Perceived Importance and Confidence in Leadership Ability: A National Survey of Final Year Canadian Engineering Students

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Introduction

Engineering leadership as a field of study has grown rapidly in the last two decades (Handley et al., 2018; Klassen et al., 2016), but there is limited understanding of how engineering students view the importance of leadership skills generally and how they appraise their confidence in their own leadership skills. Emerging research indicates that they place high significance on such leadership-related skills as teamwork and communication but a lower significance on leadership itself than on problem-solving, ethics, and technical skills (Bielefeldt, 2018; Passow, 2012). While this research contributes to our general understanding of the extent to which engineering students perceive leadership skills to be important to the engineering profession, it has fallen short of disaggregating data across demographic and academic variables, thus running the risk of homogenizing engineering students. Further, the research rarely examines the relationship between two distinct measures—the extent to which engineering students perceive leadership skills to be important in becoming a successful engineer and the extent to which they consider themselves confident in these skills—so it is unclear to what extent there are differences or similarities between the two.

The examination of students' importance and confidence ratings of leadership skills is important for two main reasons. First, understanding students' perceived importance of leadership skills, as well as their perceived competency in these skills, can shed light on their motivation to develop and practice them (Eccles & Wigfield, 2002; Chan et al., 2017). According to the expectancy-value theory on which we draw in this paper, students' motivation to learn specific skills is influenced by their perceived level of importance of, and their perceived competency in, those skills. The more that students value a skill and the more confident they feel in having it, the more likely they are to develop and practice it. Second, conducting such an examination, especially among final year students, can help to assess where these students stand in their values and ability beliefs about leadership. Existing research demonstrates that engineers overall resist the idea of leadership (Rottmann, Sacks, & Reeve, 2015). However, accreditation entities (ABET, 2017) and employers (Hartmann & Jahren, 2015) expect engineering students and professionals to demonstrate leadership.

This paper addresses the aforementioned gaps in the existing research by investigating how a sample of 2,485 final year Canadian undergraduate engineering students perceive the importance of leadership ability; how confident they are in their own leadership ability, and how these two measures interact across demographic and academic variables. The paper is based on a secondary analysis of two parallel sets of questions included in a national survey of engineering students which asked them to rate their proficiency in 11 skills and evaluate the importance of these skills to engineering. One out of 11 of these was leadership ability. The following questions guided our analysis: compared to other skills, (1) How do the respondents rate the importance of leadership ability? (2) How confident are they in their leadership ability? and (3) How do these two measures compare to each other? Where possible, we disaggregated the data across demographic (gender, race, and residential status) and academic (discipline and academic standing) variables.

In what follows, we present our literature review findings on the importance-confidence ratings of different skills among engineering students and recent graduates. We then outline our conceptual framework and methodology. After that, we present and discuss our findings and

conclude with recommendations for engineering leadership education practice and research.

Literature Review

Our literature review revealed that while there is some research on how engineering students and recent graduates perceive the importance of different skills to engineering (Chan et al., 2018; Direito et al., 2012; Passow, 2012; Sheppard et al., 2010), there is not much that focuses specifically on leadership (Bielefeldt, 2018). Further, with the exception of a few studies (Chan et al., 2018; Direito et al., 2012), little research examines engineering students' and recent graduates' confidence in their skills as it relates to their perceptions about the importance of these skills. Lastly, the available research on the topic rarely disaggregates data by demographic or academic variables, though some studies point, for instance, to the impact of gender, race, socio-economic status, coursework, or extra-curriculars on students' leadership learning outcomes, including their confidence in their skills (Magarian & Olechowski, 2018; Ro & Knight, 2016; Sheppard et al., 2010). In what follows, we present our analysis of existing studies in order to contextualize our own study.

The studies that examine and compare students' perceived importance of, and confidence in, skills focus mainly on generic, soft or transferable skills. (For the purposes of this paper, we will refer to these skills as professional.) These studies find that students view most of the professional skills to be important to their future profession and that they rate the importance of professional skills more highly than their proficiency in these skills. In regards to leadership, these studies find that students neither overemphasize nor underemphasize the importance of leadership as compared to other professional skills and that they rate their competence in leadership skills lower than they do the value of those skills. For instance, in Direito et al.'s study (2012) of Portuguese electrical and electronic engineering students, the participants assigned lower levels of importance to leadership itself than to such leadership-related skills as teamwork, communication, listening, networking, and time management. Their confidence in their leadership ability was lower than the importance they ascribed to it. In Chan et al.'s studies (2017, 2018), freshman engineering students gave leadership—conceived as motivating and supervising others, coordinating and planning tasks, and building team cohesion—neither high nor low importance ratings among 38 professional skills. However, within leadership skills the students assigned a much higher value to coordinating and planning tasks and building team cohesion than to motivating and supervising others, which shows that they ascribe different value to different leadership skills. As in Direito et al.'s study, the participants in Chan et al.'s studies rated their confidence in leadership skills lower than they did the importance of those skills.

While these studies provide us with an understanding of the value that engineering students ascribe to leadership and other professional skills and of their ability beliefs in these skills, they fall short of comparing the importance and confidence ratings of professional skills to those of technical skills. They also do not examine perceived importance and confidence among final year undergraduate students. The available research finds that engineering students change their perceptions of skill importance as they move through their studies. Winters et al. (2013), for example, found that while students viewed math skills to be of high importance in the early years of their studies, their perceived importance of those skills decreased towards the end of their studies. They also found that students began to ascribe higher levels of importance to communication, motivation, and teamwork skills towards the end of their studies.

Studies that compare the perceived importance of professional skills to that of technical skills provide mixed evidence. While some show that students value technical more than professional skills, others paint a somewhat different picture. In a national study of senior U.S. engineering students, for instance, Sheppard et al. (2010) found that the students perceived math and science skills to be more important than professional and interpersonal skills (self-confidence, leadership, public speaking, communication, teamwork, and business ability). In contrast, in her study of the perceived importance of leadership among senior civil engineering students, Bielefeldt (2018) found that the participants placed a high value on both technical and professional skills. In particular, her study revealed that out of 24 outcomes the participants viewed the following eight as the most important to engineering: problem-solving, teamwork, communication, ethics, design, project management, technical specialization, and leadership. Although leadership was the eighth most frequently cited outcome, it aligned closely with four higher-rated outcomes: teamwork, communication, ethics, and project management.

