

The Case for Leadership Skills Courses in the Engineering Curriculum

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Abstract

Leadership courses are often encouraged, but not mandatory for an undergraduate engineering degree. The research presented here focuses on implementing specific undergraduate leadership courses as part of an American Board of Engineering and Technology (ABET) accredited program at a Midwestern University.

The purpose of this study is to identify what professional skills engineering companies expect students to develop through coursework before they can graduate from a large Midwestern university. The hypothesis of the project was: Engineering employers surveyed will validate the importance of each of the introductory leadership course goals as it relates to what they are seeking in potential hires. The research question of the project was: How important are formal leadership education coursework and opportunities in college to the engineering workforce? The web-based survey was sent to over 200 engineering employers that recruit at the Midwestern University with 53 responses equating 26.5% response.

The survey administered to employers in this project was created by faculty from the Electrical Engineering and Leadership Education departments and the author, a graduate student in the Leadership Education program, who incorporated the following tools:

- A United Kingdom (UK) survey facilitated in 2005.
- Accreditation Board for Engineering and Technology (ABET) accreditation Criterion 3 guidelines.
- The Introductory Leadership Course objectives in the syllabus provided to students.

The survey responses indicated that not only is the development of professional leadership skills by engineering students appreciated, it is required if they are to meet the demands of the engineering workforce. Many employers responding to the survey defined these skill sets as fundamental for future engineers.

Background

The global market for engineering graduates is becoming increasingly competitive. The study, “Educating Engineers for the 21st Century: The Industrial View” which surveyed more than 400 engineering companies located in the United Kingdom reveals a pressing need to overhaul undergraduate engineering education. “Engineering courses need to be better aligned with industry needs, which can be achieved in part by industry becoming more involved with engineering education. The Academy calls for closer collaboration between schools, universities and industry to counteract the perceived skills deficiency in graduate engineers.” (Spinks, Silburn & Birchall, 2006). One remedy for this challenge is a diversified engineering curriculum

including required leadership courses. Leadership courses are often encouraged, but not mandatory for an undergraduate engineering degree. Leadership courses can be housed in many undergraduate colleges and school academic programs. The research presented in this paper focuses on implementing specific undergraduate leadership courses as part of the American Board of Engineering and Technology (ABET) accredited program at a large university, located in the Midwest.

The U.S. Census Bureau reports that beginning in 2012, approximately 10,000 Americans will turn 65 every day and by 2030, about 20 percent of the U.S. population, or roughly 71 million people, will be 65 or older. (U.S. Census Bureau, 2003). Based on those figures, there will be more baby boomers leaving the work place than there will be employees to replace them. Thus, the need for well-rounded, diverse engineering students in the United States is at an all-time high. As a result, the role of leadership curricula and professional skills training during the undergraduate education is more important than ever.

The research on professional skills and leadership attributes is both practical and theoretical in nature. The research for the importance of this set of skills has become more abundant in the last nine years with the change of ABET accreditation standards.

The purpose of this study is to identify what professional leadership skills engineering companies expect students to develop through coursework before they graduate from a large Midwestern university. Students at this university can achieve technical skills through the program's theoretical and scientific curriculum. However, if the professional leadership skills desired by companies are part of the required engineering coursework, graduates of this program may have a competitive advantage in the global marketplace.

Hypothesis 1: Engineering employers surveyed will validate the importance of each of the introductory leadership course goals as it relates to what they are seeking in potential hires.

H1a. Engineering employers will be surveyed on the importance of these skills in the workplace.

H1b. Engineering employers will be surveyed on their satisfaction with undergraduate students at a large Midwestern university in comparison with other graduates they hire. This information can provide the push to add more specified coursework to the engineering undergraduate curriculum at this university.

This paper addresses the following research question:

How important are formal leadership education coursework and opportunities in college to the engineering workforce?

By exploring the relationship between leadership education and the engineering industry's needs, we can better understand curriculum changes needed to give students completing the

undergraduate engineering program the tools they need to have a competitive edge. Currently, at the university conducting this study, there are nine undergraduate engineering departments. Just one, the electrical engineering department, requires an interpersonal skills course for graduation. Three other undergraduate engineering departments offer courses to develop interpersonal skills among their elective courses.

