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Identity-based Engineering Leadership Instruction: a Reflexive Instruction Model and Its Impact

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Abstract

The growing perception of the engineering profession as a sociotechnical discipline has provided rich soil to cultivate leadership within a professional context. While skill- and behavior-based approaches are ubiquitous in engineering leadership programs, identity is emerging as a powerful framework for understanding engineering leadership development. This practice paper presents the design and implementation of an identity-based engineering leadership instructional module, along with empirical evidence assessing its impact on student leader identity and understanding.

While many university programs focus on leadership skills or behaviors, a growing literature base suggests that seeing oneself as a leader is a powerful influence on long-term leadership development. Identity-- or how one sees oneself, and is seen by others, in society— provides insight into the dynamic, multi-faceted and individual nature of leadership development. This research builds on emerging research that has identified potential features of an identity-based instructional approach, but it is not yet clear how one might operationalize this approach or what its impact might be on the engineering leadership development of college students.

The primary purpose of the practice paper is to present a short-term activity that models an identity-based approach (reflexive instruction) to engineering leadership instruction. By using a modular format that can be easily scaled, this research presents instructional activities that can be applied easily in a wide spectrum of courses, from introductory engineering to senior capstone classes. The lessons take 1-2 class periods; they are based on easily accessible resources; and they require minimal preparation by instructors. Activities include an introduction into several leadership styles, a teamwork activity, class discussion, and two essays.

In addition, this paper summarizes the impact of reflexive instruction interventions. Undergraduate student participants at multiple universities were surveyed on their leader identity and engineering leadership understanding. Self-reported retrospective surveys were analyzed to measure instructional impact. Two research questions drove the quantitative analysis: Does reflexive instruction about engineering leadership influence leader self-identity; and does it influence engineering leadership understanding?

Findings from a multi-institution implementation of this activity indicated both that leader identity increased, and that leadership understanding shifted over the timeframe of the intervention. These findings suggest that students respond well to an identity-based leadership approach. This has implications for research, as it contributes to our understanding of how students may be affected by identity-based initiatives. More relevantly, this has implications for practice, as it models one approach to engineering leadership growth, with empirical support for its impact. This may hold particular importance to LEAD Division members as an empirically grounded activity that can be integrated with a wide variety of programs at scale.

Introduction

Over the past two decades, industry demand for leadership skills[1] has precipitated widespread support for engineering leadership development at the institutional, curricular, and programmatic levels [1]. While many of these initiatives focus on leadership skills and behaviors, there is a question about how these programs impact the long-term, deep perspective changes needed for success in the profession [2] [3]. To add to this uncertainty, the empirical evidence demonstrating leadership program effectiveness is mixed [4-6]. Identity has emerged as a potentially effective approach to leader development in both the leadership studies and engineering leadership fields, as it addresses the complex, dynamic, and long-term aspects of leader development.

This project leverages identity — how one sees oneself, and is seen by others, in society [e.g., 7, 8]— to understand and support the leader development process. Using preliminary research on instructional features of an identity-based approach (reflexive instruction), this project empirically measures the impact of identity-based reflexive instruction on student leader identity and perceptions of leadership. Results indicate that reflexive instruction is effective in impacting both student leader identity growth and development of more expansive views of leadership. In addition, this project accomplished a core goal of creating an engineering leadership instructional module that can be easily integrated in existing curricular and programmatic structures.

Literature Review

While engineering education has long successfully attended to technical preparation for the profession, the past several decades have seen an increasing focus on developing professional skills, such as communication and teamwork. Leadership has emerged as a core skill for the success of new graduates and career growth. While the leadership studies field enjoys a broad literature base, there is concern that many leadership development efforts have not demonstrated quantitatively substantive impacts on their students [9]. Some suggest this may be due to the complex, individual, and dynamic nature of leader development [10].

Identity

One approach that has emerged to meet the challenges of leader formation is identity (how one sees oneself, and is seen by others, in society). This approach has seen growth in the leadership studies field (e.g.,[3]) but is yet to be widely applied within an engineering context [11]. That said, some scholars interested in engineering leadership development have begun to leverage identity-based frameworks within engineering educational (e.g., [11]) and professional (e.g., [12]) settings. Within that literature base, identity has commonly been leveraged primarily as a useful explanatory framework (e.g., [13]), whereas very limited work has explored how identity might inform the actual design of leadership development initiatives [14]. While the identity concept spans a broad spectrum of fields, four identity lenses stand out as particularly relevant to this research, in terms of processes or values: personal, professional, leader, and engineering leader identity (Figure 1).

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[1] Because of the opaque use of the word leader/ship, a brief statement on its use is in order. In this paper, *leadership* refers to the *process* of leading. *Leader* refers to the *individual* who is leading, regardless of status; hence, leader identity is preferred to leadership identity, as a process is not an identity. However, where the literature commonly uses the designation 'leadership identity' (e.g., the LID model), deference will be given to common use.

Personal Identity

While many theories have explored the process of taking responsibility for one's life path (a core idea in human development), Kegan's self-authorship has emerged as an important model to describe college student development [15]. Self-authorship describes the ability of an individual to construct their own knowledge and to reflectively engage with others (in interpersonal, intrapersonal, and cognitive domains). It is often critical to college students' development as they begin to distinguish ideas grounded on the internal self from those grounded on others' influence. More it is essential for pursuing self-directed skills-- for example complex, personal and non-linear skillsets, such as leadership [16]. Specifically, Baxter Magolda found that self-authorship consisted of four pillars in her qualitative research of 39 young adults: "learning how to make knowledge claims [i.e., trusting yourself], gaining confidence in doing so, learning to balance external forces with one's own perspective and knowledge, and developing an internal identity that supports acting on one's knowledge and priorities [i.e., acting on one's environment effectively]" [17]. [15] found that subject-object inquiry-- where the distinction between one's previous perceptions and reality are probed-- useful in this transition. Important to this approach is exploring the limits and boundaries of one's self-knowledge, which might be accomplished by asking about changes in beliefs [15]. Similarly, [18] found that experiences that demanded sophisticated meaning-making "…promoted substantial developmental shifts." (p. 866). More specifically, their research found that self-authorship grew when students were expected to create their own views and take responsibility for them (p. 878); self-authorship also grew when critical approaches were scaffolded in class concurrent with guidance and support from both supportive faculty and peers (p. 879).