Studies that examine the perceived importance of technical and professional skills among recent engineering graduates produce similar findings to those of Bielefeldt (2018): while graduates value technical skills, they consider some professional skills more important than technical skills. For instance, in his study of recent engineering undergraduate alumni of one U.S. university, Passow (2012) found that among all ABET competencies the graduates most highly valued teamwork, communication, data analysis, and problem-solving skills. These skills were followed by math, science and engineering skills, ethics, life-long learning, design, and engineering tools. While these three studies show the importance that senior engineering students and recent graduates ascribe to technical and professional skills, only the study by Sheppard et al. (2010) provides any information about how confident students consider themselves in these skills. Sheppard et al. note that students were more confident in their math and science skills than in their professional and interpersonal skills and that confidence in these skills was positively correlated with their perceived importance.

Lastly, studies that examine students' perceived importance of specific skills to engineering and/or their confidence in these skills rarely disaggregate their data across demographic or academic variables. As a result, we do not know whether there is any correlation between students' gender, race or academic standing, among other variables, and their importance and confidence ratings. While some research points to differences across genders and races, for instance, others find no significant differences across these variables. In regards to gender, Sheppard et al.'s study revealed that senior male engineering students were more confident than their female peers in their problem-solving skills; that there was a slight difference in self-rated math and science skills between the two groups, and that there was no difference in self-rated professional and interpersonal skills. The study also found that females assigned higher value than males to professional and interpersonal skills and that there was no significant difference in the perceived importance of math and science skills between females and males. In regards to underrepresented racial/ethnic minority (URM) groups, Sheppard et al.'s study did not detect any significant differences between senior URM and non-URM students with respect to their confidence in math and science skills but they found that senior non-URM men ascribed lower value than URM men to math and science skills. The study also revealed that senior non-URM students attached lower importance to professional and interpersonal skills than URM students. In contrast to Sheppard et al.'s study, Passow's study (2012) did not find any significant differences in the perceived importance of ABET competencies across gender or race.

In regards to leadership specifically, Bielefeldt (2018) found that female students were less likely than their male peers to ascribe high value to leadership; however, the difference was only marginally significant statistically. Magarian and Olechowski (2018) did not find any significant difference in leadership role confidence across gender or race in their study of engineering students across nine U.S. universities. As these studies demonstrate, the role of demographic variables such as gender and race in students' importance and confidence ratings of skills is not clear cut and needs further attention, especially in the context of engineering leadership research which rarely disaggregates data by demographic or academic variables.

In sum, our literature review revealed three major gaps in the existing research. First, there is limited research that investigates the extent to which students perceive leadership skills to be an important feature of their professional lives and consider themselves proficient in these skills as compared to other skills. Second, there is a lack of studies that examine students' importance and confidence ratings of leadership skills at the end of their undergraduate studies. Lastly, the available research rarely disaggregates data across demographic and academic variables. As a result, we know little about similarities or differences across different student groups. We address these gaps by examining how a sample of 2,485 final year Canadian undergraduate engineering students perceive the importance of, and their competence in, leadership ability as compared to math and science and other professional skills, across demographic and academic variables.

Conceptual Framework

Like Bielefeldt (2018) and Chan et al. (2017), we draw in this paper on expectancy-value theory to conceptualize the relationship between students' perceived importance of leadership ability to becoming a successful engineer and their confidence in their own leadership ability. Eccles and colleagues (1983, 2000, 2002) developed this theory to explain the achievement motivation of students. They define expectancies as "beliefs about how one will do on different tasks or activities" and values as "incentives or reasons for doing the [task or] activity" (Eccles & Wigfield, 2002, p. 110). According to the theory, both expectancies and values motivate individuals toward positive outcomes and predict subsequent performance and occupational aspirations, and competence-related beliefs and values become positively related to each other (Eccles & Wigfield, 2002, p. 110). In the context of this study, the expectancy-value theory predicts that students' motivation to develop and practice leadership will be influenced by their perceived level of importance of, and their subjective competency in, this skill. Understanding students' perceived importance of leadership ability and their confidence in it can therefore shed light on their motivation to develop and practice this skill (Chan et al., 2017).

In the expectancy-value theory, expectancies can also be understood in terms of self-efficacy, in that "an individual's beliefs about their abilities influence their motivation to engage in related learning activities" (Chan et al., 2017, p. 303). In other words, students' perception of their competency in specific skills can influence their motivation to engage and persist in the learning of such skills. According to the theory, task-value has four components: attainment value, intrinsic value, utility value, and cost. Attainment value refers to the personal importance of doing well on the task. Intrinsic value means the enjoyment one derives from performing the task. Utility value, or usefulness, is associated with how well a task relates to current and future goals, such as career goals, and represents extrinsic reasons for performing the task. Cost means the negative aspects of engaging in the task such as anxiety or the amount of effort made. In this study, we draw particularly on the idea of utility value. As Chan et al. (2017) and Bielefeldt (2018) note, students are more likely to be motivated to learn skills that they believe will be

important to their personal development or future career due to their utility value. For instance, if a student believes that leadership will be helpful to their personal development or future career, this belief would contribute to the utility value of acquiring leadership skills in university or the workplace (Bielefeldt, 2018).

According to existing research, individuals' perceptions of their own experiences and a variety of socialization factors influence their expectancies and values. In the context of this study, this would mean that students' perceptions about the importance of leadership ability, and their confidence in their own leadership ability, may be shaped by their participation in curricular and co-curricular activities during their undergraduate studies, as well as by their pre-existing characteristics such gender, class or race and their previous experiences. The available research demonstrates that curricular (Knight & Novoselich, 2017) and co-curricular (Rottmann et al., 2016) activities facilitate, to various extents, the development of leadership skills and identity among engineering students. It also shows that female engineering students, for instance, value professional skills, including leadership, more than their male peers (Sheppard et al., 2010).

