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# LEADing The Way: A Review of Engineering Leadership Development Programs

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# LEADing The Way: A Review of Engineering Leadership Development Programs

## Abstract

This paper is based on the results of a national survey of ASEE Engineering Leadership Development Division (LEAD) members to compare and contrast the innovative components that have been implemented within various engineering leadership development programs. Data were collected from participants (University Faculty) from 30 North American, African, and European Universities. The following components were examined: cross-cultural education, team-based applied projects, mentorship, and corporate sponsorship. The main objective of this paper is to examine these components, identify innovative practices, and promote the importance and growth of engineering leadership education. Through presenting our preliminary findings, we hope to encourage other programs to participate in the survey so that we can obtain a more comprehensive picture of engineering leadership development practices.

## Background

The United States' global leadership is predicated upon not only a sufficient technical workforce, but more critically, leaders among them who will inspire them to create the technology better and faster than our competitors[1,2]. Over the past 15 years, academia[3,4], private industry[5], and the U.S. government[6] have all proclaimed that engineering education is not producing graduates with the skills necessary to succeed as an engineer in the 21$^{st}$ century. Specifically, there has been a call for engineering undergraduate programs to place more emphasis on developing graduates with professional skills (e.g., soft skills and leadership)[4]

The need is so critical that fortune 50 companies such as Caterpillar[7], General Electric[8], Lockheed Martin[9], and Siemens[10] among others have created their own internal leadership development programs. This not only highlights the need for strong leadership in a work environment, but it also reveals the necessity for leadership education in new engineering employees. Industry is also responding to this shortage by investing in the creation of technical leadership development programs at universities via corporate sponsorship. Through these partnerships, students supplement their technical skills with soft-skills education and business acumen[3]. Universities and industry can also work together to implement a specialized curriculum that makes program graduates skilled and competent in their field upon graduation. The Vice President of Human Resources for one large manufacturing company provided the following statement regarding leadership development program graduates they have hired.

> "(Institution's name omitted)'s engineering leadership development program does an outstanding job of preparing the students to enter the workforce with the readiness to assume leadership positions quickly. (Manufacturing companies name omitted) utilizes this program as one of our key talent pools for leadership roles. Through the program's rigorous academic and extracurricular requirements, I have found that these graduates have an exceptional work ethic, take initiative, and strive for excellence much more than the typical college graduate."

Graduates from universities with a formalized commitment to leadership are often able to quickly contribute in industrial settings due to their ability to communicate to solve problems and lead teams[2]. Hiring graduates who have participated in engineering leadership programs may also help organizations cut costs associated with sending employees through their company's internal leadership development programs.

The purpose of this survey was to collect data from various institutions to examine the types of programs utilized and highlight innovative practices. This paper will provide insight into various types of leadership development programs that have been implemented and examine their key components. Existing programs can use this information to help optimize their current engineering leadership program. In addition, universities looking to create programs can use this information to examine the structure of other engineering leadership development programs.

## Method

### *Participants and Procedures*

This paper is based on data that were collected from faculty members representing 30 universities that were recruited via the ASEE Engineering Leadership Development Division (LEAD) listserv. The ASEE LEAD listserv is comprised of approximate 700 members (per Division Chair estimate). We requested information on the number of unique universities represented on the listserv (as the survey is limited to one faculty member per university), however, the division did not have access to this information.

The ASEE LEAD Division Chair sent initial emails to the listserv on October, 9th, 2015, and three reminder emails containing the survey link between the dates of 11/19/2015 and 01/30/2016. The email also requested that universities have only one faculty member per university fill out the survey.

In total, 53 participants gave consent to participate in the survey. Of these 53, a total of 36 participants (i.e., 68.9%) advanced to the next page to enter their universities name and a total of 26 participants (i.e., 49.1%) completed the survey. Four additional participants (i.e., 7.5%) provided partial responses (i.e., at least answered the items regarding which components are at their university or under development) and are also included in this paper. However, six participants (i.e., 11.3%) entered their university's names and then closed the survey. As a result, their results were omitted from this report since they did not answer any substantive questions on the survey. All 30 participants referenced in this paper were from unique institutions (i.e., there were no duplicate submissions).

