Correlation Between Engineering Student Leadership Practices, Personality Types, and Demographic Characteristics

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***Abstract*—This study examines the degree to which engineering and science students' personality and demographic characteristics are associated with their leadership practices, an area that few studies have explored. The data was from a sample of 70 students attending two institutions (Massachusetts Institute of Technology [MIT] and the Singapore University of Technology and Design [SUTD]) who participated in a 2-month-long leadership program. The participants self-rated their personality types using the Myer-Briggs Type Indicator (MBTI-Form College Edition) and their leadership practices using the Student Leadership Practices Inventory (SLPI). Results from both correlation and multiple regression analyses showed that extraversion is a significant predictor of various types of leadership practices. Gender differences on SLPI leadership practices were found, but there were no unique association between gender and leadership practices after controlling for personality and student institution affiliation. The findings may assist leadership curriculum developers to create leadership programs based on students' personality and/or characteristics.**

Keywords—leadership; personality; cross-culture

I. Introduction and Literature Review

In the twenty-first century, engineers must be able to offer more than technical expertise—they must possess the leadership skills needed to guide culturally, socially, and educationally diverse people and organizations to find innovative solutions to our world's economic, social, and environmental challenges. As the American Society of Mechanical Engineers (ASME) has noted, "Engineers must take leadership roles not only on technical projects but in society more generally. Engineers must lead in their communities, in local, state and federal governments, and help lead society to a sustainable world. There are probably no second chances, now is the time for action, and we have to get it right. Now is the time for engineering leadership, our country needs it and our planet needs it." [1]

Many universities are rising to the challenge of developing the leadership skills of engineering students and investing time and resources to develop effective leadership programs. Various types of leadership programs have been created, among them service and community engagement projects, certification programs, academic courses, for-credit programs, and workshops. Many studies have examined these programs' effect on student leadership development. Other studies have examined how to integrate leadership pedagogies inside [2] and outside [3] of engineering classrooms and have developed assessments to measure students' leadership skills [4]. Few studies, however, have examined the potential influence of student characteristics on the success of a leadership program. Prominent among these factors are students' personality attributes and demographic characteristics (specifically, gender and national background). Understanding how leadership skills, personality, and demographic characteristics relate may provide data useful for tailoring the design and delivery of engineering leadership programs to the specific needs of their students.

Past studies have examined the personality of engineering students using the Myers-Briggs Type Indicator (MBTI). For example, some studies [5] show that most common MBTI personality types among engineering students are Introvert, Sensing, Thinking, and Judging (see Table II for definitions of these terms). Others have examined the relationship between engineering students' personality type and the effective method for teaching them [6, 7]. Felder and colleagues [7], for example, administered the MBTI to students enrolled in an introductory chemical engineering class and then taught the class using active learning techniques and presenting materials in an inductive manner. The researchers found that extraverted students responded better to this pedagogical approach than introverted students. Further, the study found that students who were classified as Sensing and Intuitive types found cooperative learning to be valuable. Missing from the literature is any examination of (1) the relationships between engineering students' MBTI personality types and leadership practices and (2) the effects of gender and culture on students' leadership practices.

II. Research Questions

The purpose of this study was to investigate the relationship between engineering students' MBTI personality types and leadership practices and the relationship between their leadership practices and their gender or culture (reflected by two institutions from the U.S. and Singapore). The research questions for this study are:

1. Are MBTI personality types correlated with leadership practices for engineering and science undergraduate students?
2. Do students show different levels of leadership practices based on their gender or institutional affiliation?
3. Do any MBTI personality types, genders, or institutional affiliations have unique associations with specific leadership practices?

The ultimate goal of this study is to improve engineering leadership programs by giving their curriculum designers a better understanding of how students' personality types, gender, and culture have potential effects on their leadership skills. Armed with this knowledge, instructors will be able to modify course content and delivery methods to best leverage students' strengths and preferences.

