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Veteran Student Leadership Skills in an Engineering Technical Writing Course

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Student Veteran Leadership Skills in an Engineering Technical Writing Course

Technical proficiency is a desirable skill for engineers, but often is only one proficiency on a list of required skills from employers. Within industry and education, there has been a pivot, resulting in engineering curricular changes that emphasize professional skills: organization, communication, ability to function on a team, and leadership, to name a few. Student veterans upon graduation provide many of these skills to industries and organizations. Requiring a highly structured leadership curriculum and formal experience for all their cadet students, service academies and senior military colleges provide optimal conditions for better understanding veteran classroom contributions, as well as the role of leadership inside the classroom and out. However, due to military obligations, much of this talent will not be immediately available to industry. Because many veterans served in the military before acquiring their academic education, student veterans are well-poised to exercise leadership roles and responsibilities immediately in and out of the classroom. Leadership training at The Citadel is formative and summative throughout a student's four-years. The institution has a formal, four-functional area leadership model that assesses leader development in multiple ways. Integrated in the leadership model are Leader Characteristics that describe a leader's actions. At The Citadel, professors help students develop the intellectual capacity to be leaders, by developing critical thinking, communications, philosophical, theoretical, and analytical skills associated with their development. In the model, sophomores engage by learning the skills associated with direct leadership of individuals and small teams and the management of duties. In a sophomore-level technical writing course (required of all engineering and computer science majors), sophomore-level leader development was assessed using the institution's criteria. These small teams had a hands-on, technical assignment that lasted several weeks. There was a difference in leadership skills and communication skills observed between the traditional students with their formal leadership curricula and the student veterans. Student peers consistently rated student veterans higher in all areas of the leadership attributes, demonstrating that the student veterans were having a positive impact in the classroom. This paper presents a brief overview of a new project-based assignment in a technical writing course designed to assess multiple outcomes, its institution-specific implementation, and current veteran success indicators. Data from surveys and institutionally-defined leadership characteristics are presented. Finally, by teaming student veterans with traditional students, technical writing educators can provide opportunities for student veterans to demonstrate in-classroom leadership and contribute experiential insight for the collective benefit of student veterans and their traditional student counterparts.

Introduction

Industry has recognized the need for engineers with multidisciplinary backgrounds, blurring the lines between discipline-specific boundaries. Machines, materials, and processes constantly grow in complexity due to their purpose and flexibility as well as customer expectations. However, there is growing emphasis on engineers with "professional skills" as well. The National Academy of Engineering (NAE) in two reports [1],[2] stresses the need for engineers to possess leadership abilities. The former emphasized engineering graduates "must understand the principles of leadership and be able to practice them in growing proportions as their careers advance."

Fundamental engineering, very applied and hands-on, is a stated need by industry. The ASME Vision 2030 [3] states that the problems that mechanical engineers work on often include elements of other engineering disciplines, require systems thinking in problem formulation and solution, and asserts that we must educate engineering students for a technological era of increased scope, scale, and complexity. However, this directive requires greater sophistication in curricular design, providing an interface between basic science and engineering at the systems level, and leadership for innovation. These curricular priorities also exert their influence on the kinds of engineering skills needed in the work force. Expertise related to communication, innovation, and leadership will be required to a much larger degree in accelerated product development. Topics such as these are typically not a significant part of the mechanical engineering curriculum.

The civil engineering curriculum may also see an increase in communications-related course topics. According to ASCE [4], with the introduction of powerful computer technology and the trend toward increasing specialization, civil engineers' roles often limit their leadership opportunities. Civil engineers will have to command the multidisciplinary, multi-cultural, team-building, and leadership aspects of their work in order to lead and execute complex projects that involve many and varied stakeholders and meaningful collaboration.

Even with evidence cited in the vision papers from the NAE and specific disciplines, there still exists a paucity of opportunities for teaching and developing professional skills, including leadership, to engineering undergraduates. Some universities have developed leadership programs, minors, and certificates to address this need and close the gaps identified by others [5]. Some formal leadership programs have created "leadership labs" to create a safe environment for students to practice leadership skills [6]. These labs may be exported to other universities and embedded into existing courses.

