already, and may not appreciate having to train a graduate student in the same way they might expect to work with undergraduates. Experiential education requires planning, forethought (intentionality and reflection), and also requires the degree program to make contacts with industry for students to work with. This does create an additional burden for the faculty or institution in providing employers for this type of industry experience.

Classes included in the plan of study

Classes in professional skills are also helpful in meeting the need for adequately prepared graduates. Many technical programs are housed in institutions where courses in professional skills are available, either "in-house" or elsewhere on campus. Courses such as leadership and ethics, managerial-level ethics, or engineering ethics and social responsibility have become more common. Courses may also be available in creativity and creative problem solving, leadership, and other professional skills. Of course, if such courses exist in the University but outside the school, college or degree program, faculty will need to discuss the elements and requirements of the plan of study and arrive at a consensus on what courses would be allowed in the graduate plan of study, especially if they come from outside the technical program. In some cases, courses that focus on such professional skills have suffered from being considered "fluff" or insufficiently related to a technical program to warrant a place in the plan of study. There does seem to be some tension (and sometimes a lack of respect)[23] between the heavily quantitative people and the often qualitatively-oriented people who teach professional skills. Many who teach qualitative skills appreciate the quantitative, but find that quantitative skills alone do not make for a well-rounded and professionally skilled graduate who will thrive in the workplace. A deeper understanding of the necessity for professional skills may help

address the tensions in this area. And of course, there is also a tension between making sure the plan of study has adequate development of technical skills: the limited number of courses in a master's plan of study may leave little room for allowing or requiring additional courses in professional skills.

Conclusion

Recent research suggests that professional skills are very important for the success of college graduates, both at the undergraduate and graduate levels. Degree programs and faculty should be encouraged to examine their graduate programs in engineering and engineering technology to explore ways to incorporate professional skills practice within courses and within the plans of study.

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[1] The ILL-Prepared U.S. Workforce, 2009. The report can be found at: www.conference-board.org/Publications/describe.cfm?id=1676 (August 2009): Jill Casner-Lotto, Mary Wright, authors. Report number BED-09Workforce_RR

[2] See e.g. Dan Pink, and media reference: Joyce Gannon, "Creativity Trumps Analytical skills in new economy, expert says", Pittsburgh Post-Gazette, March 16, 2007.

[3] www.abet.org/. Criteria for all programs can be found at http://www.abet.org/forms.shtml

[4] http://atmae.org

[5] http://atmae.org/accred/2009accreditationhandbookcomp.pdf

[6] The ILL-Prepared U.S. Workforce by Jill Casner-Lotto, Elyse Rosenblum, and Mary Wright, found at:

[7] See p. 5 of the report.

[8] See above.

[9] Page 7 of the report.

[10] Of the employer respondents answering the question of rating their workforce readiness programs, only one respondent reported its workforce readiness training programs to be "very successful" in raising skill levels from deficient to adequate. A little over half rated their programs as moderately or somewhat successful, and about 40% rated their programs as successful. Less than 20% of the 97 employers who offer remedial training rated their programs as very successful in moving new employees to the next level, either from deficient to adequate, or from adequate to excellent. In going from adequate to excellent, only 17.5% said their programs are very successful in raising skill levels. Most viewed their programs as moderately or somewhat successful, (59.7%), while 19.3% viewed their programs as merely "successful". See pages 7-8 of the Report.

[11] See page 7 above.

[12] See page 7.

[13] Page 7.

[14] Page 7.

[15] Report, p. 22.

[16] See Discussion in Report, pp. 16-17.

[17] Report, p. 19.

[18] Report, p. 21

[19] 2006 Are They Really Ready to Work Report Card can be found at: www.cvwf.org/node/105

[20] OSDS, Occupational Supply Demand System, www.occsupplydemand.org
[21] http://online.onetcenter.org/link/summary/17-3027.00
[22] http://online.onetcenter.org/link/summary/11-9041.00
[23] Sadly, this is often a two-way street; the qualitative people may assume that the quantitatively-oriented people may not have adequate interpersonal skills.