The committee for Educating the Engineer for 2020 (National Academy of Engineering) calls for substantive changes in curriculum, emphasizing the importance of using different learning methods to create leaders of the future. It is important to understand the learning abilities of engineering students and to acknowledge that professional skills courses can improve not just their education, but also the future of the engineering workforce. The industry commentators are recommending an education where the professional skills are addressed during undergraduate education. Engineering courses can help students develop these skills through integrated classes with a focus on teamwork and communication. However, leadership courses at universities and colleges can also play a larger role in this request from industry.

Design/Method

This study was based on information obtained from a survey of engineering employers that have recruited undergraduate engineers during the past three years at this university. The survey administered to employers in this project was created by investigators, including the author, who incorporated the following tools:

- The United Kingdom (UK) survey of 2005.
- The Accreditation Board for Engineering and Technology (ABET) accreditation Criterion 3 guidelines.
- The Introductory Leadership Course objectives in the syllabus provided to students.

The survey is a mix of multiple select questions, essay/text box response questions, and ranking questions. Posing questions in different ways allowed for a full spectrum of responses from participants. Because the list of employers was broad, the researchers found it important to ask questions specific to both the type of industry the employers were in, as well as the disciplines of engineers they seek. The goals and outcomes of the introductory leadership course (entailing all objectives of the professional skills) offered at the Midwestern university were used as a form of measurement within the survey through a ranking system of importance and satisfaction among those being surveyed.

Solicitation for survey participants was made via e-mail to more than 200 employer contacts provided by university Career Services offices. These employers have active relationships with the university through career fairs and campus visits. Employer representatives contacted for this survey include human resource professionals, project engineers, chief executive officers, managers, and engineering alumni from the university. Of those surveyed, 85 opened the link and 53 submitted responses to the questionnaire. Participation in the survey was voluntary.

Participants were notified of the study by the lead investigator through e-mail contact. The investigator sent a consent message with each e-mail and the participants had to initial the consent to continue with the online survey. Questions were permitted.

The ABET accreditation board has been in existence since 1932. Its standards for accreditation are reviewed and released annually and its methods of evaluation have remained consistent across the spectrum of engineering programs. It is hard to measure reliability and validity of this survey because this is the first time it has been administered in this form. However, because this survey was based on valid curriculum measures which employers expect amongst engineering graduates, it is reasonable to state that the survey measurements are in line with industry standards and expectations.

Results

Many essay questions in the survey reiterated the need for professional leadership skills in the curriculum. In question 5, the professional engineering skills were defined as theoretical understandings, practical applications, and technical breadth of the bachelor's degree. The survey asked participants to describe what they require of incoming employees regarding these professional engineering skills. A summary of the responses (number of responses in parentheses) follows:

- Solid technical knowledge (16)*
- Previous experience through internship or co-op (9)
- Strong coursework in structural buildings (4)
- Computer science/computer understanding background (4)
- Background in hydraulics, surveying, water and sewer design and construction (1)
- HVAC design (1)
- Biomedical education (1)
- Critical thinking skills, thinking skills, decisiveness, ability to follow through on procedures (3)
- Field knowledge/construction process (7)
- Real life engineering practical applications (11)
- AutoCAD (6)
- Basic leadership skills (2)
- Effective communication and interpersonal skills essential (8)
- Excellent organizational and planning skills (6)
- Basic supervisory skills (1)
- Attention to detail (4)
- Strong work ethic essential to be successful (3)
- Ability to communicate technical issues with a wide range of people (7)
- Solve problems (6)
- Work independently (1)
- Business knowledge (2)
- Theoretical understanding (8)

- Writing skills (4)
- Project management (2)
- Time management skills (4)
- Ability to travel (1)
- Software programming (5)
- Ability to work well with others (4)
- Ability to handle multiple tasks (3)

As is apparent, many responses refer to the professional skills identified in the introduction. Communication skills, teamwork, organizational skills, problem-solving skills, and even leadership skills all were mentioned throughout essay responses.

This leads to the following analysis of the Hypothesis and Research questions raised in the introduction.

Hypothesis 1: Engineering employers surveyed will validate the importance of each of the introductory leadership course goals as it relates to what they are seeking in potential hires.

H1a. Engineering employers will be surveyed upon the importance of these skills in the workplace.