III. Methods

A. Settings and Participants

The study was conducted at the Singapore University of Technology and Design (SUTD), and participants were engineering and science undergraduate students enrolled in the Leadership Exploration and Development (LEAD) program. The LEAD program was developed for both SUTD and visiting Massachusetts Institute of Technology (MIT) students at SUTD. Its goal is to mold students into effective leaders by providing them with engaging opportunities to practice leadership skills via student-centered activities such as collaborative work, hands-on projects, and role playing. During the eight-week summer program, participants met two days a week for a two-hour evening session. One of the weekly sessions was created and facilitated by the two program coordinators (Ahn, one of this paper's authors, was a coordinator), and the other was led by teams of MIT and SUTD students. Session topics included group dynamics, leadership styles, creativity, conflict resolutions, and understanding others. The program had a total of 80 students (55 from SUTD, 25 from MIT).

B. Measures

a) Dependent variable (DV): Leadership practice - Student Leadership Practices Inventory: To assess student leadership practices, the Student Leadership Practices Inventory (SLPI) developed for college students by Kouzes and Posner [8] was administered. The SLPI was chosen because it has strong internal reliability and validity [9]. This inventory categorizes leadership behaviors and actions into five exemplary practices: Model, Inspire, Challenge, Enable, and Encourage (see Table I). The inventory has 30 items consisting of five sets of six descriptive statements, one set for each of the five leadership practices. Students are asked to rate how frequently they engage in the behavior described in each statement using a 5-point Likert-type scale, with 1 indicating rarely or seldom and 5 indicating very frequently. A single category score ranging from 6 to 30 is computed for each category by aggregating the scores of five categories' corresponding statements, with a higher score indicating greater use of a particular leadership category.

TABLE I. STUDENT LEADERSHIP PRACTICES (FROM POSNER [10] AND [11])

1. **Model the Way**: Student leaders clarify values by finding their voices and affirming shared ideals and set an example by aligning their actions with shared values.
2. **Inspire a Shared Vision**: Student leaders envision the future by imagining exciting and ennobling possibilities and enlist others in a common vision by appealing to shared aspirations.
3. **Challenge the Process**: Student leaders search for opportunities by seizing the initiative and by looking outward for innovative ways to improve and experiment and take risks by constantly generating small wins and learning from experience.
4. **Enable Others to Act**: Student leaders foster collaboration by building trust and facilitating relationships and strengthen others by increasing self-determination and developing competence.
5. **Encourage the Heart**: Student leaders recognize contributions by showing appreciation for individual excellence and celebrate values and victories by creating a spirit of community.

b) Independent variable (IV): Personality types - Myers-Briggs Type Indicator: The Myers-Briggs Type Indicator (MBTI) college edition was used to determine students' score in the test's four categories of personality types: Extraversion or Introversion; Sensing or Intuition, Thinking or Feeling, and Judging or Perceiving (see Table 2). The MBTI was selected because it is based on psychological theory [12] and is widely used to describe personality [13, 14]. In the MBTI college edition, students complete 93 forced-choice questions and receive a report showing their four preferred types (abbreviated to the first letters of the types, for example, ESTP) and a score ranging from -30 to 30 indicating the strength of their self-selections for the MBTI's two polarities: scores from 1 to -30 indicate the pole of extraversion, sensing, thinking, and judging, and scores from 1 to 30 indicate the pole of introversion, intuition, feeling, and perceiving. The higher the score, the more clearly students expressed a preference for a pole. According to Myers and McCaulley [14], a continuous score scale is recommended for correlational research.

