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On the effect of SHPE's social-cognitive leadership theory to Hispanic professionals' leadership self-efficacy (work in progress)

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On the effect of SHPE's social-cognitive leadership theory to Hispanic STEM professionals' leadership self-efficacy (work in progress)

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Abstract

Despite the rapid growth of Hispanic undergraduate student enrollment into engineering programs, there is limited work on the post-graduation ability of these engineers to succeed in leadership workforce roles. The Society of Hispanic Professional Engineers (SHPE) developed and implemented a leadership framework that integrates McCormick's socio-cognitive leadership theory and SHPE's annual programing. SHPE hosts the annual National Institute of Leadership Advancement (NILA) for its chapter leaders (i.e., university students and engineering professionals). NILA serves as a leadership development intervention for its leaders by developing their individual, community, and organizational leadership skills. The NILA framework and its effect on undergraduate students during NILA 2019 is detailed in the ASEE CoNECD conference proceeding titled, "Social-cognitive leadership theory of SHPE's premier leadership conference for undergraduates and professionals in the STEM workforce." The development of leadership self-efficacy of Hispanic engineering professionals in the workforce that attended NILA 2019 is considered in this work. An internally developed leadership self-efficacy assessment was issued to the attendees pre- and post-NILA. Following the same methods as the student study, the professionals' self-efficacy is analyzed using the leadership factors determined for the students from an Exploratory Factor Analysis. Strategy-oriented leadership was seen to be most increased among the professionals and students. The analysis showed the feasibility of the framework as a unified curriculum for both students and professionals and supplied valuable lessons learned for future NILA assessments.

Nomenclature

EFA	Exploratory Factor Analysis
CCLP	Certified Chapter Leaders Program
NILA	National Institute for Leadership Advancement
SHPE	Society of Hispanic Professional Engineers
STEM	Science, Technology, Engineering, and Mathematics

1. Introduction

Leadership studies have shown a direct connection between self-efficacy and leadership effectiveness, in which leaders adopt a self-confidence behavior to produce desired outcomes and influence others to accomplish a common goal [1]. Goals and self-efficacy have an independent relationship; however, combining these two characteristics can directly correlate with the performance of the individual and team [2]. Successful leadership is a complicated cognitive and behavioral task that includes organization, processes, and motivating others to act [3]. Self-efficacy training is relevant for new leaders within the organization to enhance self-efficacy and achieve leadership effectiveness [3].

Universities have responded to the needs of Science, Technology, Engineering, and Math (STEM) industries and accreditation requirements by explicitly incorporating leadership development in their engineering curricula [4]–[6]. This has been incorporated differently depending on the institution, and ranges across leadership-specific coursework, workshops, minors, and other experiential learning opportunities. For example, the University of Texas at El Paso (UTEP) recently established an innovative Engineering Leadership (E-LEAD) bachelor's degree, the first of its kind in the U.S., whose engineering curriculum is grounded on collaborative learning [7]. Other institutions have developed leadership programs that can be pursued concurrently with an engineering major, such as Georgia Institute of Technology, Northeastern University, Massachusetts Institute of Technology, Pennsylvania State University, University of Maryland, University of Central Florida, Iowa State University, and West Point Military Academy [6], [8]. However, UTEP's E-LEAD program is the only one to structure their engineering coursework's pedagogical approach to intentionally develop engineering leadership skills [7].

Despite the importance that engineering education researchers, practitioners, policymakers, and advocates have highlighted on leadership development, such efforts have been siloed into industry practices and either curricular or co-curricular experiences [9]. Significantly less focus has been placed on intentional leadership development in extra-curricular activities, even though the engineering education literature continues to highlight the importance of such experiences in students' overall development while pursuing higher education and professions in the field [10]. A vital part of extra-curricular activities for engineering education is participation in national engineering professional and/or diversity organizations. Within that, pursuing leadership positions in underrepresented-based engineering organizations has been shown to have a positive impact for a multitude of student outcomes, including leadership development [11]. These organizations host self-efficacy conferences with the aim to develop undergraduate students' leadership skills. However, to the authors' knowledge, there are no self-efficacy training programs for current Hispanic professionals in STEM or at least to the extent of having a leadership framework as that detailed in [12]. Moreover, no work currently exists exploring the leadership development and self-efficacy of practicing engineers who take part in minority-based engineering organizations.