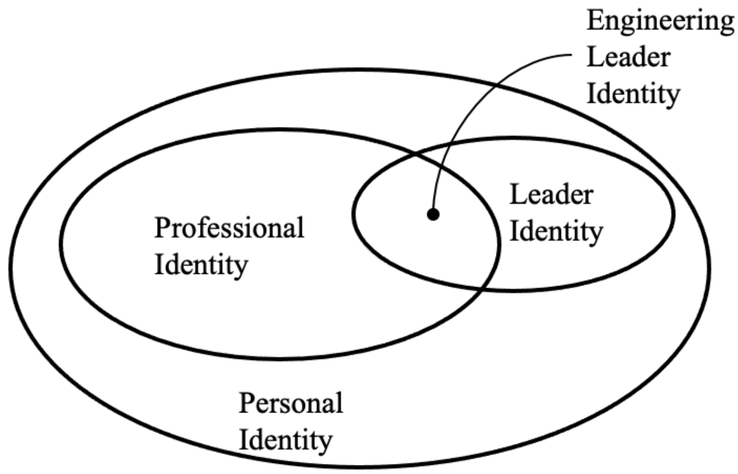


Figure 1: Identity Fields

Professional Identity

According to Chickering and Reisser, a foundational component of one's overall identity is competence, most relevantly captured here in one's professional identity [19]. The Community of Practice (COP) [20] model is a widely adopted framework in the professional identity literature that has been useful in understanding engineering identity (e.g., [21-23]). The Community of Practice model consists of members of a professional community who surround a core of practicing experts. Belonging in this community is experienced through three modalities: imagination (i.e., how can I see myself as a member?), engagement (i.e., how can I participate in this community?), and alignment (i.e., how do my values align with this community's?).

An especially relevant component of this framework is situated learning, where learning occurs within a particular context, as learners struggle to make meaning of their experience and knowledge, primarily through three instructional components: modeling, scaffolding, and coaching [20]. Modeling involves learner observation of direct demonstration of expert practice.

Scaffolding involves learner practice with "gradual withdrawal of teacher from the process… so that students can learn to accomplish cognitive challenges" [24]. Coaching involves learner reflection about thinking and practice, facilitated by instructor feedback [25]. Finally, [25] suggests that situated learning in the classroom empowers engineering students to both learn about engineering and begin to behave like (and identify with) professional engineers.

Leader Identity

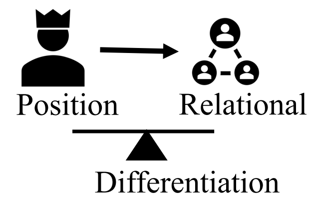


Figure 2: LID Differentiation

While the leadership studies field has explored multiple conceptions of leader identity, one model has emerged as particularly useful in the engineering leadership space: the Leadership Identity Development (LID) model [26-28]. This 6-staged model of relational leadership traces the progression of an individual as they become increasingly aware of leaders to the point where they are comfortable stepping into leadership roles for the sake of the project and continued success of the group. Under this model, those transitioning from a positional to a relational view of leadership—often college students—benefit from learning the language of leadership. Positional leadership is based on power, where an individual holds authority to assign responsibilities, make decisions, and takes action. Relational leadership, on the other hand, consists of "…people together attempting to accomplish change or make a difference to benefit the common good" [29]. This transition (from Stages 3 to 4, called Differentiation, Figure 2) is characterized by realizing the conditionality of leadership, how it is not bound to position, and how individuals can develop their own leader capacities. [26] suggested that scaffolding of leadership theory and helpful collaborative techniques help students in their growth during differentiation. Finally, holding leadership positions—especially in authentic projects--seems instrumental in developing a shared leadership approach in collaborative work. Differentiation is especially important for those in autonomous professions (such as engineering), as influence is derived less from position than from expertise [30].

Engineering Leader Identity

Literature in professional identity development provides a global view of how novices join and participate in professional communities, yet many maintain that the ways engineers navigate this experience are unique, even compared to other autonomous professions [e.g. 31, 32-34]. While several scholars have explored how leadership is practiced in the engineering profession, one has emerged as particularly useful; [12] proposed a model of three leadership orientations in the profession:

1. Technical Mastery –leadership practiced by teaching others;
2. Collaborative Optimization – leadership practiced by gathering and influencing teams;
3. Organizational Innovation— leadership practiced by creating market solutions.

These three orientations reflect the skills, behaviors, and values commonly exhibited by leaders in the engineering profession; they also provide a coherent and grounded scaffolding for the types of roles for which engineering students need to be prepared. It should be noted that this research found a great deal of heterogeneity amongst engineering professionals regarding leadership. Most relevant to this research, many engineers exhibited resistance to calling oneself a leader, due to perceived charismatic, hierarchal, or "great man" characterizations traditionally associated with leadership. [12] suggested contextualizing leadership within the profession to address this resistance, possibly by describing it in terms of professional practice and values.

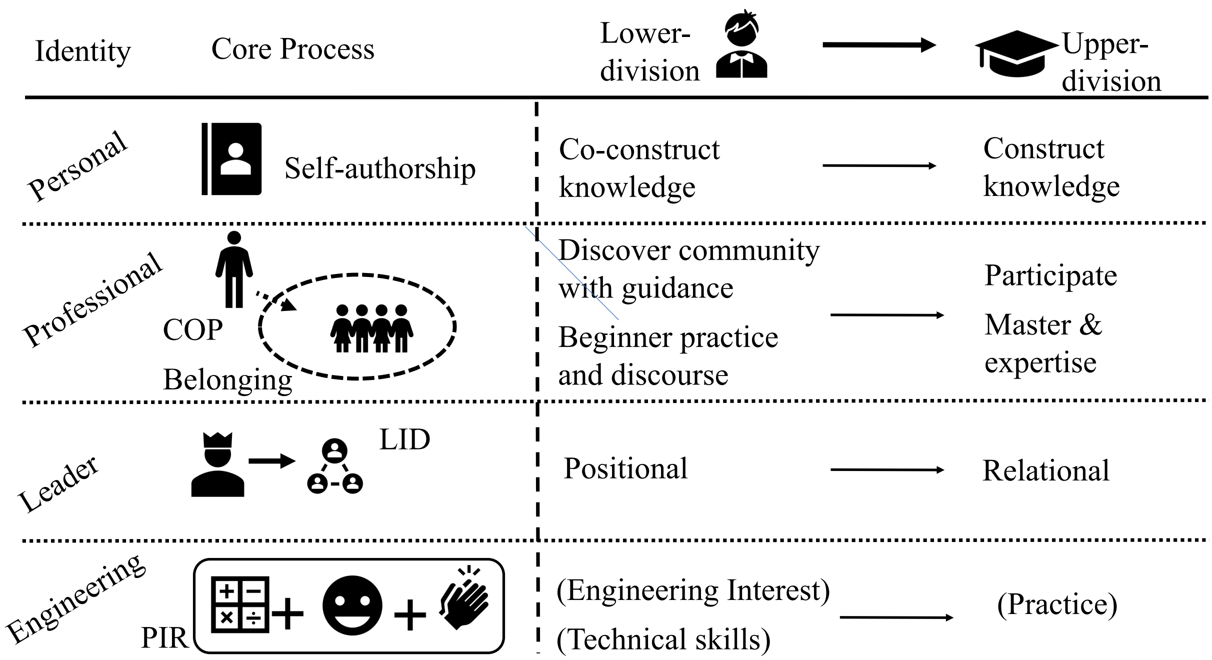


Figure 3: Identity Development Summary

Summary

The literature outlines four core identity frameworks that relate to engineering leader identity. These frameworks provide insight into elementary developmental processes and typical perspectives amongst lower- and upper-division students (see Figure 3). While they address relatively distinct characteristics and processes within one's sense of self, there is also a great deal of interdependence between them, reflecting the complex nature of human experience. For

