Longitudinal Evolution of an Inclusive, College-Wide Integrated Engineering Leadership Curriculum

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Abstract

Like many engineering programs, the Ira A. Fulton College of Engineering at Brigham Young University has recognized the need for cultivating leadership skills in its engineering students. In 2005, planning efforts were initiated for rolling out an inclusive, college-wide engineering leadership curriculum. These efforts have resulted in a structured experience that provides graduates with proficiency in leadership knowledge and skills starting with the freshmen year and culminating in practiced leadership experiences in senior project courses[1]. Implementation of an inclusive curriculum required substantial support from each of the individual college units, thus the roll-out was staged with strong consideration to department timelines. Each program in Brigham Young University's College of Engineering and Technology has integrated the leadership curriculum into its individual graduation requirements for seniors graduating in 2014 and beyond. Early adopting departments now have several years of experience. Enrollment in the required sophomore Leadership Foundations course has risen from several dozen students to roughly 1,000 students annually including approximately 20 percent student participation from outside the college since it is an approved General Education course. This paper presents the longitudinal evolution of the curriculum in response to faculty concerns, student interest and experience levels, and departmental constraints.

Introduction and Background

Leadership skill development has become an option or component of engineering education in many programs across the country[2,3,4,5]. Indeed, development of leadership skills have been indicated as potential key differentiators in the career paths of current graduating engineers[6,7,8,9]. The combination of strong engineering problem solving skills with leadership skills provides a powerful catalyst for addressing the grand engineering challenges that will so dramatically affect our future. In addition, these combined skills are essential to assuring that engineers remain relevant in our increasingly interconnected technical environment.

Prior to 2005, Brigham Young University's (BYU's) approach to incorporating leadership skills into the engineering curriculum was similar to that of many other engineering programs working to make progress in this area. Leadership skills were presented in various departmental courses, but lacked a centrally unified curricular integration. Some programs within the college (for example, engineering education) provided a stronger leadership focus that was evident in both required and elective courses. Other programs implemented a more "ad hoc" approach that provided sufficient exposure to leadership principles to satisfy accreditation evaluators that departmental outcomes related to leadership were being achieved. The college supported a senior-level technical elective course on engineering leadership and ethics. This course serviced less than 100 students annually. These efforts were valuable and their value was validated by feedback from college and departmental external advisory boards and recruiting employers. However, many students in the college were not able or not choosing to leverage the provided opportunities to develop and enhance their leadership skills.

Thus, in 2005, the Ira A. Fulton College of Engineering and Technology at Brigham Young University initiated a staged roll-out of an inclusive, college-wide integrated leadership curriculum. Elements of the curriculum are specifically directed towards each year of engineering education. Freshmen and sophomore efforts are orchestrated from the college level, while junior and senior efforts are tightly integrated and controlled by individual departments. These efforts have resulted in a structured experience that provides graduated proficiency in leadership knowledge and skills starting with the freshmen year and culminating in practiced leadership experiences in senior project courses[1].

The transition to a more unified leadership curriculum raised both logistical and philosophical hurdles that needed to be addressed. The purpose of this paper is to describe the longitudinal evolution of the curriculum, with specific attention to faculty concerns, student interest and experience levels, and departmental constraints.

Overview of the Inclusive, Integrated Leadership Curriculum

The Leadership Curriculum is staged with a structured escalation of leadership education towards higher levels of cognition [10]. Freshmen and sophomore efforts are oriented towards motivation, and remembering, understanding and applying leadership knowledge to structured problems. Junior and senior level efforts are oriented towards analyzing leadership situations, evaluating potential approaches to applying leadership principles, and creating and utilizing effective leadership structures. Expert resources, both curricular and personal role models, are provided to assist both students and faculty.

There are five core elements of the integrated engineering leadership curriculum at BYU (Figure 1): 1) Freshmen Leadership Introduction, 2) Sophomore Leadership Foundations Course, 3) Junior "Controlled Environment" Team Leadership Experiences, 4) Senior Project Courses, 5) Leadership Lecture Series. The remainder of this paper provides longitudinal evolution of each of these elements throughout the last seven years as well as the motivating factors that precipitated evolutionary changes in each element and their current status.