The Society of Hispanic Professional Engineers' (SHPE) mission is to empower the Hispanic community to realize its fullest potential and affect the world through STEM awareness, access, support, and development. Towards fulfilling this mission, SHPE has hosted an annual three-day

conference in the first week of August, known as the National Institute for Leadership Advancement (NILA) for the last 30+ years. NILA attendees are elected SHPE chapter leaders from universities (student members) and the engineering workforce (professional members). In 2019, the authors, along with SHPE staff, developed a leadership framework that was applicable across its nationally organized conferences. The framework provides the abstraction necessary to map and evaluate NILA's pedagogical approach with leadership theory in the literature. In our earlier work [12], the social-cognitive leadership theory of [3] was shown to be compatible and mapped with NILA and SHPE's national chapter program. Moreover, our earlier work focused on the results of the SHPE student member participants.

The focus of the present work is on the NILA leadership concepts' applicability to the STEM workforce and its effect on the professional chapter leaders' self-efficacy. The hypothesis is that the social-cognitive leadership theory within NILA (i.e., the leadership framework) increases the SHPE professional members' leadership self-efficacy in the same fashion as the students. As a result, the framework would be shown to be useful in creating a universal leadership self-efficacy curriculum for students and professionals in the STEM workforce and Hispanics. The proceeding is organized as follows. For brevity, the NILA's leadership framework, curriculum, and mapping to McCormick's social cognitive leadership model are detailed in our previous work and omitted in this work [12]. In Section 2, the NILA attendees' leadership self-efficacy evaluation method is briefly presented. The results of the survey for the professionals are detailed in Section 3. The conclusions and outlook on future NILAs are detailed in Section 4.

2. Methods

We assess the extent to which the NILA curriculum develops Hispanic professionals' leader cognitions and compare the results to the student study. To do so, NILA has within it the Certified Chapter Leaders Program (CCLP), which assesses the curriculum's effect on the professionals' self-efficacy. The methods used here are the same as the student study [12], were reviewed by an external Institutional Review Board, and approved for exemption. In our earlier work, we conducted an Exploratory Factor Analysis (EFA) using SPSS v26 and proved the validity of the survey.

2.1 CCLP assessment

The CCLP assessment has two parts: a leadership self-efficacy survey and a workshop knowledge test. Attendees were informed that the survey was voluntary. Only attendees who consented to the self-efficacy part of the survey were included in the analysis for this study. The leadership self-efficacy survey was formed of questions on a five-point Likert-scale format, with responses ranging from "not at all confident" to "absolutely confident." The research team had no influence on the workshop knowledge test, the questions were provided by the workshop speakers. The test had 15 questions with (3) multiple-choice questions for each of the five workshops. There was one correct answer for each of the questions, a maximum of five answers.

The study follows a group pre-/post-test research design and is a cross-sectional analysis from a self-selected purposeful sample. The data had the responses of 146 and 37 incoming SHPE student and professional chapter leaders, respectively, that attended NILA 2019. In addition to the assessment responses, only the following attendees' demographic information was collected and considered for this analysis: gender/sex, first-generation college attendee, first time their SHPE chapter attended NILA, and engineering major. After removing the responses from participants who did not consent to either the pre- or the post-self-efficacy part of the survey, a total of 156 responses were considered. Due to the smaller group of professionals attending the conference, the validated results and leadership factors from students are used in the professional's responses analysis. In the later section, we discuss the implications of this smaller sample size and improvements for future studies.