### *Measures*

Participants were administered the 72-item *Engineering Leadership Development Program Survey*. This survey was created by the Engineering Leadership Development Lab at Southern Illinois University, along with collaboration from faculty representing Brigham Young University, the University of Calgary the Georgia Institute of Technology, Marquette University, Pennsylvania State University, and the University of Toronto. The purpose of this survey was to collect data on various program components utilized by engineering leadership development programs across the nation and to collect qualitative data on specific innovative practices.

Prior to creating the survey we found that there were no clear operational definitions of engineering leadership development program components, so we sought to work with the team of eight engineering faculty to create operational definitions so that we could ask follow-up questions isolating the structure of specific components. Components were categorized as Engineering/Technical Leadership "Degree", "Minor", "Certificate", "Coursework", and "Other".

These categorizes were operationalized with the following definitions and provided to survey participants.

1. Degree - A program that offers a degree in Engineering/Technical Leadership or a closely related field.

2. Minor - A program that offers a minor in Engineering/Technical Leadership or a closely related field.

2. Certificate - A program that offers a certificate in Engineering/Technical Leadership upon completion.

4. Coursework - A program that offers coursework not part of a degree/minor/certificate in Engineering/Technical Leadership Program.

5. Other - Please select other if your program type does not fit into the categories listed above. Selecting other will allow you to provide additional information regarding your program type (e.g., a registered student organization devoted to Engineering/Technical Leadership, etc.).

Participants were asked to respond *yes*, *no*, *under development*, or *don't know* regarding if their university's engineering leadership program utilizes, a degree, minor, certificate, coursework, or a component that could be classified as "other". Participants were then prompted to answer specific questions about each specific program component separately including questions concerning cross-cultural education among other questions of interest. Skip logic was applied to the questions, thus only participants who respond *yes* to a category would receive the items related to that category.

Next, participants were asked to answer questions regarding all of the engineering/technical leadership programs utilized at their university (i.e., includes all degrees, minors, certificates and other coursework). The questions asking about all program components examined areas such as team-based applied projects, leadership coursework, mentorship, and corporate sponsorship. Several items provided open-ended text boxes that allowed participants to describe unique features of their programs (We elaborate on the open-ended responses in the conclusions section)

## Results

We used IBM SPSS to calculate frequencies of the data collected. The results section will feature frequency tables for each item followed by a brief write-up describing key findings. Further interpretation is offered in the discussion section.

### *University Information*

Of the 30 valid participants, 28 (i.e., 93.3%) responded representing a university located in North America (see Table 1) with 26 out of the 28 coming from the United States (see Table 2). Regional analysis of the 26 U.S. Universities show that approximately 34.6% are located in the Southern region of the U.S. (defined by the U.S. Census Bureau's official U.S. regions)[11], 26.9% from the Northeast, 23.1% from the Midwest, and 14.4% from the West (see Table 3).

The states with the greatest number of participants were Texas (*n* = 4) and Massachusetts (*n* = 3; see Table 3 notes). International participates were excluded from table 4. These participants represented universities in Ontario, Canada (*n* = 2), Leinster, Republic of Ireland (*n* = 1), and Eastern Cape, South Africa (*n* = 1). Seventeen (57%) participants were from universities classified as public and 13 (43%) participants were from universities classified as private.

Table 1
*Continent of Participating University*

| **Continent** | **Frequency** | **%** |
|---|---|---|
| Africa | 1 | 3.3 |
| Europe | 1 | 3.3 |
| North America | 28 | 93.3 |
| Total | 30 | 100 |

Table 2
*Country of Participating University*

| **Country** | **Frequency** | **%** |
|---|---|---|
| Canada | 2 | 6.7 |
| Republic of Ireland | 1 | 3.3 |
| South Africa | 1 | 3.3 |
| United States | 26 | 86.7 |
| Total | 30 | 100 |

Table 3
*Region of Participating U.S. Universities*

| Region | Frequency | % |
|---|---|---|
| Midwest | 6 | 23.1 |
| Northeast | 7 | 26.9 |
| South | 9 | 34.6 |
| West | 4 | 14.4 |
| Total | 26 | 100 |

