AC 2012-3593: LEADERSHIP EDUCATION FOR ENGINEERS: ENGINEERING SCHOOLS INTEREST AND PRACTICE

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LEADERSHIP EDUCATION FOR ENGINEERS: ENGINEERING SCHOOLS' INTEREST AND PRACTICE

Abstract

Leadership has long been a hot topic in business and education, but until recently has not been a focus in science and engineering. Based on our experience in expanding the curriculum to incorporate a series of leadership courses for graduate engineering students, we were interested in knowing whether others were teaching leadership in their programs. We wanted access to information on other engineering programs that was not available in the literature, which led to developing a survey to gather this data. Our motivation for this research was based on experience as authors from industry. We noticed that academia was sub-optimizing the potential of engineers to fully exercise their knowledge, skill and other leadership capabilities in the workplace. This paper presents the motivation for our research, the process we used to gather the data, and assessment and evaluation of the responses. Examples of the current practice of providing leadership education to engineers are described and suggested alternatives are presented.

Introduction

We chose to administer the survey electronically. Our experience with surveys over the past decade has shown we get a higher response rate with electronic, rather than paper surveys. In collaboration with ASEE and the Engineering Deans Council in 2009-2010, we chose to direct our survey to deans of engineering programs in the United States. We asked whether they offered leadership education in their programs and requested responses to a series of questions including whether they believed leadership education was important for engineers. The objective of the survey was to determine the extent to which engineering programs perceived the need to provide graduates with an understanding of leadership, how they were addressing this need, and what they saw as barriers to incorporating leadership education in their curricula.

Approximately 14% of engineering schools responded to the survey. The results show that 100% of respondents believe leadership education is important for engineers; yet fewer than half of these schools include this in undergraduate programs and just 21% in the graduate curriculum. While stating they believe strongly in the importance of this topic, the major reason that more do not include leadership is that it is difficult to fit into already tight curricula. Some have found creative ways to integrate components of leadership across several courses, often linking topics with Engineering Accreditation Commission (EAC) of ABET criteria. With the rapid expansion of knowledge requirements in all fields of engineering, and the constraints on credit hours, leadership often takes a back seat. We are interested in seeking to better understand how this problem can be solved.

The survey of engineering deans reinforces the need for developing science and engineering leaders. Despite a packed schedule, engineering schools need to find ways to integrate educational components focused on leadership into their curriculum. We have learned that one

way this can work is by introducing a series of courses over the student's total educational experience that incorporates key leadership development concepts, exercises, and action learning projects that inspire emerging leaders to continue to develop their capabilities over a lifetime.

Motivation for doing the research

We, as experienced leaders in industry, know how important it is for science and technology professionals to understand and practice leadership as they apply their technical prowess to their business needs and goals. Beyond their businesses, the world is in serious need of innovative solutions to the problems that face our collective human population. Most of these problems involve innovative technical solutions that suggest more than ever, we need creative people to lead the way toward problem resolutions. Without a clear idea of what leadership is or how to lead, we are in trouble. Because we saw and felt this need so clearly, in our academic roles, we decided to step up to the challenge of shaping courses and key experiences that would develop highly competent technical leaders.

We created and delivered a series of leadership courses for graduate students in our School of Engineering with excellent results, and have reported on these in several previous articles (Millam and Bennett 2004, 2011c,d), (Bennett and Millam 2011a,b) and a book (Bennett and Millam 2012). In the course of this work, we felt a strong need to find out what other engineering schools and universities were doing to ensure their graduates were fluent in their understanding and practice of leadership. Our research, utilizing a simple survey of deans of engineering schools, was designed to determine how widespread the interest was in leadership education for engineers, and to document those findings in hopes that others would find this work useful.

We were surprised to find how little was being done, even though everyone saw and felt the need for doing more to ensure their students were equipped with leadership capabilities. Since this initial research, we wondered how we might help others within academia overcome the obstacles that seem to be in their way. This paper is a first step in sharing the results of the research, hopefully offering some solutions and awakening others who were not participants in the survey to share more broadly their experiences in shaping educational experiences that begin to make a difference for emerging technical professionals.

