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Pedagogical approaches for facilitating engineering leadership development

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Abstract

This article describes transformative, impactful pedagogical practices that engage students in the process of leadership development. We share practical examples of instructional strategies and facilitation techniques from curricular and co-curricular initiatives.

INTRODUCTION

Engineering leadership (EL) programs employ transformative, diverse, entrepreneurial pedagogical approaches to move students from conceptual understanding to active leadership. Pedagogy, which refers to the methods, strategies, and practices used to teach (Smith et al., 2005), can take the form of lecture-based instruction to experiential learning and reflective practice. Examples within the field of EL education include reflection (Didiano et al., 2019; Pitts et al., 2013), teamwork (Bayless, 2019; Evans et al., 2013), service-learning (McMartin, 2013), project-based learning (Cain & Cocco, 2013), case studies (Ahn et al., 2014; Rottmann & Reeve, 2020), coaching (Cowe Falls et al., 2015; Handley et al., 2019), and mentorship (Gipson et al., 2015).

With many pedagogical approaches from which to select, it is essential to understand your student population and desired learning outcomes. Understanding your student population cultivates a foundational awareness of students' academic, professional, and personal needs, while understanding programmatic outcomes informs your goals. The process of critically reflecting on your pedagogical approach transforms traditional, lecture-based instruction into experiential, active, collaborative learning environments. It inspires a deeper appreciation of leadership prompting students to move beyond a conceptual understanding to practicing and engaging with concepts. It also enhances the student experience by fostering connections, networks, and sharing of diverse perspectives.

This chapter summarizes a range of pedagogical approaches that create meaningful learning experiences in curricular and co-curricular EL initiatives. We organize these approaches into three sections: (1) fostering self-awareness, (2) learning with and from others through teamwork, and (3) online leadership competency development. The first two are pillars of many leadership models (Komives & Wagner, 2009; Komives et al., 2011), and engineering leadership programs (Kendall et al., 2018; Klassen et al., 2016), while the third

has become a salient focus of engineering educators throughout the COVID-19 pandemic. We conclude the chapter by sharing recommendations to help EL educators integrate pedagogical approaches into their work.

FOSTERING SELF-AWARENESS

Leadership begins with a deep understanding of self (Komives & Wagner, 2009; Komives et al., 2011). This awareness allows students to define their unique leadership style, which is the launching pad for leveraging their strengths and skills in group contexts. Reflection, strength assessments, and narrative exploration are powerful pedagogical tools when working to increase students' self-understanding.

Reflection

As a form of critical thinking, reflection involves active, persistent, and careful consideration of new knowledge in relation to prior thoughts and experiences (Dewey, 1933). It is an essential skill that lays the foundation for self-aware EL development. A graduate course at the University of Guelph and Queen's University in Ontario, Canada, uses a leadership reflection journal for students to describe, analyse, and evaluate their weekly activities and experiences in relation to their leadership development (Donald et al., 2020). Bayless (2016) at Ohio University addressed student concerns about reflection as "looking backward" by supplementing reflection with forward planning in an undergraduate leadership development course. Each week, students reflected on how they might have improved the outcome of their previous leadership experiences using new skills learned in class.

Strength assessments

Strength assessments are popular pedagogical tools used to provide students with an awareness of their strengths and preferences (Komives et al., 2011). Several of these assessments have been used extensively in EL programs to catalyse self-awareness. For example, the Bolton and Bolton Work Styles Inventory was developed by psychologists Robert Bolton and Dorothy Grover Bolton (2009) to help individuals assess their dominant leadership styles along two orthogonal dimensions: assertiveness and responsiveness. The resulting four leadership styles include: driver, analytical, amiable, and expressive. This tool has been integrated into many EL programs, including a semester-long leadership development class at Ohio University in which it is used to form cross-functional teams. Preliminary results indicate stronger initial team creativity outcomes than had been the case with the self-selected team baseline (Bayless, 2019).

Another popular tool used by EL program leaders is the Myers Brigg Type Indicator (MBTI) (Briggs Myers et al., 2009), a personality inventory that assesses individuals along four dimensions, resulting in one of 16 personality types. The Gordon Engineering Leadership Program at Northeastern University uses this self-assessment to support students as they get to know themselves and members of their project teams (Pitts et al., 2013). Later in the program, students write a report on an engineering leader, including selecting the MBTI type that best describes the leader (Klosterman et al., 2015). Assessments such as the MBTI and Bolton and Bolton help students identify their preferred style while gaining appreciation for others, and the capacity to leverage a group's collective competence.

