

A Comprehensive Leadership Development and Assessment System for Engineering Students

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Abstract

In this paper, we describe the development, testing, and scaling of a leadership development program specifically designed for engineering students and faculty. Such leadership development seeks to catalyze college-wide culture and performance and enhance student success. Program design, content, and process are described. The program combines a system thinking approach, visual models, and principle-based leadership to grow leaders and systems thinking ability concurrently. The program has been tested in small group cohorts, an engineering undergraduate program, and a college-wide co-curricular offering. Our research seeks to assess the effectiveness of the program framework and content as well as the nature and audience of delivery. A process for training faculty is described.

The program layers development in learning, practice, and mastery levels similar to Six Sigma programs. Techniques for student retention and assessment are detailed at each level. The program is organized to allow student leaders to perform program assessment, improvement and sustainment. Program expansion to faculty and staff is planned in order to facilitate college-wide leadership culture.

Keywords

Leadership, Systems Thinking, Assessment

1. Leadership Development Overview

Many universities issue aspirational vision statements seeking to “create leaders.” For example, our College of Engineering vision states we aspire to “Cultivate leaders who excel in academics, innovation and research.” Specifically in engineering education, a number of institutions have implemented supplemental leadership development programs. More frequently, however, leadership development takes the form of channeling high achievers into a limited number of “leadership” roles. To achieve the organization vision, leadership growth should be accessible to every student, staff, and faculty. The resulting leadership culture can catalyze higher levels of organizational performance.

A number of studies have addressed leadership in engineering [1-4] with associated goals/purpose in building leaders, associated competencies and skills, and effective pedagogy and process. One review of 11 engineering leadership programs [3] yielded a framework suggesting five programmatic goals (effective leadership, systems thinking, experiential learning, independent learning and innovation & technology) and six engineering leadership competencies (communication, teamwork, innovation, personal drive, creativity, and execution).

One comprehensive approach to systemic leadership development in engineering education is suggested in [5]. The approach employs system thinking [6] to inform the design and communication of leadership development content. The approach graphically defines “leadership operating space” as a function of capacity and character. Each combination of capacity and character is assigned a “persona” to facilitate discussion (see Figure 1). The design of the leadership development program is to move to the right while moving up each capacity level.

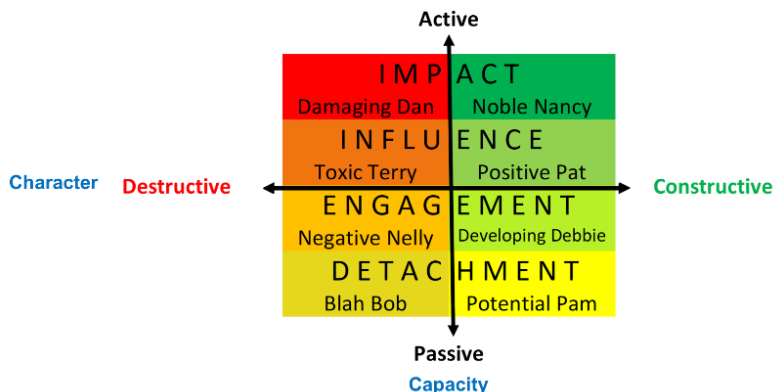


Figure 1: Leadership Operating Space

Leadership is viewed as functional, not based on position or title, so it may be exercised by everyone. Since the environment of leadership application will vary widely, we choose more universal characteristics and associated principles at each capacity level to guide development. Principle-based leadership recognizes the power of “simple rules” to provide guidance across diverse and complex situations. Leadership development content, organization, process, and assessment is driven by these principles.

The effort is concurrently undertaken at the college level to advance the mission and at the industrial and systems engineering program level in support of ABET accreditation program educational objectives and student outcomes. Specifically, our program has aligned curricular content to produce graduates who are “LIT,” leaders, integrators, and transformers.