Methodology

This paper is based on a secondary analysis of data collected via the Engineers Canada's Final Year Student Exit Survey (henceforth the survey). The survey used to be administered annually to engineering students across 46 Canadian post-secondary institutions that offer engineering programs. For this paper, we use the data from the 2017 survey. A total of 2,485 final year undergraduate engineering students responded to the survey, which constitutes approximately 16% of engineering students who were awarded undergraduate degrees in 2017.

Our analysis focused on two parallel sets of questions that we had the opportunity to add to the survey. The first set of questions asked respondents to rate themselves on 11 skills in comparison to their classmates on a five-point Likert scale (lowest 10%, below average, average, above average, and highest 10%). These skills were: critical thinking, math ability, science ability, ability to apply math and science principles in solving real world problems, self-confidence, leadership ability, public speaking ability, communication skills, teamwork skills, and the ability to take initiative. The second set of questions asked the respondents to evaluate the importance of these skills to their professional engineering development process on a five-point Likert scale (not important, somewhat important, important, very important, and crucial/absolutely essential). Both sets of questions included "I am not sure how to respond" as an option.

These two sets of questions were adopted with permission from the U.S. Academic Pathways of People Learning Survey (APPLES; Sheppard et al., 2010). In the project, they were used to measure students' perceived importance of skills and their confidence in these skills. We made three minor modifications to the APPLES' list of skills. First, we added "ability to take initiative" to the original list of skills, as we consider it to be an important leadership-related skill (see Hartmann & Jahren, 2015). Second, we changed the wording of "ability to perform in teams" to "teamwork skills" to simplify the wording. Third, we added "critical thinking skills" to the question that measured the perceived importance of skills in order to ensure consistency between the two questions for the sake of comparison. In the APPLES, the "critical thinking skills" item was included only in the question that measured students' skill confidence.

In order to group 11 skills, we ran an exploratory factor analysis of student confidence ratings on those skills and identified two factors that explained 55% of the total variance. Based on the

result from the factor analysis, we categorized the 11 skills into two groups: professional skills and math and science skills, while leaving out critical thinking skills, which straddled these two groups. Professional skills consisted of self-confidence, leadership ability, public speaking ability, communication and teamwork skills, business ability and ability to take initiative. Math and science skills encompassed math ability, science ability, and the ability to apply math and science principles in solving real-world problems. This categorization is consistent with that of the APPLES project (Sheppard et al., 2010). In order to compare the importance and confidence ratings of leadership skills to those of other skills, we further created two aggregate measures by averaging the ratings of the six other professional skills and three math and science skills. The Cronbach's alphas for the six professional skills were .752 for the confidence ratings and .784 for the importance ratings; the Cronbach's alphas for the three math and science skills were .808 for the confidence ratings and .838 for the importance ratings. All these alpha values were above .70, indicating that they had good internal consistency.

In order to analyze the collected data in response to our research questions, we conducted three lines of analysis examining students' importance and confidence ratings of the indicated skills separately. First, we compared the perceived importance, and confidence in, leadership ability with those of two aggregate measures—professional skills and math and science skills. Second, we compared the perceived importance and confidence in leadership ability with those of six other individual professional skills. Lastly, we compared the importance and confidence ratings of the indicated skills. We conducted these lines of analysis for the total sample and across five variables: gender, residential status, race, engineering discipline, and academic standing (see Table 1 for the distribution of the survey respondents by these variables).[1] We ran independent or paired t-tests on all these comparison analyses and calculated Cohen's *d* for all the differences that were statistically significant. We used the following criteria to interpret the effect size: when the *d* value is 0.2, the effect size is small; a *d* value of .5 represents a medium effect size; and a *d* value of .8 means a large effect size (Cohen, 1977).

Our study has three major limitations. First, since we could not compare the total sample with the total population of 2017 final year Canadian undergraduate engineering students across demographic and academic variables, we do not know the extent to which our data and thereby findings are representative of the total population. Second, the findings should also be taken with caution because of the potential social desirability issue. Some respondents may have rated the importance of the 11 skills and their confidence in them in ways that do not reflect their true values and ability beliefs about these skills. We did not have any means to triangulate the collected data. Lastly, given that the leadership ability item was loosely defined in the survey, it is not immediately clear what the survey respondents thought of leadership when completing the survey, which may have influenced their importance and confidence ratings of it.[2] Despite these

[1] We decided to examine students' perceived importance of, and confidence in, leadership ability as compared to other skills across these demographic and academic variables because existing research shows that students' values and ability beliefs can vary by gender (Bielefeldt, 2018; Sheppard et al., 2010), race (Sheppard et al., 2010), and residential status (Bennett et al., 2015; Nguyen, 2016). The available research also shows that academic programs socialize students into different value systems and behaviours (Brint, Cantwell, and Hanneman 2008; Lattuca et al., 2010) which might influence their perspectives on leadership. Lastly, the existing research indicates that student performance accomplishments tend to be the most compelling source of self-efficacy (Sheu et al., 2018).

[2] While we ourselves subscribe to the idea of leadership as a process (Northouse, 2019), we understand that some students may view it in positional terms. 'Positional' leadership is based on traditional notions of a leader as an individual with power and authority due to their position within an organization or society. In contrast, 'process' leadership is rooted in the idea of an individual influencing a group of individuals to achieve a common goal without using traditional means of power and authority (Northouse, 2010, p. 3).

limitations, the study still contributes to the limited research on students' perceived importance of and confidence in leadership.

