



Developing Leaders by Putting Students in the Curriculum Development Driver Seat

Miss Yazmin Montoya, LEAD

Mr. Aaron Eduardo Pacheco Rimada, University of Texas at El Paso

Erwin Delgado, University of Texas at El Paso

Isaiah Nathaniel Webb,

Dr. Meagan R. Vaughan, University of Texas, El Paso

Dr. Meagan R. Vaughan received her PhD from The University of Texas at Austin where her research focused on the design of a low-cost, volume adjustable prosthetic socket. Now an Assistant Professor at The University of Texas at El Paso, she is helping develop a new Engineering Leadership Program to help students to bridge the gap between traditional engineering education and what they will really experience in industry. Her research interests span the areas of engineering education, biomechanics, and product design methodology.

Developing Leaders by Putting Students in the Curriculum Development Driver Seat

Abstract

Upon graduation, engineers entering the workforce are not always trained to work in a collaborative environment where a detailed understanding of common business, project management, and leadership skills may be required. In order to create a paradigm shift in engineering education, where students' capacities are pushed beyond their limits in order to redefine what an engineer is and develop these skill sets, Engineering Leadership (E-Lead) students at The University of Texas at El Paso have taken ownership of not only their own education, but the education of future students.

In order to develop students as leaders, the current Introduction to Engineering Leadership course has been developed and taught by second year Engineering Leadership students. Second year students were placed in educator/mentor positions in order to develop their leadership skills. The purpose of the course was not only to give second year students a leadership opportunity and an understanding of the importance of guiding people, but also to introduce a unique culture being created in the Engineering Leadership program and provide leadership models for incoming students to learn from second year students.

These second year students, also called Mavericks, worked closely with Engineering Leadership faculty, as well as faculty from Franklin W. Olin College of Engineering (Needham, MA), throughout the summer in order to develop curriculum for the incoming cohort of students in the fall of 2014. The goal of the course was to create an immersive learning environment that was also social, relatable, and inspiring to the instructors and the students. In order to achieve that goal, the Mavericks were given the opportunity to teach the course. The curriculum developed by the students was created to focus on three major disciplines: leadership identity development, innovative thinking, and hands on skills. These disciplines were taught in a studio environment through group discussions and interactive individual and group projects.

This redesign effort by students not only resulted in a refined curriculum for the E-Lead program, but also improved the course by increasing the feeling of community for incoming students and thereby increased retention in the course from 60% to 92% (measured by the ratio of students that completed the course to those enrolled as of census day). More importantly, this experience of being placed in the curriculum development driver seat, also served to help the Mavericks redefine leadership, gain a better understanding of leadership, and increase their leadership skills (4.5, STDV 0.55; 4.67, STDV 0.52; 4.67, STDV 0.52; based on an ordinal scale with 1 being strongly disagree and 5 being strongly agree). The experience also helped them increase their Character, Competence, and Capacity (4.67, STDV 0.52; 4.33, STDV 0.82; 4.92, STDV 0.20). The Mavericks also agreed that the experience helped them increase their innovative problem solving and thinking skills (4.17, STDV 0.41) and develop their identity (4.25, STDV 0.76). Overall, this research demonstrated the feasibility and effectiveness of allowing students to develop their leadership skills through taking on the role of instructor in an introductory engineering course.

Introduction

Engineers with strong leadership skills are increasingly in demand due to the evolving environment and roles engineers have to perform in the workplace. The world of engineering has become a more collaborative environment in which engineers and their peers must understand how to work with one another on multicultural and/or multidisciplinary teams on projects that do not always fit in a single traditional field of engineering. Unfortunately, there is a lack of focused leadership development in traditional engineering courses at the undergraduate level. A goal set by National Academy of Engineers in *The Engineer of 2020: Visions of Engineering in the New Century*, and shared by our program, is to develop the skills and knowledge needed for students to become the leaders of tomorrow.¹ As engineering has evolved over time, so have the demands placed on the engineer. It is important that the global community of engineering educators encourage its students to close the gap between current engineering education, and real world demands by becoming leaders and developing the capacities needed to function in the 21st century.

