



Engineering Leadership Development Programs: Universities Respond to Critical Needs in the US and Internationally

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Introduction

In a world where technological innovation continues to accelerate, engineers need to continuously evolve and improve, just like the new technology they are developing. The need for engineers to be effective leaders and lifelong learners is critical for the world's health and development.

Addressing the complex challenges of the 21st century successfully can only be achieved if an engineer also has highly developed soft skills; especially—leadership. The university's role in preparing engineering students to be the future technical leaders is essential to address this need. Providing a safe and constructive leadership experience early in a young leader's life will make students develop and maintain a positive mindset to be a lifelong learner.

It is well-known that successful leadership is gained through deliberate practice and constructive feedback. The more a person puts their leadership skills into practice and learn from their mistakes, the more successful they will be at becoming an effective leader. The best time to develop these skills are during the undergraduate education of an engineer. This is a time that the student can practice, without serious consequences for making mistakes.

Therefore, the university's role in providing programs to prepare students to not only be lifelong learners, but also leaders, has gained a greater significance in the last ten years. In order to meet industry's growing demand for future technical leaders, university sponsored undergraduate engineering leadership development programs have been increasing steadily. Table 1 lists the rapid growth in the development of these programs.

Table 1. Engineering Leadership Program and the year they were founded

Engineering Leadership Program	Year	Engineering Leadership Program	Year
Tufts University's Gordon Institute	1987	Rice Center for Engineering Leadership	2010
Penn State's Engineering Leadership Development Minor	1995	UC Berkley Fung Institute for Engineering Leadership Professional Program	2010
Southern Illinois University Carbondale	2006	University of Colorado's Engineering Leadership Program	2011
MIT's Gordon Engineering Leadership Development Program	2007	Miami of Ohio's Lockheed Martin Engineering Leadership Institute	2012
Northeastern University's Gordon Leadership Program	2007	Drexel's Lockheed Martin Engineering Leadership Program	2014

Yet, the demand for leaders continues to grow and consequently the opportunities for developing leadership programs. Universities all over the world need to understand, recognize, and act towards this development.

Demand for STEM Leadership

The importance of leadership skills has been recognized by business and academia^{1,2}. The National Academy of Engineering³ outlined the significance of engineers understanding the principles of leadership and being able to practice these principles in growing proportions as their career advances. Additionally, research conducted by professor Woodie Flowers (2009)⁴ of MIT

provided a conclusion that soft skills, of which leadership is among them, are more important to an engineer's career than the core technical subjects that the students were required to take at MIT.

Likewise, in a business context, leadership skills are considered a top critical factor for a company's success. According to the survey Job Outlook 2015 (2014, NACE)⁵, when employers were asked which attributes they look for on a candidate's resume, the largest group of respondents (77.8 percent) chose leadership. Also a survey conducted by the Deloitte University Press (2014)⁶ shows the critical need for leadership: executives "viewed leadership as the highest-priority issue of all the issues, with 86 percent rating it urgent or important" (p. 25). Additionally, this survey points out that human capital priorities vary in every industry, with only one exception: Leadership⁷.

The demand for better leaders in the STEM field is also highlighted by Michael K. Young⁷: "As the boundless opportunities continue to grow in our backyard, critical fields in science, technology, engineering and math (STEM) are demanding more highly trained leaders, doers and thinkers."

It is clear that the need for leadership occurs at all levels, across all industry areas and all over the world. "This continuous need for new and better leaders has accelerated. In a world where knowledge doubles every year and skills have a half-life of 2.5 to 5 years"⁸(p. 7), leadership development is completely necessary.

The Leadership Development Gap

Despite the importance of leadership in an engineering education, the quality of leaders is declining over the last decade, according to Deloitte⁹. Faced with this situation, there are numerous opportunities for universities to develop leadership development programs and work towards the improvement of engineering leadership education. Additionally, according to the Deloitte 2014 Millennial Survey⁹, 50 percent of the organizations believe they could do more to develop future leaders, which is clearly an opportunity for interaction between business and universities in order to better prepare future engineers.

The Leadership Gap research conducted by the Center for Creative Leadership¹⁰ shows that leaders are not adequately prepared for the future. Today's leadership capacity is insufficient to meet future leadership requirements and a gap between current leadership bench strength and future leadership demands.