Engineering curricula are typically inflexible, allowing the fewest electives due to sequential learning in prerequisites for many courses. Addressing leader development in a busy engineering curriculum poses additional problems. The authors of this paper recognized the value of student veterans as informal leaders on campus, but wanted to assess their leadership skills and classroom value more formally against a campus-implemented leadership model.

Background

Students at The Citadel take an institution-wide core curriculum in liberal arts, math, and science that comprises much of the first four semesters. For engineering majors, the majority of the courses in the remaining four semesters builds on this foundation in discipline-specific engineering.

Creating hands-on experiential learning opportunities is increasingly important for today's students, who are usually very comfortable with technology, have shorter attention spans, a lower threshold for boredom, resist memorization and homework and favor action to observation

[7]. Learning styles of these students are more visual and active rather than verbal. Given the characteristic preferences of these students, educators are exploring different and innovative teaching strategies that effectively address students in terms that they easily recognize and comprehend. Each successive generation is more comfortable with technology than the last [8]. Brown suggests that authentic learning requires the learner to communicate detailed understanding of a problem or issue rather than memorize sets of isolated facts, and must result in achievements that have relevance beyond the classroom [9].

One of the hardest things to do in our profession is to motivate and inspire students to learn. There are numerous examples of methods used to motivate students [10]. However, every teaching method has its advantages as well as its difficulties, so effective instruction uses multiple approaches. Lang connects internal and external learning opportunities [11], concluding "comprehension lies outside of the classroom," meaning that students need time to process and implement the traditional lecture material.

Caudron [12] suggests that educators consider the following five areas when teaching students—with many of these strategies exemplified in the recent improvement of this class:

(1) Make learning experiential by engaging students in cooperative learning experiences.
(2) Give students control over their learning.
(3) Highlight key points, as new learners are 'surfers' and 'scanners' rather than readers and viewers.
(4) Motivate learning by engaging students in their own learning environment.
(5) Challenge students to construct knowledge from their experiences.

During sophomore year, engineering students take Technical Writing and Communications where they are introduced to the fundamental principles of technical writing and use a project-based learning model.

Taking the aforementioned points into consideration, the technical writing instructor and engineering faculty tried a new approach to add realism to the technical writing course content. The course recently implemented a team exercise with iFixit [13] where student teams of four had to troubleshoot an unserviceable item (laptop, kitchen appliance, smart phone, etc.) and repair it. As part of the project, teams documented their written procedures with pictures. Some students gained a greater understanding of how a product works, as well as learned some new skills [14] - [15]. Their submissions were graded by the instructor, who is iFixit certified and trained, and by a team of outside evaluators at iFixit.

Research Questions

Student veterans are accustomed to a previous lifestyle of pressure, regimented routine, and goal orientation. Finding ways to unite this group of students with traditional students in the classroom can be difficult [16]. Veteran and active duty students bring persistence and mental toughness for academic work stemming from their goal-oriented work ethic in the military [17], [18]. Some of these veterans and active duty students initially entered college after high school, performed poorly due to a lack of mental toughness and persistence, and then entered the military [19]. As students who are now traditionally older and more cognitively developed, they are better equipped to scaffold more traditional students through complicated problems and interactions [20]. In addition, their world experience provides a different and critically broad experience, which contrasts with the traditional student cohort who may not have traveled outside of the state. Further, veteran students have spent years working with diverse groups and have the skills and experiences to lead small teams.

One goal of the collaborative work between the Technical Writing Course and the School of Engineering is to identify best practices to support the leadership assessment goals of the institution and the engineering disciplines. Because all students are trained periodically on the institution's leadership model, the instructor could focus more on content and assessment rather than explaining the leadership model and requirements. With a readily available leadership assessment tool, two questions the instructor wanted to answer include:

(1) Are student veterans' leadership skills different from traditional students in a non-engineering course?
(2) Can the institution's new leadership assessment tool be used in a variety of courses? How versatile is it?