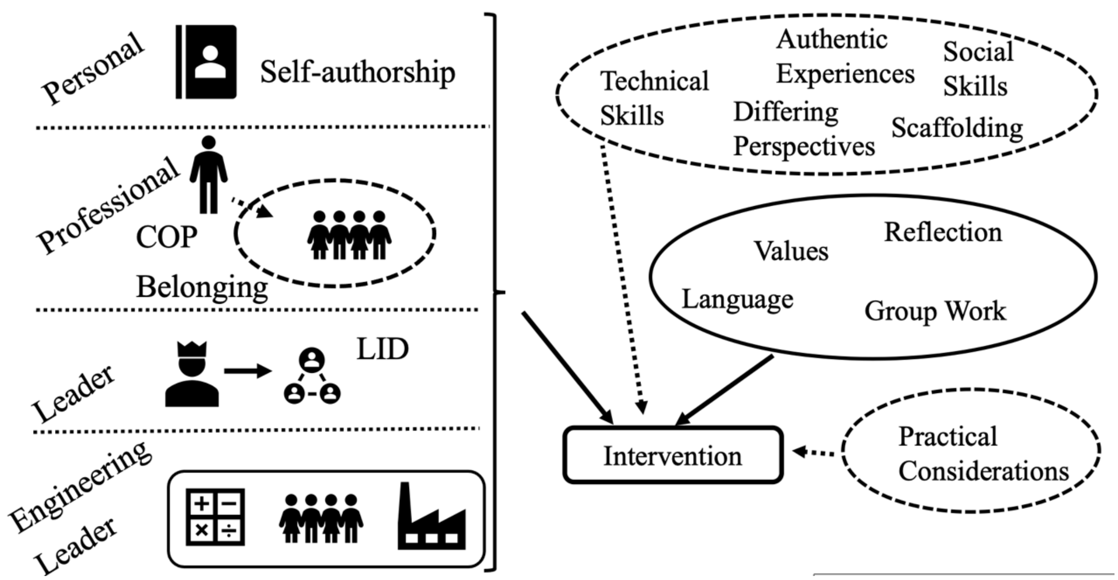


Figure 4: Intervention Foundations

example, self-authorship (personal identity) impacts leader identity: by learning to trust oneself, one is more willing to act on one's environment effectively, which is important to differentiation in the LID model. And, self-authorship promotes increased internal locus of control, which enables one to consider aligning one's values with those of the profession (important to belonging in the COP model). These examples illustrate the interdependence between identity frameworks, thereby demonstrating the complexity the leadership development process.

Theoretical Framework

Adopting these four frameworks enabled this research to examine potential instructional approaches based on the developmental processes or values that they support (e.g., using scaffolding to empower students to take increasing responsibility for complex challenges). In addition, the frameworks provide concepts and vocabulary for interpreting student responses, both quantitatively and qualitatively (Figure 4). Finally, these four frameworks align with the initial work that this research continues, which leveraged a systematic literature review of engineering leadership and identity literature [14].

Reflexive Instruction

As mentioned, this intervention continues the work of [14], which identified nine instructional features that align with an identity-based approach to engineering leadership development. This approach, described as *reflexive instruction*, supports personal, professional, leader, and engineering leader identity development. Per Table 1, the nine instructional features defined by this approach are Values, Language, Reflection, Authentic Experiences, Scaffolding, Group

Table 1: Instructional Features

Instructional Features	Definition; Impact
Values	principles essential to an ideology or mission; essential to professional belonging
Language	medium of both thought and communication; provides ability to clarify, develop, and communicate complex concepts
Reflection / Feedback	these two combine to support evaluation and adjustment of behavior; because of its role in self-authorship, possibly the most vital component of identity growth
Authentic Experiences	collaborative and independent experiences in a meaningful environment; these facilitate autonomy, cultivate engagement-belonging, and foreground leadership importance
Scaffolding	providing—and gradually withdrawing—needed structures and guidance; provides support for developing more complex frameworks and behaviors
Group Learning	peer group engagement during learning; clarifies and strengthens ideas while promoting reflective reasoning
Diverse Perspectives	engagement with those with differing backgrounds, experiences, or perspectives; important to distinguishing one's own way of being
Technical Skills	capabilities directly relating to the application of science; core criteria for professional competence
Social Skills	capabilities in navigating interpersonal challenges; facilitates expansive views and practices of relational leadership

Learning, Diverse Perspectives, Technical Skills, and Social Skills. After evaluating these instructional features to find those that were less commonly used, those that were easily implemented, and those that could be scaled for broader use; four especially potent instructional features emerged (bolded in Table 1): Values, Language, Reflection, and Group Learning. Preliminary research on a related pilot study operationalized this approach; modifications were made for this intervention to improve validity through increased sample population and more a streamlined intervention. The pilot study presented promising empirical results as it indicated that the intervention increased interest in and value of leadership within engineering [35].

Research Approach
This research has two aims: first, to operationalize an identity-based approach (reflexive instruction) to engineering leadership; second, to explore the impact of reflexive instruction on engineering leader identity. In other words, what might a reflexive instructional approach do for students? Two research questions were developed to address these gaps in the literature:

RQ1: Does reflexive instruction about engineering leadership influence leader identity?

RQ2: Does reflexive instruction about engineering leadership influence engineering leadership understanding?

Intervention Overview
The intervention for lower- and upper-division participants consisted of four components, bookended by a pre-survey and a post-survey, as illustrated by Figure 5: outlook essay, pre-lecture videos, classroom discussion, and reflection essay. The lower-division intervention lasted one class session (50 minutes) and included relevant preparation and follow-up student work. The upper-division intervention lasted two class sessions (100 minutes total, due to additional content) and included class preparation, a short-term assignment, and a longer-term assignment. Because the intervention only took 1-2 class periods (and directly supported professional skill development), it was relatively easy to integrate in introductory engineering courses and upper-level technical courses. Its modular format furthermore facilitated student preparation and assessment, as well as instructor preparation.

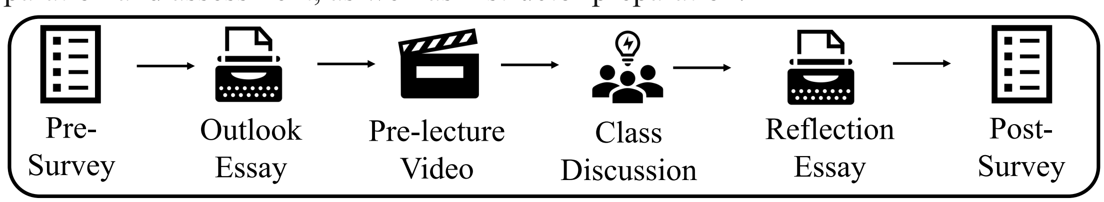


Figure 5: Intervention Components

Intervention Design
To create the intervention activities, four central considerations were iteratively addressed. Most importantly, each activity was informed by the four core instructional features from [14] (Reflection, Group Work, Language, and Values). These features describe important aspects of the classroom experience that cultivate leader identity growth, but are often neglected in traditional lecture settings [14]. Second, key identity developmental processes were also considered: self-authorship, belonging, and differentiation. Third, where possible, the remaining

five (of nine) identity-based features were integrated (e.g., Social Skills). Fourth, pragmatic concerns were considered, such as class size and presentation limitations.