The Survey Process

We created a simple survey to identify whether other engineering programs offered leadership courses, what books or articles they were using in these courses, and whether these programs believed leadership education was important for engineers, and why.

As noted earlier, the survey was administered electronically to deans of engineering programs in the U.S, and was aimed at asking whether they offered leadership education in their programs, and more specific questions about their programs including whether they believed leadership education was important for engineers. The primary objectives of the research were to determine the extent to which engineering programs perceived the need to provide graduates with an

understanding of leadership, how they were addressing this need, and what they saw as barriers to incorporating leadership education in their curricula.

The original survey was sent to deans of all the engineering schools in the United States, asking that it be forwarded to an appropriate person to respond. Initially we received 37 responses, approximately 10% of engineering schools. A second round was sent several months later to increase the response rate; an additional 11 schools responded, for a total of 48 engineering schools. The second survey was shortened to a subset of the original; results are reported for both surveys on the questions in the shortened version.

The second survey read as follows:

> ***What are you doing to help your engineering students become leaders?***
>
> *The University of St. Thomas (UST) School of Engineering has been offering leadership courses for engineering graduate students for 10 years. These graduates say their experience in these courses have been eye-opening for them. Their learning has caused them to step up to a whole new role resulting in powerful impact in their organizations.*
>
> *Last year, we surveyed engineering deans on this subject. Thirty-seven schools responded, and the results of that survey are attached.*
>
> *We are asking your help to increase the number of responses. If you did not respond to the first survey, your input will help determine if the first sampling is representative of all engineering schools.*
>
> *We, as co-authors of a potential textbook on leadership for STEM professionals and students, want to know what you are doing to facilitate leadership know-how with your students.*
>
> *Would you be willing to take 5 minutes to answer a few short questions related to what you do today and intend for the future? If so, please proceed.*
>
> 1. *Do you teach a course in leadership for undergraduate students in engineering*
> 2. *Do you teach a course in leadership for graduate students in engineering?*
> 3. *If yes, how many students per year take the class?*
> 4. *If yes, what is the primary focus of these courses?*
> 5. *What specific learning outcomes are expected in these courses?*
> 6. *What is the name of the institution where the course is taught?*
> 7. *Is the syllabus available online?*
> 8. *Do you use a textbook?*
> 9. *If yes, please provide the author and title.*
> 10. *If no to the above, do you provide seminars, non-credit courses, etc. on leadership for your students?*
> 11. *If yes, how many students per year participate in the seminars, non-credit courses, etc.?*
> 12. *Does your institution feel leadership for engineering and science students is important for the future? Why?*
> 13. *If so, what is your intention for ensuring these learners get exposure to understanding and applying leadership principles and practices?*
> 14. *Please provide your email address if you want follow-up to this survey.*

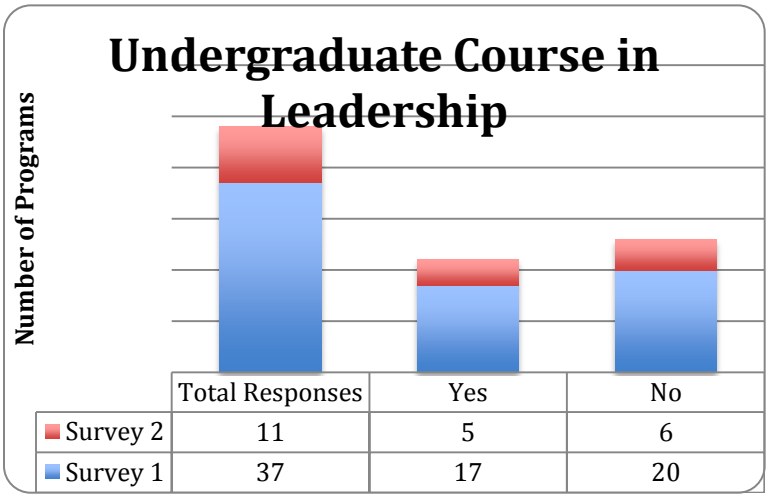
Survey Results

We received a total of forty-eight (48) responses to the two surveys[1], representing 14% of engineering schools in the United States. Out of the 48 responses, fewer than half offer any seminars or courses focused on leadership. Currently these schools report more than 3950 students are taking leadership courses in engineering programs plus 3000 others (students from non-engineering programs, faculty, and staff) on their campuses.