TABLE II. THE FOUR CATEGORIES OF MBTI PERSONALITY TYPES (FROM BROWN AND REILLY [15])

1. **Extraversion or Introversion: where you focus your attention**
   - Extraversion: People who prefer extraversion tend to focus their attention on the outer world of people and things.
   - Introversion: People who prefer introversion tend to focus their attention on the inner world of ideas and impressions.
2. **Sensing or Intuition: the way you take in information**
   - Sensing: People who prefer sensing tend to take in information through the five senses and focus on the here and now.
   - Intuition: People who prefer intuition tend to take in information from patterns and the big picture and focus on future possibilities.
3. **Thinking or Feeling: the way you make decisions**
   - Thinking: People who prefer thinking tend to make decisions based primarily on logic and on objective analysis of cause and effect.
   - Feeling: People who prefer feeling tend to make decisions based primarily on values and on subjective evaluation of person-centered concerns.
4. **Judging or Perceiving: how you deal with the outer world**

- Judging: People who prefer judging tend to like a planned and organized approach to life and prefer to have things settled.
- Perceiving: People who prefer perceiving tend to like a flexible and spontaneous approach to life and prefer to keep their options open.

Upon receiving the approval from both MIT and the SUTD Institutional Review Board offices, all LEAD participants were asked to complete the MBTI College Edition at the beginning of the two-month program and the SLPI about three-quarters of the way through the program. Gender, institution, and majors were also collected as part of the demographic questionnaire. The study includes only the 70 participants who completed both the MBTI and the SLPI. Table 3 shows descriptive statistics for the collected data.

TABLE III. DESCRIPTIVE STATISTICS

	N	*M* (SD) Proportion (%)	Range
Model the way	70	22.47 (3.12)	12 – 29
Inspire a shared vision	70	21.34 (4.36)	12 – 30
Challenge the process	70	22.89 (2.82)	16 – 28
Enable others to act	70	24.91 (2.73)	14 – 30
Encourage the heart	70	21.80 (4.49)	9 – 30
Gender (1=female)	70	48.57%	
Institution (1=SUTD)	70	68.57%	
Extraversion (-) or Introversion (+)	70	1.53 (17.34)	-30 – 30
Sensing (-) or Intuition (+)	70	4.10 (12.32)	-27 – 30
Thinking (-) or Feeling (+)	70	-2.80 (13.40)	-28 – 30
Judging (-) or Perceiving (+)	70	-1.23 (14.57)	-30 – 30

C. Analyses

To evaluate if and how individual differences (e.g., personality, gender, and institution) contribute to individual leadership practices in engineering contexts, correlational, t-tests, and multiple regression analyses were run. First, correlation analyses were conducted to identify correlations between the four categories of MBTI personality types and the five leadership practices. Second, t-tests were conducted to identify group differences in leadership practices by gender and institutional affiliation (i.e., MIT vs. SUTD). Third, multiple regression analyses were conducted with all IVs (i.e., personality types, gender, and institutional affiliation) included in the model simultaneously. In this way, the *unique* association between each personality IV and the five leadership practices was able to be examined above and beyond the potential association between other IVs' with the leadership practices. Across all analyses, each of the five leadership practices (DVs) was separately analyzed.

IV. RESULTS

A. Research Question 1. Correlations Between Personality Types and Leadership Practices

As shown in Table 4, the results from the correlation analyses showed that the Extraversion personality type moderately correlated with all five types of leadership practices. Specifically, students with a higher extraversion score showed higher scores in the following leadership practices: *Model* (r = -.37; p < .01), *Inspire* (r = -.44; p < .001), *Challenge* (r = -.38; p < .01), *Enable* (r = -.26; p < .05), and *Encourage* (r = -.29; p < .05). Furthermore, the Sensing personality type was found to correlate with the *Enable* leadership practice (r = -.24; p < .05) and the Feeling personality type was found to correlate with the *Encourage* leadership practice (r = .28; p < .05).

