Bridging Learning and Leadership: Alumni and Employer Insights from an Undergraduate Engineering Leadership Program

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Abstract

Engineering leadership programs are increasingly integrated into undergraduate curricula to complement technical expertise with the professional competencies demanded by industry. The Emerging Engineering Leadership Development (EELD) program at the University of Georgia integrates leadership modules into the senior capstone sequence, ensuring that all graduates participate in structured leadership development. This mixed-methods study examines the long-term impact of the EELD program by exploring which leadership skills recent engineering graduates find most helpful in their early careers, which leadership skills employers most expect from early-career engineers and how closely these perspectives align or differ. Originally conceptualized as a qualitative study, the research adopted a convergent mixed-methods approach by incorporating end-of-course survey data to strengthen alumni representation and provide a broader view of program outcomes. Survey responses from two cohorts (2023–2025; n = 660) were deductively coded to nine predefined modules. Students identified the modules titled Leadership Styles, Working Across Generations, Managing Conflict, Stakeholder Engagement and Making Group Decisions as the most helpful. Focus groups with alumni and industry partners revealed strong convergence around communication proficiency, accountability, and conflict resolution as foundational early career competencies. Beyond the required technical credibility of early-career engineers, employers emphasized professionalism and resilience as prerequisites for trust and advancement, and uniquely emphasized initiative, including self-starting behaviors, proactive communication, and willingness to take ownership as critical to early-career success. Alumni, in contrast, emphasized adaptive communication, boundary-setting to prevent burnout, and relational trust as central to effective collaboration. These findings underscore the EELD program's effectiveness in cultivating adaptable, communicative, and accountable engineers while also identifying opportunities for enhancement, particularly in more explicitly articulating initiative-related behaviors within the curriculum. By triangulating alumni and employer perspectives, this study informs continuous improvement of the EELD program and contributes to engineering education scholarship by demonstrating how embedded leadership programs can align curricular outcomes with evolving workforce expectations.

Keywords: Alumni outcomes, Capstone design, Engineering leadership, Leadership development, Mixed-methods research, Professional skills, Workforce readiness.

1. Introduction

The engineering education field has experienced a significant transformation in recent years, with the emergence and proliferation of Engineering Leadership (EL) programs across North America. These initiatives aim to bridge the gap between technical expertise and essential leadership skills, preparing engineering students for the complexities of modern professional environments. Spurred by industry demands, accreditation standards and the recognition of leadership as a critical competency for engineers, EL programs have expanded rapidly. Today, over 50 such programs have been established, ranging from structured courses to co-curricular initiatives, underscoring the growing emphasis on producing well-rounded engineering graduates.

Many of these programs, however, are still in their formative or early operational years. It is estimated that fewer than 10 of the most active programs operating today were launched prior to 2010. For instance, the Gordon-MIT Engineering Leadership Program, established in 2007, has become a flagship model, blending technical rigor with leadership training [3]. Another early example is the University of Toronto's Engineering Leadership Program, part of the Troost Institute for Leadership Education in Engineering (Troost ILead), which was launched in 2002. This program integrates leadership principles with hands-on projects and industry partnerships [5]. Additionally, the Rice Center for Engineering Leadership (RCEL) was established in 2009 in Houston, Texas, with a focus on cultivating leadership skills in engineering students [22]. These early initiatives set foundational models for engineering leadership education, offering frameworks and insights that newer programs continue to build upon.

Building on the success of these foundational models, the Emerging Engineering Leaders Development (EELD) program at University of Georgia represents a significant addition to the rapidly expanding ecosystem of EL programs. Launched in 2016 and now embedded college-wide, EELD integrates leadership development into the senior capstone design sequence, ensuring all engineering majors receive structured training. Spanning two semesters, the program combines classroom instruction with real-world application through capstone projects and client interactions, positioning leadership as a core competency for all students. The EELD program exemplifies the ongoing growth and diversification of EL initiatives in higher education.

Given the early stage of widespread EL program implementation, only a limited number of studies have explored the long-term outcomes of alumni who have participated in these programs. For instance, [13] surveyed 136 alumni to assess job placement, career advancement, and alumni perceptions of skill development resulting from EL program participation. Expanding on this research, [20] evaluated both EL program alumni and non-alumni, each with up to 25 years since their undergraduate degree, to compare their self-assessed achievement of the program's learning outcomes. In addition, [17] conducted interviews with 12 alumni spanning four graduation years to examine how EL capabilities influenced early career success.