Table 1 represents the mean response of each engineering department employers across all 26 items that were rated in question 17 of the survey.

Table 1: Mean Score and Standard Deviation Question 17

Question 17: Reflecting on the future of your organization, what do you think on a scale of 1-5 (1=very low importance; 5=very high importance) will be the most important skills and attributes needed by the engineering graduates your organization will expect to be recruiting?

<u>Major</u>	<u>Number</u>	<u>Mean</u>	<u>Standard Deviation</u>
Electrical	19	4.43	0.38
Mechanical	27	4.21	0.46
Civil	31	4.33	0.49
Chemical	17	4.28	0.44
Ag/BSE/BioMed	12	4.11	0.56
Industrial	15	4.22	0.49
Computer	9	4.39	0.32
Construction Eng	18	4.39	0.41
Architectural	8	4.56	0.34

Note: Agricultural, Biological Systems, and Biomedical Engineering were combined for future analysis due to small sample size and similarity of program requirements.

A score of 4 equals important and a score of 5 equals very high importance and would be the “ideal” response from employers. As the results indicate, across the industry, all 26 items identified in question 17 that are part of the professional skill courses are at least valued at a level of importance (4) So, the hypothesis is verified - employers did validate the importance of these introductory leadership (professional skill) course goals. Some essay responses emphasize this as well. In survey question 8, the group is asked to assess the needs of the future and how the changes in the next five years will affect their organizations. Some employer responses are presented here:

- Students will need to be equally skilled in technical knowledge, business knowledge, and interpersonal communications.
- Engineering will shift toward a people-relationship business as technical competence will become an expected commodity.
- Students will need strong communication skills, writing skills, leadership skills, and business knowledge.

H1b. Engineering Employers will be surveyed on their satisfaction with undergraduate students at a larger Midwestern university in comparison with other graduates they hire. This information can provide the push to add more specified coursework to the engineering undergraduate curriculum at the Midwestern University.

Table 2: Mean Score and Standard Deviation with each major for Question 13

Question 13: On a scale of 1-5 (1=very dissatisfied; 5=very satisfied) how satisfied is your organization with the following skills and attributes of newly hired engineering graduates from the Midwestern university?

Table 2 shows the mean rating across all 26 items in question 13. A score of 3 equals neutral, 4, equals satisfied and a 5 equals very satisfied.

<u>Major</u>	<u>Number</u>	<u>Mean</u>	<u>Standard Deviation</u>
Electrical	19	3.93	0.52
Mechanical	24	4.01	0.61
Civil	29	3.77	0.65
Chemical	16	3.82	0.71
Ag/BSE/BioMed	10	3.74	0.85
Industrial	14	4.16	0.53
Computer	8	4.05	0.32
Construction Eng	15	3.69	0.59
Architectural	7	3.71	0.41

Note: Agricultural, Biological Systems, and Biomedical Engineering were combined for future analysis due to small sample size and similarity of program requirements.

Question 13 requested ratings on the current standing of engineering graduates of the university from employers. An ideal score from employers for this question would be a score of “5” which means very satisfied. These numbers were lower than the importance ratings found in question 17. This information is beneficial to the engineering departments because it helps demonstrate the need to incorporate general leadership education courses as part of engineering graduation requirements. The survey results are broken down to provide information for specific departments. For instance, an employer who hires mechanical engineers rates their satisfaction on each of the 26 items. These results will give department faculty and staff the information they need to assess what changes would improve their curriculum. The leadership courses offered at this university can assist in addressing these deficiencies, so that faculty does not have to reinvent the wheel but can take advantage of existing classes to address these needs.

How important are formal leadership education coursework and opportunities in college to the engineering workforce?

As noted previously, when employers answered question 17, the mean ratings were all above 4, which emphasizes the importance of these skills once a student moves into the engineering workforce. This also can bolster the case for addressing these skills during college. Of the 26 items ranked in question 17, there were 6 items that were rated as a 5 by many of the survey participants, indicating these items are viewed as being very important. Those professional skills identified as being very important were:

- Practical application of engineering concepts (31 of 46)
- Ability to manage time effectively (33 out of 46)
- Ability to communicate effectively in written (including electronic) form (28 out of 46)
- Excellent verbal communication skills (29 out of 46)
- Ability to work effectively in a team environment (32 out of 46)
- Ability to use innovation in solving problems (28 out of 46)

All of these items are part of the professional leadership skills coursework at the university. This course could even include practical applications that can be implemented in engineering classes. One respondent to question 20, which seeks additional feedback, offered this observation: “We are a client-driven business, so, good communication skills and relationship skills are as necessary to our success as technical skills.”