By addressing these four central considerations, activities were iteratively proposed and revised, until a group of activities emerged that met these considerations: outlook essay, pre-lecture videos, discussion, and reflective essay (Figure 5). The outlook essay provided a benchmark for leadership beliefs and enabled later reflection. This essay was important to document participant engineering leadership beliefs going into the intervention, both for the student (to reflect on previous beliefs) and for the researcher (to provide a rich data source). The pre-lecture videos presented introduced various aspects of engineering leadership including relational and various positional approaches. The discussion activity provided opportunity for group discussion, class-wide sharing, and instructor feedback and scaffolding. The reflective essay facilitated personal reflection on engineering leadership. Finally, survey participation was optional, participation in the intervention was expected, and assessments were completion-based. These activities are explained below in additional detail, first for the lower-division intervention, then for the upper-division intervention.

Lower-division Intervention

Outlook Essay. The first core activity (following the pre-survey) was a 1-page outlook essay, asking the participants to define leadership and reflect on their own perspective of being "an emerging engineering leader." The activity had several purposes. First, it established a baseline for leadership beliefs that was revisited during the second essay. Second, it primed students to think about engineering leadership, which is important to the Community of Practice (COP) mode of imagination and alignment belonging [20]. Third, it served as a source of supplemental qualitative data on student perspectives, supporting interpretation and discussion of quantitative results.

Pre-lecture Videos. The second core activity consisted of three pre-lecture videos on leadership, assigned after completion of the outlook essay. The first video had been used in previous courses, so no new content was needed; the subsequent two videos were created for this project following video lecture good-practices (as defined by [36] and [37, 38] [39]). The first video outlined three types of positional leadership (autocratic, democratic, and laissez faire), thereby illustrating a diversity of practices, while also introducing students to basic leadership terms [40]. Next, students viewed an instructional video that outlined positional and relational leadership, addressing beliefs common during the LID differentiation stage [26]. Finally, all students viewed a video that described three orientations of engineering leadership: technical mastery, organizational innovation, and collaborative optimization [12]. This provided scaffolding of what leadership looks like in the profession, which can be valuable for cultivating belonging by aligning values with those of the profession (per COP) and for envisioning relational leader identity. It also provided vocabulary and context for students to talk more clearly about engineering leadership, giving them a chance to see it in a more heterogeneous and personal way (they later wrote about which style they might pursue).

Discussion. The third core activity was in-class discussion. For lower-division students, a single intervention class session focused on the prompt: "What type of engineering leader do you envision yourself becoming? Why?" A three-step interview was conducted, in groups of four students. A three-step interview involves two students interviewing one another about the prompt (steps one and two). The third step requires one of those two students to summarize the other's perspective, to a second pair of students. This third step was followed for all four participants in the two pairs [per best practices in 41]. This experience leveraged the benefits of reflection [13], group work [42] and experiencing differing perspectives [21]. Next, groups were invited to share some of their interview results, allowing the instructor to scaffold more complex ways of thinking (e.g., re-phrasing student anecdotes using precise leadership language), to use the language of leadership, to provide feedback on group discussion, and to contextualize the value of leadership in engineering. Here, it is instructive to note that scaffolding of leadership styles was not done in a hierarchal manner (e.g., relational is better than autocratic), but in a conditional manner (i.e., leadership styles vary in effectiveness based on context). This enabled students to think more critically about the characteristics and appropriateness of leadership styles. The class concluded with a brief discussion of practical steps for students interested in pursuing engineering leadership further, such as connecting with a faculty mentor [e.g., 26, 34] or investing in an interesting classroom or co-curricular group project [5].

Reflective Essay. The final core activity was a 1–2-page reflection essay, assigned after the final in-class discussion. For lower-division students, the essay was due soon after the single class intervention. This essay included two prompts: "How has your perspective on engineering leadership changed / strengthened / weakened since your outlook essay?" and "Which—if any—practical steps [to develop as engineering leadership] sound personally interesting?" This activity had three purposes:

1. It provided a reflection opportunity for students to consider how their own ideas had changed to leverage Kegan's [15] subject-object interviewing benefits;
2. It provided qualitative insight into how the intervention had affected the students;
3. It allowed students to reflect on practical steps to pursue leadership development (e.g., extra-curricular experience, mentorship, curricular engagement), thereby facilitating all three belonging modes of the CoP [20].

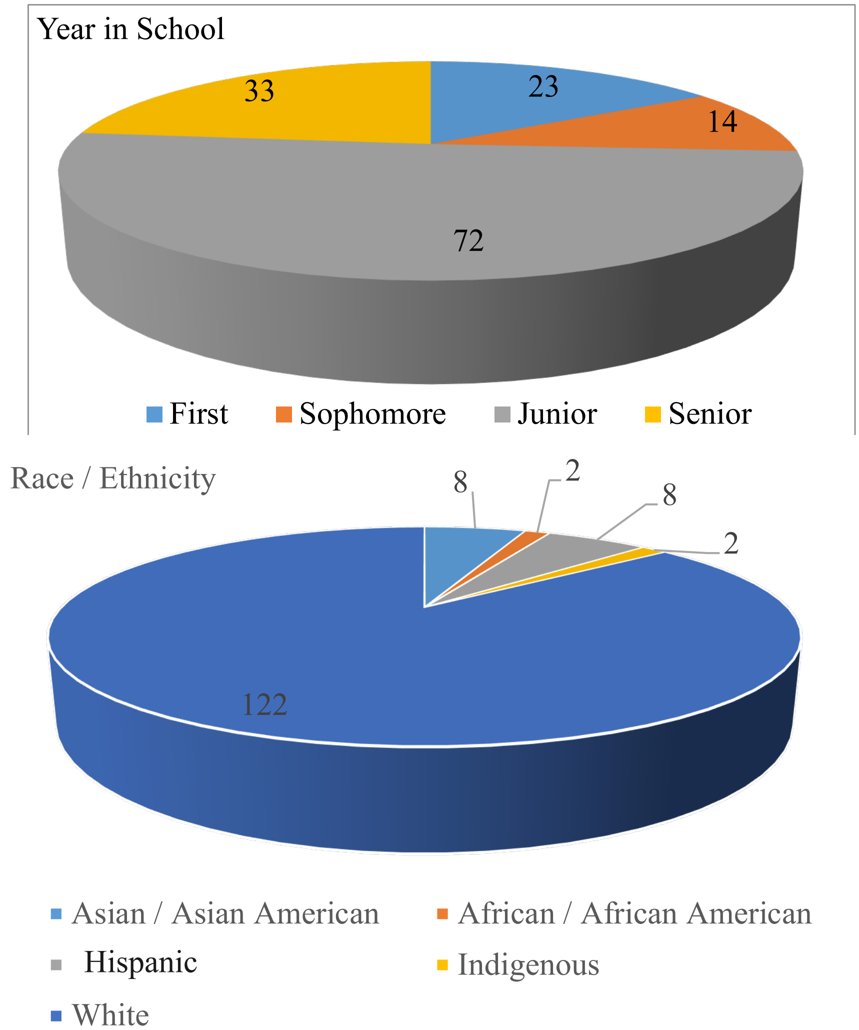
Upper-division Intervention

The intervention used for the upper-division students followed a similar structure as that for the lower-division participants, except for the slight modifications detailed below.