*Note*. Based on U.S. Census Official Regions: Midwest = Illinois (*n* = 2), Indiana, Iowa (*n* = 1), Kansas, Michigan, Minnesota (*n* = 1), Missouri, Nebraska, North Dakota, Ohio (*n* = 1), South Dakota, and Wisconsin (*n* = 1); Northeast = Connecticut (*n* = 1), Maine, Massachusetts (*n* = 3), New Hampshire, New Jersey, New York (*n* = 1), Pennsylvania (*n* = 2), Rhode Island, and Vermont; South = Alabama, Arkansas, Delaware, District of Columbia, Florida (*n* = 1), Georgia, Kentucky, Louisiana, Maryland (*n* = 1), Mississippi, North Carolina, Oklahoma (*n* = 1), South Carolina, Tennessee, Texas (*n* = 4), Virginia (*n* = 1), and West Virginia; West = Alaska, Arizona, California (*n* = 2), Colorado (*n* = 1), Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah (*n* = 1), Washington, and Wyoming.

### *Component Specific Questions*

Engineering leadership degrees are currently in-place at seven of the 30 universities (i.e., 23%). In total, 21 universities (i.e., 70%) do not have an engineering leadership degree (nor one under development), and two (i.e., 7%) universities are in the process of developing an engineering leadership degree (see Table 4). Undergraduates are eligible to participate in degree programs at three (i.e., 43%) of the seven universities, graduate students are eligible to participate in degree programs at six (i.e., 85%) of the seven universities, and non-students are eligible to participate in degree programs at three (i.e., 43%) of the seven universities.

Engineering leadership minors are currently in-place at five of the 30 universities (i.e., 17%). Twenty universities (i.e., 67%) do not have a minor, and five universities (i.e., 17%) responded that they are currently developing a minor related to engineering leadership. Undergraduates are eligible to participate in minor programs at four (i.e., 80%) of the five universities, graduate students are eligible to participate in minor programs at two (i.e., 40%) of the five universities, and non-students are eligible to participate in degree programs at two (i.e., 40%) of the five universities.

Engineering leadership certificates are currently in-place at 10 of the 30 universities sampled (i.e., 33%). Fifteen universities (i.e., 50%) reported that they do not have an engineering leadership certificate, and 16.7% reported that they are currently in the process of developing an engineering leadership certificate. Undergraduates are eligible to participate in certificate programs at nine (i.e., 90%) of the ten universities, graduate students are eligible to participate in certificate programs at four (i.e., 40%) of the ten universities, and non-students are eligible to participate in certificate programs at two (i.e., 20%) of the ten universities

Engineering leadership coursework is currently available at 22 of the 30 universities (i.e., 73.3%). Six universities (i.e., 20%) reported that they do not have engineering leadership coursework, and one university (i.e., 7%) reported that they are currently in the process of developing engineering leadership coursework. One of the respondents quit the survey before completing the items regarding program eligibility, so the adjusted total is 22. Undergraduates are eligible to participate in engineering leadership coursework at 20 (i.e., 91%) of the 22 universities, graduate students are eligible to participate in engineering leadership coursework at 13 (i.e., 59%) of the 22 universities, and non-students are eligible to participate in engineering leadership coursework at one (i.e., 5%) of the 22 universities.

A total of ten participants (i.e., 33%) have a component classified as "other" at their university. A total of 18 participants (i.e., 60%) said that they did not have a component classified as "other" and two (i.e., 7%) reported that a component classified as "other" is currently under development. Undergraduates are eligible to participate in the component classified as "other" at 9 (i.e., 90%) of the 10 universities, graduate students are eligible to participate in the component classified as "other" at 4 (i.e., 40%) of the 10 universities and non-students are eligible to participate in the component classified as "other" at 2 (i.e., 20%) of the 10 universities. Participants were given the opportunity to provide an open-end description of the component they classified as "other". The 10 open-ended "other" responses were coded based on main themes. One participant (i.e., 10%) reported their program had multiple features categorized as "other": chemical engineering leadership program, a social design project, and a club leader's roundtable. Another (i.e., 10%) reported their program had a "college wide engineering program", as well as an international education focused curriculum. Two participants (i.e., 20%) reported a component related to coursework. Each of the following components were reported by one participant (i.e.,10%) respectively: joint five-year engineering-business degree program, professional education component (tailored for working professionals), an internship co-op with local companies, certificate program, and hands on learning through peer collaboration on projects. One participant (i.e., 10%) did not provide an open-ended response.