To this end, the Bachelor of Science in Engineering Leadership degree at The University of Texas at El Paso seeks to develop students as leaders through building their Character, Competence, and Capacity; the three pillars of the Engineering Leadership program (E-Lead). In this paper, the methods and outcomes are presented for how these pillars were put into practice by the E-Lead students through experience-based learning in our Introduction to Engineering Leadership course. This course is intended to introduce incoming student to both the culture of the E-Lead program as well as equip them for success in their college career. Piloted in the fall of 2013, the initial response from students was less than satisfactory and a change was needed. Relying on their personal experience and feedback from their peers and the E-Lead faculty, a group of students that completed the pilot course proposed a major reform for the following year. In the summer of 2014, the group of now second year students, who are referred to as Mavericks, worked closely with Engineering Leadership faculty, as well as Franklin W. Olin College of Engineering (Needham, MA) faculty, to develop new curriculum for the incoming class. The goal of the redesigned course was to create an immersive learning environment that was also social, relatable, and inspiring to the instructors and the students. In order to achieve that goal, Mavericks were given the opportunity to also teach the course.

As a result of this experience, the hypothesis is that the Mavericks would be able to practice their leadership skills and directly impact the Engineering Leadership program by: enhancing their own leadership capabilities though mentoring the incoming class during this teaching and curriculum development opportunity while simultaneously improve incoming student retention in the course (and therefore the program). To develop their leadership abilities through this experience, it is expected that *Character* would be developed within the Mavericks by giving them the opportunity to mentor and collaborate with incoming students and express their own identities as leaders. *Competence* would be developed through the research and understanding of the diverse topics that they had to be capable of teaching. Finally, the Mavericks would expand their *Capacity* by learning to teach, lead, and mentor. Retention rates were anticipated to rise due to the improved curriculum as well as the influence of peers as opposed to faculty in the introductory course. If this course instruction method proves effective,

this pattern of allowing a group of students to redesign and teach the course each year will be maintained for future incoming classes.

Background

In developing The University of Texas at El Paso's Bachelor of Science in Engineering Leadership (BSEL), a blend of effective leadership development philosophy and innovative pedagogy was sought. To this end, partnerships were strategically formed with institutions that excel in these areas. Among these are the Franklin W. Olin College of Engineering – for its progressive pedagogical approaches to teaching engineering – and the United States Military Academy (West Point) –for their leadership development process. Although the program seeks to develop itself by learning from the collective knowledge and experience of these institutions, it also seeks to create its own identity and set of values appropriate for its student population while using a pedagogical approach that is transferrable.

Pedagogical Approach

Engineering Leadership's pedagogical approach is the result of close collaborative efforts with Olin College. Olin is a small, private engineering-only college with a progressive perspective on engineering education with an admission rate of 16.8%.² In contrast, the University of Texas at El Paso, with an admission rate of 99.8%,³ is a urban, commuter based, and minority-serving university.⁴

A method commonly employed in the Engineering Leadership program to explore leadership development is experience-based learning.⁵ As such, students in the program are often placed in situations designed to stretch their leadership capabilities and potential through the development of their Character, Capacity, and Competence, rather than focus on traditional lecture based teaching styles. This approach to education is evident even in the classroom, where students are encouraged to take leadership of themselves initially, by taking control of their education. Using a flipped classroom approach, or one in which students are tasked with learning the material on their own and are given an opportunity to synthesize and apply it in the classroom, is one of the many ways the program promotes leadership of the self. Once a student becomes comfortable with the idea of self-discipline and motivation, the specific development of one's Character, Capacity, and Competence can commence.

Leadership Development: The Three C's Defined

The foundational philosophy of our program's leadership development methodology is inspired by West Point's three C's: Character, Capacity, and Competence (the three C's).⁶ Based on this theory, optimal leadership is achieved when an appropriate balance between these three exists. Sustainable leadership is not possible if any one of these pieces is missing. Among the most important facets of the BSEL leadership philosophy is a focus on the development of cyclical leadership, that is, a leadership style that encourages the development of leadership in others. An ideal leader in our program, therefore, is one who not only works towards an appropriate balance of character, capacity, and competence, but also seeks to incite that balance within others.

Engineering Leadership defines *Character* as “who you are.” There are two components involved in this. The first encompasses an individual’s personal identity and the resulting development of a value system. This includes investigation of concepts such as integrity and selflessness. The second component is centered on one’s ability to live by and practice their core beliefs. One of the ways Engineering Leadership promotes character development is through community building by interacting with a diverse group of people in curricular and extracurricular settings. The program hopes to expose its students to different personalities and give them the chance to grow from this exposure. Engineering Leadership also seeks to develop one’s character by placing students in situations where friction between individuals may arise, this includes class projects and team activities. Students are expected to develop emotional intelligence to deal with multiple situations from failure to success. The programs allows these concepts to coexist, and create an atmosphere of reflection and individual feedback that forms the foundation for continuous improvement.