2. Leadership Development Content and Organization

At each capacity level, we sampled the expansive set of leadership literature and selected three frequently occurring characteristics. For each characteristic, we collaboratively crafted “principle” statements. Recognizing that principles may be challenging to remember and apply, we have selected and developed a set of more memorable and applicable leadership content that covers the principles. Effective leadership content blends a variety of didactic types: common vocabulary, stories and examples, models and pictures, protocols and methods. Leadership tools are focused and most have a visual representation to enhance learning. Organization of the program elements has been thoughtful to facilitate delivery, shared vocabulary, assessment and evaluation. Key data entities in the program organization are shown in Table 1. Table 2 shows the nine program principles with associated characteristic, vocabulary, and tools.

Table 1: Leadership Development Entities

Entity	Description
Capacity Level	Leadership is categorized at three levels: 1. leading oneself (engagement), 2. leading others (influence) and 3. leading in community/organizations (impact).
Characteristic/ Principle	Trait of effective leaders / Description of how effective leaders demonstrate characteristic at each capacity level.
Vocabulary	Terms where shared understanding promotes dialog and leadership culture. Attributes: definition. Relationships: principle(s) and scenarios.
Tool	Memorable and applicable models, stories, and processes that support principles. Attributes: description, one page overview. Relationships: principle(s) and scenarios.
Persona	Combination of capacity and character that facilitates leadership discussion.
Scenario	Description of a leadership application relevant to learning audience. Relationships: principles, tools, and vocabulary.
Persona Response	Description of how a persona would respond to a given scenario.

Leadership content has been tested in a variety of environments including executive education, student cohorts, departmental faculty, and student specialist staff. Content is currently divided into four interactive modules (an introduction module and one module for each capacity level).

Table 2: Leadership Characteristics, Principles, Vocabulary and Tools

Concept	Principle	Vocabulary (partial)	Tools
1.1 Identity/ Integrity	Leaders develop an authentic leadership identity by exhibiting self-awareness and integrity.	Authenticity, Integrity, Identity, Vulnerability, Self-Awareness	24/7 Leadership Mobius Strip Johari Window
1.2 Growth	Leaders seek, throughout their life, to grow personally and professionally and to maintain mental and physical health.	Holistic, Reflection	Growth Mindset 80/20 Leadership
1.3 Persistence	Leaders demonstrate persistence in the face of challenges, accept responsibility adapt to change, and grow through failure.	Agility, Persistence	Learning Curve Positive Pivot
2.1 Relationships	Leaders value relationships over personal agendas creating a healthy community.	Community, Mental Model, Relationship, Transparency, Trust	Cookie Thief (Mental Models), Grade Story
2.2 Inclusion	Leaders allow others to provide ideas from diverse perspectives and participate in decisions.	Diversity, Inclusion	Robin Hood Story [7] Cultural Systems [7]
2.3 Communication	Leaders engage in open, safe and direct dialogue to advance learning and resolve conflict.	Direct Dialog, Open Dialog, Safe Dialog	Sit-Beh-Impact Crucial Conversations
3.1 Vision	Leaders set clear direction, align to it, and commit to success.	Alignment, Commitment, Direction, Vision	DAC Stool, DAC Process
3.2 Multiplication	Leaders build leaders who build leaders. Leaders develop and empower others.	Development, Multiplication	Multipliers/Diminishers Kudzu/Legume TALL Process
3.3 Transformation	Leaders actively produce positive change in themselves, others, and their community.	Impact, Influence, Service, Transformation	A&T Four Story Leadership Ladder

3. Leadership Development Process

Based on initial testing and refinement of the leadership content, a three-level development process is being pursued as shown in Figure 2. The process is similar to the Six Sigma martial arts inspired belt levels. Our levels are named more descriptively as Learn-Do-Lead with each typically associated with a period of one year. Teaching sessions (green), assessment (blue), student actions (purple) and writing (brown) are shown in the figure.