2.3 Leadership self-efficacy scales and factors

The survey items for the individual sub-scale were adapted from an available instrument developed by [13]. The 19 questions used in the student study included three sub-scales: individual (11 questions), community (three questions), and organizational leadership self-efficacy (six questions). The four factors determined from Horn's Parallel Analysis from the student analysis are used for the smaller professional data set [12], [14], [15]. These four factors in ranking order are F1: strategy development, F2: direct control, F3: direct influence, and F4: community. Factor F1 involved questions Q12-15 and were associated with a strategic mindset, entrepreneurial mindset, and goal development. Factor F2 involved questions Q1-4 and Q9 and is associated with setting up goals, starting projects, and working/managing others. Factor F3 involved questions Q5, Q7, and Q8 and is associated with direct influence over a team or community. Factor 4 (Q17-19) focused the professionals' self-efficacy towards affecting their community.

3. Results

3.1 EFA results

Due to the low sample size of 25 usable professionals' entries after the data imputation, EFA was not ran on the professionals' responses. Moreover, the Central Limit Theory for the assumption of normality is not applicable; hence non-parametric tests had to be conducted. Instead, the factor distribution from the student data was used, and further analyzed, when analyzing the professionals' responses, see Table 3 of [12] for a complete list of questions and EFA results. As expected, the four factors ranked in the same ascending order of importance for the professionals' responses as the students. The professionals' responses to factor F1 explained 42.8% of the variance in the EFA. It is possible that the strong loading was due to the Q12 and Q13 being similar and back-to-back in the survey. Factor F2 had 9.5% of the EFA variance. It is noted that these questions focused on the individual's ability to explain/do something to the group as to influence the group, which is the third factor. Factor 3 explained 7.7% of the EFA variance. Factor F4 explained 6.4% of the EFA variance. Interestingly, although SHPE was not directly mentioned in the questions, the fact that they loaded on the same factor suggests that people see SHPE as their
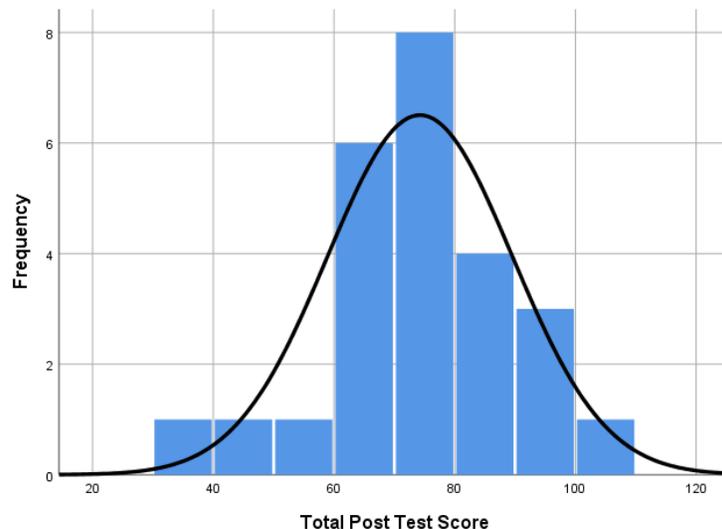
Figure 1. NILA 2019 professional workshop knowledge post-test score distribution. Mean: 74.2, standard deviation: 15.3, and N = 25.

"communities" or that the communities SHPE serves are the same types of communities they influence.

Assessing the EFA of the professionals' responses shows that the factors correlate well with the NILA leadership framework. While the survey was strong in differentiating spaces and context of the professionals' spaces and context of their self-efficacy, it was limited in differentiating the different traits of leadership. An example of this is the words "goals," which was contained in the questions across three of the factors. Interestingly, the factors of (i) time management and (ii) conflict resolution were not statistically significant. In future surveys, questions will need to be added to show whether the NILA leadership framework and curriculum elevates the professionals' self-efficacy in these areas. To decide if these factors connect with the model requires intentional inclusion of specific questions of the leadership framework, specifically including those on personal career goals.