Table 4
*Engineering Leadership Components Offered*

| | **Degree** | | **Minor** | | **Certificate** | | **Coursework** | | **Other** | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Response** | **Freq.** | **%** | **Freq.** | **%** | **Freq.** | **%** | **Freq.** | **%** | **Freq.** | **%** |
| Yes | 7 | 23.3 | 5 | 16.7 | 10 | 33.3 | 22 | 73.3 | 10 | 33.3 |
| No | 21 | 70.0 | 20 | 66.7 | 15 | 50.0 | 6 | 20.0 | 18 | 60.0 |
| Under Dev. | 2 | 6.7 | 5 | 16.7 | 5 | 16.7 | 2 | 6.7 | 2 | 6.7 |
| Total | 30 | 100 | 30 | 100 | 30 | 100 | 30 | 100 | 30 | 100 |

*Note*. Under Dev. = Under Development, Freq. = Frequency. These program categories are not mutually exclusive, so Universities were asked to select yes or no for each type of program.

### *International/Cross-cultural Experiences (Based On Specific Components)*

Five of the seven programs (i.e., 71%) that have an engineering leadership degree, reported offering student's opportunities to participate in international/cross-cultural education, six of the seven programs (i.e., 85.7%) reported offering student's opportunities to participate in engineering/technical cultural collaboration, and two of the seven programs (i.e., 29%) reported offering student's opportunities to participate in international travel (see Table 5).

Four of the five programs (i.e., 80%) that have an engineering leadership minor, reported offering student's opportunities to participate in international/cross-cultural education, four of the five programs (i.e., 80%) reported offering opportunities to participate in engineering/technical cultural collaboration, and three of the five programs (i.e., 60%) reported providing students opportunities to participate in international travel (see Table 6).

Table 5
*Degree Component: International/Cross-cultural Experiences Offered*

| **Response** | **Frequency** | **%** | **Frequency** | **Response** | **Frequency** | **%** |
|---|---|---|---|---|---|---|
| Yes | 5 | 71.4 | 6 | 85.7 | 2 | 28.6 |
| No | 2 | 28.6 | 1 | 14.3 | 4 | 57.1 |
| Do not know | 0 | 0 | 0 | 0 | 1 | 14.3 |
| Total | 7 | 100 | 7 | 100 | 7 | 100 |

*Note*. Only the seven participants who responded that their program had a degree component received this item.

Five of the ten programs (i.e., 50%) that have an engineering leadership certificate reported offering student opportunities to participate in international/cross-cultural education, five of the ten programs (i.e., 50%) reported offering student's opportunities to participate in engineering/technical cultural collaboration, and two of the ten programs (i.e., 20%) reported offering student's opportunities to participate in international travel (see Table 7).

Table 6
*Minor Component: International/Cross-cultural Experiences Offered*

| | **International/Cross-Cultural Education** | | **Cultural Collaboration** | | **International Travel Opportunities** | |
|---|---|---|---|---|---|---|
| **Response** | **Frequency** | **%** | **Frequency** | **%** | **Frequency** | **%** |
| Yes | 4 | 80.0 | 4 | 80.0 | 3 | 60.0 |
| No | 1 | 20.0 | 1 | 20.0 | 1 | 20.0 |
| Do not know | 0 | 0.0 | 0 | 0.0 | 1 | 20.0 |
| Total | 5 | 100 | 5 | 100 | 5 | 100 |

*Note*. Only the five participants who responded that their program had a minor component received this item.

One of the 22 programs that reported having engineering leadership coursework quit the survey before researching the cross-cultural/international education items. As a result, only 21 participants received these items. Thirteen of the 21 programs (i.e., 62%) that have engineering leadership coursework, reported offering student's opportunities to participate in international/cross-cultural education, 14 of the 21 programs (i.e., 67%) reported offering student's opportunities to participate in engineering/technical cultural collaboration, and four of the 21 programs (i.e., 19%) reported offering student's opportunities to participate in international travel (see Table 8).