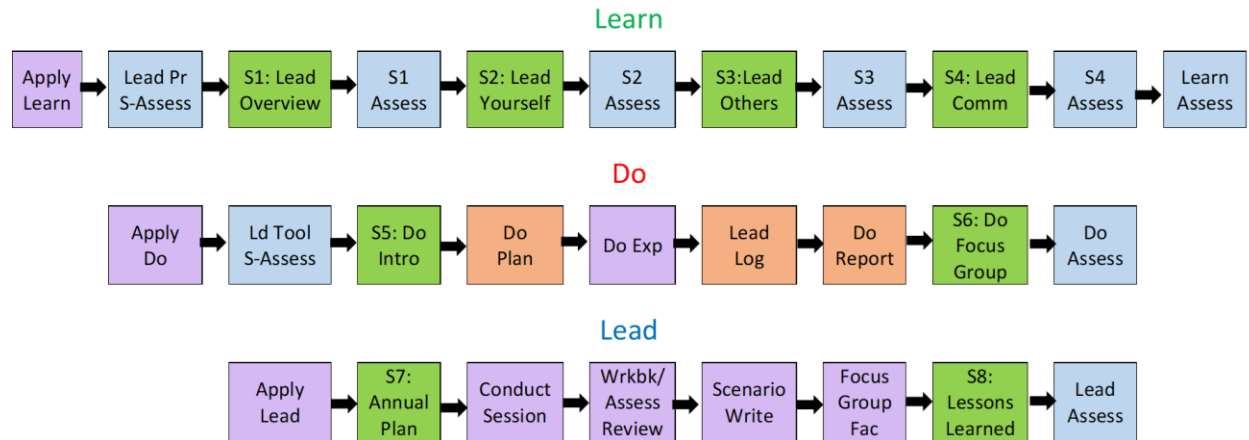


Figure 2: Learn-Do-Lead Leadership Development Process

The “Learn” level provides a fundamental understanding of leadership and leadership content along with an initial assessment of leadership strengths and limitations. Students attend four interactive sessions aligned with the earlier described modules. After each session, students provide feedback on session and content value. Additionally, students take review assessment to ensure learning. At the end of the level, students take a learn level certification exam.

The “Do” level enables the student to engage in a specific leadership role which may be flexibly determined. The process enables connection of the student to mentors at the Lead level, peers at the Do level, and facilitated connection to content from the Learn level. Student process is documented for feedback and assessment with a plan, guided journal prompts, and final report. At the end of the level, students take a do level certification exam.

The “Lead” level provides students an opportunity to sustain, deliver and improve the program (acknowledging faculty/staff involvement is required for long term stability). Students look at the prior year to develop an improved plan for the upcoming year. Students at this level conduct learn sessions, facilitate focus groups with and give writing feedback to do students, and prepare additional content/assessment materials for future use. At the end of the level, students take a reflective lead level certification exam.

The program is initially focusing on the development of students and is being conducted at two levels. First, it is implemented as an integral part of the Industrial and Systems Engineering (ISE) undergraduate curriculum. All ISE students go through the learn process in a sophomore level professional development class. Department faculty have been trained on leadership content and reinforce elements of it in junior and senior level courses.

Additionally, an extra-curricular offering of learn is made available to College of Engineering (CoE) students with evening offerings. Students from both pools are combined in the do and lead levels. Students are not required to complete all levels.

Student Leadership Development councils are being formed at the ISE and CoE levels (will operate collaboratively). Upon completion at each level, students are issued a certificate for badging on their resume and a level-dependent stole worn at graduation.

4. Leadership Development Assessment

Assessment is designed to be sustainable and valuable at the program and student level. A database of student participants and their associated performance is integrated with the database of leadership content from Section 2. This integration enables individual reports to be provided for student feedback and aggregate reports to measure program effectiveness. Assessment data is collected in the form of student surveys, objective assessments, reflective essays, and experiential application feedback. Student surveys (see Table 3) enable identification and trending of student application of principles. Students receive an automated report showing their response to self-assessment questions, their average performance across principles and related measures across cohorts. Early empirical experience with the program indicates student appreciation for “good” leadership is underdeveloped prior to the program with a bias that can lead to overrating. The survey has been formatted for peer or faculty/supervisor feedback with normalizing instructions.

Leadership content understanding and relevance and effectiveness of training sessions is being assessed and improved. Externally developed leadership inventories might also be incorporated.