Another goal of the faculty is to ensure the students have a positive experience in each course. Writing and communication disciplines are traditionally taught by disseminating information and content, making them particularly fit for lecture [10], but in the case of this course, the instructor wanted to gage the students' opinions regarding the open-ended project approach and evaluate how it impacted their learning. This information supplemented the leadership assessment tool described later in this paper, allowing the instructor to contextualize inconsistencies if necessary. Overall, student evaluations of the course and material were very positive.

Teaching Methodology

The iFixit project was organized along 5 major milestones, outlining each phase of the documentation project. Each milestone was subject to review by iFixit technical writers and the instructor. The final product was evaluated by peer teams at The Citadel.

- Getting Started: Provides learner content and primers in how to use site resources, creating a profile, and registering student teams. Example successful project proposals are detailed, and students are asked to complete a resource checklist and then send all proposals to iFixit.
- Milestone 1: Provides resources for the creation of a troubleshooting wiki for each device, with planned repair guides linked under appropriate sections. Troubleshooting wikis provide general device information, and require students to research known common repairs as well as anticipate repairs that are likely to be needed due to the normal wear of moving parts and device design choices.
- Milestone 2: Provides tips for the creation of a device page that will house all device-related information, including device general research, troubleshooting wikis, and future repair guides.

- Milestone 3: Provides a tutorial in the proper pairing of device photography and technical prose, such that both are semantically redundant, and either could be followed in isolation to correctly execute a repair process. Students create 5-7 repair guides for various device components that they identified in their project proposal.
- Milestone 4: Provides standards for usability testing and peer review of the three resource pages described above (troubleshooting wiki, device page, and repair guides).

Sample Projects

Producing content comparable to operator-level repair manual, student teams solved component repair issues by hand and developed instructions for replicating simple repair tasks. Students implemented technical writing fundamentals they were learning in class, but with a real-world context. This approach also provides ownership of the group's project and empowers the students to experiment and be creative with their system. The following successful repair projects featured in Figure 1 and Figure 2 were veteran-led and resulted in 100% publication of student-created repair guides to the public side of the site. In contrast, 46% of repair documentation created by non-veteran led teams was published on the public side of the site. At the time of this writing, the excerpted veteran-led guides featured in Figure 1 and Figure 2 have each received over 200 online views from iFixit customers.