Narrative exploration

Narrative exploration is the process of telling stories to make meaning of experiences. It engages students in developing communication skills by sharing their stories and cultivates self-awareness and confidence by examining and articulating life experiences. Through personal history exploration, students claim their experiences and the personal identities that have shaped their strengths, perspectives, and leadership approach. In addition, hearing others' narratives promotes a greater understanding of different viewpoints and perspectives (Denning, 2005). For example, the Troost Institute for Leadership Education in Engineering (Troost ILead) at the University of Toronto has a course called "The Power of Story: Discovering Your Leadership Narrative". They use a life history process based on Dan McAdams' (1997) work to support students' exploration and articulation of difficulties, curveballs, and opportunities. Students divide their life into book chapters and then answer questions such as: 'Describe the people who had the most positive influence on you?', 'Identify a turning point or major challenge and how it impacted your understanding of yourself', and 'Identify an event from your teenage years that is especially significant or important' (Kinnear & Simpson, 2016). Students then share their answers with others. Shifting from verbal to visual representation, a first-year introductory leadership course at University of Texas El Paso uses an Identity Sculpture Project where students create a sculpture that depicts the story of who they are (Montoya et al., 2015). Part of the sculpture is made in the machine shop, bridging a connection between leadership education and technical engineering.

LEARNING WITH AND FROM OTHERS THROUGH TEAMWORK

Applying leadership skills and principles to a situation alongside others helps move students' understanding of leadership from concept to collaborative practice. In this section, we review the use of teamwork, alumni engagement, and case studies as a means of promoting engagement in experiential leadership education.

Teamwork

Leadership development skills are necessary for engineers to succeed in cross-functional team environments (Shuman et al., 2005). To facilitate this development, it is common practice for EL educators to incorporate team-based pedagogy and scaffolding into their programs. For example, the EcoChallenge Program at Ohio University places engineering students in multidisciplinary teams to identify, investigate, and "pitch" an economically viable solution to a sustainability issue. Students are assessed on their ability to motivate, communicate vision, listen to stakeholders, incorporate key concerns into the project vision, and empower their teammates (Bayless, 2019).

Alumni and industry professionals

Alumni and industry professionals offer unique perspectives of transferring their technical expertise and leadership skills beyond school. They bring knowledge and practical guidance that can support students to experiment with their leadership skills and build self-confidence (Singer & Hughey, 2002). Three examples of alumni and industry engagement

include the University of Calgary's conference for student leaders, Penn State University's mock career fair, and Northeastern University's informational interviews. First, the University of Calgary hosts a conference for student leaders facilitated by alumni, industry professionals, faculty, staff, and peers. One of the most popular sessions is the alumni panel with past student leaders (Cowe Falls et al., 2015). Second, Penn State hosts a mock career fair in their undergraduate EL course featuring an iterative pitch process highlighting important leadership competencies. Students create a short pitch and deliver it to a recruiter. The recruiter provides feedback, the student refines the pitch, and then delivers the pitch to another recruiter (Handley et al., 2017). Third, the Gordon EL Program at Northeastern University has students conduct informational interviews with industry professionals after lessons on networking and developing an "elevator pitch." In post-program surveys, students identified this exercise as the most significant experience because it expanded their personal network, improved their understanding of company operations, and grew their technical and industry awareness (Klosterman, 2016).

Case studies

Case studies provide students with short narratives of salient issues in context, enabling them to understand the complexities of a given situation and the consequences of their decisions (Raju & Sankar, 1999). In Purdue University's undergraduate leadership course, students develop cases based on their experiences and then invite peers to step in their shoes. Ahn et al. (2014) found that this reciprocal case study analysis process helped students apply concepts learned, reflect on one another's experiences, and generate meaningful recommendations to solve problems faced by their peers. Another example, from Troost ILead, involves the integration of ethical dilemmas faced by engineers in industry into an elective EL course. Survey findings showed that students found the anonymized cases to be significantly more practical, relatable, authentic, engaging, and helpful when dealing with ambiguity than a mandatory engineering ethics course students had completed in first year (Rottmann & Reeve, 2020). Case studies are a vehicle for students to discuss the dynamics and difficulties that engineers face, both technically and interpersonally, while inviting conversations on equity, identity, and power.

ONLINE LEADERSHIP COMPETENCY DEVELOPMENT

The COVID-19 pandemic, forced EL educators, like others, to rapidly pivot and transition offerings online. In this section, we highlight two online tools, e-portfolios and inventories, to facilitate leadership skill development. We conclude this section by discussing our lessons learned and its impact on pedagogy from remote teaching over the past year.

E-portfolio

E-portfolios, or electronic portfolios, are a tool that allows students to critically reflect on, collect artifacts, and summarize their learning in an online medium. Elements of an e-portfolio include written reflections, pictures, videos, and websites (Lorenzo & Ittelson, 2005). For example, students in the Zachry Leadership Program at Texas A&M University create an e-portfolio, similar to a personal website, that is a meta-reflection on their experience in the five-semester program. Students reflect on their strengths, preferences, values,

aspirations, and the impact of their learning on their careers, personal lives, and community contributions (Sullivan & Koufteros, 2019).