Furthermore, [23] surveyed alumni with up to 13 years of experience to assess the perceived value gained from EL course participation. A common finding across these studies is the recognition of the positive impact EL program participation has on career effectiveness. Despite the proliferation of EL programs, limited research has explored how leadership skills acquired during capstone translate into early-career practice or align with employer expectations. This study addresses that gap through three research questions:

- R1: What leadership skills do recent engineering graduates find most helpful in their early careers?
- R2: What leadership skills do employers most expect from engineering graduates in their early careers?
- R3: In what ways do the answers to R1 and R2 converge and diverge?

2. Background

Engineering employers consistently report that while graduates demonstrate strong technical proficiency, gaps in leadership and professional skills persist, particularly in initiative, collaboration, and communication [9]; [10]. These findings are consistent with industry-validated competency frameworks identified through Delphi research, such as [1], which highlight communication, collaboration and initiative as critical leadership competencies in post-secondary engineering contexts. To address these needs, the EELD program embeds nine leadership modules directly into the year-long capstone design course. These modules are titled Leadership Styles, Communicating in a Virtual World, Stakeholder Engagement, Making Group Decisions, Managing Conflict, Working across Generations, Risk and Entrepreneurial Innovation, Creating My Leadership Vision, and Developing Personal Accountability. Unlike elective leadership offerings that reach a small subset of students, EELD is required for all majors, positioning leadership as a core competency for graduates

as they set to enter engineering practice. This approach reflects national calls to move beyond technical mastery and include professional competencies as essential learning outcomes [18]; [13]. By embedding leadership development within the capstone design course, EELD ensures students apply these concepts in authentic, team-based, and real-world engineering contexts.

This study is significant because it addresses a critical gap in engineering education research by examining the long-term impact of embedded leadership development within capstone design courses. While EL programs have proliferated, few studies explore how leadership skills acquired during undergraduate training translate into early-career practice or align with employer expectations. By triangulating perspectives from alumni and industry partners, this research provides actionable insights for curriculum refinement and contributes evidence to the broader discourse on workforce readiness. Findings from this study will inform continuous improvement of EELD and contribute evidence to the broader discourse on embedded leadership education in engineering.

3. Methods

3.1. Study Design and Context:

This study employed a convergent mixed-methods design with multisource triangulation to examine outcomes and workplace relevance of an embedded engineering leadership development program. Qualitative data from end-of-program student surveys over two cohorts (2023-2025) were deductively coded and transformed into quantitative frequency data, then analyzed alongside qualitative data from semi-structured focus groups with program alumni and employers. Each dataset was analyzed separately using descriptive statistics for quantitative items and thematic analysis for qualitative data. Findings were integrated at interpretation using joint displays to compare convergence, complementarity, and divergence across stakeholder groups.

3.2. Participants and Data Sources:

Qualitative survey responses were deductively coded and transformed into quantitative frequency data across two cohorts (2023–2025; n = 660). Surveys achieved a 100% response rate among students receiving program certificates. Qualitative data were collected through focus groups with alumni and industry partners. who responded to targeted email invitations sent to separate alumni and employer listservs maintained by the College of Engineering. Recruitment messages were distributed to 895 alumni and 109 employers. The qualitative sample included five alumni and 16 industry partners representing 11 engineering firms of varying sizes and sectors.

The survey sample included all students who completed the program and received certificates, making it a census of program completers rather than a subset, ensuring full representation of cohort experiences. Survey responses were analyzed using descriptive statistics, including frequency counts and rank-ordering, to identify the most frequently cited modules and leadership skills. The qualitative sample was purposively selected to capture diverse perspectives from alumni and employers with relevant professional experience. Focus group transcripts were deductively coded based on a priori leadership competency modules and themes were quantified to indicate frequency and convergence across participants. This combination of quantitative survey analysis and thematic coding allowed for triangulation of findings, linking module preferences to real-world leadership practices and perceptions.

3.3. Data Collection Procedures:

The end-of-course survey included open-ended items designed to elicit participants' perceptions of helpful leadership skills and program components. This study analyzed responses to the question, *"Which EELD topic was most helpful?"* from the 2023–2025 cohorts, mapping responses to one of the nine modules. Focus groups followed a semi-structured protocol that explored how leadership skills were perceived and enacted in early-career workplace contexts, including examples of use, perceived gaps, and contextual constraints. Alumni and employer focus groups were conducted over video conferencing and each lasted one hour. Sessions were recorded as audio and video files and stored on secure university-provided systems with restricted access; transcripts were produced internally for thematic analysis.

3.4. Data Analysis:

Open-ended survey responses were analyzed using a deductive coding approach aligned with the nine predefined leadership modules of the EELD curriculum. Each response was manually coded to the single module identified by the participant as most helpful. Following coding, frequency counts were calculated to identify which leadership modules were most frequently perceived as high impact across cohorts. All coding and counting procedures were conducted manually by the research team without the use of qualitative analysis software.