Table 7
*Certificate Component: International/Cross-Cultural Experiences Offered*

| | International/Cross-Cultural Education | | Cultural Collaboration | | International Travel Opportunities | |
|---|---|---|---|---|---|---|
| **Response** | **Frequency** | **%** | **Frequency** | **%** | **Frequency** | **%** |
| Yes | 5 | 50.0 | 5 | 50.0 | 2 | 20.0 |
| No | 5 | 50.0 | 5 | 50.0 | 7 | 70.0 |
| Do not know | 0 | 0.0 | 0 | 0.0 | 1 | 10.0 |
| Total | 10 | 100 | 10 | 100 | 10 | 100 |

*Note*. Only the ten participants who responded that their program had a certificate component received this item.

Three of the ten programs (i.e., 30%) that have an engineering leadership component that falls under the "other" categorization reported offering students opportunities to participate in international/cross-cultural education, four of the ten programs (i.e., 40%) reported offering students opportunities to participate in engineering/technical cultural collaboration, and three of the ten programs (i.e., 30%) reported offering students opportunities to participate in international travel (see Table 9).

Table 8
*Coursework Component: International/Cross-cultural Experiences Offered*

| | International/Cross-Cultural Education | | Cultural Collaboration | | International Travel Opportunities | |
|---|---|---|---|---|---|---|
| **Response** | **Frequency** | **%** | **Frequency** | **%** | **Frequency** | **%** |
| Yes | 13 | 61.9 | 14 | 66.7 | 4 | 19.0 |
| No | 8 | 38.1 | 7 | 33.3 | 16 | 76.2 |
| Do not know | 0 | 0.0 | 0 | 0.00 | 1 | 4.8 |
| Total | 21* | 100 | 21* | 100 | 21* | 100 |

*Note*: Only the 22 participants who responded that their program had coursework were supposed to receive this item. *Denotes 22 universities reported having engineering leadership coursework. One of these universities quit the survey before receiving this item.

Table 9
*Other Component: International/Cross-cultural Experiences Offered*

| | International/Cross-Cultural Education | | Cultural Collaboration | | International Travel Opportunities | |
|---|---|---|---|---|---|---|
| **Response** | **Frequency** | **%** | **Frequency** | **%** | **Frequency** | **%** |
| Yes | 3 | 30.0 | 4 | 40.0 | 3 | 30.0 |
| No | 7 | 70.0 | 6 | 60.0 | 6 | 60.0 |
| Do not know | 0 | 0.0 | 0 | 0.0 | 1 | 10.0 |
| Total | 10 | 100 | 10 | 100 | 10 | 100 |

*Note*. Only the ten participants who responded that their program had a component categorized as "other" received this item.

### ***Team Based Applied Projects***

When participants were asked about all engineering leadership programs at their university, 23 of 28 (i.e., 82.1%) reported that their university requires students to collaborate on team-based applied projects (see Table 10).

Table 10
*Team-Based Applied Project Requirement*

| Response | Frequency | % |
|---|---|---|
| Yes | 23 | 82.1 |
| No | 4 | 14.3 |
| Do not know | 1 | 3.6 |
| Total | 28* | 100 |

*Note*. *Denotes two participants quit the survey before receiving this item.

### ***Mentorship***

Of the 27 participants that completed the mentorship items, 22 (i.e., 81.5%) reported having, at least, one type of formal mentorship (see Table 11).

Results from specific "mentorship type" items indicate that 18 participants (i.e., 66.7%) reported utilizing faculty mentors, 16 participants (i.e., 59.3%) reported utilizing peer mentors, 15 (i.e., 54.6%) reported utilizing corporate mentors, and five participants (i.e., 18.5%) reported that their university utilized mentors who are classified as "other" (see Table 12). The five *other*: please specify responses include the following: requires students obtain a mentor with "experience in engineering leadership practice", students are asked to obtain a mentor from their internship, graduate students serve as mentors, and members of non-government agencies serve as mentors.