TABLE IV. CORRELATION BETWEEN MBTI PERSONALITY TYPES AND LEADERSHIP PRACTICESDESCRIPTIVE STATISTICS

	Model	Inspire	Challenge	Enable	Encourage
	r p	*r* p	*r* p	*r* p	*r* p
E (-) or I (+)	-.37**	-.44***	-.38**	-.26*	-.29*
S (-) or I (+)	-.03	.11	.22	-.24*	.08
T (-) or F (+)	.04	.15	-.10	.21	.28*
J (-) or P (+)	-.14	-.14	-.05	.02	-.07

Note. * $p \leq .05$; ** $p \leq .01$; *** $p \leq .001$

B. Research Question 2. Gender and Institutional Affiliation Differences in Leadership Practices

The t-test results showed gender differences in two of the five leadership practices. Female students showed lower scores for the *Model* (mean difference = 1.49; p < .05) and *Inspire* (mean difference = 2.15; p < .05) leadership practices than male students. The results also uncovered an institutional difference in one particular leadership practice: SUTD students showed higher scores for the *Model* practice (mean difference = 1.81; p < .05) than MIT students.

C. Research Question 3. Unique Association Between IVs and Leadership Practices

We conducted multiple regression (MR) analyses to identify unique associations between each IV and the five leadership practices, controlling for other IVs (see Table 5). Similar to the correlation analyses and t-tests, we separately ran an MR model for each of leadership practices.

Results from the *Model* practice model showed that SUTD students scored higher for the *Model* practice than MIT students (b = 1.99; p < .05). Also, more extraverted students reported higher *Model* practices than less extraverted students (or more introverted student; b = -.07; p < .001). Gender differences for the *Model* practice disappeared after controlling for student MBTI personality type and institutional affiliation in the model.

Results from the *Inspire* practice model showed that the Extraversion personality type predicted a higher score for the *Inspire* practice (b = -.11; p < .001) even after controlling for other IVs. Gender differences disappeared after controlling for student's MBTI personality types and institutional affiliation.

Results from the *Challenge* practice model showed that the Extraversion personality type predicted higher *Challenge* practice scores (b = -.06; p < .01) after controlling for other IVs.

Results from the *Enable* practice model showed that Extraversion (b = -.06; p < .01) and Sensing (b = -.10; p < .001) predicted higher Enable practice scores after controlling for other IVs. Interestingly, the Feeling personality type became significant (b = .06; p < .05) after controlling for other IVs in the analytical model.

Results from the *Encourage* practice model showed that high scores for the Extraversion (b = -.09; p < .01) and the Feeling (b = .10; p < .01) personality types significantly predicted higher scores on the *Encourage* practice. Interestingly, SUTD students showed higher scores on the *Encourage* leadership practice than did MIT students (b = 2.42; p < .05) after controlling for other IVs in the model.

TABLE V. RELATIONSHIPS BETWEEN LEADERSHIP PRACTICES, MBTI PERSONALITY TYPES, AND STUDENT DEMOGRAPHICS

	Dependent variable				
Variable (IVs)	Model	Inspire	Challenge	Enable	Encourage
	b P	*b* P	*b* P	*b* P	*b* P
E (-) or I (+)	-.07***	-.11***	-.06**	-.06**	-.09**
S (-) or I (+)	-.02	.02	.05	-.10**	-.01
T (-) or F (+)	.03	.07	-.02	.06*	.10**
J (-) or P (+)	-.02	-.06	-.02	.04	-.03
Gender	-.84	-1.60	-.22	.70	.45
Institutional affiliation	1.99*	1.82	.78	-.06	2.42*

Note. * $p \leq .05$; ** $p \leq .01$; *** $p \leq .001$

V. DISCUSSION

These findings consistently showed that extraverted students presented higher levels of leadership practices across all five practices. Furthermore, students who scored high in the Sensing personality attribute also demonstrated high levels of the *Enable* leadership practice, and students who scored high in the Feeling personality attribute demonstrated high levels of the *Encourage* leadership practice. There is a possible explanation for each of the findings. Extraverted students may have overstated their leadership practices more often than introverted students, or introverted students may have understated their leadership practices. High-Sensing students may have scored higher on the *Enable* practice because they tend to pay attention to physical reality (that is, what is present, current, and real), to collect information from others, and to build trust, all of which lead them to share their powers and enable others to act. High-Feeling students may have scored higher on the *Encourage* practice because they tend to base decisions on what other people care about and take in others' point of view in a situation, leading them to readily express appreciation and care to others, to foster a spirt of community in a group, and to help others focus their energies so that they can make progress toward a goal.