Pre-lecture videos. Upper-division students were not shown the first video (on positional leadership). This video was omitted in the interest of intervention brevity and the expectation that it would have minimal impact (due to the presumed increased leadership experience that older students are likely to have). Finally, it was expected that many of the students had already seen the video, as it was a component of a prerequisite course.

Discussion. For the upper-division intervention, the third activity involved two class sessions, with an interim individual assignment. The first in-class activity focused on practical steps a student might take to develop as an engineering leader, using a group round robin. A group round robin involves each person (in a 4-5 member group) suggesting one practical step for leadership development, in turn [41]. This approach introduces multiple perspectives and highlights the value of each member by focusing equal attention on everyone. Moreover, talking about practical steps frames leadership in an active, authentic context. A class-wide discussion of group responses was guided by the instructor. Like the lower-division discussion, it concluded with a summary of the practical steps discussed.

For these students, an additional assignment focused on practical steps that individuals might take towards leadership growth during the coming semester. This additional step leveraged reflective practice (e.g., considering and pursuing one's own leadership goals). To provide a framework for these practical steps, students were given a 5–10-minute overview of SMART goals (Specific, Measurable, Achievable, Relevant, Time-bound) [43, 44]. At the subsequent class session, the instructor led a class-wide discussion about participants' SMART goals, for approximately 15 minutes. This discussion explored various practical goals and types of engineering leaders. In addition, the instructor answered questions and normalized self-directed development.



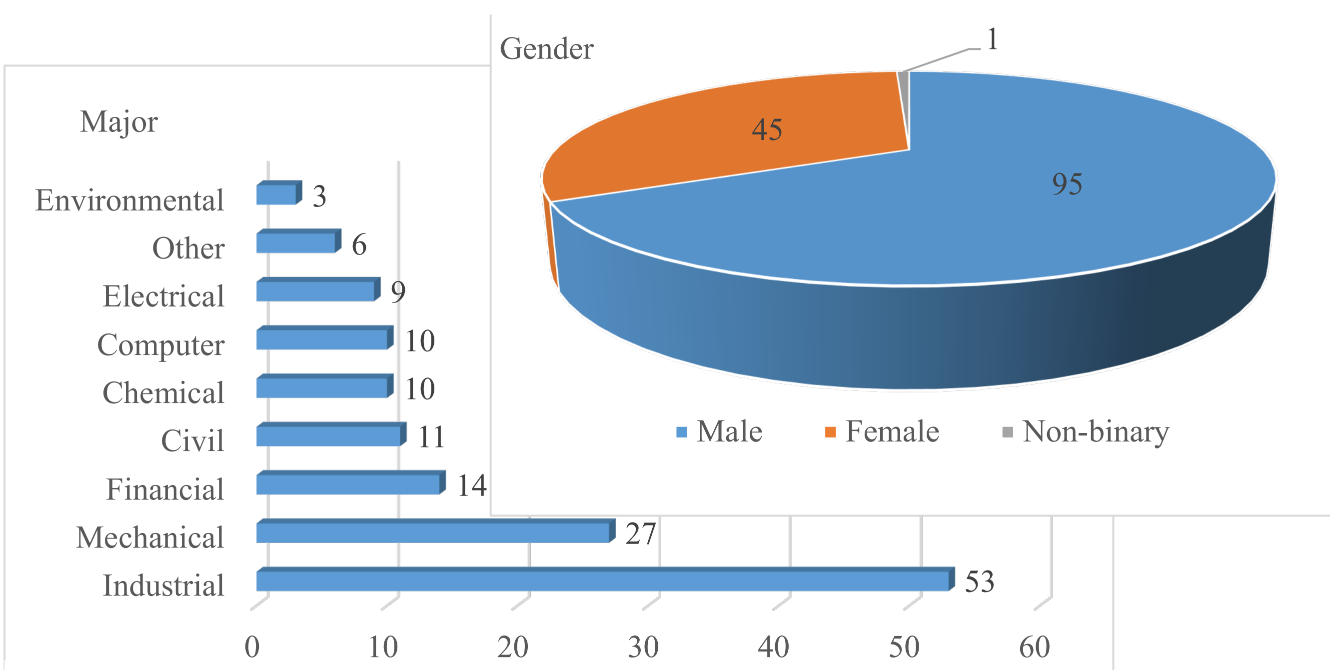


Figure 6: Participant Demographics

Reflective Essay. For upper-division participants, the reflection essay also included reflection on the impact of practical steps taken and SMART goal achievement. The essay was due late in the semester to give students time to pursue SMART goal practical steps.

Analysis Methodology

This study implemented a retrospective post-survey research approach to measure the perceived impact of the intervention. A retrospective approach asks participants to "...to simultaneously assess their capacity at the beginning of the [intervention] and… at the end of the [intervention]" [13]. These assessments are designated as BEFORE and NOW, respectively. This format has been shown to measure leadership development effectively, especially in terms of response-shift bias [45, 46]. Using a 7-item Likert-type scale, the survey measured leader identity (RQ1) and leadership understanding (RQ2), as well as several two secondary leadership variables: interest and self-efficacy.

Leader identity and leadership understanding were measured by Hiller's [47] Leadership Self-Identity (LSI) and Orientation to Leadership (OTL) [48] measure, respectively: both measures were further refined for this study by eliminating items that loaded poorly in previous research. The OTL addresses three perspectives important for student progression through the LID Differentiation stage leadership as power (OTL-P), as a developed capability OTL-(D), and as shared (OTL-S). In addition, participant belief about the relationship between engineering and leadership (ELR) was measured using one item, modified from a published engineering identity measure [49].

Analysis used a paired t-test comparing retrospective (BEFORE) with NOW post-survey results for both research questions. Significance criteria was $\alpha = 0.05$, unless noted otherwise. Because of family-wise error related to the four variables associated with RQ2, a Bonferroni correction was used, resulting in $\alpha = 0.0125$ (= 0.05 / 4) for respective significant tests. Incomplete survey responses were address using pairwise deletion. While any modifications to data may compromise integrity of the findings, pairwise deletion tends to incur negligible parameter bias when used in less than 5% of cases: 0.04% of data was affected in this study [50].