Focus group data were analyzed using a listening-based approach [19] informed by live coding practices [15]. Live coding involved analyzing audio and video recordings directly, allowing analysts to attend verbal content alongside paralinguistic features such as tone, pauses, emphasis, and group dynamics. Two independent analysts conducted initial coding cycles and produced analytic

summaries documenting emergent themes. Facilitator notes were subsequently triangulated with these analytic summaries to refine and finalize thematic interpretations. This multi-analyst, multi-step analytic process strengthened credibility through iterative comparison and integration of perspectives.

3.5. Integration and Trustworthiness:

Integration occurred during interpretation using a side-by-side comparison and weaving approach. Findings from student end-of-course survey analysis were compared with themes from alumni and employer focus groups to identify patterns of convergence, complementarity, and divergence. Convergence refers to topics emphasized similarly across data sources; complementarity captures how different sources illuminate distinct dimensions of the same construct; and divergence identifies areas where stakeholder perspectives differ in analytically meaningful ways. These integration procedures informed the discussion and the identification of curriculum relevant insights.

To ensure trustworthiness, multiple strategies were employed. Primary coding of focus group data was conducted by two independent analysts within the College of Engineering who were not affiliated with the EELD program. Facilitator insights were provided by two researchers who also serve as EELD instructors and incorporated after initial coding to enrich interpretation and provide contextual depth, rather than drive coding decisions. This multi-analyst approach, combined with iterative comparison and peer debriefing, enhanced credibility. An audit trail of coding decisions and analytic summaries was maintained throughout the process. Triangulation in this study refers to the integration of independent coding reports with facilitator perspectives, strengthening confirmability, and reducing single-source bias.

3.6. Ethics:

The study received approval under protocol PROJECT00011836. Participants provided informed consent, and data were stored on a secured university-provided system with names on transcripts coded for researcher use. No incentives were offered.

4. Findings

Survey analysis across two cohorts from 2023-2025 (n = 660) identified the most frequently cited modules as Leadership Styles, Working Across Generations, Managing Conflict, Stakeholder Engagement and Making Group Decisions. Alumni and employer focus groups showed clear

convergence on several leadership capacities. Both groups emphasized the importance of effective communication and awareness of communication preferences, including selecting modes that prevent miscommunication. Alumni described shifting from text-based exchanges to real-time kickoff meetings and calls to avoid misunderstandings, while employers emphasized awareness of communication preferences and deliberate mode selection. These findings align with prior research showing that communication competency is a foundational leadership skill across engineering disciplines [16].

Both groups stressed relationship-building and stakeholder orientation as critical early-career skills. Alumni shared vivid examples of proactive gap-filling such as preparing meeting minutes to accelerate their transition into client-facing responsibilities. Employers reinforced the need for strong interpersonal awareness to move projects forward. Similarly, conflict management emerged as a shared priority. Employers described solution-focused approaches and tone checks, while alumni underscored maintaining a united front and processing critiques internally. While prior studies emphasized conflict resolution broadly, the alumni focus on internal processing and boundary-setting highlights context-specific strategies relevant to contemporary hybrid workplaces [4]. Accountability surfaced across both groups as a baseline leadership expectation, reflected in employer emphasis on consistent follow-through, transparency when constraints arose, and reliability in meeting commitments. Alumni emphasized boundary-setting and workload management as strategies for sustaining performance and preventing burnout.

In terms of complementarity, alumni and employers highlighted different dimensions of shared skills. Although both groups emphasized communication and relationship-building, they offered complementary insights into how these skills unfold in practice. Alumni described communication as relational, emphasizing trust-building, clarity, and the need to manage their own emotional boundaries to avoid burnout. Employers focused on communication as an operational efficiency tool, emphasizing documentation, clarity, selecting the right mode, and providing closure in communication.

Alumni foregrounded boundary-setting and workload management as essential for sustained accountability, which was less visible in employer accounts, but increasingly relevant in hybrid, high-pressure environments. These micro-strategies extend prior engineering leadership research [7] by highlighting how early-career engineers manage internal states and work conditions, which provides a more nuanced understanding of the practice of accountability.

Divergence appeared around initiative, professionalism and written communication. Employers

uniquely emphasized initiative by name, which included self-starting behaviors, proactive communication, and a willingness to take ownership. Alumni did not foreground initiative in this way, instead emphasizing relational trust and workload boundaries as precursors for effective teamwork.

Employers also placed distinctive emphasis on professional demeanor and polished email craft including precision in requesting information and creating clear documentation. Alumni mentioned written communication less frequently, consistent with observations by [24] that written professional communication often lags in undergraduate programs.