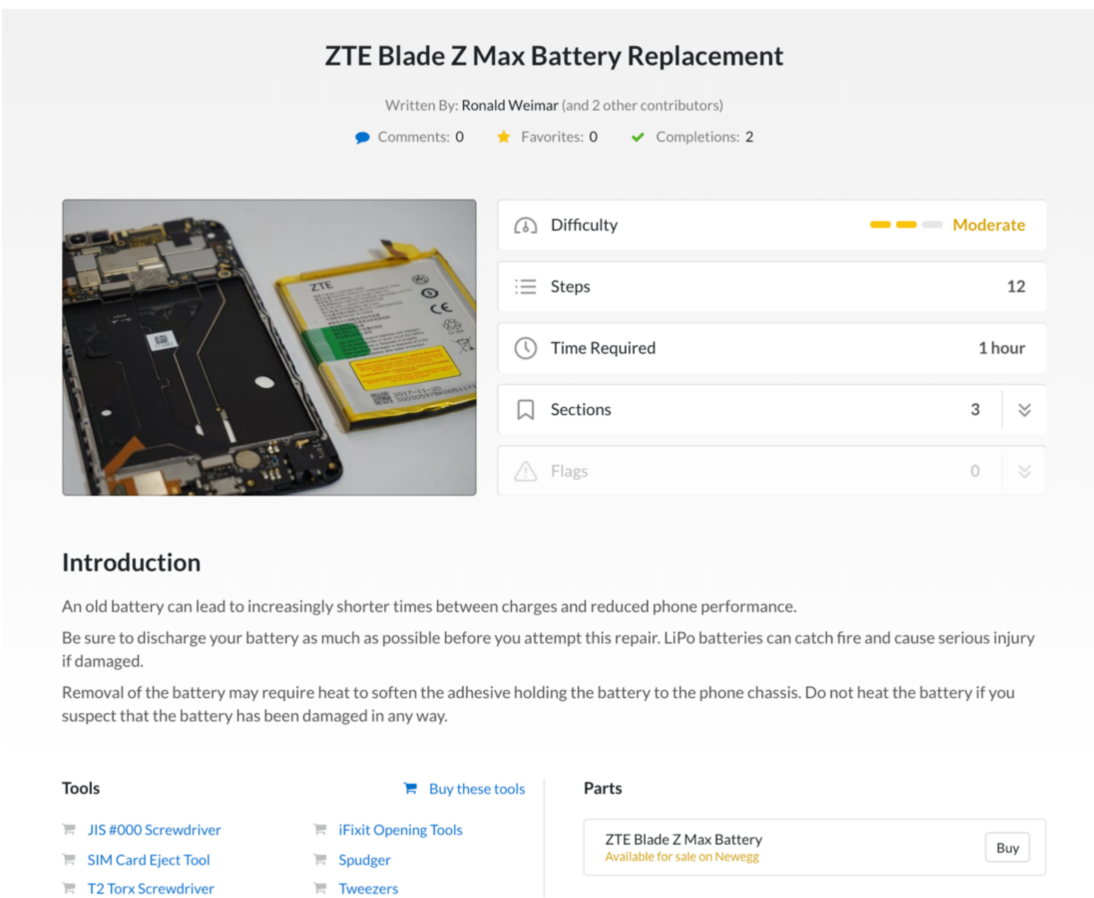

Figure 1: Cell Phone Repair Project

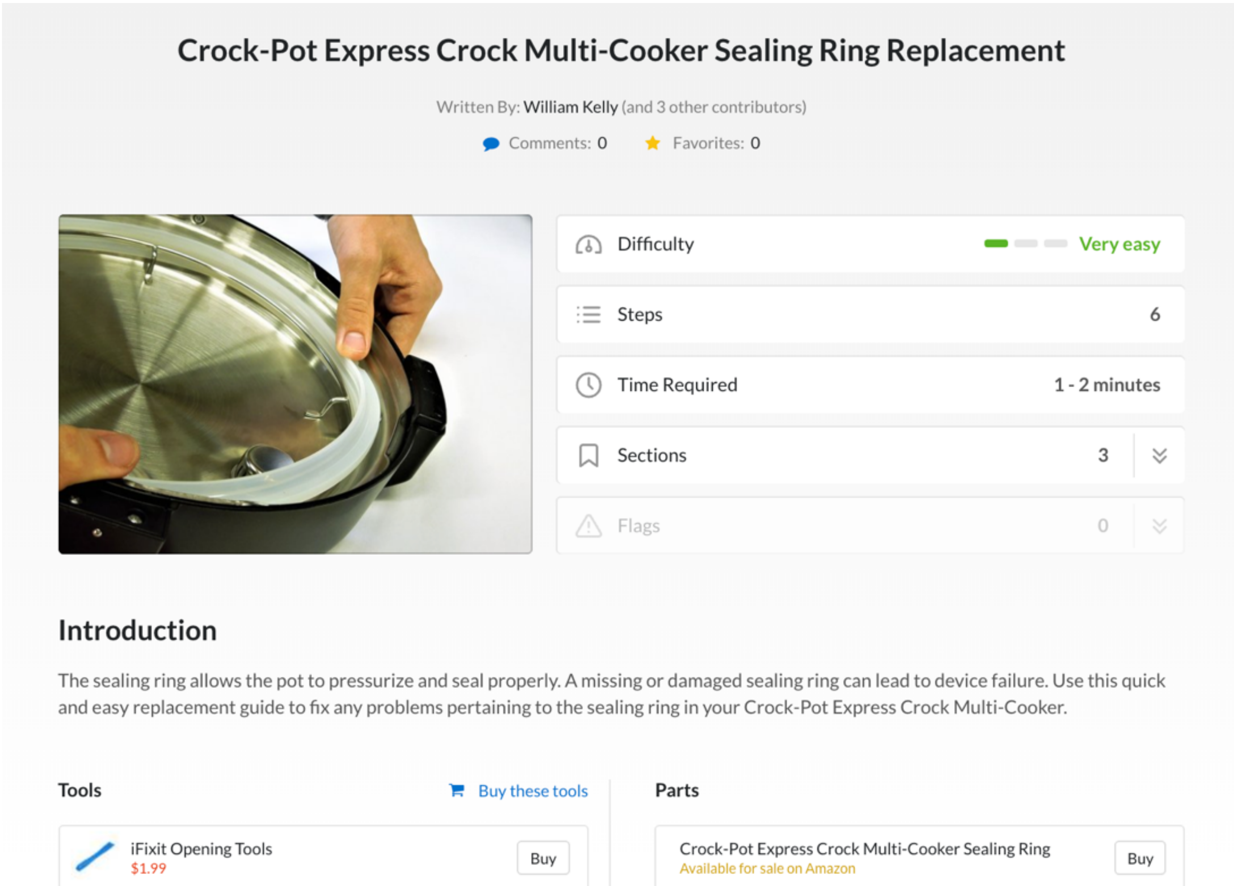

Figure 2: Multicooker Repair Project

These two lab projects are just a sample of the many ideas the students developed for mechatronic applications.

Assessment

The assessment method included collecting student survey data after the first milestone of the hands-on iFixit project (1 week) and at project completion (5 weeks). The students completed a seven-question survey on the Characteristics of Principled Leaders, rating each team member including him/herself. All students were familiar with the Characteristics of Principled Leaders, and shorter definitions were included with each characteristic to remind students of the characteristic. Table 1 shows an excerpt of the survey, excluding only the elicited answer fields designed for the individual student and his or her team members.

Table 1: Characteristics of Principled Leaders

	Leadership Attribute
1.	**Leads with humility;** creates conditions for the team to succeed as a whole.
2.	**Embraces a true, authentic self;** develops and leads according to a principle-based leadership philosophy.
3.	**Acts and speaks with courage;** performs critical leadership functions to overcome resistance leading to positive change and outcomes.
4.	**Develops and values people and resources;** exhibits characteristics of a global citizen and displays desire to openly serve.
5.	**Empowers and holds others accountable;** delegates authority, allows others to optimize unique abilities leading to beneficial results of the collective team.
6.	**Respect others by building trust and learning from mistakes;** demonstrates inclusive leadership traits that embraces diversity, creates security, opportunity and fulfillment.
7.	**Serve others before self;** expands outreach and engagement with broader community.

Data from 43 students was included in this study. A standard five-level Likert Scale (Table 2) was used to assess the level of agreement or disagreement for the leadership criteria given (Table 1), and each rating was associated with a descriptor, as shown in Table 2. The rating scale is a normal set of responses used at the institution for student surveys. Students and faculty alike are familiar with the same standard set of responses and their interpretation.