A total of 12 respondents (i.e., 44.4%) of the 27 that received the corporate sponsorship items reported that their program has, at least, one corporate sponsor. The number of corporate sponsors ranged from 1 to 20, with a mean equal to 5.75, and median equal to 3.5. The mode number of corporate sponsors was one, which was selected by four of the 12 universities (i.e., 33.3%) with corporate sponsors.

Table 11
*Program that Utilizes at Least One Form of Mentorship*

| Response | Frequency | % |
|---|---|---|
| Has at least one mentorship component | 22 | 81.5 |
| Does not have any mentorship components | 5 | 18.5 |
| Do not know | 0 | 0.0 |
| Total | 27* | 100 |

*Note*. Three participants quit the survey before receiving this item

Table 12
*Type of Mentorship Utilized*

| | Corporate Mentor | | Faculty Mentor | | Peer Mentor | | Other Mentor | |
|---|---|---|---|---|---|---|---|---|
| | **Freq.** | **%** | **Freq.** | **%** | **Freq.** | **%** | **Freq.** | **%** |
| Yes | 15 | 54.6 | 18 | 66.7 | 16 | 59.3 | 5 | 18.5 |
| No | 12 | 44.4 | 9 | 33.3 | 10 | 37.0 | 17 | 63.0 |
| Do not know | 0 | 0.0 | 0 | 0.0 | 1 | 3.7 | 5 | 18.5 |
| Total | 27* | 100 | 27* | 100 | 27* | 100 | 27* | 100 |

*Note*. *Denotes three participants quit the survey before receiving this item, Freq -= Frequency. These mentorship categories are not mutually exclusive, so universities were asked to select yes or no for each type of mentorship.

## Discussion

The goal of this research was to compare and contrast the innovative components that have been implemented within various engineering leadership development programs. While engineering leadership education can have a profound impact on the U.S. economy, and the workforce of the 21st century[1,2], formalized curricular programs (e.g., degrees, minors, certificates) still appear to be the exception rather than the norm based on the participating universities. Within our sample, engineering leadership coursework appears to be relatively commonplace. As leadership coursework continues to spread throughout the engineering curriculum, the number of degrees, minors, and certificates may continue to increase. Likewise, the call for a new generation of more technical leaders in the workforce[1] may hasten the development of new formalized programs.

Several programs used open-ended response opportunities to describe unique programs that are currently at their institution. One university faculty member stated: "currently, a leadership development association exists for women engineering students only. We are looking at developing an inclusive engineering leadership program" (South African engineering faculty member). Given the underrepresentation of women in Science, Technology, Engineering, and Mathematics (STEM) fields[12,13], universities may benefit from creating programs targeted at females in engineering. The development of these programs may also help limit the feelings of marginalization among female students and increase their social support network[14]. Another program offers a 124 credit hour Bachelors of Science in Engineering Leadership degree. This program focuses on developing students through a curriculum focused around "Entrepreneurship/Innovation, Business Acumen, and Leadership Development" (Southern U.S. engineering faculty member).

### *Cross-cultural education*

Globalization has resulted in massive shifts in the STEM workforce[15]. Barriers that once limited the entry of global competition such as access to education[16] have become less inhibitive for students overseas to get a quality engineering education without leaving their home country[17]. As a result, the world is now a global market. Many engineers are now going overseas to work[16] and many engineers produced overseas, are now finding employment in the U.S.[18] As a result, the engineering workforce of the 21st century must be competent, global citizens capable of working with and respecting the customs of peers from varying backgrounds.

Many engineering leadership development programs have begun implementing aspects of cross-cultural education into their curriculum. A large proportion of programs that have degrees, minors, and coursework reported having international/cross-cultural educational opportunities (i.e., coursework focusing on values, norms, and traditions of other cultures) and Cultural Collaboration opportunities (i.e., opportunities to engage in activities with individuals from another culture). However, most programs reported that they do not currently have international travel opportunities in their programs. The engineer of tomorrow will likely need a great deal of cultural competence in order to inspire and lead all members of their team to success[19,20]. As such, we have identified this as a potential area programs may want to develop.