Table 1. Sample Characteristics

Characteristics	Frequency	%
Gender		
Male	1779	71.6
Female	684	27.5
Other & non-response	22	0.9
Residential status		
Domestic	2361	95
International	124	5
Race		
South Asian	177	7.1
East Asian	310	12.5
Southeast Asian	72	2.9
Middle Eastern	108	4.3
Black	68	2.7
British	331	13.3
Western European	325	13.1
Southern or Eastern European	196	7.9
Indigenous people	49	2.0
Not included in analysis*	525	21.1
Did not identify race	324	13.0
Engineering discipline		
Biosystems	389	15.7
Chemical	176	7.1
Civil	451	18.1
Computer	128	5.2
Electrical	461	18.6
Engineering Physics	85	3.4
Industrial or Manufacturing	128	5.2
Mechanical	323	13
Software	70	2.8
Other (Environmental, Geological, Material/Metallurgical, Mining / Mineral)	106	4.3
Other (miscellaneous)	164	6.6
Did not identify discipline	4	0.2
Academic standing		
High-performing, A-, A or A+ (3.5 or above)	890	35.8
Average-performing, B or B+ (2.9 to 3.4)	1067	42.9
Low-performing, C+ or B- (2.8 or below)	484	19.5
Did not identify academic standing	44	1.8

*Only single-race and Indigenous students were included in the analysis.

Findings

In what follows, we present our findings about perceived importance and confidence in leadership ability across five variables. We found that final year Canadian undergraduate engineering students considered leadership ability as important to becoming a successful engineer and considered themselves to be relatively confident in it. We also found that students rated their proficiency in leadership ability slightly higher than the importance of it. Lastly, we found that while students from most demographic and academic backgrounds had similar values and ability beliefs about leadership as the total sample, there were differences across some variables.

Perceived Importance of Leadership Ability

Our findings revealed that students overall valued leadership ability highly and viewed it as important to becoming a successful engineer. Twenty three percent rated it as crucial, 40% as very important, 27% as important, 9% as somewhat important, and 1% as not important. These figures show that students generally ascribe a relatively high utility value to leadership. When compared to aggregate measures of other skills, our findings revealed, students ascribed *slightly* lower value—as suggested by the small effect size of the difference—to leadership ability than to other professional skills and they viewed leadership ability and math science skills as *almost* equally important (see Table 2). This suggests that students may prioritize the learning of other skills over leadership at least at the early stage of their career given that they attach a slightly higher value to those skills.

Table 2. Perceived Importance of Leadership Ability as Compared to Aggregate Measures of Other Skills

	Importance		**Compared with leadership ability**				
	Mean	SD	Mean Diff.	df	t	p	Cohen's d
Leadership ability	3.74	0.95	-	-	-	-	-
Professional skills	3.84	0.61	0.10	2452	7.22	p<.001	0.15
Math and science skills	3.83	0.77	0.09	2463	4.10	p<.001	0.08

We observed a pattern similar to that of the total sample when we compared the perceived importance of leadership to that of other skills across five variables. Regardless of their backgrounds, students valued professional skills and math and science skills more than leadership ability, except for females, most racial groups, and some engineering disciplines (see Table 3). For these students, either there were no significant differences in the perceived importance of the indicated skills or they valued leadership more than math and science skills. We also found a larger magnitude of difference in the importance ratings of the three skills among some groups of students than among the total sample. As compared to the total sample, international students, South Asian and East Asian students, and those from computer and software engineering valued professional skills more than leadership ability. Similarly, international students, South Asian, East Asian and British students, high-achieving students, and those from biosystems, computer and electrical engineering and engineering physics ascribed a *slightly* higher value to math and science skills than to leadership than the total sample did. These findings suggest that some groups of students are more likely than others to deem leadership as less important than other skills and to be more motivated to learn these skills than leadership skills.

Table 3. Perceived Importance of Leadership Ability as Compared to Aggregate Measures of Other Skills cross Variables

Variables		Importance of leadership ability (LA) as compared to professional skills (PS) and math and science skills (MS)
Gender	Males	LA < PS (d = -0.18); LA < MS (d = -0.11)
	Females	n.s.*
Residential status	Domestic	LA < PS (d = -0.14); LA < MS (d = -0.07)
	International	LA < PS (d = -0.28); LA < MS (d = -0.32)
Race	South Asian	LA < PS (d = -0.28); LA < MS (d = -0.18)
	East Asian	LA < PS (d = -0.31); LA < MS (d = -0.21)
	Southeast Asian	n.s.
	Middle Eastern	n.s.
	Black	n.s.
	British	LA < PS (d = -0.12); LA < MS (d = -0.11)
	West European	n.s.
	Southern or Eastern European	n.s.
	Indigenous people	n.s.
Academic standing	High-performing	LA < PS (d = -0.13); LA < MS (d = -0.11)
	Average-performing	LA < PS (d = -0.14)
	Low-performing	LA < PS (d = -0.19)
Discipline	Biosystems	LA < PS (d = -0.18); LA < MS (d = -0.20)
	Chemical	n.s.
	Civil	LA > MS (d = 0.11)
	Computer	LA < PS (d = -0.31); LA < MS (d = -0.19)
	Electrical	LA < PS (d = -0.17); LA < MS (d = -0.23)
	Engineering Physics	LA < PS (d = -0.20); LA < MS (d = -0.27)
	Industrial or Manufacturing	n.s.
	Mechanical	LA < PS (d = -0.14)
	Software	LA < PS (d = -0.33)
	Other	LA > MS (d = 0.22)

*n.s. means not significant

Further, our comparison of leadership importance to six other individual professional skills revealed that students ranked it as the fifth most important skill to becoming a successful engineer. We also found that students attached *substantially* lower value to leadership than to teamwork and communication but ascribed higher value to leadership than to public speaking and business abilities (see Table 4). These findings suggest that while students overall value leadership, they see a lower utility value in it than in some other professional skills and thus may be less motivated to develop and practice it than those other skills. We observed a similar pattern when examining the ranking of the perceived importance of leadership across five variables. Students from most demographic and academic backgrounds ranked leadership as the fifth most important skill. These findings further show that, regardless of their background, students may prioritize other professional skills, especially teamwork and communication, over leadership.