Table 2: Assessment Scale

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

This leadership model and identified attributes are part of the institution wide leader development and school brand [21]. It was validated and developed over several years through the Leadership Department and in consultation with military and corporate leaders. Students learn and experience the leadership model over four years. At the time of this survey, all students had at least one or more years of the model as part of their formal leadership education. Students use the attributes to rate peers in traditional leadership roles (student clubs, ROTC, dorm cadre, etc.).

Results

The 43 students were divided into teams of four or five individuals. Each team scored their teammates using the questions from Table 1 using the Likert Scale. A leadership score was calculated for each individual by: 1) averaging the scores of all the team members (with self), and 2) excluding the individual's own self-assessment scores (without self). The latter data was a comparison to see if there were any personal bias, either positive or negative. The veteran population in this data set was limited with only three veterans. Although this sample of veterans was small, the results were consistent. Future longitudinal work will track consistency of results.

The first research question examined by this paper is to determine the degree that student veterans' leadership skills differ from traditional students in a non-engineering course. It is important to point out that student veterans enrolled in the sophomore level Technical Writing Course are mixed with students from four different engineering majors and two science majors. Additionally, the traditional students share many campus activities: dorm life, dining facility meals, etc., and have increased contact with each other when compared to the student veteran.

Figure 3 shows aggregated results of the leadership survey. Results were normalized so a 1.00 indicates an average or expected rating based on all seven leadership attributes (Table 1). Any score above 1.00 indicates the individual is performing better than average in the leadership characteristics. Any score below 1.00 shows the individual is performing worse than expected.