Freshmen Leadership Introduction

Establishment of student awareness and expectations regarding the role of leadership in the engineering curriculum is accomplished during the freshmen year through direct interaction with the college and the Weidman Center for Global Leadership. The college leadership training model and a motivational discussion of the attributes of engineers who will be able to successfully address the challenges of the future are presented to incoming freshmen students during a semi-annual "new student leadership lecture". Additional exposure to these topics is given to incoming women engineering students and minority engineering students during targeted outreach activities.

Leadership elements of the curriculum were formalized in 2008. This was followed by a formalization of companion outcomes and curriculum in global competence. Portions of the global outcomes were combined with the leadership outcomes to create an overall model[11]. Key categories of outcomes can be seen in the college leadership model[1] represented in Figure 2.

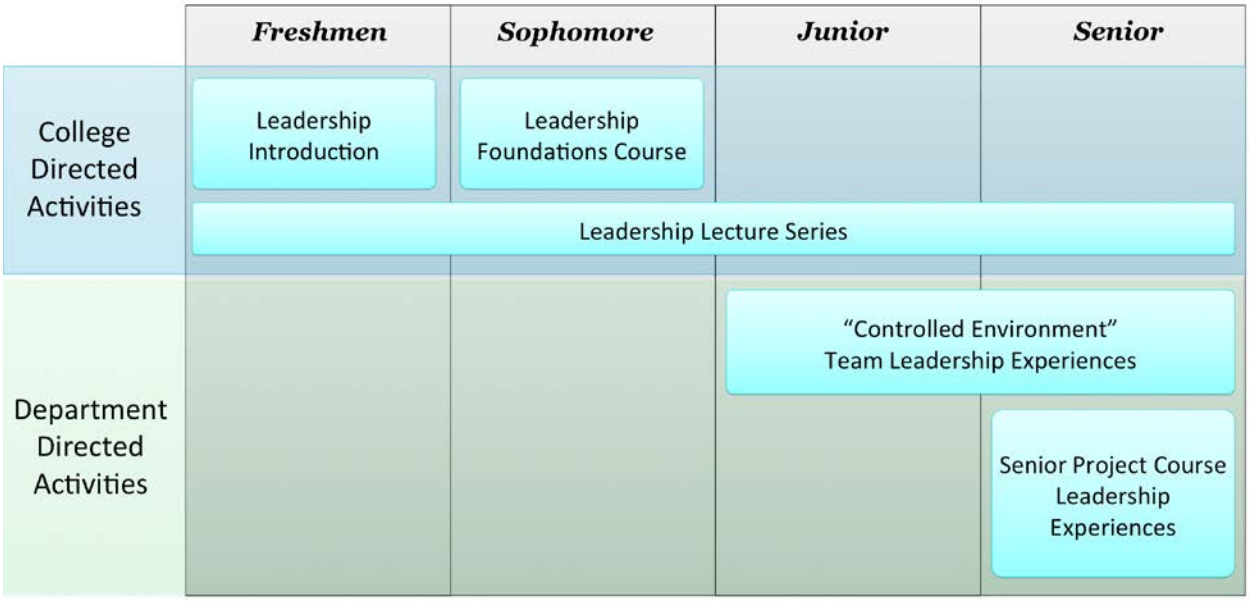

Figure 1. Core elements of the integrated engineering leadership curriculum

From the model, the attributes of engineers prepared to successfully address the challenges of the future (Program-level Leadership Learning Outcomes, Table 1) were developed and formalized in order to provide a common reference point for the entire leadership curriculum.

Challenges and Longitudinal Evolution

The Freshmen "new student leadership lecture" and outreach elements to women and minority engineers are handled through the college and require very little investment from departments. The primary challenge for this element of the integrated leadership curriculum was associated with developing the common vocabulary that would be used for the "college leadership training" model and the "attributes of engineers who will lead" description. To develop these elements, a college leadership committee was formed with representatives from each department. The committee obtained substantial input from department chairs and college leadership, and draft versions of these documents were presented at an annual college retreat and further refined based on faculty feedback. Due to these preparatory efforts and the relatively low implementation burden for department faculty, longitudinal evolution of the Freshmen Leadership Introduction has been minor, and largely limited to logistical considerations.