One hundred percent of the respondents felt that leadership was critical to a technical student's educational program. Note the large gap between felt need and school offerings.

Undergraduate Programs

Forty-six percent (46%) of undergraduate institutions stated that they offer a course in leadership for undergraduate students.



The number of undergraduate students enrolled annually in these courses range from 20 to 3,000, averaging 329 students per school. The total number of undergraduates in leadership courses reported by these institutions is 3,950 per year,

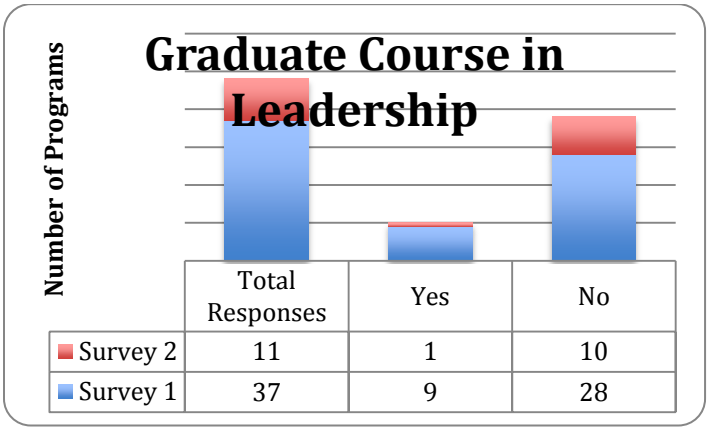
Some of the courses are for credit, others are non-credit. Since we did not ask this question specifically, we cannot report percentages. Some respondents volunteered this information; we

[1] Forty eight (48) Respondents: Including St. Mary's University—Texas, Seattle University, Brigham Young University, University of Illinois at Urbana-Champaign, Purdue University, Louisiana Tech University, Ohio University, Universitat Rovira i Virgili , Liberty University, University of Cincinnati College of Engineering and Applied Sciences, Penn State University, Lawrence Technological University, Michigan Technological University, Ohio University—Russ College of Engineering & Technology, Lee College UNC Charlotte, Gannon University, Rowan University, LeTourneau University, University of Notre Dame, Purdue University, FIU, UC Berkeley, Iowa State University, Smith College, Florida Gulf Coast University, Lawrence Technological University, University of Maryland College Park, Wichita State University, Alfred University, University of Minnesota Duluth, Syracuse University, University of Florida, Seattle Pacific University, San Jose State University.

can report only that the practice of offering leadership classes for credit or not varies with institution.

Graduate Programs

Twenty-one percent (21%) of responding institutions offer a course in leadership for graduate students.



The number of graduate students enrolled annually in these courses range from 15 to 30, averaging 20 students per school. The total number of graduate students in leadership courses reported by these institutions is 101 per year.

Focus

Our results show a mixed and broad array of offerings, from seminars, to a single course, to integration of leadership concepts into technical course offerings and other unique expectations of students to take on leadership projects at their school and report on the experience. It is difficult to see a generalized theme, but one might assume that a primary focus of the leadership offerings is based on a belief that a graduating student can lead from any level in his/her organization. Emphasis is placed on students exploring their own leadership abilities and the ways in which they influence group outcomes: interpersonal skills, judgment, moral courage, innovation, sustainability, global collaboration and emotional intelligence appear as key topics, as does the notion of the interrelatedness of ethics and sustainability in a societal context. Others also emphasize the importance of ethical decision-making, group dynamics, goal setting, visioning, networking, delegation, motivation, conflict resolution and diversity. One program has students prepare a leadership portfolio as a culmination of their leadership education and experiences. Another has students keep an electronic journal (blog) of their reflections of each class activity, reading, speaker and discussions.

One program (Lawrence Technological University) has taken its commitment even further by creating a comprehensive leadership curriculum so that students graduate with both the technological and leadership skills they need to be successful in their professional and personal lives.