Capacity is the various applications of one’s knowledge and the roles it enables one to take on. This is primarily developed in the classroom, first, by encouraging students and providing them with diverse opportunities to contribute to extracurricular efforts, form part of diverse communities, or organizations. Secondly, classes teach students on the importance of identifying and assigning distinct roles within projects and team efforts. Students learn about all of the parts and roles required in the process of taking ideas to realities and producing a desired outcome. Students are presented with multiple opportunities to develop skills that diversify their abilities, thereby expanding their competence.

Engineering Leadership curriculum is especially tailored to build diverse *Competence*. While students build a wide foundation of engineering technical knowledge during their BSEL, they are also placed in situations where they must be proficient in non-engineering subjects - from business to marketing. Engineering Leadership heavily promotes understanding how to learn, synthesize information, and apply it in diverse and innovative ways. Leaders must be competent in various disciplines and, as such, must understand how to learn and relate their learning to their everyday lives.

Evolution of the Introduction to Engineering Leadership Course

To begin mentoring incoming students in the Three C’s concepts and the style of learning to expect during their BSLE, an Introduction to Engineering Leadership course was first developed and piloted in the Fall of 2013. Unfortunately, having relied too heavily on traditional teaching styles, a lack of structure and synthesis of all of the subjects rendered the class unsuccessful. Retention rates in the course were poor and most students had strong negative feedback on the course. Several students, however, provided viable suggestions for modifying the course in their feedback. In an effort to improve on the shortcomings of the first class and develop leadership skills in students, the Engineering Leadership faculty decided to cede a majority of the control of the class to the students for the following fall 2014 course. This included curriculum design and the teaching of the course.

Upon being given the opportunity, the students were hired to work closely with The University of Texas at El Paso and Olin College of Engineering to identify the three main focus areas they wished to address in the course as well as an overall goal for the course. These instructional focus areas were leadership identity development, innovative thinking, and hands on skills. They were selected with the ultimate goals of introducing new students to engineering leadership, building an engaging and interactive course, and initiating the students' leadership development.

Methods

In keeping with the philosophy of leadership described earlier, the methods employed in this research relied heavily on the development and assessment of students' character, capacity, and competence. To this end, a process to craft the curriculum for the course and a leadership assessment plan was developed. However, since the focus of this paper is on the development of leadership in the Mavericks, as opposed to a deeper treatment of the curriculum developed, a greater emphasis is placed on describing their process, how they were assessed, and the resulting outcomes.

Curriculum Development

During the summer, Mavericks collaborated with faculty to work through a series of curriculum development workshops. The goal of the workshops was to allow the Mavericks to develop an improved, student-driven introductory course to focus on leadership identity development, innovative thinking, and hands on skills. Engineering Leadership and Olin College faculty facilitated the workshop to teach pedagogy as needed and ensure adequate scope for the course and that assessment measures were appropriate. Over the course of two workshops, the Mavericks took their past experience in the pilot introductory course and worked with the faculty to develop the new curriculum.

The first of these workshops was specifically focused on the curriculum for the new introductory course. The Mavericks, along with the faculty, first outlined the strengths and weaknesses of the pilot course. To isolate key themes, individual strengths and weaknesses were written on sticky notes and then grouped. Mavericks then took the emerging themes and brainstormed methods for maintaining or improving each part of the pilot version of the course. Taking a step back, the Mavericks and faculty also worked to generate a list of the key skills with which the degree, as a whole, should equip students. These broad skills were distilled down to the fundamental skills that the incoming students would need in order to lay a foundation for excellence in the E-Lead program. The key skills that remained became the new focus of the introductory course: leadership identity development, innovative thinking, and hands on skills.

To further develop the curriculum, Mavericks brainstormed ways to provide incoming students experiences through which to grow in the three focus areas. These ideas were grouped into three different categories: needs development, can be implemented, and blue sky ideas. The Mavericks then took the ideas, especially the blue sky ideas, and worked on making them into implementable ideas. From there, the two main projects for the course were developed. The first

was the Identity Sculpture and the Entrepreneurship Project (focused on the innovative thinking and business acumen).

As an engineering *leadership* degree, leadership identity development was a key skill to develop in the incoming students. To help students begin to articulate their own identity, the Identity Sculpture project focused on identity development and the use of common tools. To complete this project, students were instructed to create a sculpture of their choosing that they believe best tells the story of who they are and who they want to become. During the creation of their sculpture, students were trained on how to use tools in the machine shop and were required to manufacture at least one part of their statue in the machine shop. In the Entrepreneurship Project, students were introduced to innovative thinking, teaming, and business skills while developing a product prototype and pitch for their own small startup company. (Additional details on other course activities provided in the Results.)