It is urgent that business and academia recognize the opportunity to address the leadership void in business, so they can re-focus their leadership development efforts. As Richard K. Miller, president of Franklin W. Olin College of Engineering, stated, "engineering education remains mostly stuck in the late 20th century, when what we need are largely educated engineers who bridge many disciplines and have the skills and perspectives that will be necessary in the future."¹¹ (p. 51)

The Deloitte survey concluded that there is "a significant gap between the urgency of the talent and leadership issues leaders face today and their organizations' readiness to respond"¹² (p. 4). The capability gap between readiness and urgency is a worldwide challenge, but there are programs around the world that have started addressing this problem.

How leadership can be developed within the university

It is clear that the industry demand for leaders is a growing movement. However, its development within the universities is a daunting task, presenting a two-way challenge: universities need to provide effective programs and the students need to understand, recognize its importance, and consequently put sustained effort in developing the skills necessary to be work ready upon graduation. Usually, students feel overwhelmed by their classes, exams and homework, and do not seek more activities that can develop lifelong learning for their career. It is necessary that the university provide programs that are able to inspire young people through a precise purpose and shared vision of committing themselves to work preparation training.

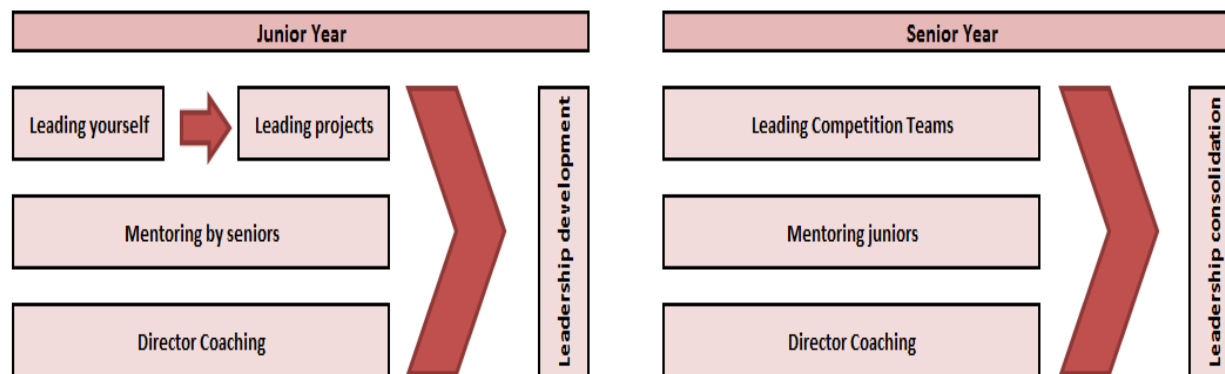
By analyzing university-based programs all over the world, two specific ones have shown great success in meeting industry's demand for future leaders with each of them having their own particular strengths. The Leadership Development Program (LDP) at Southern Illinois University (SIUC) serves as an outstanding model for other universities, globally, on how to develop an engineering leadership program that produces technical leader¹³. The Brazilian Junior Enterprise Movement (JEM) serves as a notable example for developing leaders by the means of business experience. Both programs have the mission to educate and prepare future professionals that will impact positively the society and will lead their teams to achieve world class results; consequently strengthening their country's economy. These programs believe that learning is better achieved through a blend of formal academic training and experiential learning that is achieved when students apply their technical knowledge to lead real-world projects.

The SIUC Leadership Development Program

The LDP is a two-year program whose purpose is to train students for future challenges by developing team-building, interpersonal skills, character, and leadership skills. Student's skills are improved by experiences the program provides, such as life skills lectures, leadership classes, individual mentoring, community service projects, and leading engineering student competition teams.

The program participations are divided into two groups: the first year students (a.k.a. Juniors) and the second year students (a.k.a. Seniors). Juniors development consist of adopting the values of the program, developing the ability to lead themselves and leading short duration projects. Some of the projects led by the Juniors are: community clean-ups, raffle project for the college laboratories, American Red Cross blood drive, women's center projects, science center projects, city park tree planting and many others. Also, Juniors are required to develop important habits for industry, such as arriving early for the meetings, knowing how to give a proper handshake, facilitating a social conversation, active participation in meetings and conferences, holding themselves accountable and demonstrating excellence in all they do. Seniors with more developed skills are required to lead a Registered Student Organization (RSO) within the university, mentor a group of Juniors, and keep everyone accountable to the program's values. During the program, the director supports the development by offering personal coaching to all members so they can develop a learning mindset and reach their full potential. The flow map in Figure 1 shows how the program develops lifelong learning skills and prepares students to be technical leaders with highly developed skills.