After paired t-test results addressing the research questions were identified, subsequent analysis explored the two secondary leadership variables. Correlation analysis tested for significant relationships between these variables and leader identity (RQ1) and engineering leadership understanding (RQ2). Background control variables (e.g., experience and demographics) were omitted from this analysis.

Participants in the study were engineering students at two western public universities, both with demonstrated interest in engineering leadership research. Conducted in the Spring of 2021, classes were conducted through a mix of in-person and on-line formats in six engineering courses. 166 student participants (44 lower-division and 122 upper-division) met the criteria-based convenience cluster sampling approach used. Background data are illustrated in Figure 6.

It should be noted that this study is part of a larger mixed-methods project that explores the impact of reflexive instruction on engineering leadership perceptions of engineering students. While the larger project included a previous pilot survey, more extensive quantitative analysis, and mixing of qualitative and quantitative data, this paper is limited to core findings on leader identity and engineering leadership understanding.

Results

Overall, results indicate that the intervention effectively impacted growth in engineering leader identity and shifts to more expansive views of leadership (i.e., decrease in OTL-P and increase in OTL-D, OTL-S, and ELR). In addition, the intervention led to increased leadership interest, self-efficacy, and engineering identity.

RQ1: Does reflexive instruction about engineering leadership influence leader identity?

Analysis addressing RQ 1 provided evidence that reflexive instruction significantly and positively influences leader identity, for both lower- and upper-division students, per Table 2. Students reported significant increases in leader identity ($t\ (27) = 4.46$, $p < 0.001$; $t\ (51) = 4.58$, $p < 0.001$; lower-division and upper-division, respectively). Strong effect sizes of .86 and .64 were seen for lower- and upper-division students, respectively. Participants also indicated significantly higher leadership interest ($p < 0.001$) and self-efficacy ($p = 0.001$), per Table 3. Moreover, effect sizes were high, ranging from .63 to .95. Further exploration of the results identified how increases in identity varied by participant characteristics. Correlation analysis compared change in leader identity with absolute measures in other outcomes (i.e., interest and self-efficacy). This analysis found two significant relationships for upper-division students; leadership interest ($r\ (50) = -.454$, $p = 0.001$) and self-efficacy ($r\ (50) = -.535$, $p < 0.001$) were both negatively correlated with identity growth.

Table 2: *t*-test for Change in Leader Identity, by Class Level

Outcome	*t*-value	Sample size	Effect size	*p*-value
Change in LSI, lower-division	4.46	27	.86	< 0.001
Change in LSI, upper-division	4.58	51	.64	< 0.001

Underlined indicates significance at $\alpha = 0.05$

Table 3: t-test for Change in Other Outcomes, by Class Level

Outcome	Population	*t*-value	Sample size	Effect size	*p*-value
Leadership interest	Lower-	4.91	27	.95	< 0.001
Leader self-efficacy	division	3.70	27	.71	0.001
Leadership interest	Upper-	4.72	54	.64	< 0.001
Leader self-efficacy	division	4.62	54	.63	< 0.001

RQ2: Does reflexive instruction about engineering leadership influence engineering leadership understanding?

Analysis addressing RQ 2 provided evidence that instruction significantly influenced leadership understanding, leading to more expansive views of leadership for all students (Table 4). Moreover, effect sizes were high, ranging from .581 to 1.250 ($|\eta|_{AVE} = .835$). Students reported greater belief in a Shared and Developmental views of leadership, while simultaneously decreasing their belief in the Power dimension of leadership (the only construct to decrease)

($t\,(27) = -3.59$, $p = 0.001$; $t\,(55) = -5.08$, $p < 0.001$; lower-division and upper-division, respectively). Assessment of the relationship proximity between engineering and leadership (ELR) significantly increased ($t\,(28) = 6.61$, $p < 0.001$; $t\,(54) = 5.80$, $p < 0.001$; lower-division and upper-division, respectively).

Table 4: *t*-test for Change in Leadership Construct, by Class Level

Variable	*t*-value	Sample size	Effect size	*p*-value
Change in OTL-P, lower-division	-3.59	27	-.691	0.001
Change in OTL-D, lower-division	3.83	26	.751	0.001
Change in OTL-S, lower-division	4.97	27	.956	< 0.001
Change in ELR, lower-division	6.61	28	1.250	< 0.001
Change in OTL-P, upper-division	-5.08	55	-.685	< 0.001
Change in OTL-D, upper-division	4.42	54	.581	< 0.001
Change in OTL-S, upper-division	7.24	55	.977	< 0.001
Change in ELR, upper-division	5.80	54	.789	< 0.001

Underlined indicates significance at $\alpha = .0125$.

Table 5: Descriptive Statistics, Identity and Construct, by Class Level

Variable	Class Level	N	Mean, BEFORE	Mean, NOW	St Dev
Ldr Identity	Lower	27	3.867	4.500	1.622
OTL-Power	Lower	27	3.531	2.901	1.114
OTL-Develop	Lower	27	3.676	4.320	0.935
OTL-Shared	Lower	27	4.648	5.926	1.290
Engr Ldrshp Relation	Lower	28	4.536	6.143	1.644
Ldr Identity	Upper	51	4.663	5.147	1.243
OTL-Power	Upper	55	3.145	2.551	1.018
OTL-Develop	Upper	54	3.532	3.981	0.896
OTL-Shared	Upper	55	4.709	5.564	0.777
Engr Ldrshp Relation	Upper	51	4.706	5.595	1.432

Implications and Conclusion

The results from this study provide evidence that an identity-based approach to teaching engineering leadership can have substantive short-term impact on engineering students. Reflexive instruction seems to expand their understanding of leadership, from position-based authority to more relational forms of influence that can be developed. In addition, students were more willing include engineering leadership in their view of themselves due to this identity-based approach. This is meaningful, as the literature suggests that one's identity is an important factor in continued long-term leadership development [3].

Intervention

Practically, this research has presented a reflexive model of an identity-based approach to engineering leadership instruction. Moreover, the model may be applied in a wide variety of engineering classes, given the central role that leadership plays in training for the profession. That said, in a lower-division setting, the lower-division lesson plan may provide an introduction and contextualization of leadership in the engineering profession. Therefore, it might be most appropriate for an engineering survey course, as students are introduced to various aspects of the engineering profession.

The upper-division lesson plan can provide richer insight into how engineering leadership is practiced, as well as practical scaffolding for students' pursuing their own professional development. Therefore, in an upper-division setting, it might be most appropriate in a project-based or capstone course. However, it could also be used in other upper-level technical courses if students were encouraged to leverage the teachings in other project-based courses.

Furthermore, this research took great efforts to create a model that could be widely applied. Its modular nature enables it to be easily integrated in existing courses, with required instructional resources available in the Appendices. This facility also supports scaling the activities across a broad range of institutional settings. Finally, its use of identity as a core guiding framework may give the instruction flexibility in being effective in a variety of settings. This is because regardless of specific leadership contexts, identity formation is vital to continued growth in the complex, individual field of leadership [3].