Note selected comments from respondents regarding their primary focus:

- Understanding basic theory and understanding inter-relatedness of leadership, globalization and integrity. At the graduate level, deeper comprehension of what it means to lead, follow, and how to manage influence and power
- Interpersonal skills and emotional intelligence
- Leadership, policy and change in STEM education
- Development of skills, mentoring, global and social context
- Team leadership development
- Emphasis on organizational culture and the learning organization
- Leadership principles and practice, diversity, global collaboration, sustainability, innovation, ethics, judgment, and moral courage
- The entrepreneurial mindset and problem solving
- Develop understanding of the importance of leadership in achieving goals
- Applying leadership in diverse engineering contexts
- Learning that individuals can lead from all levels in the organization

Learning outcomes

One major learning outcome is to be able to differentiate between leadership and management. Students should understand the theory behind the practice of management and leadership, and to broaden their understanding of themselves and their leadership potential. One program (Iowa State) specifically cited the understanding the complexities of leadership in building/nurturing an organization, understanding communication and decision-making styles, conflict and change management, and the importance of creating a legacy.

Some (for example, University of Maryland, College Park) strive to increase self-awareness through the exploration of values, beliefs, culture and identity; learn the basics of group roles, dynamics and decision-making in order to function constructively in group settings; apply critical thinking to leadership theories in an engineering context; build an awareness of leadership issues facing our communities, the engineering profession and society; and increase leadership and communication efficacy and skill in order to be successful in engineering practice.

One program (Universitat Rovira i Virgili) strives for effective demonstration of eight competencies: integrity, results orientation, client orientation, team work, interpersonal communications, response to change, drive for excellence and commitment to learning. This same program uses an assessment tool that is designed around the same competencies to measure one's level of competency.

Another program (Lawrence Technological University) states the primary goal of the leadership curriculum is to see that undergraduate receive an education that enables them to develop, practice, and exhibit leadership and innovation skills. The five learning outcomes are defined as "Graduates will have:

- had experiences that promote a high level of professionalism and integrity, responsible decision making, confidence in approaching opportunities, and pride in their activities.
- had experiences that promote the understanding of themselves and others, sensitivity to other cultures in the context of globalization, and interpersonal skills.
- had experiences that promote the ability to analyze unfamiliar situations, assess risk, and formulate plans of action.
- been made aware of the importance of lifelong learning, and
- had experiences that promote a global and societal perspective.

Examples of the expected learning outcomes from the leadership courses are:

- Effective demonstration of eight competencies (see above)
- Understand the theory behind the practice of management
- Demonstration of communication skills rhetorically, interpersonally, and in writing
- Self knowledge—character, communication, ethics, innovation/creativity, skills in economics, marketing, teamwork, global awareness/world view, project planning, sustainability
- To learn the basics of leadership and start "to do it."
- Differentiate between management and leadership
- Learn the fundamentals of leadership and skills needed to become real leaders
- Increase self awareness - explore values beliefs, culture and identity; develop confidence, pride in abilities, judgment
- Build awareness of leadership issues facing our communities, the engineering field and society

Textbook

Twenty-six percent (26%) of the institutions report using a textbook or a selection of articles. Many courses require students to read a number of books, as many as 15 in one case. A variety of references are used, with typical textbooks including:

- *Good to Great* by Jim Collins
- *Seven Habits for Highly Effective People* by Stephen Covey
- *Executive EQ* by Dan Goldman
- *How to be a Star at Work* by Robert Kelley
- *The Entrepreneurial Engineer* by David Goldberg
- Readings such as "The Power Principles, Influence with Honor" by Blaine Lee, "Leadership 101" by John Maxwell, "The Contrarian's Guide to Leadership" by Stephen

Sample, "People's Styles at Work" by Robert Bolton and Dorothy Bolton and "Leadership that Gets Results" by Dan Goldman

- *Exploring Leadership for college students who want to make a difference*, by Susan Komives, et al.
- *Reframing Organizations: Artistry, Choice and Leadership* by Bolman and Deal
- Other leadership books by Warren Bennis, John Maxwell, Warren Blank, Daniel Coleman, Robert Bolton and selected readings from the Harvard Business Review

As is evident, all of the books are generally more popular leadership books, not focused on the engineering, scientific or technically educated professionals. Some of the books are dated, and not reflective of researched theory from leadership literature. Others are clearly primers for understanding what is entailed in effective leadership.