Table 4. Perceived Importance of Leadership Ability as Compared to Other Individual Skills[3]

	Importance		Compared with leadership ability				
	Mean	SD	Mean Diff.	df	t	p	Cohen's d
Leadership ability	3.74	0.95	-	-	-	-	-
Teamwork skills	4.38	0.75	0.64	2468	32.61	p< .001	0.66
Critical thinking skills	4.37	0.73	0.63	2463	30.63	p< .001	0.62
Communication skills	4.3	0.78	0.56	2470	29.83	p< .001	0.60
Ability to apply math and science principles in solving real world problems	4.24	0.80	0.51	2466	21.97	p< .001	0.44
Ability to take initiative	3.93	0.87	0.19	2467	10.28	p< .001	0.21
Self-confidence	3.81	0.88	0.07	2465	3.64	p< .001	0.07
Science ability	3.63	-0.91	0.12	2466	-4.83	p< .001	-0.10
Math ability	3.62	-0.95	0.11	2466	-4.62	p< .001	-0.09
Public speaking ability	3.46	1.00	-0.28	2470	-16.06	p< .001	-0.32
Business ability	3.17	0.98	-0.57	2460	-29.35	p< .001	-0.59

The skills are listed in descending order of the mean values. Professional skills are highlighted in red.

Finally, our examination of the perceived importance of leadership ability across five variables revealed significant differences with small and medium effect sizes only across genders and some races and disciplines (see Table 5). More specifically, we found that females ascribed *slightly* higher value than males to leadership. We also found that Black and Middle Eastern students valued leadership *moderately* more than their Indigenous, East Asian, and British peers. Lastly, we found that students from "other" engineering disciplines attached a *moderately* higher value to leadership than those from software engineering and engineering physics. These findings show that students from some gender, racial, and disciplinary backgrounds ascribe a higher utility value than others to leadership and may therefore be more motivated to develop and practice it.

Table 5. Perceived Importance of Leadership Ability: Summary of Significant Differences Across Variables

Variables	Importance of leadership ability
Gender	Males (M= 3.69, SD= 0.96) < females (M= 3.88, SD = 0.91), t(1301.58)= -4.56, p < .001, Cohen's d = 0.20
Residential status	n.s.
Race	Indigenous (M=3.65, SD=1.07), EA (M= 3.66, SD= 0.94), Bri (M=3.68, SD= 0.95) < Black (M=4.05, SD= 0.74), ME (M=4.02, SD= 0.89), Cohen's d [0.37, 0.40]
Discipline	Soft (M= 3.37, SD= 0.98) < Other (M= 3.9, SD = 0.90), t(174)= -3.64, p < .001, Cohen's d = -0.56 EPhy (M= 3.56, SD=1.04) < Other (M= 3.9, SD = 0.90), t(144)= -2.35, p<.05, Cohen's d = -0.35
Academic standing	n.s.

[3] Although this table focuses on comparing the importance of leadership ability to other professional skills, we also included in it individual math and science skills and critical thinking skills so that readers could see how students value leadership ability as compared to all of the individual skills included in the survey.

Perceived Confidence in Leadership Ability

Our findings revealed that students were relatively confident in their leadership ability. Twenty eight percent rated their leadership ability as being in the highest 10% of their class, 42% as above average, 24% as average, 6% as below average, and 1% as being in the lowest 10%. Further, when compared to aggregate measures of other skills, we found that students considered themselves to be *slightly* more competent in leadership than other professional skills and math and science skills (see Table 6). These findings suggest that students are overall likely to engage in learning leadership because of their relative high confidence in it. However, as will be shown in the discussion section, this conclusion should be taken with caution because students' relatively high confidence in their leadership ability may not always translate into learning it, especially when they deem leadership to be less important than other skills.

Table 6. Confidence in Leadership Ability as Compared to Aggregate Measures of Other Skills

	Confidence		**Compared with leadership ability**				
	Mean	SD	Mean Diff.	df	t	p	Cohen's d
Leadership ability	3.91	0.89	-	-	-	-	-
Professional skills	3.75	0.62	-0.16	2410	-12.08	p<.001	-0.25
Math and science skills	3.71	0.73	-0.20	2454	-8.99	p<.001	-0.18

As in the total sample, students from most backgrounds were more confident in their leadership ability than in their professional skills and math and science skills, except for East Asian and high-achieving students (see Table 7). These students were more confident in their math and science than their leadership skills, which suggest that they may prioritize the development of these skills over leadership, at least at the early stage of their career. As in the case of importance ratings, we also found that there was a larger magnitude of difference in the confidence ratings of the three skills among some groups of students than among the total sample. In particular, as compared to the total sample, students from all three European groups were *moderately* more confident in their leadership ability than other skills. Further, in comparison to the total sample, low-achieving students were much more confident in their leadership ability than in their math and science skills.

Table 7. Confidence in Leadership Ability as Compared to Aggregate Measures of Other Skills Across Variables

Variables		Confidence in leadership skill (LA) as compared to confidence in professional skills (PS) and math and science skills (MS)
Gender	Males	LA > PS (d = 0.24); LA > MS (d = 0.14)
	Females	LA > PS (d = 0.26); LA > MS (d = 0.29)
Residential status	Domestic	LA > PS (d = 0.26); LA > MS (d = 0.20)
	International	n.s.
Race	South Asian	LA > MS (d = 0.17)
	East Asian	LA < MS (d = -0.23)
	Southeast Asian	n.s.
	Middle Eastern	LA > PS (d = 0.29); LA > MS (d = 0.28)
	Black	n.s.
	British	LA > PS (d = 0.42); LA > MS (d = 0.37)
	West European	LA > PS (d = 0.37); LA > MS (d = 0.26)
	Southern or Eastern European	LA > PS (d = 0.30); LA > MS (d = 0.28)
	Indigenous people	LA > PS (d = 0.34); LA > MS (d = 0.34)
Academic standing	High-performing	LA > PS (d = 0.27); LA < MS (d = -0.13)
	Average-performing	LA > PS (d = 0.24); LA > MS (d = 0.29)
	Low-performing	LA > PS (d = 0.25); LA > MS (d = 0.56)
Discipline	Biosystems	LA > PS (d = 0.23); LA > MS (d = 0.18)
	Chemical	LA > PS (d = 0.16)
	Civil	LA > PS (d = 0.25); LA > MS (d = 0.23)
	Computer	n.s.
	Electrical	LA > PS (d = 0.26); LA > MS (d = 0.18)
	Engineering Physics	n.s.
	Industrial or Manufacturing	LA > PS (d = 0.22)
	Mechanical	LA > PS (d = 0.37); LA > MS (d = 0.23)
	Software	n.s.
	Other	LA > PS (d = 0.34); LA > MS (d = 0.25)