***Applied team-based projects***

In today's engineering work environment, teams are becoming more common in order to develop quality products in a shorter amount of time[21, 22, 23]. Research has shown that effective teamwork has been associated with improved quality and organizational efficiency[24, 25]. A majority of the programs included in this study require students to collaborate on team-based applied projects. A common theme found in the open-ended responses about these team-based applied projects was that most occur at the end of the program, usually acting as a capstone or senior project. As a result, many these projects occur as part of academic classes within their respective programs. Projects tend to be tailored to meet the needs of different majors, as well as the current needs of industry and the community. For example, some of these projects may benefit the community or a company by having students build a product that can be used (e.g., a piece of specialized equipment or a campus bridge). Likewise, these applied products help the student gain direct experience (e.g., skills and knowledge) working on a specialized project in their field of interest (e.g., a mechanical engineer working to create a moon-buggy).

These team-based applied projects are important for developing the next generation of engineering leaders. These projects allow students to address industry and societal problems that they will see in the workforce. Additionally, these projects offer engineering students the experience of working on a team, as well as highlight the importance of leadership and teamwork skills.

***Mentorship***

Another important aspect for career and leadership development is having a mentor. Individuals with a mentor have been linked to increased work effectiveness, job satisfaction, promotion rates, and higher salaries [26, 27]. A majority of the programs indicated the use of a formal mentorship program for their students. The mentors include faculty, more advanced students, and corporate employees. Many of the programs used a combination of all three types of mentors, yet faculty mentors are the most common. Through mentorship relationships, students can learn from the experiences of their mentor. As a result, students are likely to be better prepared to navigate the workplace environment.

***Corporate sponsorship***

In order to ensure that engineering students are obtaining useful skills, we must ensure that the programs are tailored (e.g., curriculum and experiences) to match industry needs. This collaboration between universities and companies can also be mutually beneficial for both parties. For example, one program (Midwestern U.S.) reported working with industry advisors to design a curriculum to meet the needs of the workforce. The corporate sponsors typically help cover costs associated with student activities and provide students with in-house internships. As a result of this tailored knowledge and internship experiences, the students often have a competitive advantage on the job market (especially if they apply to the firm that helped develop the training).

Our results also indicated that many programs do not currently have corporate sponsors. We anticipate that many of the universities that currently do not have corporate sponsors, would welcome the opportunity to collaborate with industry if approached by a reputable company. Smaller universities and those in more rural areas may also have more difficulty securing corporate sponsors. One faculty member (Midwestern U.S.) suggests "It is commonplace for alums to contact their alma mater when looking to hire new graduates, so when we tell them about the training our students receive in the leadership development program, they are often receptive to becoming sponsors of the program". There are many benefits to this collaborative partnership between academia and corporations, and we anticipate that it will continue to become more popular.

### *Practical implications*

An initial practical implication of this study is that the results can be used by engineering leadership program directors to benchmark their program's components in comparison to other programs. Likewise, the results of this survey can be used as a tool for future universities interested in starting a Leadership Development Program. It can provide them a reference guide to see what established and successful programs are doing to create the engineering leaders of tomorrow.

### *Limitations*

One limitation of this study is that we were only able to obtain useable data from 30 universities. As a result, this data is likely not an accurate representation of the entire population of engineering leadership development programs. As such, we urge readers to avoid making broad generalization based on this data. However, this survey is still active and we hope to acquire data on additional universities to provide comprehensive overview of the structure of engineering leadership development programs.

Another limitation of this study is we were only able to collect data from two universities located outside of North America. As a result, we cannot accurately compare and contrast the data obtained from the North America sample to data collected from other continents.

### *Future Research*

Although our original research goal was to collect data from North American universities, the participation of international universities was a welcomed surprise. Future research should seek to obtain adequate samples from Africa, Asia, Europe, North America, and South America to compare engineering leadership programs between continents.

Research could also conduct follow-up studies to examine the role engineering leadership development program structures have on student success (i.e., GPA, retention rate, graduation rate, placement rate, and career advancement). This information could be used to identify whether there are any common factors among the most successful programs. This in turn could be used to help ensure students are receiving the skills that put them in the best position to succeed.

Future research may also want to look at longitudinal changes in the field of engineering leadership education. A number of programs in this survey stated that they had components that are "under development. A longitudinal study tracking the development of new programs (and development of new components at existing programs) could provide insight into how engineering leadership development programs progress over time.

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