Figure 2. Visual representation of the three dimensions of the College Leadership Model

Table 1. College Program-level Leadership Learning Outcomes

Leadership Dimension	Program-level Leadership Learning Outcomes
Personal Leadership	Is committed to the highest standard of integrity, prepared to handle issues with ethical implications and able to make wise, value-based decisions.
	Effectively solves problems through sound reasoning and innovative thinking, with genuine concern for others.
	Is self-aware and strives to constantly improve.
Organizational Leadership	Develops and practices effective interpersonal skills.
	Understands group dynamics, teamwork, and how to function as a productive member of a team.
	Can articulate a vision, formulate a strategy and develop plans to accomplish project and organizational goals.
Global Agility	Understands the impact of the global economy and international business environment on organizations and communities.
	Appreciates the value and impact of culture and diversity in the composition and operation of organizations.
	Understands and is prepared to address important global concerns such as global climate change, population growth, clean water, energy, etc.

Sophomore Leadership Foundations Course

A fundamental element of the inclusive leadership curriculum is a required, 15 week, 3-credit hour (i.e., 3 weekly, in-class instructional hours, 6-9 weekly, out-of-class hours for completing assignments, etc.) The sophomore-level Leadership Foundations course provides instruction of common core topics in personal leadership, organization leadership, and global agility. This course is primarily taught by tenured faculty members with external industry experience. Enrollment in the course has risen from several dozen students to roughly 1,000 students annually. Key instructional aids and resources from this course are provided via the internet and department servers to college faculty to facilitate follow-up in later stages of the curriculum.

The sophomore Leadership Foundations course is structured to address three dimensions of engineering leadership. Personal leadership includes topics on self-awareness, ethical dilemma identification and resolution, time-management, goal setting, and leadership theory. Organizational Leadership includes topics on team development, communication, project management, organizational vision and mission, and motivational theory. Global Agility includes topics on universal values, cultural differences, international trade, international organizations and leveraging diversity. Fundamental core elements of the course include the development of a Personal Leadership Portfolio, as well as participation and feedback in roles as both a leader and a team member on substantial course projects.

Challenges and Longitudinal Evolution

The course curriculum for the sophomore Leadership Foundations course was adapted and evolved from a popular, senior-level elective class offered by the college. The course was originally developed and taught by a trio of motivated professors with an interest in engineering education. The focus of the class was on moral and ethical engineering leadership and provided

a context for that leadership in the global environment. As a pilot program, in 2010, additional instructors for the class were recruited from several departments around the college. Student interest in the class was already high, and sections of 35-50 students filled quickly. Based on positive feedback from both students and involved faculty, the college supported an initiative to ask departments to include the class as a required element of their curriculum.

The primary concerns from departments were not unexpected, and included a common complaint that adding additional required course credits was challenging, concerns over increased teaching loads, and uncertainty as to the availability of sufficiently qualified and interested faculty to serve as instructors. Some of these concerns were eventually resolved by identifying overlap of course content with BYU's General Education Requirements. Minor modification of the course allowed certification as a General Education course, eliminating the need for "extra" course credits. This brought an additional benefit to the class as it increased the diversity of majors in the class. It is common for practicing engineers to work on teams with non-engineers[12,13,14], however this aspect of diversity is typically unaddressed in engineering leadership curriculums due to logistical aspects. Since certification of the class as a general education class in 2011, enrollments have included approximately 20% non-college majors and have facilitated heterogeneous teams and discussions on the value of team diversity.

Also, because of the certification as a General Education course, additional university resources were made available to the college commensurate with the additional teaching load, partially mitigating some of the department concerns regarding increased teaching loads.