Conclusions

The hypothesis and research question set out to determine if employers in the engineering industry deemed it important for students graduating from engineering programs to possess leadership skills, as well as technical capabilities. The survey responses indicated that not only is the development of leadership skills by engineering students appreciated, it is required if they are to meet the demands of the engineering workforce. Many employers responding to the survey defined these skill sets as fundamental for future engineers.

Results of the study support the conclusion that employers hiring engineering school graduates desire them to be equipped with leadership skills, and that courses addressing these skills should be required in undergraduate engineering programs. Since all engineering students must take general electives as part of their degree requirements, it seems logical to fulfill part of that requirement with a course that focuses on these competencies.

There are many opportunities from this data for leadership education programs. There are some universities that actually offer a leadership minor across campus, to all educational programs. If this type of course is implemented in the engineering curriculum at different universities, it could open up the possibilities for more leadership course offerings, and possibly minors in the area for students. Faculty from both the leadership and engineering departments could co-instruct courses together as well. The potential opportunities for future research in this topic are plentiful for leadership departments.

It is important to acknowledge that many of these abilities also can be addressed in core engineering classes. Students often work in teams for projects, and must give oral and written presentations of their ideas. One benefit to requiring additional courses is to increase the opportunity for engineering students to work with students from diverse academic backgrounds. In a general elective course, students have that opportunity to share ideas and solve problems with students from other academic specialty areas. This offers an excellent opportunity to apply leadership skills to real situations. This will better prepare engineering graduates to be successful in the work place, where they are bound to interact often with people from a wide range of professional backgrounds. In other words, if they can practice communication skills, leadership skills, and teamwork with diverse groups in college, they will be ready for the world of work.

Limitations

The survey was completed by 53 respondents. The confidential nature of the study, however, poses a problem in evaluating the results. It is impossible to know who completed the survey: Was it a human resources staff member, a manager, a supervisor, or even young alum? Results could be very different, depending on who answered the questions. If this survey is administered again, it is recommended that controls are used to address that issue. Ideally, the survey would be circulated to engineers who work in a supervisory role. They are more likely to work with graduates and observe their work on a daily basis. They also would be in a better position to assess their skills.

Another limitation to the survey could be its scope. A broad range of questions were included in the survey. The goal was to validate levels of importance of the professional skills as well as to assess the level of satisfaction of employers regarding the current graduates at one particular university.

Besides those goals, the survey attempted to determine if the electrical engineering department, which is the only department that now requires a professional leadership skills course, had a different outcome in the results.

Additional information also was collected in the survey regarding community outreach, training and development provided at the company, but consequent curriculum recommendations that could also be analyzed further but were not assessed for this project. Community outreach, training and development and curriculum all play important roles in the overall engineering student experience, and the information gathered is valued and helpful to the university, but due to the nature of this study, the information was not thoroughly addressed. This research did not address internships or co-ops and the value those experiences have in helping engineering students develop professional and leadership skills. In their responses, many employers discussed the need for practical experience, and internships do offer that opportunity. Internships also can develop student's abilities to work in teams and communicate more effectively. While this survey did not directly ask about how internships might play a role in the improvement of the professional skills, there clearly is interest from industry for providing this experience to graduates, and that may be an important topic to consider in future studies.

Another area not thoroughly evaluated was the topic of service learning. More than 80 percent of the respondents, however, indicated they participate in community outreach, which incorporates the fundamentals of service learning. Many leadership programs incorporate aspects of service learning in the classroom/course experience as well. Because so many of the respondents participate in outreach, which are essentially service learning activities, more studies in this area also are warranted.

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Biography

Kaylea Dunn is a Human Resources Coordinator for Olsson Associates, an engineering consulting firm located in Lincoln, NE. Kaylea is also a graduate student in the Department of Agricultural Leadership, Education and Communications at the University of Nebraska – Lincoln.