Our comparison of confidence in leadership skills to confidence in six other individual professional skills revealed that the students' confidence in leadership ranked as third highest. We also found that students were *slightly* less confident in their leadership ability than in their teamwork and initiative-taking skills and that they were *moderately* more confident in their leadership ability than in their public speaking and business ability (see Table 8). When we examined students' confidence ranking of their leadership ability in comparison to that of six other professional skills across five variables, we detected patterns similar to those observed in the total sample. Confidence in their leadership ability of students from most backgrounds ranked as third or forth highest. The exceptions were those from "other engineering" and Western European students who ranked their confidence in leadership ability as second, and East Asian students who ranked it as fifth. Further, as in the total sample students from most backgrounds were most confident in their teamwork, initiative or communication skills. This suggests that regardless of their backgrounds, and with few exceptions, students may prioritize the development of these skills over leadership because of their higher confidence in them.

Table 8. Confidence in Leadership Ability as Compared to Other Individual Skills

	Confidence		Compared with leadership ability				
	Mean	SD	Mean Diff.	df	t	p	Cohen's d
Leadership ability	3.91	0.90	-	-	-	-	-
Critical thinking skills	4.02	0.78	0.11	2453	5.95	p<.001	0.12
Teamwork skills	4	0.79	0.10	2461	5.15	p<.001	0.10
Ability to take initiative	3.98	0.86	0.08	2462	4.34	p<.001	0.09
Communication skills	3.9	0.86	-0.00	2466	-0.19	n.s.	
Ability to apply math and science principles in solving real world problems	3.76	0.82	-0.15	2458	-6.61	p<.001	-0.13
Science ability	3.71	0.82	-0.19	2465	8.20	p<.001	-0.17
Math ability	3.65	0.93	-0.25	2470	9.82	p<.001	-0.20
Self-confidence	3.61	0.97	-0.30	2460	-14.99	p<.001	-0.30
Public speaking ability	3.57	1.02	-0.33	2464	-17.66	p<.001	-0.36
Business ability	3.42	1.01	-0.49	2436	-23.34	p<.001	-0.47

The skills are listed in the descending order of the mean values. Professional skills are highlighted in red.

Lastly, our examination of students' confidence in their leadership ability across five variables found significant differences only across some races (see Table 9). Southeast Asian and East Asian students were *moderately* less confident in their leadership ability than their peers from all other racial groups. These findings suggest a correlation between racial background and beliefs about leadership ability. Because students from certain backgrounds have high confidence in their leadership ability, the findings can also identify which student groups are likely to be motivated to enhance and practice their leadership ability.

Table 9. Confidence in Leadership Ability: Summary of Significant Differences Across Variables

Variables	Confidence in Leadership Ability
Gender	Males (M = 3.93, SD = .91) > females (M = 3.85, SD = .87), t(2449)= 2.00, p < .05, Cohen's d = 0.09
Residential status	n.s.
Race	SEA (M = 3.6, SD = .91), EA (M = 3.57, SD = .96) < All other racial groups, Cohen's d [0.30, 0.67]
Discipline	n.s.
Academic standing	n.s.

Comparison of Perceived Importance and Confidence in Leadership Ability

Our comparison of importance and confidence ratings revealed that students rated their proficiency in leadership ability *slightly* higher than its importance (see Table 10). In contrast, they rated the importance of professional skills and math and science skills *slightly* higher than their proficiency in these skills.

Table 10. Comparison of Importance-Confidence Ratings

	Importance		**Confidence**						
	Mean	SD	Mean	SD	Mean diff.	t	df	p	d
Leadership ability	3.74	0.95	3.91	0.89	-0.16	-7.34	2460	p <.001	-0.15
Professional skills	3.84	0.61	3.75	0.61	0.09	6.35	2398	p <.001	0.13
Math and science skills	3.83	0.77	3.71	0.73	0.12	6.81	2450	p <.001	0.14

When we compared the importance-confidence ratings of leadership ability across five variables, we observed a pattern similar to that of the total sample. The confidence ratings of students from most backgrounds were higher than their importance ratings (see Table 11), except for females, international students, those from chemical, civil and "other" engineering and engineering physics, and South Asian, Middle Eastern, Black and Indigenous students. For these students, there were no significant differences between their importance and confidence ratings of leadership ability: they had similar levels of perceived importance of leadership and confidence in their own leadership skills. Further, we found that for some groups of students the magnitude of difference between importance and confidence ratings of leadership ability was much larger than that of the total sample. For males, students from electrical, industrial/manufacturing, mechanical and software engineering, and all European groups of students there was a larger gap between their values and ability beliefs about leadership.

Further, using the means of importance (3.74) and confidence (3.91) ratings of the total sample as cut-off points, we divided students across five variables into four groups on the basis of their importance and confidence ratings: (1) low perceived importance but high confidence (males, electrical and mechanical engineering, and three European groups); (2) low perceived importance and low confidence (low-performing students, software, computer, and industrial/ manufacturing engineering, and East Asians); (3) high perceived importance but low confidence (average-performing students, biosystems engineering, and Southeast Asians); and (4) high perceived importance and high confidence (permanent residents and high-performing students).[4] For students to engage in learning and practicing leadership, their importance and confidence ratings ideally need to be similar. According to Grier (2013) and Harter (1999), who argued that the perceived importance mediates the impact of perceived competence on a positive self-image or sense of self-worth, competence in areas deemed important serves to enhance a positive self-image while competence in areas deemed unimportant or less important has less of an impact. In our case, it can be argued that students with high perceived importance and confidence in leadership ability are more likely than others to engage in leadership learning. Others may need support for their perceived importance or confidence, or both, in order to be more motivated to learn leadership.

[4] We included in these four groups only those with statistically significant differences between their importance and confidence ratings.