Seminars

Thirty-two percent (32%) of the respondents reported they offer leadership seminars. Some of these are for undergraduates, more informally discussing what makes for effective leadership. Many integrate leadership concepts into their capstone design courses.

One program (University of Illinois at Urbana-Champaign) offers seminars through a campus leadership center, encouraging engineers to participate. This program also offers weekly personal coaching.

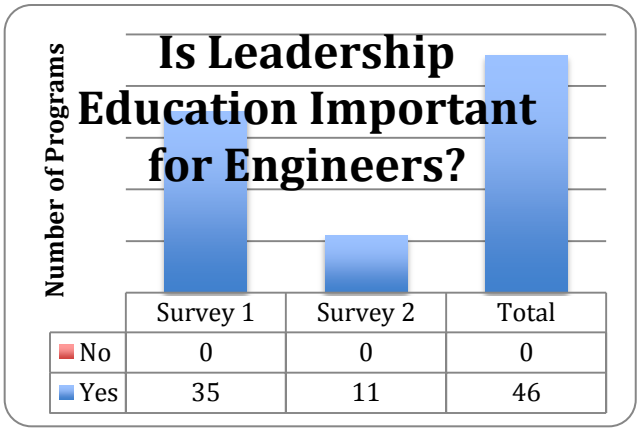
One program (Lawrence Technological University) offers a course open to all students, staff, faculty and alumni in addition to the students enrolled in the course. In this case, the course is non-credit.

None of the respondents report that they have business partnerships in their local communities that might be partners in creating seminars or forums for discussing or learning about leadership for technical professionals.

None of the respondents report that they encourage their students to enroll in leadership seminars that are aimed at technical leaders, often sponsored by technology companies and/or public offerings.

Is leadership education important?

One hundred percent (100%) of institutions responded that they consider leadership education is important for engineering and science students.



Reasons cited include:

- Engineers should and will lead
- Survey of alumni report they see a leadership vacuum in engineering
- Leadership is a key factor to foster innovation
- We expect engineers to change society
- Technology will require dynamic professionals
- Technical competence is necessary but not sufficient
- This is an area lacking in our curriculum yet critically needed in the future

While the respondents in our survey obviously feel strongly that leadership education is a critical need, there are unseen or unstated obstacles that are keeping them from doing more to ensure that this happens at their institutions.

Intentions for the future

Survey participants articulated their intentions to ensure learners are exposed to understanding and applying leadership principles and practices. Here are some of their intentional statements:

- Would like to co-create a leadership course for undergraduates
- Motivation, awareness, pro-active career planning
- Ensure that students are fully engaged with the resources and services available to them
- Training, experiential learning and personal development are intertwined.
- Give them opportunities integrated within existing curriculum without having a stand-along course
- Multiple sessions of seminars and service learning
- Recently identified by MIT as a leading example of global best practice in engineering leadership education
- Future leaders must understand engineering and science to make educated decisions.
- We try to provide an environment in which students can develop their leadership skills by applying leadership principles and practices in real-world settings.

Our Assessment and Evaluation

Despite the exemplary work being done at some institutions, we see the present state of affairs as sorely lacking in providing innovative educational offerings for students at both the undergraduate and graduate levels. We along with others know that leadership is learned whether done intentionally or left to happenstance. We believe that educational institutions need to take action.

Our research suggests that administrators in engineering schools see and understand the critical need, but for many reasons find the obstacles to making change a bit overwhelming. Is this because they are not being forced yet to make the changes, or is it truly that difficult to make changes in the credit hours that students need to have? What might be some possible solutions?

Our experiences in stepping up to the challenge were essentially driven by our business partners telling us "we want the graduate students we send to St. Thomas to graduate with a strong base of leadership capabilities." They wanted to partner with us to shape how that might look, and took a strong role in supporting the professionals they sent to the University, making it possible to set up real time action learning projects at their business.