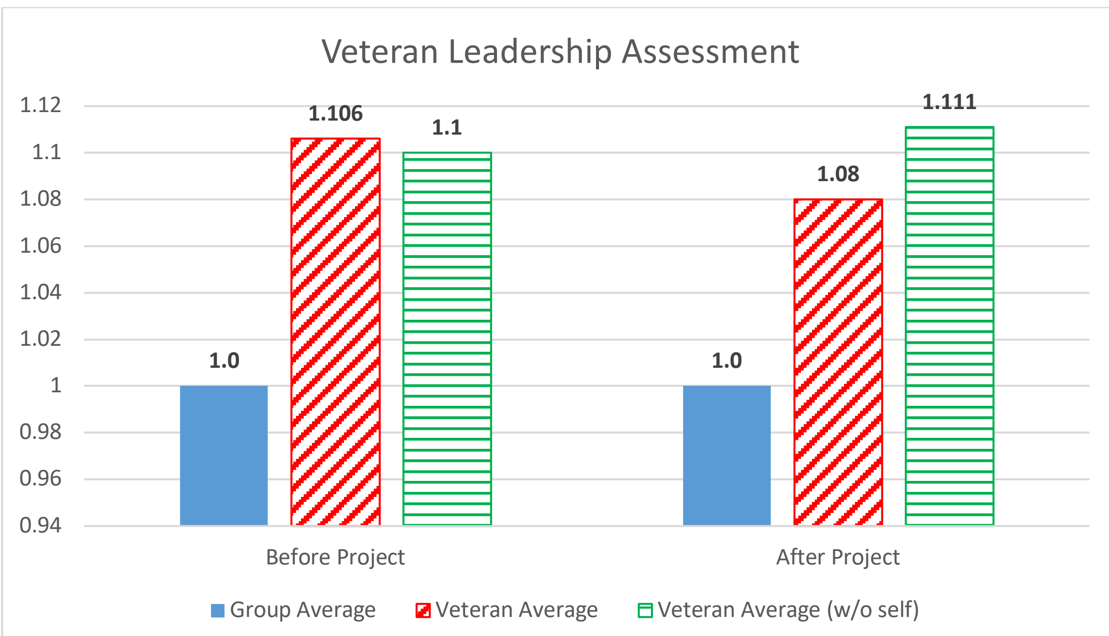

Figure 3: Veteran Leadership Comparison

Overall, students viewed the veterans as exceeding the expectations of the leadership characteristics they have chosen to follow and internalize. Incoming GPAs for the veterans taking this course showed they were right at the average of all the other students (+0.01). The student veterans had no academic superiority or reason that fostered a "follow me" team environment. In all student groups, there was another student who received an above average leadership assessment, but the veteran student was always the highest rated individual in the team. With an average rating 10% higher on a normalized scale early into the technical writing project, and after project completion, the scored student veterans' leadership characteristics exceed the traditional students' scores. For context, these high veteran scores were observed despite traditional students' daily exposure to the institution's principled leadership model.

A specific look at the student veterans' ratings within their groups shows the comparison of the veterans against their peers. Figure 4 shows three groups with student veterans (solid bar within team grouping) early into the project at one week. The student veterans were consistently rated higher than the team average (1.00) with and without the team member's self-assessment. Although this is a small sample of student veterans (3 veterans and 40 traditional students) this corroborates the observation in the literature that veterans have often developed abilities to handle complex tasks and technical skills that may be applicable to engineering practice, as well as enhanced teamwork, leadership, and communication skills [20].