Leader Identity

The empirical results from the reflexive instruction module were encouraging. The intervention helped students see themselves more as engineering leaders. From observation of classroom activities and essays, students seemed to readily integrate leadership vocabulary, especially in their interpretation of previous experiences. It is suspected that the short videos of various leadership styles enabled students to think more critically about leadership simply by introducing clear language. This approach has been suggested for supporting student adoption of more complex and relational forms of leadership (e.g., LID). In addition, the videos contextualized leadership within the engineering profession; this provided a model for practicing leadership in a way that aligns with the values of engineering. [12] argues that this may be particularly important to those engineering students who are resistant to leadership because they view it as charismatic control devoid of technical grounding. Hence, learning about leadership in a professional context may reduce their resistance to more power-based ideas of leadership [12]. This perspective may also explain increases in leadership interest and self-efficacy, as students integrate more expansive approaches to leadership into their goals and existing capabilities.

Moreover, this perspective may make sense of the correlation that emerged amongst upper-division students; those who had lower leadership interest and self-efficacy reported significantly greater leader identity growth after reflexive instruction. It may be that low interest and self-efficacy reflects the long-term impact of resistance to leadership. If so, it is precisely those students most resistant to engineering leadership that are most positively impacted by an identity-based approach to leadership development in this study. Hence, reflexive instruction may hold promise for programs interested in developing leadership amongst all their engineering students, even more so than programs designed for a select cadre. Regardless of the cause, this finding demonstrates that reflexive instruction may be especially valuable for those students least likely to pursue leader development in college. In other words, this intervention didn't just preach to the choir; it empowered those college students least interested or engaged in leadership (at least upper-division).

Leadership Understanding
Like the results from analysis of leader identity, the reported empirical shift in leadership understanding was encouraging. These shifts aligned with expected outcomes based on existing literature. As with leader identity, it is suspected that the videos did much to reduce resistance to engineering leadership by shifting how students thought about it. For example, by introducing engineering group situations, where teams require diverse skillsets, students could easily envision a shared, relational approach to leadership. And, by exploring the multiple ways leadership can be exercised, students may be more likely to appreciate the many skills required, thereby appreciating the developmental characteristic of leadership.

Finally, decrease in a power-based orientation reflects students taking a more expansive view of leadership, as they realize that authority and coercion is not the sole way in which leadership is practiced. It is suspected that group work and class-wide discussion during the intervention may have been influential, due to two effects. First, students can share supportive and destructive behaviors from various leaders, managers, and superiors in their experience. Second, students were able to integrate leadership style vocabulary into this discussion (e.g., democratic and autocratic styles) that they had learned through pre-lecture videos. Third, through class discussion, expansive ways of thinking about and applying leadership styles were scaffolded.

Summary
These results indicate that an identity-based intervention impacts engineering students towards more expansive views of leadership, as well as greater professional connection with leadership. Given the importance of identity to longer-term development, reflexive instruction may hold promise as an important approach to complex role development; it also seems to lead to more expansive views of leadership that are more commonly practiced in the profession. Not only does this prepare students for the realities of professional practice, but it provides students with a realistic and accurate vision of the professional community. Of particular interest is the outsized impact that reflexive instruction had on those least interested and confident in leadership. This is a promising finding, as institutions search for ways to prepare all students for the leadership roles required of them in the engineering profession.

Limitations and Future Directions
The intent of this research was to present an identity-based instructional approach that leverages a modular engineering leadership unit. The results are promising; taking an identity-based approach and presenting leadership within an engineering professional context seems to help students to envision themselves as engineering leaders. In particular, engineering education administrators may benefit from cultivating environments that actively lower the barriers between engineering education and the types of skills and experiences common in the actual engineering profession. The broader impact of a scaled version of reflexive instruction is promising for the field. This provides a first step for engineering educators to integrate theoretically sound exploration of leadership as a professional skillset important to the engineering profession. That said, several limitations and open questions emerged from this research.

The biggest outstanding questions concern why these results were observed. While identity lenses provide some insight into potential causal and mediating mechanisms of engineering leader identity development, there is still a great deal of uncertainty that warrants further investigation. For example, because no background-related control variables were used in analysis, one wonders what a more comprehensive exploration of influential experiences might uncover, such as gender, institute and program male/female ratio, previous types of leadership experiences, or existing co-curricular leader positions. In addition, qualitative methods may provide insight on the causal mechanisms and developmental processes observed in leader identity and leadership understanding changes.

In addition to questions about causes of these results, one also wonders about where this research might lead. One wonders about the longer-term impact of this instruction. Will the short-term impact lead to developmental steps that further one's practice of leadership? If so, what types of opportunities and experiences best support further growth? Second, one wonders how this intervention itself might be modified to better support identity growth and various programmatic and institutional goals. Might a more involved instructional approach leader to stronger and longer-lasting leader growth (e.g., team-based weekly meetings that highlight progress on SMART goals that support leader development)? Third, one wonders about the connection between engineering leadership understanding and identity. Does the development of more expansive views of leadership lead to a stronger leader identity? Finally, the population demographics raise questions about the generalizability of these findings to a more representative population. Further research on reflexive instruction is needed to address these questions.

As engineering education scholars continue to pursue better ways to prepare engineering students for the profession, the growing demand for professional skill competencies only makes this challenge harder. Leadership sits at the head of professional skills in navigating the engineering professional community, and faculty need the tools to prepare their students. This research explored a modular, identity-based instructional approach that demonstrated impact both on how students saw themselves as leaders, and what students even meant by the word 'leader'. Most promising, this intervention was designed to by implemented across institutions and programs with varied approaches and goals. These types of easily scalable instructional modules may provide the engineering leadership field with education solutions that are not only highly efficient, but also empirically grounded, effective, and refined.

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Appendix 1: Outlook Essay Assignment

Engineering Leadership, Homework 1 ENGR Xxx, Spring 2021

Directions:
[1-page maximum. Write an essay that answers both questions posed below. Justify your responses with at least two specific examples. The assignment will be graded on completion only—no penalties for grammar mistakes or weak style. However, your submitted work should represent an honest and sincere effort —so put your best foot forward!]

Essay Questions:

1. How would you define engineering leadership?

2. Would you consider yourself as-– or becoming– an emerging engineering leader? If so, in what way? If not, why not?

Appendix 2: Lower Division Lesson Plan

Topic:	0.3 Class Discussion (Engr. Ldrship, Lower-division) v1
Learning Targets:	Understand different types of positional leadership; Understand relational leadership; Understand three types of engineering leadership.
Class prep/resources:	Post and assign videos
Pre-video	Three videos on leadership: Authoritarian, Democratic, & Laissez Faire; Positional vs. Relational; and Tech. Mastery, Coll. Opt., and Org. Innov.
Pre-Reading:	Completion of Pre-survey and Outlook Essay
Homework due:	Prepared to discuss type of engineering leader that is most interesting to you.