Table 11. Comparison of Importance-Confidence Ratings of Leadership Ability Across Variables

Variables	Importance		Confidence						
	Mean	SD	Mean	SD	Mean diff.	t	df	p	d
Male	3.69	0.96	3.93	0.90	-0.24	-9.04	1760	p<.001	-0.22
Female	3.88	0.90	3.85	0.87	0.04	0.84	679	n.s.	
Permanent resident	3.75	0.94	3.92	0.89	-0.17	-7.42	2338	p<.001	-0.15
International student	3.69	1.03	3.73	1.03	-0.04	-0.42	121	n.s.	
High-performing	3.76	0.94	3.93	0.88	-0.17	-4.65	882	p<.001	-0.16
Average-perform.	3.75	0.93	3.91	0.87	-0.16	-4.74	1057	p<.001	-0.15
Low-performing	3.69	1.00	3.89	0.96	-0.20	-3.86	478	p<.001	-0.18
Biosystems	3.75	0.93	3.89	0.91	-0.14	-2.47	385	p<.05	-0.13
Chemical	3.83	0.97	3.78	0.84	0.05	0.60	175	n.s.	
Civil	3.87	0.92	3.95	0.91	-0.08	-1.51	446	n.s.	
Computer	3.58	0.94	3.77	0.91	-0.19	-2.00	124	p<.05	-0.18
Electrical	3.68	0.97	3.92	0.93	-0.24	-4.29	455	p<.001	-0.20
Eng physics	3.56	1.04	3.70	0.97	-0.15	-0.87	80	n.s.	
Industrial/ manufacturing	3.69	0.91	3.91	0.89	-0.22	-2.94	126	p<.01	-0.26
Mechanical	3.68	0.95	3.97	0.84	-0.30	-4.82	319	p<.001	-0.27
Software	3.37	0.98	3.74	0.81	-0.37	-2.75	69	p<.01	-0.33
Other	3.90	0.90	4.01	0.85	-0.11	-1.13	105	n.s.	
South Asian	3.85	1.01	3.91	0.92	-0.07	-0.78	174	n.s.	
East Asian	3.66	0.94	3.53	0.97	0.13	2.14	307	p<.05	0.12
Southeast Asian	3.93	0.93	3.46	1.01	0.47	3.58	70	p<.01	0.43
Middle Eastern	4.03	0.90	4.10	0.90	-0.08	-0.75	104	n.s.	
Black	4.01	0.82	3.82	0.98	0.19	1.54	67	n.s.	
British	3.68	0.95	4.01	0.80	-0.33	-5.27	327	p<.001	-0.29
Western European	3.71	0.92	3.98	0.87	-0.28	-4.53	321	p<.001	-0.25
Southern or Eastern European	3.74	0.96	4.00	0.94	-0.26	-3.36	192	0.001	-0.24
Indigenous people	3.65	1.07	3.96	0.82	-0.31	-1.70	48	n.s.	

Discussion

Our secondary analysis revealed three key sets of findings. First, final year Canadian undergraduate engineering students overall viewed leadership ability as important to becoming a successful engineer and were relatively confident in their own leadership ability. In light of the expectancy-value theory, because of their relatively high importance-confidence ratings of leadership it can be anticipated that when they enter the workplace they will be motivated to work towards developing and practicing it. However, students rated the importance of leadership ability *substantially* lower than other professional skills such as teamwork and communication, which aligns with the findings of Bielefeldt (2018) and suggests that they may be more motivated to develop and practice these skills over leadership, particularly at the early stage of their careers. Further, the fact that students viewed leadership ability and math and science skills as almost equally important to becoming a successful engineer, and that they ascribed only a *slightly* lower value to leadership ability than to other professional skills, shows that they may have developed a sense of the "heterogeneous" nature of engineering work by the end of their undergraduate studies (Faulkner, 2007).

Second, the students rated their proficiency in leadership ability *slightly* higher than the importance of it, which could be attributed to their not being aware of the importance of leadership to becoming a successful engineer or not considering it as important to success in engineering at this stage of their career. This finding dissents from those of Chan et al. (2017) and Direito et al. (2012) who found the opposite. Our importance-confidence comparison finding further suggests that students are less likely to be motivated to develop and practice leadership ability at the early stage of their career. They deem it less important than other skills even though they are confident in their own leadership ability. As mentioned in the previous section, competence in areas deemed important serves to enhance a positive self-image while competence in areas deemed unimportant or less important has less of an impact on self-image, which is a leader-engineer in our case. Further, our study revealed that the students were more confident in their leadership ability than in their professional skills and math and science skills. This may be due to their being unaware of how complex and challenging leadership can be as compared to math and science skills or other professional skills, which are all central features of their undergraduate education experiences. As the existing research (Magarian & Olechowski, 2018) demonstrates, leadership education is not well-integrated across the curriculum, so students may not have a good understanding of it.

Third, while students from most demographic and academic backgrounds held similar values and ability beliefs about leadership to those of the total sample, there were differences across some variables. Although our analysis showed that the students' importance ratings of leadership ability alone varied by gender, race, and discipline and that their confidence ratings varied only by race, the picture of students' leadership values and ability beliefs appeared to be much more complex. With respect to gender, we found that females may be more likely than their male peers to practice and develop leadership skills at the early career stage. They valued leadership ability as much as other professional skills and math and science skills, and there were no significant differences between their importance-confidence ratings of leadership ability. In contrast, even though males were *slightly* more confident in their leadership ability than females, they ascribed a lower utility value to leadership than to other professional skills and math and science skills, which suggests that they are less likely than females to intend to learn leadership skills, at least at the early stage of their career. Our gender findings align with those of Sheppard et al. (2010), who found that females ascribed higher value than males to professional skills, including leadership ability, and dissent from those of Bielefeldt et al. (2018), who found that final year civil engineering females valued leadership less than their male peers.

In regards to residential status, we found that international students may be less likely than their domestic peers to be interested in learning leadership. There were no significant differences in values and ability beliefs about leadership between these two groups; however, international students ascribed a higher utility value than their domestic peers to other professional skills and math science skills than to leadership ability. They also had relatively low importance and confidence ratings of leadership ability. All of this suggests that international students are likely to focus on developing other skills than leadership, at least at the early stage of their career. This could be attributed in part to the cultural backgrounds of international students that privilege technical aspects of engineering education over social ones, and to their lower levels of engagement in extra-curricular activities that offer opportunities for leadership learning.