When using the students' EFA factors, we saw the same factor variance trend in the professional self-efficacy. Strategy development being the highest-ranking growth between the pre- and post-test was expected given the NILA's leadership framework and curriculum focus on the development in these areas. The average mean for leadership self-efficacy increased from 4.0 to 4.3. The increase was significant, and it shows that NILA had a measurable positive effect. Nevertheless, the effect may or may not be sustainable. Most of the change was explained by the lower values (pre-test minimum=2.6, post-test minimum=3.0), which is reflected in a smaller standard deviation for the post-survey. This shows that the effect may be larger for those who come in with lower self-efficacy than those who are already confident in their abilities. While the sample size was small, the EFA analysis is statistically significant to tentatively support our hypothesis. However, this can change with larger sample size. The current instrument would need refinement and a significantly higher sample size (+100 professionals' responses) to support the hypothesis, leadership framework, and validate the instrument for engineering professionals.

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3.2 Analysis of t-tests

Conducting independent sample t-tests, no differences across sex (male and female), the SHPE chapters first time sending an attendee to NILA, or first-generation college attendee were identified for any scale or sub-scale. For the paired t-tests, the hypothesis tests showed that there is a statistically significant difference, in a 95% confidence interval, between pre- and post-survey scores ($p=.000$) and self-efficacy average scores ($p=.001$). Additionally, the strategy development ($p=.000$), direct control ($p=.084$), direct influence ($p=.003$), and community averages ($p=.017$) showed statistically a significant difference between the pre- and post-survey.

3.3 Workshop knowledge test results

Figure 1 shows the professional post-test scores distribution. The distribution more closely resembled a normal distribution than those of students (see figure 8 of [12] for student post-test scores distribution). Student's performance on the post-test was higher on average than professionals. This result was expected as professionals attending NILA do not have the time bandwidth to view the pre-NILA online seminar content presented three weeks before NILA, which is also evaluated in the workshop knowledge tests. Nevertheless, the professionals' leadership self-efficacy is increased between pre- and post-tests, showing that the content stays beneficial. The average of the professional tests scores are not passing scores. We address this during the NILA curriculum by providing a review of the test questions with the answers near the of the conference.

3.4 Recommendations for future NILAs

The knowledge test and leadership self-efficacy survey results show improvements in the post-test and confirm our hypothesis. However, the study was limited due to the limited number of professionals attending NILA and lack of specificity of the leadership questions to find sub-leadership domain improvements and interests. To apply the Central Limit Theorem and Exploratory Factor Analysis, the number of professionals taking part in the CCLP will be increased in future NILAs. NILA 2020 was held virtually and significantly increased the number of professionals from 37 to 140. Beyond 2020, future NILAs are planned to be hybrid events combining an in-person and virtual event to enable higher professional member attendance. Future surveys will include more personal career goal-oriented leadership questions. The results for such questions will enable researchers to determine which NILA curriculum components most effectively increase the attendees' leadership self-efficacy.

4. Conclusions

The effect of SHPE's NILA leadership framework on Hispanic engineering professionals' leadership self-efficacy that attended NILA 2019 is considered and compared with the student results of an earlier study. NILA's CCLP had two components: the knowledge test and leadership self-efficacy survey, which were used to quantify the professionals' self-efficacy development and knowledge attainment, respectively. From the leadership self-efficacy test, strategy development leadership self-efficacy increased the most among the professionals and students because of the NILA experience. This result is expected due to the professionals' engineering work environment

and needing strategy-oriented leadership skills, knowledge, and abilities, provided at NILA, to obtain career upward-mobility in the workforce. The variance in the factors results suggest a moderate correlation between the increased leadership self-efficacy and the leadership framework. Additionally, the analysis results show that more specific survey questions and a higher sample size (N = +100) are needed to support the leadership framework hypothesis. More personal career goal-oriented leadership survey questions are needed to delineate which components of the NILA curriculum most effectively contribute to the attendees' leadership self-efficacy. While preliminary, the current results are promising in showing the framework's feasibility as a unified curriculum capable of increasing Hispanic engineering professionals' and students' self-efficacy. Moreover, NILA 2020 addresses this limitation with over 200 professional members attending the virtual conference and with an improved leadership self-efficacy survey. Since the leadership framework is focused on leadership skills and is not focused on a particular culture, it serves as an example for other university and national STEM diversity organizations with similar leadership advancement conferences.

Acknowledgments

5. References

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