Figure 1. LDP Student Development Model



In order to develop leadership skills, technical skills and other essential soft skills requested by industry, the program requires that the students attend a team building week during the summer, go to weekly workouts, develop and join leadership workshops, read leadership books, write book reports, practice giving presentations, participate in a summer internship, take extra classes important to an engineering curriculum and maintain a 3.0 GPA. The results of all those activities are recorded and analyzed using a powerful tool called the Hoshin Kanri X-Matrix for strategic planning to evaluate the success of the program and to teach students how to develop a strategic plan ¹⁴. Furthermore, LDP uses The Leadership Challenge Model's ¹⁵ five exemplary practices of student leadership as a guide for developing leadership skills.

Results

LDP results have been significant and transformational not only for the university and the students, but also for the program's corporate sponsors. Below is a partial list of results that the program has achieved:

- 40% increased graduation rates compared to peer comparison groups
- 95% of the graduates have received career offers prior to graduation;
- Generated over \$2 million in Six Sigma cost saving;
- Held RSO president positions in 10 out of the 14 of the college RSOs;
- Many corporate sponsors have provided internships for the LDP members and have hired graduates from the program;
- Led over 40 community service projects

The program's success has led many companies such as Advanced Technology Service (ATS), Boeing and Nucor to become sponsors of the program. These companies are willing to hire these students because they are better prepared to work in their companies and to be the future technical leader that the company needs. The endorsement of ATS summarizes the program's outcome:

“SIUC’s Leadership Development Program does an outstanding job of preparing the students to enter the workforce with the readiness to assume leadership positions quickly. ATS utilizes this program as one of our key talents pools for leadership roles. Through the program’s rigorous academic and extra-curricular requirements, I have found that these graduates have an exceptional work ethic, take initiatives, and strive for excellence much more than typical college graduate (James Hefti – ATS Vice President of Human Resources).”

Brazilian Junior Enterprise Movement

The Brazilian Junior Enterprises Movement is a movement formed by the merger of the Junior Enterprises (JE), State Federations and a Brazilian Confederation to form a network who's propose is to shape leaders that will advance the development of the country. A JE is a university supported program formed only by undergraduate students to implement projects and services in their field of study, such as engineering and business. The students are challenged to manage an actual business enterprise by team work and lead the organization.

A JE is created by not only the initiative of the university, but also of the students who will manage the enterprise. Like any other company, a JE needs to make a profit to survive in a very competitive environment. The advantage of these enterprises is that the students are not paid with salaries, so they can perform service for the community at a very low cost. All money that a JE makes is invested in the enterprise infrastructure and the member's education; such as leadership training and other training related to their field of study.

As a company managed only by students, they need to take initiatives and be proactive in order to succeed. Therefore, this experience serves as a laboratory for real market situations where each student needs to develop critical soft skills and technical skills. Every JE has a hierarchy that gives the student the opportunity to gain experience. For example, manage meetings, set department goals, and have contact with real customers while performing real projects related to their field of study. The flow map in Figure 2 shows how the students develop lifelong learning skills and become an entrepreneur with highly developed skills.

Figure 2. JE Student Development Model



Results

The program results have been very significant and have had a positive impact on the country and the development of students. The most relevant results are:

- JEs completed 2216 projects in 2013 averaging 6.07 projects per JE;
- Those projects generated an estimated revenue of \$4,100,000 (USD) for 2013;
- The program in Brazil has over 8500 students;
- Last national meeting had attendance of 1700 members

The movement is sponsored by three of the largest Brazilian companies: Inbev (biggest company in Latin America), Itaú Bank (biggest Bank in Brazil) and Falconi (leader in business consulting). The interactions between businesses and universities have been able to expand the movement and its results, developing highly skilled students and generating high impact across the country. The endorsement made by Itaú's HR Director summarizes the program's outcome:

“A student who worked in the Junior Enterprise Movement has a differential when he enters in the company. It looks like he has had a previous experience and that's pretty cool. This helps a lot on the daily activities and in the integration with our bank.” (Sergio Fajerman, HR Director, Itaú Bank)

Developing Tomorrow's Global Engineering Leadership Program

Common aspects of these two programs

Comparing the two program's purposes, methodologies and results, it is clear that they have much in common. The similarities range from why they were created, to the impact leadership has on their country's future. Both programs are analogous in the critical factors that lead leadership programs to success. These vital prerequisites are:

- **Strong purpose:** When an organization achieves the sense of ownership in the members through an inspiring vision, mission and purpose, the students understand and recognize its importance and then put greater effort into the activities; which enables greater development;
- **Learning through experiences:** the most effective learning for a student happens through experiences. It is extremely important that the program provides many experiences which each student will learn from both their successes and disappointments. The program must make sure that the students will receive feedback that will enable them to learn from their mistakes;
- **Business sponsor and involvement:** The partnership between businesses and universities are a great opportunity for both. Business participation in leadership programs can maximize their results through sponsorships and involvement. The program needs to make sure that the lessons learned in the program can be applied to the sponsors through internships and career opportunities. Also, the program may request that the sponsor provide: (a) knowledge to help in structuring the program; (b) lectures and presentations; (c) mentoring activities; and (d) funding.
- **University support:** The university needs to be very committed and provide resources for the development of the activities and high quality professionals willing to dedicate enough time to the development of the students.