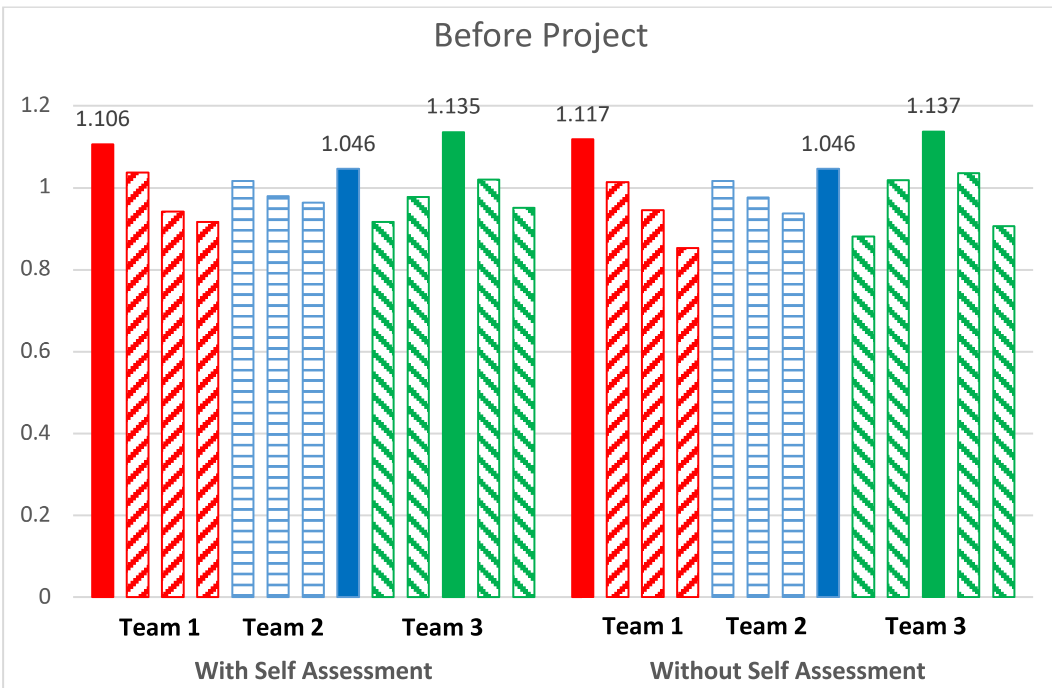

Figure 4: Student Veteran Leadership Assessment Before the Project

Figure 5 shows the same three groups with student veterans (solid bar within the team grouping) near the end of the project at five weeks. Again, the student veterans were consistently rated higher than the team average (1.00) with and without the team member's self-assessment.