Having ideas for the two main projects for the course, the Mavericks then considered the reactions of an important stakeholder: the students who would be taking the course. To do this, hypothetical student profiles were created, using the current demographics of UTEP and Engineering Leadership population. With these profiles, the Mavericks assessed how each student might react to and feel in the new course. This activity helped the Mavericks better identify ways to enhance the learning environment for a broad range of students and further refine the course projects and activities. By the end of the first workshop, the backbone of the new course was established but still needed to be better connected to the overarching goals of the Engineering Leadership degree plan.

In a second workshop, Mavericks worked with the entire Engineering Leadership faculty to connect the goals of the course to the goals of the degree. The Mavericks presented the curriculum developed to this point and the faculty gave feedback to help further advance the curriculum. Once the curriculum was finalized and classes started, the Mavericks were presented with different challenges that limited some of the activities and lessons that were planned, this caused the curriculum to evolve as the course went, but thought out it maintained its main purpose and overall structure.

Leadership Development Assessment

To assess their growth as leaders, interviews were completed with each of the Mavericks at the end of the course by a faculty member in the Engineering Leadership program (also an author of the paper) not overseeing the course. The interviews were a blend of open-ended and structured questions requesting students rate their agreement to a given statement based on an ordinal scale from 1 to 5, with 1 being strongly disagree and 5 being strongly agree. Each Maverick was individually interviewed at the conclusion of the course for approximately 30-45 min. Questions in the interview covered the following topics:

- Demographic data: age, gender, year in college, and role in the course.
- Course design, classroom setting, and meeting time
- Likes and dislikes about the course
- Leadership development in the 3 C's

Results

As a result of being empowered by the faculty in the Engineering Education and Leadership department at UTEP, the Mavericks were able to experience the other side of education and overhaul the Introduction to Engineering Leadership course. By reflecting on their own experience in the pilot course the prior school year, the Mavericks were able to identify the strengths and weaknesses of the previous course design. They then developed the new introductory experience for the incoming Engineering Leadership students. Following the completion of the course development and subsequent instruction of the course in the fall of 2014, the Mavericks were interviewed as described above. In addition, observations about the response of the incoming cohort of students are also shared.

Participant Demographics

Demographic data was collected for each of the Mavericks interviewed (Table 1).

Table 1: Student-Teacher Demographic Data

Gender	Number	Average Age [Ave(STDV)]	Ethnicity	Classification
<i>M</i>	3	20.0(0.0)	2 Hispanic, 1 Caucasian	All were 2nd year E-Lead students but 3rd year by credit.
<i>F</i>	3	19.33(0.58)	3 Hispanic	One student 2nd year student in E-Lead and by credit, Two were 2nd year E-Lead but 3rd year by credit.
Total	6	19.67(0.52)	5 Hispanic, 1 Caucasian	All but one were 2nd year E-Lead but 3rd year by credit.

Introduction to Engineering Leadership Course Outline

Using the methods described above, the Mavericks developed the materials outlined in Table 2. A required zero-credit course for all students pursuing the Bachelor of Science in Engineering leadership, the class met on Friday afternoons from 3-5pm in a studio style setting with movable tables and chairs and ample whiteboard space. On an average week, the Mavericks met twice with the teaching team: once to prepare the material for the week and again to receive feedback from the supervising faculty member. While all Mavericks attended the class each week, smaller sub-teams shared primary material delivery responsibilities in order to share the teaching and perpetration load.

Summarized in Table 2, specific activities were designed to enhance leadership identity development in the three C's, innovative thinking, and hands-on skills.

Table 2: Activities and Discussion Topics for Redesigned Course

Week	Course Goal	Outcome Statement	Course Activity
1	Leadership Identity Development	Show students how their identity is going to be developed along their college life and beyond.	Identity Sculpture - students designed a sculpture that they believe best tells the story of who they are and who they want to become.
2	Group Dynamics	Gain insight to the overall “personality” of a team.	Lecture and discussion about leadership through TV and movie clips
3	Leadership Introduction	Demonstrate to students what leadership truly means, and how great leaders achieve greatness.	Discussion and group activity on past ‘leaders’
4	Invention and Innovation	Understand the difference between invention and innovation	Group discussion on various everyday items
5	Innovative Thinking	Introduce the students to innovative thinking	Second project introduction: improve on an object that already exists
6	Identity Development	Reflect on Project One and the Course	Project 1 Reflection Discussion
7	Young Entrepreneurs	Introduce Entrepreneurship and its role in Engineering	Professional sales pitches on their up and coming ideas
8	Leaders Have Fun	Help students apply a couple of group dynamics understanding, and have fun!	Lego Mindstorm robotics development
9	Hands-on Skills	Students will understand the basics of circuits	Students will use breadboards to make a circuit with an LED that blinked at faster or slower rates depending on temperature.
10	Hands-on Skills	Introduce students to CAD software	Computer Aided Design
11	Innovative Thinking Application	Understand how to apply an innovative mindset	Group discussion on previous war, tech, and everyday products: how have they evolved? Why?
12		Address final concerns and last minute adjustments to project two	Last Minute Feedback Session
13	Communication Skills, Identity Development	Present final Project and give an understanding of the skills and knowledge they have gained	Final Project Presentation
14	Reflection	Get feedback from students about the course and their experience	Course Evaluation