In terms of race, Middle Eastern, East Asian, and European students stood out the most. Middle Eastern students appeared to be most confident in their leadership ability and valued it very

highly, along with other skills, which suggests that they are more likely than others to learn and practice leadership. In contrast, East Asian students ascribed a much lower utility value to leadership than to other skills and were the least confident in their own leadership ability as compared to other skills. Thus, they may be less likely than others to intend to develop and practice leadership, at least at the early stage of their career. In comparison to other groups, all three groups of European students were the only ones who appeared to have high confidence in their leadership ability while ascribing a low utility value to it. With a few exceptions, other groups had either a high perceived importance and low confidence in leadership skill or both low perceived importance and confidence in it. Our findings about European students supports those of Sheppard et al. (2010), who found that senior non-URM students valued leadership and other professional skills less than their URM peers.

With respect to disciplines, we found that students from civil and "other" engineering disciplines may be more likely than their peers, especially those from software engineering and engineering physics, to be motivated to learn leadership. "Other" engineering was composed of environmental, geological, material/ metallurgical, and mining/ mineral engineering and it is not clear whether students from all these disciplines had the same levels of perceived importance and confidence in their leadership ability. However, the group as a whole attached high importance to leadership ability and appeared to have high confidence in their own leadership skills. The same pertains to students from civil engineering. In contrast, students from software engineering and engineering physics ascribed low utility value to leadership and had low confidence in their leadership ability, which suggests that they are less likely than others to engage in learning leadership at this stage of their professional career. Notably, we did not find any significant differences in confidence ratings in leadership ability and observed only a few significant differences in importance ratings across the selected disciplines, which suggests that students from most disciplinary backgrounds, with some exceptions, have similar levels of perceived importance and confidence in their leadership ability. However, when we compared students' importance-confidence ratings of leadership ability, we found that they fell into different categories across disciplines on the basis of their ratings. These differences could be attributed to disciplinary cultures that inculcate in students discipline-specific values and beliefs which influence their values and ability beliefs about leadership.

Finally, we found that academic standing did not make much difference to students' importance and confidence ratings of leadership ability. Students across all academic standings equally valued leadership, were equally confident in their leadership ability, and rated their proficiency in leadership slightly higher than its importance. However, when we compared their ratings of leadership importance and confidence to those of other skills, we found that academic standing appeared to be associated with students' intentions to learn leadership. More specifically, we found that average and low-performing students valued leadership ability as much as math and science skills; that they ascribed a *slightly* higher value to other professional skills than to leadership ability, and that they were more confident in their leadership ability than their other skills. In contrast to them, high-performing students valued math and science skills *slightly* higher than leadership ability and were *slightly* more confident in their math and science skills than their leadership skill. Although the detected differences had a low practical significance, it could be argued that average and low-performing students are more likely than their high-performing peers to be motivated to develop leadership ability over math and science skills.

Conclusion

Our paper has examined how a sample of final year Canadian undergraduate engineering students perceive the importance of leadership ability; how confident they are in their own leadership ability, and how these two measures compare and interact across demographic and academic variables. Our secondary analysis revealed that the students view leadership ability as important to becoming a successful engineer and are relatively confident in their ability; that they rate their proficiency in leadership ability *slightly* higher than they do its importance; and that students' importance and confidence ratings of leadership ability are associated with particular demographic and academic variables. Our findings contribute to the limited body of research that examines engineering students' values and ability beliefs about leadership. They also contribute to the scholarly discussion about the effect of demographic and academic variables such as gender, residential status, race, discipline, and academic standing on students' leadership values and ability beliefs. Broadly, they underscore the heterogeneity of engineering students' leadership values and ability beliefs and challenge a 'one-size-fits-all' logic to teaching and developing leadership.

Engineering faculty members and leadership educators can make use of our findings to create supports for students to increase their awareness of the importance of leadership to becoming a successful engineer and strengthen their confidence in their own leadership. As our findings show, even though students overall value leadership, they ascribe a lower utility value to it than to other professional skills such as teamwork and communication and thus are less likely to be motivated to practice it than these other skills. In light of this, we can draw on the expectancy-value theory to suggest that engineering leadership educators scaffold their students' leadership learning by helping them to recognize the importance of leadership ability in relation to their professional lives. Once engineering students appreciate the centrality of leadership to their professional development, educators will be in a better position to integrate leadership learning opportunities into the formal curriculum, and thus to provide students with regular opportunities to refine the social, technical and leadership skills necessary for professional success. By doing so, they will also be able to help students to build confidence in their leadership ability.

As our findings demonstrate, different groups of students have different needs when it comes to leadership development. For instance, males, electrical and mechanical engineering students, and all groups of European students could benefit from a higher awareness of the importance of leadership to their professional lives and a more critical perspective on their leadership ability. Low-performing students, international students, those from software engineering, computer, and industrial/manufacturing engineering and engineering physics, and East Asian students could benefit from supports that help them to increase both their awareness of, and their confidence in, leadership. Students who already ascribe a high utility value to leadership ability and are confident in it might need supports to help them to maintain and further develop their leadership values and beliefs. In this study, these students were females, permanent residents, those from "other" and civil engineering, and Middle Eastern students. In short, engineering educators need to be aware of differences that exist among engineering students in regards to leadership values and ability beliefs and devise appropriate supports to facilitate students' awareness of the importance of leadership to their professional lives and to build confidence in their own leadership ability.

Finally, while our analysis provided new insights into engineering students' leadership values and ability beliefs, it also prompted several questions. In particular, what individual and structural

factors have contributed to the relatively high confidence in their leadership ability displayed by final year engineering students? What factors account for the differences in leadership values and ability beliefs between students from different demographic and academic backgrounds? Given that the literature suggests a positive association between individuals' values and ability beliefs and their motivation and self-worth, how would empirical data support this association in research on leadership ability? Our data did not allow us to address these questions, but we encourage other researchers to pursue research into these topics and to provide further evidence-based insights into the leadership values and ability beliefs of engineering students.

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