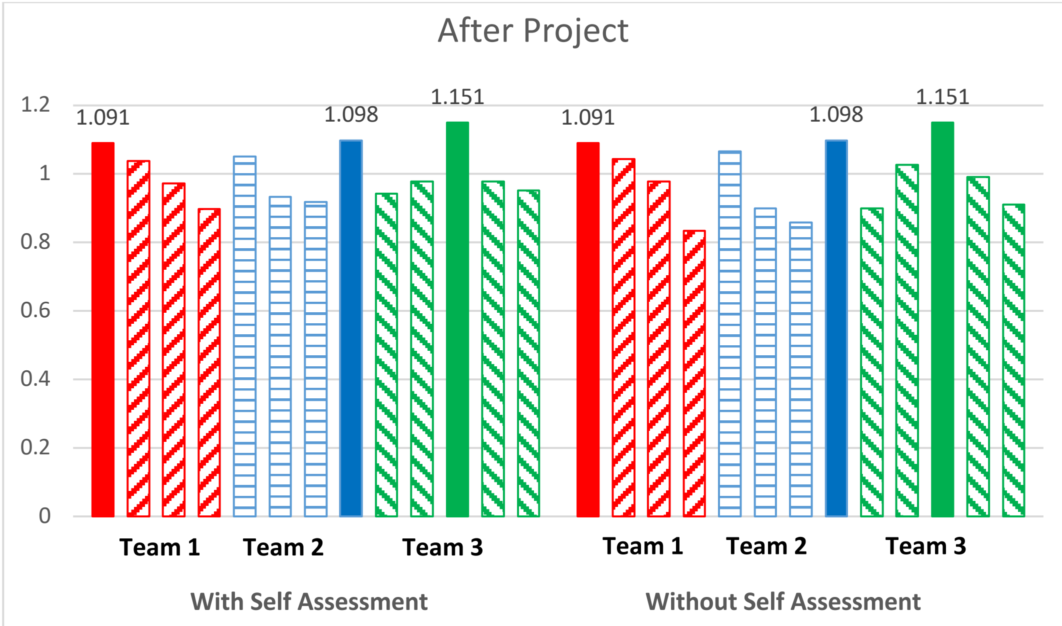

Figure 5: Student Veteran Leadership Assessment After the Project

The second research question concerns how well can the institution's new leadership assessment tool be used in a variety of courses—how versatile is it? Although originally developed as an overall assessment tool for traditional student leader development, the survey has been implemented in engineering senior design courses. This paper shows that it can be implemented earlier in the curriculum stream, when incorporated as part of a project-based learning event in the technical writing and communications course.

Leadership assessments can have near-term positive opportunities for learners. This peer feedback uses social comparison. Social comparison theory suggests that we make better assessments of others and ourselves when we make relative comparisons. Relative comparisons involve comparing several people and ourselves at the same time when providing ratings [22]. The example in Table 3 is a sample of self and peer assessment for Student X. The seven Leader Characteristics are listed horizontally with assessment from self on the first line and peer assessment on the subsequent lines. The normalized scores are on the right and listed as with and without self-assessment to check if the student's self-perception matches the group's. Software was formatted to color cells when assessment data was +/- 0.05 or greater (< 0.95 = orange, > 1.05 = green), making it easy to find low and high performers.

Table 3: Student X Assessment at Project Initiation

Student X								
L	E	A	D	E	R	S	w/self	w/o self
5	5	5	5	5	5	5		
4	4	4	4	4	4	4	0.901	0.911
5	5	5	5	5	5	5		
3	3	2	3	3	2	2		

When presented with this information early in the semester, the instructor can counsel the student with this aggregated information and specific areas to improve. For this particular student, the three lowest rated areas were: 1) Acts and speaks with courage; 2) Respect others by building trust and learning from mistakes; and 3) Serve others before self. Student X wanted to improve as a team member (internal motivation), had the tools to improve (leadership model and attributes), and the information from the instructor on specific areas (direction).

Table 4 below shows the same student's assessment after the group's project. The student still rated himself '4' across all categories, but his peers rated him higher. His aggregate normalized score shows he was performing much better than his peers.

Table 4: Student X Assessment at Project Completion

Student X								
L	E	A	D	E	R	S	w/self	w/o self
5	5	5	5	5	5	5		
4	4	4	4	4	4	4	1.043	1.098
5	5	5	5	5	5	5		
5	5	5	5	5	5	5		

Given the amount of content and requirements in a technical writing course, initial results indicate that leadership assessment and development can provide auxiliary support for learning, which in turn, support the outcomes of the multiple engineering disciplines, and mission of The Citadel.

This assessment tool is general enough to be used on traditional students and student veterans alike, provided that it is scaffolded elsewhere in a curriculum as well. Student X above was a traditional student, and developed some leadership proficiency when counseled. Student veterans' pre- and post-project assessments were very consistent with no large variation such as Student X. Veterans, assessed on the same standards and criteria, show that they excel in the professional skills, such as leadership and teamwork, sought by many engineering disciplines, even in non-engineering courses.

Conclusion and Future Work

This paper describes recent changes in a project-based technical writing course where leader development and assessment occurred. Using a proven leader development model and assessment tool in a technical writing course is novel. The benefits of using technical writing requirements to address real world problems include the enthusiasm apparent among students and faculty. This drives student engagement, as they become invested in the projects, reinforcing the idea that students must continually strive to update their skills throughout their careers. Incorporating leadership in an engineering curriculum is not easy, but programs should realize the benefits of coordination with non-engineering faculty and using veterans as examples. Leadership development at The Citadel where veterans and active duty students are involved is successful due to direct or indirect involvement of the veteran and active duty students. Veteran leaders are making a difference and setting the example among traditional students. Their ability to organize, plan, and execute is a model for the traditional student population, which receives much more current and formal leadership training. As the US, and the world, need more engineers, one way to narrow that gap is to recruit and retain veterans that matriculate on campuses wanting to be engineers. They retain their leadership skills and are ready to use them in the classroom and beyond.

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