- **Lifelong learning mindset:** Both programs develop a positive mindset in their participants of lifelong learning. In the LDP, the graduate from the program achieves the "leadership consolidation", as described in Figure 1, consequently the graduate understands and recognizes the importance of being a lifelong learner. Likewise, in the JEM approach, when a student achieves the "embodiment of the purpose", the student becomes a lifelong learner.

Complementary aspects of these two programs

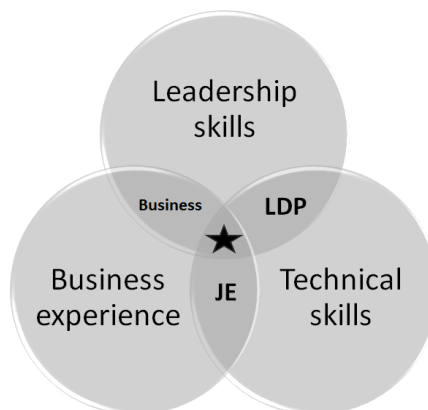
By analyzing the two program's methodologies, some important differences and similarities appear in the approaches they apply to student leadership development. Those programs were selected for this paper because they have different strengths, but also share complementary approaches to prepare students with leadership skills. The following paragraphs describe the program's unique strength and outcomes.

The focus of the LDP is to develop future technical leaders by focusing on: leadership skills and technical knowledge. In the LDP, students have the opportunity to explore the technical aspect of engineering and apply leadership knowledge by developing projects and leading RSO's in a real-project context. The outcome is a student that deeply understands, recognizes and is able to apply leadership skills and technical knowledge in any situation as his career advances.

On the other hand, Junior Enterprises have the purpose to develop future entrepreneurs by focusing on: business experience and application with technical knowledge. Their approach is letting students lead themselves to explore highly technical knowledge in a business application. It happens by being part of a real company that needs to achieve goals and make a profit and by developing projects for these companies where technical knowledge is needed. The outcome is a student that profoundly understands, recognizes and is capable of applying the technical knowledge that is taught in classes and business applications.

Despite the differences, both programs have been generating excellent outcomes for their societies and have been developing better prepared student for the workforce. Yet, it is clear that the SIUC LDP has a gap in providing business experiences that enables students to rapidly apply their knowledge in a business context. The JEM has a gap in formal leadership development that enables students to understand the fundamentals of leadership and apply them in the most effective way possible. Therefore, by combining the two program's strengths, a new world-class engineering leadership development program model can arise t, as Figure 3 illustrates:

Figure 3. Three aspects of tomorrow's global leadership program



The future leadership program would focus on developing the work-ready students with the leadership skills to use as soon as they graduate. It means that the student will have a combination of technical skills, leadership skills and business experience. The student will be capable of understanding a business context in order to put in practice all knowledge and skills that the student has been learning in the engineering leadership program.

Additionally, the U.S. can enhance the outcome of an Engineering Leadership Program by learning how to integrate leadership training with business applications. JE has created a network that enables continuous knowledge exchange and leadership opportunities for students. By having a structured network that can replicate the program for universities, the engineering leadership program of the future will be able to expand quickly, generate results in large scale and enhance the outcome for the country.

Conclusion

Both programs have been generating excellent results for their stakeholders and the combination of their approach is an opportunity to create an improved global Engineering Leadership Programs of the future. Their combination can maximize results and can serve as an example for the development of more leadership programs.

Their noted impacts are on engineering education programs, students' leadership preparation, preparing industry's workforce and communities served. Assessing these combined contributions equates to progress towards improving the world's health and development.

As the demand for engineering leaders increase, businesses and universities in countries like the US and Brazil are responding with innovative engineering leadership development programs that generate great economic and social impact for the country. Universities role in providing successful programs to address the leadership demand is essential to face the challenges that engineers have. Universities all over the world must continue to meet this challenge by further creating innovative leadership development programs that encompass leadership skills, technical skills, and business experience

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