The third significant concern from department faculty was with regards to identification of sufficiently qualified and interested faculty to serve as course instructors. As the course has ramped up from under 100 students per year to over 1000 students per year, there has been a need for substantial increases in engineering faculty involvement in the course. It has been a fundamental goal of the college to keep teaching of the course internal to the college of engineering, rather than recruiting faculty from Philosophy, Education, or Business programs. We feel that when engineers share their own experiences with leadership, it places an increased emphasis on the topic and provides intrinsic motivation for engineering students who can see application of these "soft topics" to practical engineering projects.

Other authors have commented on "imposter syndrome" – a common concern of faculty trained as researchers who step into roles as teachers[15,16]. We have found that this concern is also prevalent when even experienced engineering educators are asked to teach leadership principles. The primary leadership literature is replete with analogies and observations connecting leadership to teaching [17,18,19,20] and many engineering faculty across our college have had meaningful leadership experiences in industry prior to joining the faculty at our institution. When we queried faculty regarding specific leadership topics, we also found that most research faculty utilized a mentored leadership approach to managing students in their labs, and had an excellent practical grasp of fundamental leadership principles. Despite these observations, faculty exhibited a notable hesitation regarding their anticipated ability to effectively teach leadership principles.

This concern remains an on-going challenge, however instituting a strong and supportive course committee that provides training and shared teaching experience and resources has resulted in a core of passionate and excellent course instructors and has allowed the course to develop in concert with student demand. Key to this effort has been establishment of a model curriculum with an associated schedule, lecture materials, readings, handouts, assignments, team projects, and exemplar exams.

Another significant challenge for the course resulted from the change in sequencing from a senior level technical elective to a sophomore level, required, general education course. Senior level team experiences required significantly less guidance to produce excellent team experiences. Anecdotally, sophomore students have also required greater prescription in class schedule and assignments (i.e., sophomore students are less receptive to an "on-demand" learning model that is responsive to instructor observed needs). Engineering student expectations regarding workload and time management are not as fully developed at the sophomore level, and student expectations of workload for a General Education class are not at the same level as those for more technical engineering classes. Nevertheless, "priming" [21,22] of student expectations at the start of the semester has proven to be effective for most students, and has allowed the course to address a full range of leadership topics in moderate depth.

The course is now required for all students graduating in 2014 and beyond for every department within the college of engineering and technology. Integration of this course as a requirement for individual programs was encouraged by the college leadership, but was approached using an iterative process that took a few years to roll out. Throughout this process, there was substantial attention given to receiving and responding to faculty feedback. Interestingly, nearly every department within the college has now identified the course as a key element in their strategy for addressing Accreditation Board for Engineering and Technology (ABET) requirements in our upcoming accreditation cycle.

Junior "Controlled Environment" Team Leadership Experiences and Senior Project Course Leadership Experiences

At the junior level, students are heavily engaged in fundamental technical classes that vary by department. Thus, control and integration of leadership into the curriculum is most effectively done by the individual departments. By leveraging the common leadership core provided by the sophomore Leadership Foundations course, instructors develop meaningful team leadership experiences with a relatively modest amount of orientation to leadership principles. Each department decides which classes are the most appropriate venues for these experiences. In the junior year, the team leadership experiences are in a fairly tightly controlled environment (i.e., limited scope, duration, and accountability). Resources from the sophomore Leadership Foundations course are provided to college faculty so that they can reference a common leadership vocabulary and have an awareness of the core leadership principles and experiential learning activities that students have experienced.

Similar to the junior level, control of the leadership curriculum at the senior level is done by the individual departments. Many technical elective classes incorporate team project experiences, with a focus on applying leadership principles. Most departments also leverage their senior

design or project class as a particularly effective environment for implementing and assessing leadership principles.

Challenges and Longitudinal Evolution

Since the Leadership Foundations course is required of all BYU College of Engineering and Technology students graduating in 2014 and beyond, some students have not welcomed the idea that leadership should be an important part of their academic preparation. Many students recognize the importance and benefit of additional leadership development, but some students feel they already have enough leadership experience or that leadership is not necessary for students graduating in engineering and technology. This sentiment is also reflected in a small portion of the faculty who have been passive or resistant to the college-wide effort of leadership development. Mitigating of these perceptions is still an on-going challenge in implementation.