Activity	Purpose	Tin
Welcome to class. Introduce today's topic-- engineering leadership.	**Transition into class, intro.**	
Quiz– three types of englineering leadership; 2 types of positional leadership; difference between positional vs. relational. [App. 1]	**Focus, reflect, review content**	
Group Activity [Appendix 2]	**Explore E L types with partner(s)**	
Class-wide Discussion of engienering leadership types. 2-3 interesting comments from groups. Instructor normalizes terms: leadership, influence, responsibility, interdependence. Normalize action: get involved in a professionally interesting project (list examples, maybe even with contact info). What to do now? What are barriers?	**Review, action items, talk.**	
Homework: Reflection Essay, then post-test survey [App. 3]	**Reflection of growth / measure**	

Appendix 2: Lower Division Lesson Plan (continued)

Attachment 1: Formative Quiz

1. List 2 types of positional leadership types.
2. In one sentence, describe the difference between positional and relational leadership
3. List 3 types of engineering leadership (descriptions are acceptable.

Attachment 2: Group work

1. Take 2 minutes to talk about the quiz with your partner. Go over answers as a class (students provide answers). Questions?
2. Take 2 minutes in silence to consider:
   a. What type of engineering leader do you envision yourself becoming? Why?
3. Interview your partner for 3 minutes on this topic.
4. Switch roles.
5. Merge with another group.
6. Each of the four of you will now present a 3 minute summary of your partner's perspective on the question.

Attachment 3: Homework 2, Reflection Essay

Engineering Leadership, Homework 2 ENGR 1xx, Spring 2021

Directions:
1-2 pages. Reread your first essay (Homework 1). Write an essay that answers both questions posed below. Justify your responses with at least two specific examples. Again, the assignment will be graded on completion only—no penalties for grammar mistakes or weak style. However (again), your submitted work should represent an honest and sincere effort —so put your best foot forward!

Essay Questions:

1. How has your perspective on engineering leadership changed / strengthened / weakened since your first essay?

2. Which-- if any-- practical steps (that were discussed in class) sound personally interesting

DUE: 1 week.

Appendix 3: Upper Division Lesson Plan, Day 1

Topic:	4.3 Class Discussion (Engr. Ldrship, Upper-division) v1
Learning Targets:	Understand relational leadership vocabulary, ; Understand three types of engineering leadership.
Class prep/resources:	Post and assign videos
Pre-video	**Required**: Two videos on leadership: Positional vs. Relational; and Tech. Mastery, Coll. Opt., and Org. Innov.
Pre-Reading:	Completion of Pre-survey and Outlook Essay
Homework due:	Outlook essay done. Prepared to discuss type of engineering leader that is most interesting to you.

Activity	Purpose	Time
Welcome to class. Introduce today's topic-- engineering leadership.	**Transition into class, intro.**	
Quiz-- three types of englineering leadership; difference between positional vs. relational. [App. 1]	**Focus, reflect, review content**	
Group Round Robin [App. 2]	**Explore E L types with group**	3
Class-wide Discussion of engineering leadership types. 5-10 interesting next steps from groups (by each of 3 E L orientations). Any brilliant insights on next steps, from group? Instructor normalizes terms: leadership, influence, responsibility, interdependence. Normalize action: practice leadership, develop skills (list examples, maybe even with contact info). SMART goal introduction	**Review, action items, talk.**	1
Homework: Practical step assignment, HW 2[App. 3]		

Appendix 3: Upper Division Lesson Plan, Day 1 (continued)

Attachment 1: Formative Quiz

1. In one sentence, describe the difference between positional and relational leadership
2. List 3 types of engineering leadership (descriptions are acceptable).

Attachment 2: Group work, Round Robin

1. Take 2 minutes to talk about the quiz with your group. Go over answers as a class (students provide answers). Questions?
2. Take 2 minutes in silence to consider:
    a. What practical steps might one take to develop in one of these three engineering leader orientations?
3. Round Robin, 5 minutes.
    a. Choose a scribe.
    b. Clockwise, brainstorm one idea per person. How many rounds can you do?
4. Share Round Robin results with class.

Attachment 3: Practical Step Assignment, HW2

Engineering Leadership, Homework 2 ENGR 4xx, Spring 2021

In your team:

Discuss which type of engineering leader you envision yourself becoming (possibly)? Why?

On your own:

1. Describe one practical step you will take to develop this semester as an engineering leader (consider your team discussion).
2. Set a SMART goal to accomplish this step:
    a. S- Specific (i.e., what do you want to accomplish—make it simple & clear)
    b. M- Measurable (i.e., how will you know if you've succeeded)
    c. A- Achievable (i.e., make it realistic, but also challenging)
    d. R- Relevant (i.e., is this goal compelling, for you, right now)
    e. T- Timely (i.e., by when? This goes with M and A—what challenge will you accomplish by when?)
3. Submit a paragraph describing your goals, from #1 and #2.

DUE: Next class period. Come prepared to discuss your goal.
Again, the assignment will be graded on completion only—no penalties for grammar mistakes or weak style. But you do need to address all 5 aspects of the SMART goal.
p.s.—Pro tip-- Feel free to use a leadership goal that you are already working on…

Appendix 4: Upper Division Lesson Plan, Day 2

Topic:	4.4 Summary Class Discussion (Engr. Ldrship, Upper-division) v1
Learning Targets:	Explore and commit to growing in a particular E L construct. Identity a personally meaningful developmental step.
Class prep/resources:	Watched videos.
Pre-video	**N/A**,
Pre-Reading:	N/A.
Homework due:	One sentence practical step you plan on taking. Prepared to discuss type of engineering leader that you envision yourself becoming.

Activity	Purpose	Time
Welcome to class. Introduce today's topic-- engineering leadership.	**Transition into class, intro.**	**3**
Quiz-- three types of englineering leadership; difference between positional vs. relational. [App. 1]	**Focus, reflect, review content**	**6**
Group Round Robin [App. 2]	**Explore E L types with group**	**30**
Class-wide Discussion of engineering leadership types. 5-10 interesting next steps from groups (by each of 3 E L orientations). Any brilliant insights on next steps, from group? Instructor normalizes terms: leadership, influence, responsibility, interdependence. Normalize action: practice leadership, develop skills (list examples, maybe even with contact info). SMART goal introduction	**Review, action items, talk.**	**10**
Homework: Practical step assignment, HW 2[App. 3]		
	Total	

Appendix 4: Upper Division Lesson Plan, Day 2 (continued)

Attachment 1: Reflective Essay

Engineering Leadership, Homework 3 ENGR 4xx, Spring 2021

Directions:
1-2 pages. Reread your first essay (HW 1) and your practical step / SMART goal (HW 2). Write an essay that answers both questions posed below. Justify your responses with at least two specific examples. The assignment will be graded on completion and addressing your SMART goals (not necessarily accomplishing them, just make sure you discuss the outcome). However, as before, your submitted work should represent an honest and sincere effort —so put your best foot forward!

Essay Questions:
Review your first reflection essay & practical step (incl. SMART goals). Consider your team discussions.

1. How has your perspective on engineering leadership changed / strengthened / weakened over this semester (include discussion of your practical step and SMART goals)?

2. Which-- if any-- practical steps (that were discussed in class or in your team) sound personally interesting to you going forward?

DUE: TBD.