The cry for more effective leadership is loud and clear in all sectors, in all vocations, and if we as educators really want to make a difference, we would find some innovative and creative ways to incorporate this into the student's educational experiences. Maybe it is time for organizations such as ASEE to provide some incentives to administrators to become more fully trained in their own leadership competencies, take a more active role in acknowledging those institutions that are demonstrating some best practices in this regard, and pushing more institutions to actually partner with others to make it happen.

Conclusions

Let us repeat…major issues facing the world in this century require technical solutions. This requires that the individuals who will develop those solutions, the scientists and engineers and others technically educated, will be called upon to lead. Every engineering program that responded to our survey knows that, and that it is their responsibility to educate engineering graduates in leadership knowledge and skills. Engineering programs value leadership, and they state that teaching leadership is as important as other people-oriented topics such as entrepreneurism and organizational behavior.

Technical competence as developed by the engineering curriculum is absolutely essential, but it is not enough. It is a necessary but insufficient condition as stated by several of our respondents.

As with any major transformational change, there are barriers. Many students and faculty still do not believe that leadership can be taught. The pioneers who realize the importance of leadership education have the typical and predictable uphill fight. But they are making major progress and there is hope; these leaders are getting organized, and a major initiative in that process was the

recent formation of a Constituent Committee on Engineering Leadership within ASEE, the first step to becoming a recognized ASEE Division.

Although every respondent to our survey feels leadership should be part of every engineer's education, the competition for credit hours is a major issue. In already packed curricula, with pressure in many institutions to cut credit hours, how can leadership be added? The answer: they need to find creative ways to integrate leadership into the curriculum, or to provide leadership education through other mechanisms.

Many are taking action already and some best practices are in place; some are offering a minor in leadership development. Others have developed an Office of Leadership Programs to coordinate with all academic programs to offer comprehensive leadership curriculum for all undergraduate students. One school is working with Student Affairs and other programs to offer co-curricular leadership opportunities, developing leadership skills with an emphasis on character, integrity and professionalism. A number of schools are developing institutes for engineering leadership that take a variety of forms. Some use student clubs and extra-curricular projects as methods of developing leadership skills.

Many are seeking ways to foster opportunities to learn leadership integrated within the curriculum without having a stand-alone course. There is a cry for help in getting through the log-jam by encouraging students to take full advantage of the freely available resources and services (student affairs, library, etc.) at their university. Leadership includes information literacy, knowing how to find and use information. It fits with the notion that leadership is learning. They are asking for ideas on disseminating information on how to best present leadership topics to students. Many wish to integrate many of these principles and practices in several key courses.

The future is dependent upon engineering and science leadership. Future leaders must understand engineering and science to make informed decisions. Students need to know what leadership is. Alumni surveyed at one school see a leadership vacuum in engineering. Technology will require dynamic professionals to help resolve the needs of business and government. Because of the significance of technology, engineers and scientists need to understand how to lead teams and implement projects through positions of leadership. Leadership begins with service and goes to motivating and developing high functioning teams. Most of us believe that leadership is a key factor in fostering innovation.

Recommendations

Based on our experience and the responses to the survey of engineering deans, we recommend several actions. Among those are:

- Make full use of the new ASEE Constituent Committee on Leadership;
- Link the many leadership initiatives currently underway – institutes, stand-alone classes, leadership integrated into existing curriculum – form a series of Best Practices and widely disseminate;

- ASEE might sponsor some opportunities to teach faculty and deans about ways to incorporate concepts/practice into existing courses or development of new course/seminars, etc.;
- Partner with business advisors/sponsors in the local communities to sponsor science and engineering Leadership Conferences and/or seminars;
- Provide students with leadership coaches/mentors to assist in the learning/development process;
- Build partnerships and accompanying forums between educational institutions to innovatively partner to overcome the obstacles that face those curricula designers; and lastly:
- Think outside the box of the standard classroom experiences to make real time action learning projects and processes part of the overall educational experiences, bringing students into workplaces to help with real time problems, learning from their leadership experiences first hand.

The future is ours to form: we must be the change we want to see.

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