Mapping the end-of-course survey results onto alumni and employer focus group perspectives revealed points of alignment across data sources. The modules students identified as most helpful correspond closely with the leadership capacities emphasized in the focus groups. For example, the high value students placed on the Working Across Generations module align with the alumni descriptions of adapting tone and communication modes for senior colleagues and employer expectations for cross-generational credibility. The student emphasis on the Managing Conflict module maps to the shared emphasis in the alumni and employer focus groups on solution-focused conflict navigation, tone awareness, and maintaining trust in relationships.

The student emphasis on the Stakeholder Engagement and Leadership Styles modules complements focus-group themes related to relationship-building, client orientation, and proactive gap-filling. Lastly, identifying the Making Group Decisions module aligns with employer concerns about early-career decisions, hesitation, and underscoring the relevance of collaborative decision-making skills in engineering workplaces.

5. Discussion and Implications for Leadership Development

This study affirms the relevance of EELD's core modules while identifying opportunities to deepen leadership preparation for early-career engineers. The consistent value placed on Managing Conflict and Working Across Generations across survey and focus-group data reinforces the importance of experiential practice in navigating interpersonal dynamics within diverse, hybrid, and distributed teams. These findings align with relational perspectives on leadership, which emphasize the leader's capacity to build trust, negotiate differences, and sustain productive collaboration [21].

Alumni narratives also highlighted the developmental significance of micro-strategies for sustainable leadership, such as boundary-setting, workload boundaries, and self-advocacy. These practices

resonate with self-leadership theory, which positions self-regulation, behavioral awareness and intentional action as foundational to effective leadership [14]. Further, the practices align with identity-based leadership development, where early-career professionals cultivate internal capacities that support accountability and adaptive performance [12].

Employers, meanwhile, emphasized professionalism and written communication as core expectations for early-career engineers. Their focus on clarity in email communication, documentation norms and client-ready writing aligns with the behavioral competencies embedded in emotional intelligence–based leadership [6], particularly self-management, social awareness and relationship management. Employers' emphasis on proactive communication and self-starting behaviors also reflects the action-orientation central to emerging leader identity formation [2]. Because these expectations were less foregrounded in alumni accounts, making them more explicit within the module structure may help close the preparation–practice gap.

The strong alumni endorsement of Making Group Decisions, paired with employer observations that indecision is a recurring challenge for early-career engineers, points to a clear opportunity to expand structured decision-making practice within the program. Decision-making is a core competency across leadership theories, including adaptive leadership [8] and emotional intelligence frameworks, where leaders must integrate information, manage uncertainty and act with clarity. Strengthening this module would reinforce both the cognitive and interpersonal dimensions of leadership that early-career engineers are expected to demonstrate.

Thus, these findings illustrate how the skills cultivated throughout the EELD program map onto well-established leadership theories, demonstrating that the program not only builds practical competencies but also supports the deeper intrapersonal and relational capacities that contemporary leadership scholarship identifies as essential. In addition, the alignment between alumni and employer perspectives in this study reflects broader industry-validated leadership competency frameworks, such as [1], particularly in areas including communication, conflict management and initiative, further reinforcing the connection between EELD outcomes and workforce expectations. Strengthening these theoretical linkages within the curriculum can enhance the program's developmental impact and provide a more coherent foundation for leadership growth among emerging engineers.

6. Limitations

These findings should be interpreted in light of a few contextual factors. The study originally relied on focus group data; end-of-course survey responses were incorporated to strengthen alumni representation and provide a broader view of program outcomes. While this addition enhances data richness, survey responses reflect perceptions at graduation rather than long-term workplace experience. Qualitative insights were drawn from relatively small, self-selected samples of alumni and employers, which may limit generalizability. Because the study examines a single embedded leadership program within one institution, results may not fully transfer to elective or co-curricular initiatives. Finally, two researchers also serve as EELD facilitators. Their involvement provided a nuanced understanding of the program context and enriched interpretation; to mitigate potential bias, primary coding was conducted by two researchers within the College of Engineering but outside the EELD program, and facilitator insights were used to triangulate and bring contextual depth to the analysis rather than drive initial coding decisions.

7. Conclusion

This study demonstrates that embedding leadership development within the engineering capstone course can produce graduates equipped with competencies that align closely with employer expectations. Convergence around communication, conflict management, and stakeholder engagement affirms the relevance of EELD's core modules, while alumni insights on resilience and boundary-setting highlight the importance of sustainable leadership practices. Divergence in areas such as professionalism and written communication suggests targeted opportunities for curricular refinement to better prepare graduates for workplace expectations. By integrating alumni and employer perspectives, this research advances evidence-based strategies for strengthening workforce readiness and offers a replicable model for EL education that can inform curriculum design in other programs. Future studies should examine longitudinal impacts and explore how embedded leadership programs compare with elective or co-curricular approaches to further inform best practices.

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