To develop *Character*, the primary activity was an ‘Identity Sculpture’. For this project, incoming students had to reflect on their own personality and identify what made them unique. They then were to create a statue to visually communicate who they are and who they want to become to their peers. These sculptures not only helped the students learn more about themselves, but they also served as an icebreaker at the beginning of the course. To follow up on this exercise, students also took the Myers-Briggs Type Indicator (MBTI) self-assessment to help them discover and better express the type of person they identify with and want to be, as well as possible strengths and weaknesses.⁶ MBTI results were also used in pairing students when doing group work. Since group projects were more about further personal identity development rather than outcomes focused, students were paired with others of the same MBTI personality type hoping to make them comfortable in a group setting and allow them to see their own personality type mirrored in their peers. When working on group projects, student interactions and habits were closely observed to see their interactions with others in a group setting. Each group also had at least one Maverick with the same MBTI personality type as the incoming students to help in facilitating discussion. Students were also encouraged to interact with the Mavericks that were teaching the course in social settings. The frequency and depth of these social interactions were monitored consistently. Mavericks also kept track of their individual growth, confidence, and ability to relate to their audience and communicate information. Through this character and identity development process, students were to become more self-aware in order to become better leaders.

The *Capacity* of the students was also developed in and outside of the classroom. Students were given opportunities through the program to be part of extracurricular and volunteer activities. In these volunteering opportunities, the students got to expand their leadership skills by being part of running Innovation Session, an event to introduce high school students to the degree. In order to track the students involvement, Mavericks checked which students were attending Innovation Sessions, were involved in student organizations, had a job, or where participating in other activities. The main group project that was designed for the course was also designed to improve student capacity. Relying on the skills students had learned throughout the course, the final project they were given was to apply these skills in a project that made them think about different areas of new product design and development. Being given control of the class allowed the Mavericks to also grow with the students taking the class. Mavericks had to learn to manage their regular course schedules and prepare for the course.

Opportunities to expand their *Competence* were offered through the lessons given in class and the projects were a reflection of what the students were learning. However, Competence was rather tricky to measure mainly due to the fact that it encompasses more than just technical knowledge. To a greater extent, competence is demonstrated when students are able to take what they have learned and apply it in a tangential application in another course, at work or at home. One semester was insufficient to fully understand how much they grew in their learning and in what areas they subsequently applied this knowledge.

Besides the two main projects, smaller activities and projects were created alongside the main projects to help students connect what they were learning to real applications and practice the *hands-on* skills necessary for completing the major course projects and equip them for future Engineering Leadership courses. These activities included, but were not limited to, working in

the machine shop and building circuits. The students could then take those skills and use them to create items for their sculptures or build their product for the final project. In order to successfully teach the course, Mavericks developed their individual capacity as leaders by going through these different topics and gain the skills necessary to teach to the incoming students. While the class itself encouraged students to gain a variety of competencies, from presentation skills to business practices and engineering principles, student teachers too had to become educated on pedagogical practices as well as the material in the course.

While the lessons given to the students introduced the idea of innovative thinking, the true measure was the final Entrepreneurship Project. The objective of the project was to take an already existing product and/or materials and bring new value by creating an entirely new purpose for it. The idea was that the new product must solve a current issue using products/materials of their choice, given those materials were not originally intended to solve the issue. The students were paired in teams and given the freedom to choose anything they would like to use and the project was left very open ended to allow for creativity. This idea of not being told specifically what to do or specifically what to deliver was discomfoting to the students. They were expecting to be told what they had to deliver, but that does not capture the process of innovatively thinking and producing. Over the course of the project and the class time they became more comfortable with the idea of owning their own project and delivering something that would be completely different and presented differently than their peers. This helped encompass the notion that being innovative involves overcoming the fear of doing something different and better.