Developing capable instructors for the Foundations course has been a key aspect of the course implementation. To get started the college sought our faculty with some passion for leadership that would be willing to invest in course development. By sharing with each other and studying individual aspects of the course content, a fairly consistent approach emerged. From this developing consensus a common syllabus was created that defined outcomes for every course and student experiences that each section was to execute. The common syllabus left ample room for individual instructors to tailor the course, but began to focus outcomes and approaches across the college. As the number of sections has grown, additional faculty have been required that may not share the passion of the initial group. In service instruction, further definition of outcomes and sharing of curriculum approaches have helped to ease these growing pains, but more work remains.

Because the junior and senior level experiences are under the direct control of the individual departments throughout the college, there is more flexibility and variation in implementation approach. The principal concerns which have arisen from college faculty have been with regards to: 1) ensuring that instruction on technical topics was not curtailed in deference to leadership topics, and 2) transferring knowledge of the topics addressed in the sophomore Leadership Foundations course.

With guidance from the course committee of the Leadership Foundations course as well as experienced instructors who had taught the Foundations course several times, faculty in the college were provided training on several “key” topics and activities from the Foundations course that could be integrated into junior and senior level classes and activities with minimal preparation. Additionally, the common core of the Foundations course curriculum has been made available to college faculty via the internet and college servers.

Over the last several years, each department has refined their inclusion of leadership material into their own junior and senior level curriculum. Some college departments have also pursued development of topic review modules based on the sophomore Leadership Foundations course. These topic review modules include presentations and review videos with an associated quiz. By leveraging one or two of these modules as a homework assignment, instructors at the junior and

senior levels can choose to emphasize a leadership topic without intruding significantly on in-class instructional time. Additional evolution of the curriculum at the junior and senior levels has occurred as instructors have become more familiar with the core leadership principles from the sophomore Leadership Foundations course. Familiarity with these principles has led to synergistic sharing of leadership experiences with students, and with other college faculty. A repository of short (from 5-10 minute duration) leadership instructional activities has been developed by faculty from around the college based on their successful experiences integrating leadership into their courses. This repository serves a dual purpose in providing useful curricular tools, and in helping college faculty to identify positive experiences in teaching leadership principles in the context of technical engineering courses.

Leadership Lecture Series

The Weidman Center for Global Leadership within the Fulton College of Engineering and Technology, has instituted a regular leadership lecture series, inviting recognized national and international engineering leaders to interact with students, faculty, and staff. These lectures, which take place approximately monthly (3 times each semester), provide a unique opportunity for participants to gain insight into important leadership principles and to learn from respected industry leaders. The lectures are designed to stimulate interest and conversations on leadership topics while providing validity to the importance of leadership development in engineers. Attendance at these lectures is optional, but each lecture typically draws approximately 150 to 200 attendees. Lectures are recorded and archived on the college website hosted by YouTube and serve as perpetual resources to students, faculty and staff for instruction at all stages of the leadership curriculum. Each lecture typically receives approximately 400 additional views on the website. The Weidman Center for Global Leadership develops short leadership video vignettes that are made available to students, faculty and staff via the website for additional leadership development opportunities.

Summary and Discussion

Transition of leadership instruction in the college of engineering from an ad hoc, elective approach that reached several dozen students annually, to an inclusive, college-wide, integrated leadership curriculum that reaches several thousand students has been non-trivial. Key to this effort has been a dedicated and patient approach to seeking “buy in” from college departments and individual faculty. Leveraging university resources through certification of the sophomore Leadership Foundations course as a general education class was extremely helpful in avoiding the imposition of additional credit hour requirements on engineering students. This approach also brought additional resources to the college that could partially offset some of the increased teaching load imposed by teaching up to 12 sections of the sophomore Leadership Foundations course, annually. Junior and senior level experiences have proven to be most effective when they are tailored to the needs of the respective departments. Inclusion of a regularly scheduled, premiere engineering leadership seminar series has proven to be invaluable in maintaining student and faculty excitement regarding the inclusion of leadership topics in the curriculum.

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