Table 3: Customized Surveys

Survey	Level	Description
Leadership Beliefs	Learn	Survey of incoming leadership beliefs to gain alignment with program (every person leader, leadership functional, etc.)
Leadership Self-Assessment	Learn, Do, Lead	45 question survey to determine principle-based assessment of relative strengths and weaknesses (5 indicators per principle)
Leadership Content Assessment	Learn, Do, Lead	Assessment of the accessibility/level of understanding and the relevance of each leadership tool (and select vocabulary)
Session Feedback	Learn, Do, Lead	End of session feedback on content comprehension/learning and qualitative feedback (what worked well and what to improve)

Objective assessment seeks to determine the level of content comprehension and application with formats shown in Table 4. The database format enables the automatic creation of a wide variety of questions so that assessments may be unique, but equivalent, for each student. Review questions are used after learn level sessions with automated grading enacted. Such review assessments may be implemented to enable multiple student attempts to enhance learning.

Most assessment at the do and lead levels is based on reflective essays in response to provided prompts. Review of the do assessment is performed by lead level students. Review of lead level students work and final review of do level students is conducted by a group of leadership-interested faculty.

Program assessment is mixed mode involving student self-assessment and coding of written responses with objective measures of content mastery demonstration and impact on academic performance. Initial collected student results have been overwhelmingly positive and constructive.

Table 4: Assessment Categories

Level	Given	Task	Use	And
Learn Review		Match	Tool	Principle
Learn Review		Match	Tool/Vocabulary	Definition/Description
Learn Review	Scenario	Match	Persona	Response
Learn Certify	Principle	Describe	Application	
Learn Certify	Tool	Describe	Application	
Learn Certify	Scenario, Persona	Describe	Response	
Learn Certify	Scenario, Personas	Compare	Responses	
Learn Certify	Scenario, Tool	Describe	Application	
Learn Certify	Scenario, Principle	Describe	Relevance	
Learn Certify	Scenario	Select, Describe	Tool	Application
Learn Certify	Scenario	Select, Describe	Principle	Relevance
Do Application	Principle	Describe	Application	
Do Application	Principle	Select, Describe	Application	
Do Application	Tool	Describe	Application	
Do Application	Tool	Select, Describe	Application	

5. Conclusion and Future Work

This paper has described the organization of a leadership development program for engineering students. The program is designed using systems thinking tools. Leadership operating space is characterized with development driven by related principles and content. A three-tiered development process is proposed and described. Finally, program and individual assessment is explained as a mixture of surveys, objective assessments and reflective essays. A normalized database is used to integrate leadership content and student information. The process is designed to be sustainable and portable emphasize ownership, sustainment, and improvement by students.

Future work includes an end of year comparative assessment of student performance in the two cohorts (about 25 ISE students and about 60 CoE students). Additionally, more detail relative to the do and lead levels will be documented and distributed. Finally, expansion to and adaption for faculty and staff use is underway.

Acknowledgements

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References

- [1] R. Graham, R., E. Crawley, and B. R. Mendelsohn, "Engineering Leadership Education: A Snapshot Review of International Good Practice." *Bernard M. Gordon-MIT Engineering Leadership Program White Paper*, 2009.
- [2] R. J. Schuhmann, "Engineering Leadership Education - The Search for Definition and a Curricular Approach." *Journal of STEM Education: Innovations & Research* vol. 11, no. 3, 2010.
- [3] R. Paul and L. G. C. Falls. "Engineering Leadership Education: A Review of Best Practices," in *2015 ASEE Annual Conference & Exposition*, June 14, 2015, pp. 26.634.1-26.634.11.
- [4] B. A. Bowman and J. V. Farr. "Embedding Leadership in Civil Engineering Education." *Journal of professional issues in engineering education and practice*, vol. 126, no. 1, 2000, pp. 16-20.
- [5] P. Stanfield, "Leadership Development Integration in Engineering Education," *Industrial Management*, July 2022, pp. 18-22.
- [6] P. Stanfield, "Six Visual Models for Systems Thinking," *Industrial Management*, January 2023, pp. 18-23.
- [7] P. Stanfield, "A Systems Perspective on Diverse Teams," *ISE Magazine*, June 2022, pp. 46-50.