Leadership Assessment Outcomes

To assess their growth as leaders, interviews were completed with each of the Mavericks by a faculty member (also an author of this paper) in the Engineering Leadership program not overseeing the course according to the methods described above. When appropriate, they were asked to rate their response based on a scale of 1 to 5 with 1 being strongly disagree and 5 being strongly agree. The interview responses were deidentified and reviewed for trends. Ordinal responses were averaged across participants.

All of the Mavericks felt that the experience of redesigning the Introduction to Engineering Leadership course was able to help them redefine leadership (4.5, STDV 0.55), gain a better understanding of leadership (4.67, STDV 0.52), and increase their leadership skills (4.67, STDV 0.52). When asked whether the experience helped them increase their Character, Competence, and Capacity specifically, all students strongly agreed that it did (4.67, STDV 0.52; 4.33, STDV 0.82; 4.92, STDV 0.20). In development of their leadership, three of the Mavericks cited the actual teaching experience as being the most influential experience in their development. Others cited the mentorship they received from faculty and the process of learning to plan and work together as a teaching team. The Mavericks also agreed that the experience helped them increase their innovative problem solving and thinking skills (4.17, STD 0.41) and develop their identity (4.25, STDV 0.76). In the area of developing hands-on skills, however, the Mavericks were neutral about whether the experience helped (2.38, STD 0.75).

Other than citing issues of needing to be better organized as a team and improve communication, the Mavericks were pleased with the experience overall and had no changes to suggest for the experience. In fact, as one Maverick put it, "I'm afraid that if I took anything away it wouldn't be the same. There are lessons even from failure. I don't see anything to change." All of them, in fact, strongly agreed that they would recommend this experience to their peers (5.0, STDV 0.0). Their reasoning was, "It gives you a lot of insight you would not get otherwise. Lots of content in one experience: The chance to communicate, being forced to understand interpersonal communication, being pushed to do things you know you don't understand, and a sense of how far you've come." In fact, all the Mavericks said that they intended to stay in E-Lead (5, STDV 0). They cited the culture of the program, the range of opportunities, and the fact that "We are innovating. This is the future!" as reasons for why they plan to stay in the E-Lead program. Three of the Mavericks specifically cited the mentoring they receive from faculty as being a direct influence on why they intend to remain in E-Lead. Overall, they felt they were able to build better mentoring relationships with their professors, and become even more committed to the program. They also felt that this opportunity allowed them to take ownership of the program and do everything possible to ensure the future growth and success of the Engineering Leadership major. As a result of the experience, the Mavericks reported noticeable development in their leadership skills in areas such as strategic planning, big picture thinking, observation of detail, communication, developing relationships, preparation, and the need for deeper understanding of material to effectively deliver lessons.

Retention Rates

The student retention rate – measured as the number of students to complete the course that were enrolled as of the university census day – in the Engineering Leadership program as a result of the redesigned introductory course was 92% (Table 4). This was higher than the retention rate when it was piloted the year prior (60%). An even greater number of students were retained from the first class day in the redesigned course (70%) than in the pilot course (30%).

Table 4: Student Retention Rates

Student Groups	2013	2014
<i>Number of Students at First Day of Class</i>	50	34
<i>Number of Students Enrolled at Census Day</i>	25	26
<i>Number of Students That Completed the Course</i>	15	24

Discussion

Effectiveness of Students as Teachers

Although allowing Mavericks to teach incoming students was a step forward in the development of their leadership, the student instructors did lack the educational experience and authority that is often given a faculty member. This, at times, took away from the credibility of

the class, as the enrolled students often questioned Maverick credentials, and inquired as to the experiences that qualified them to teach the course, especially in the area of leadership. On the other hand, the student instructors were seen as ‘experienced peers’ who were able to connect on a deeper level and provide feedback to the incoming student. This allowed them to share relevant experiences in addition to technical information, such as mistakes that second year students made so incoming students would not have to repeat the same mistakes. Allowing student to be instructors seemed to encourage the incoming students to become more engaged in the classroom activities due to the fact that the student instructors were able to better relate to the incoming students. In the future, an improved balance of faculty involvement could help to lend credibility to the Mavericks while also mainlining the incoming student’s perspective of them as experienced peers.

Leadership Development Outcomes

Overall, students felt that they were able to achieve strong improvements in their leadership skills and knowledge. In particular, due to their unfamiliarity with curriculum design and any new material to be covered in the course, Mavericks developed the ability to learn thing on their own and then communicate that information to their peers. Not only did they learn about different engineering fields and create the interdisciplinary connections for themselves, but they also had to communicate this knowledge to the incoming students. Further, they not only learned basic theory of leadership, they also applied it. The position these student instructors were put in required them to become leaders - becoming more responsible, accountable, and meticulous. The Mavericks had to prepare content before classes, be ready to deliver content, and answer questions. These second year students also became role models and mentors for the new incoming students, guiding them through their first year of college. This experience helped develop a higher understanding for the Mavericks of what it takes to lead and effectively develop future leaders.