Inventory

Inventories provide an approach to personal reflection and skill development. There are numerous inventories, including the MBTI and Bolton and Bolton self-assessments mentioned previously, and many of these inventories are offered online. One example is the Team-effectiveness Learning System (TELS) from Troost ILead. This online tool is used in large design courses for teammates to provide one another with quantitative and open-ended feedback on organizational, relational, and communication-based leadership competencies (Sheridan et al., 2015). The system provides students with an anonymous summary of peer feedback, a comparative representation of the self- and peer-assessments, three areas for improvement, and a list of online resources to support students in improving those competencies. This technical tool supports engineers' leadership development by supporting their self-awareness in a team context.

Lessons learned

With the shift to remote learning in 2020, we rapidly created and re-invented pedagogy, utilised tools designed for the online space like e-portfolios and inventories, and built on the previous work of educators who have taught online and remotely. We also considered the unique challenges students faced during the COVID-19 pandemic, such as screen fatigue, distractions at home, social isolation, and varying access to internet connectivity. Below are three pedagogical strategies we found imperative for leadership development in the virtual classroom.

Community building

As students learn at a distance from their school and social networks, educators need to create opportunities for students to develop a presence and engage with their peers in virtual spaces. Unlike in-person instruction, learning online hinders organic connections and conversations among students. Some strategies to build community include: (a) setting the tone and communicating expectations by sending a welcome letter or video to introduce yourself and program or course; (b) building engagement using icebreakers and warm-ups; (c) creating opportunities for conversations using breakout rooms, discussion boards, and instant chat; and (d) creating opportunities for students to reflect and contribute to the learning using polls, whiteboards, and experimenting with traditionally in-person activities in the online space (Hanson et al., 2020).

Group work

To support students in building connections in the online space, create opportunities for discussions and group activities. Put students into small groups of three to five where they can reflect on and discuss content and develop a deeper connection with a subset of their peers. For example, Troost ILead has a cohort-based program for graduate students and

postdoctoral fellows to explore diverse career pathways. The 30 participants are placed into Peer Success Teams of four to five, where they engage in breakout discussions and group activities (Didiano et al., 2019). Feedback from the first online cohort suggests that participants enjoyed discussing concerns and getting feedback from Peer Success Teams more than any other program feature.

Flipped-classroom

One strategy that predates the pandemic involves using a “flipped classroom” to free up class time for experiential learning opportunities (Lage et al., 2000). For instance, EL educators at Penn State have long employed a flipped-classroom in their introductory, undergraduate leadership class, providing course content ahead of time, and fostering discussion during class. An unintended positive consequence of this pedagogical innovation was increased confidence among female students (Lang et al., 2018).

RECOMMENDATIONS

In reflecting on our learning and next steps for the field, we have three recommendations for engineering leadership educators.

Select pedagogical approaches that connect engineering and leadership

To create impactful leadership learning experiences for engineers, we must bridge a gap some engineers perceive between engineering and leadership. One way to do this is to select pedagogical approaches that enrich student’s understanding of leadership in engineering contexts. Some examples discussed in this chapter include: inviting alumni and industry professionals to share their reflections on enacting leadership in technical contexts, using engineering case studies to discuss leadership decisions, and using the machine shop to support students’ narrative exploration.

Expand your pedagogical toolkit through multidisciplinary teaching teams

To develop and use a range of pedagogical tools, like those outlined in this paper, requires diverse expertise. Multi-disciplinary teaching teams with educators from beyond engineering, such as psychology, sociology, social justice, business, and education support innovative program design. Not only does disciplinary bridging support pedagogical innovation, but it also models the multidisciplinary nature of engineering practice, thereby supporting students’ school to work transitions.

Use multiple formats to increase reach and accessibility

Finally, by diversifying program format, EL educators can enhance accessibility to students with differentiated levels of leadership affinity. Elective courses on engineering leadership are not the only option. Short, drop-in sessions and multi-session cohort programs provide

a low barrier to entry, while the integration of leadership content into mandatory technical courses reaches a broad audience. In 2018, Troost ILead surveyed 800 alumni to assess the long-term impact of EL programming and found that alumni who engaged in both a course and co-curricular program reported the greatest impact on their leadership development (Simpson et al., 2019).

CONCLUSION

This paper outlines a range of pedagogical approaches used to foster engineering students' leadership development. Understanding the unique context of your institution and the students you serve will help clarify program goals and the pedagogical approaches necessary to achieve them. Bringing innovative, creative pedagogical approaches to your work will create impactful learning experiences that enhance students' self-awareness, emotional intelligence, interpersonal, teamwork, communication skills, and leadership identities.

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