Our results further showed that students' personality and institutional affiliation removed any differences between male and female students' scores in the *Model* and *Inspire* practices. The gender difference in leadership practices that showed up in the correlation analysis may result from factors that are related to gender, such as personality, but not gender itself. These results suggest that there are no unique gender differences in leadership practices. This is an interesting finding given that there were no differences in scores for the five leadership practices between male and female members of test participants.

Our study of the effect of institutional affiliation showed that SUTD students tended to show higher levels of the *Model* leadership practice compared to MIT students. This result may indicate the different cultural norms for leadership practices among undergraduate engineering and science students from different countries.

The results of our multiple regression models suggested a few suppression effects. Specifically, before controlling for other IVs, no correlations were found between the Feeling personality attribute and the *Enable* practice or between students' institutional affiliations and the *Encourage* practice. However, after controlling for other IVs we did find correlations between these two sets of factors. Future studies examining the associations between personality, western-eastern cultural differences, and leadership practices could help explain this finding.

VI. IMPLICATIONS

Given the small number of participants from two universities, this study's findings are not generalizable across all the U.S. and international engineering students. However, the findings (i.e., associations between student leadership skills, MBTI personality type, and demographic characteristics) may still provide useful guidance to instructors in engineering leadership programs. Leadership instructors should be aware that students of certain MBTI types may practice some leadership practices more over others so that they can offer those students opportunities to practice their less practiced leadership practices. For example, our study found that introverted students reported lower levels of leadership practices than extraverted students across all five examined practices. Therefore, leadership instructors could implement pedagogies that give introverted students opportunities to practice all five leadership practices. One possible way to do this would be for instructors to form teams consisting solely of extraverted students, combinations of extraverted and introverted students, and solely of introverted students and then assess how the teams navigate tasks or projects. The instructors could also expose students to different leadership practices and ask them to reflect their own leadership practices. The instructors' goal should be to ensure that their program provides training in every type of leadership practice so that students are required to perform tasks using their less practiced leadership practices in a safe classroom environment. Such training will help students following graduation, when they will have to demonstrate competence in both practiced and less practiced leadership practices when leading, encouraging, and managing a diverse group of engineers.

Though there was only one unique difference between MIT and SUTD students in the examined five leadership practices, this finding points to a possible difference of the leadership practices between the U.S. and international students, which should be taken into account when designing a leadership program or placing students into teams of mixed nationalities. It may also be worthwhile for instructors to share these cultural differences among students so that they know each other's strengths and weaknesses. Such an instructional approach will be useful not only in global university partner team projects or study-abroad programs but also in the U.S. engineering and science classrooms, which include many international students.

VII. Conclusions

This study investigated the relationship between engineering and science students' leadership practices, MBTI personality type, and demographic characteristics. In addition, differences in leadership practices were examined between the U.S. students and students studying in a Singapore university. We argued that these variables are critical to designing successful leadership programs for engineering and science students. The findings will assist curriculum developers to create leadership programs that are tailored to the full range of engineering and science students. Examining the differing leadership preferences of engineering and science students is vital for designing programs to develop their leadership skills.

Acknowledgment

The authors would like thank the SUTD and MIT students who participated in this study. We are also grateful to Chris Dietzel, who provided invaluable assistance and support during the 2015 LEAD program. Additionally, we would like to thank the MIT-SUTD Collaboration Headquarters office staff as well as the SUTD administration for supporting this work.

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