While the Mavericks had felt that they improved in the areas of innovative problem solving and thinking skills (4.17, STD 0.41) and develop their identity (4.25, STDV 0.76) they were neutral about whether the experience helped improve their hands on skills (2.38, STD 0.75). As expressed during the interviews, several felt that this was due to the fact that they were largely relying on teaching hands-on-skills that they had already possessed rather than acquiring new ones. This feeling of not having grown in their hands on skills may have also been a result of a very literal definition of hands-on-skills as opposed to a more general set of practical engineering and teaching skills.

Observed Impact on Incoming Students

While the primary focus on leadership development in this research was focused on the Mavericks, leadership growth was also observed in the students taking the course in the areas of character and capacity (competence was more difficult to observe as the time limit of one semester did not allow for observation of the students applying their gained competence in a tangential application). At the beginning, the expectations for the course, as voiced by the incoming students, was that of “concern”, “uncertainty” or expecting “traditional lecture”. However, the majority were surprised by their experience and pleased with the outcome. One of

the trends observed was the incoming students consistently commenting about the “welcoming environment” in the course. This seemed to indicate a growth in *Character* for some students. For example, several shy students that never talked in class were making jokes with their peers and the student-teachers. As one student shared, “This class has really helped me break out of my shell and open up.” For students who claimed it was hard for them to meet new people, they felt that they were able to quickly made friends and were thankful for the introductory course. One student, on the other hand, claimed, “I got along with my classmates but not really made friends. It is not something that I can easily manage.” It appears that as a result of the course structure and environment, a majority of the students showed greater confidence in themselves, increased efforts in the course, and elevated interaction with student teachers and peers; this improved their team dynamics during group participations. These results will require further study.

The *Capacity* of the incoming students was observed based on their change in involvement throughout the class. From the beginning, incoming student involvement ranged from being highly involved on campus (as members of student organizations for example) to having little or no involvement outside of the classroom. In an effort to build community, the Mavericks consistently invited the students to organized social events, such as going to a movie, playing Frisbee, or going out to eat. Often, one or more faculty members also attended these extracurricular events. Participation in the after class hangouts was optional. Most students, once they attended an after class hangout, were regular attenders with few new students joining the hangouts later in the semester.

Incoming students in the Intro to E-Lead course also demonstrated growing leadership capacity and personal ownership of the Engineering Leadership program. During the semester, Mavericks held recruitment events, called Innovation Sessions, at local high schools. These three hour Innovations Sessions required continuous development, iteration, and improvement by the students running them in order to create an effective method of spreading awareness about engineering, engaging with the high school students, and provide future college students an opportunity to learn about the Engineering Leadership degree. Though not a requirement of the course, several first year students volunteered to help host the Innovation Sessions and took responsibility for leading portions of the day. These first year students had to presenting material, organizing activities, and interacting with the high school students. In fact, of the first year students that volunteered, none had previous history of being highly involved on campus. Many of these students however remained engaged and active in the Engineering Leadership program and continued to volunteer to the end of the semester. A preliminary review of current enrollment in the second course in the BSLE degree plan taught in the spring of 2015, shows a trend indicating that students that attended these organized social events often also volunteered and were more likely to remain in the program. Every student who attended socials went on to become a part of the next course (16 out of the 25 that continued the E-Lead course sequence participated in these social events). It was observed that community produced a willingness to step into leadership positions in incoming students. They also developed an understanding of the importance of their leadership development and the importance of inspiring the next group of incoming students.

Retention Rates

The resulting improvement in retention rates (from 60% in 2013 to 92% in 2014) of the first semester of the Engineering Leadership program is largely attributed to the improved community and course designed by the Mavericks. Based on feedback from the Mavericks, the pilot year took much more effort and time to build community amongst the students as well as with the faculty. When the Mavericks were given the opportunity to teach the Introduction to Engineering Leadership course, they developed relationships with the incoming students and created a safe, inviting, and friendly environment that bridged the gap between the incoming students and faculty. As a result, the incoming students in the redesigned introductory course benefitted from the program in ways that were not present the year before and the Engineering Leadership retention rate greatly improved. To date, several of the incoming students continue to come by the Engineering Leadership department on free time and say hello to faculty, student-teachers, and other students from their course. It is also prudent to note that this retention rate may have been influenced by the fact that this course and the program was in its inaugural year and this may have also influenced the differences in retention as the popularity of the program was still growing. However, most efforts to promote the program did not occur until the second year was well underway. Therefore, initial recruitment of students in the redesigned course mimicked those of the pilot course.

Cyclic Leadership and Plan for Future Semesters

Although the Mavericks were more successful in relating to the students in the course, they did lack the authority and experience in being a professor and had no upperclassmen to seek assistance from. Although progress was made, future iterations of the course should ensure that the leadership abilities of student instructors is passed down in order to perpetuate the continuous improvement of the course. In fact, the intent for this course is that each year, the students that took the course the prior year would become the new Mavericks. Lessons learned by the student-instructors the prior year would be handed down, creating a cyclic pattern of leadership in the program. In addition, this is hoped to maintain a relevant and ever evolving culture in the Engineering Leadership program. Each summer, a group of students finishing their first year in Engineering Leadership will be hired to repeat this process of iterating on the course design and content before taking responsibility for teaching the course to the new incoming students.

Study Limitations

As this research covers a single course, a single redesign iteration, and a single group of six student-teachers, one major limitation of this research is its small sample size. An additional limitation, is that a subset of the Mavericks and faculty member that did the interviews are co-authors on this paper and therefore some objectivity in the reporting is lost. Further, the students teaching the redesigned course, while second year students in E-Lead, were third year students by credit. Therefore, it will be interesting to see if the above trends continue with the next group of student-teachers that will be second year students both in the program and by credit hours. Further, no formal interviews were completed with incoming students, but informal interviews and observations were completed throughout the semester to record their experiences. Future iterations of this research should include interviews of the both the incoming students and the current student teachers. A final limitation is the technique used for assessing leadership

development of the Mavericks. Leadership assessment did not use any sort of standardized test and relied heavily on self-identification through interviews. In the future, we intend to incorporate additional validated leadership assessment tools, such as the *Student Leadership Practices Inventory*.⁸ However, this research demonstrated the feasibility and effectiveness of allowing students to develop their leadership skills through taking on the role of instructor in an introductory engineering course.

Conclusion

In the fall of 2013, an Introduction to Engineering Leadership course was piloted with the inaugural class of students in the Engineering Leadership Program. After getting numerous ideas for improvements to the course for the following 2014 year, these same students were hired to take over the redesign and implementation of a new Introduction to Engineering Leadership Course. This redesign effort by students not only resulted in a new curriculum for the E-Lead program, but also improved the course by increasing the feeling of community for incoming students and thereby increased retention (from 60% to 92%). More importantly, this experience of being placed in the curriculum development driver seat, also served to help the student-teachers redefine leadership, gain a better understanding of leadership, and increase their leadership skills (4.5, STDV 0.55; 4.67, STDV 0.52; 4.67, STDV 0.52; based on an ordinal scale with 1 being strongly disagree and 5 being strongly agree). The experience also helped them increase their Character, Competence, and Capacity (4.67, STDV 0.52; 4.33, STDV 0.82; 4.92, STDV 0.20). The mavericks also agreed that the experience helped them increase their innovative problem solving and thinking skills (4.17, STD 0.41) and develop their identity (4.25, STDV 0.76). Overall, this research demonstrated the feasibility and effectiveness of allowing students to develop their leadership skills through taking on the role of instructor in an introductory engineering course.

References

1. *The Engineer of 2020 Visions of Engineering in the New Century*. Washington, D.C.: National Academies Press, 2004.
2. "Franklin W. Olin College of Engineering." U.S. News & World Report. Accessed January 6, 2015. <http://colleges.usnews.rankingsandreviews.com/best-colleges/olin-college-39463>.
3. "University of Texas--El Paso." U.S. News & World Report. Accessed January 6, 2015. <http://colleges.usnews.rankingsandreviews.com/best-colleges/utep-3661>.
4. "Demographics." MIE UTEP. Accessed January 6, 2015. <http://research.utep.edu/Default.aspx?tabid=44271>.
5. *Building the Capacity to Lead*. West Point, New York: United States Military Academy, 2009. Web.
6. Andresen, Lee, David Boud, and Ruth Cohen. "Experience-based learning." *Understanding adult education and training*. 2 (2000): 225-239.
7. "The Myers & Briggs Foundation - MBTI® Basics." The Myers & Briggs Foundation. Accessed January 6, 2015. <http://www.myersbriggs.org/my-mbti-personality-type/mbti-basics/>.
8. Kouzes, James M., and Barry Z. Posner. *Student Leadership Practices Inventory: Facilitator's Guide*. San Francisco, CA: Jossey-Bass, 2006.