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U.S. Military Students in Civilian Undergraduate Engineering Programs: A Narrative Review of the Student Veteran and Servicemember Literature

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The ever-increasing need for engineers to offer innovative solutions to complex interdisciplinary and global-societal issues requires an engineering workforce that is broadly diverse in experience and thought. Along with current efforts being made to increase diversity in engineering education programs and the engineering workforce on national and international scales, U.S. military students are increasingly recognized in the research literature as a potential source of diverse engineers. With the understanding that military students are not a single monolithic group, we frame this review by defining our target population of *"military students"* as post-secondary undergraduates enrolled at civilian institutions of higher education who a) have completed their service and are now military veterans or b) are concurrently serving in the U.S. Armed Forces, such as in the Reserves or National Guard, while attending college. Generally, this group of military students has served or are serving as enlisted servicemembers and are likely to be first-generation or from underrepresented racial and ethnic groups that have been historically underrepresented in engineering education [1] and the engineering workforce. In addition, both prior and current enlisted military students are widely considered to be those who have developed/will develop key attributes, such as a strong work ethic, maturity, and leadership skills, during their time in service that prepare them for academic success in engineering education and for impact in engineering careers [2].

Background

The U.S. military has been a driving force in the evolution of engineering education in the United States since that nation's beginning. In 1817, the United States Military Academy at West Point became the first institution of higher education to offer formalized engineering instruction and did so for both military and civilian engineering purposes [3]. This relationship was further solidified during World War II, when the U.S. government funded university engineering programs to assist in the development of atomic weapons and other advanced technology for military use [4]. Today, the military continues to be a major source of funding for engineering research and employment for engineering graduates in the United States [5]. While it has been successfully argued that the historical connection between the U.S. military and engineering has contributed to the overwhelming predominance of white male engineers [5], it is also true that today's U.S. military is more racially, ethnically, gender, and socio-economically diverse than either the current U.S. engineering student population or engineering workforce [6]. Therefore, we suggest that *even though* the U.S. military may have been complicit in limiting diversity in engineering *in the past*, one potentially beneficial way to improve engineering diversity *moving forward* is through the strong and enduring relationship that has been built between engineering and the U.S. military over the last 220 years.

It is also important to consider how, during many eras of U.S. history, military veterans and servicemembers have been overlooked and underserved within society. Today, as the engineering education community shifts toward social justice, equity, diversity, and inclusion (JEDI), it is important to recognize how we can positively impact the lives and livelihoods of these military students. This impact can manifest through the ways we train engineers to think about and develop technology and equipment for military use, and through broader and more

deliberate inclusion of military students in engineering education. Specifically, we suggest that the engineering education community has an obligation to work toward increasing military student participation in engineering as means to provide military students inclusive access to career paths and influence within industries that engineer systems and devices for military use.

Motivation

In our work, we have found that the research literature categorizes military students in higher education in varying ways. We recognize that the definition of *military students* that we employ in this work is just one interpretation of many possible interpretations. The broadest definition of this term would likely include undergraduate students having any source of military affiliation, such as those who served (past tense) in the military and are now considered veterans, those currently serving in the Reserves or National Guard while attending school, undergraduate students enrolled as cadets in the nation's service academies and Reserve Officer Training Corps (ROTC) programs, current military officers returning to higher education for graduate study, and spouses and dependents of current or former military service members who are attending college, among others.

Instead of studying all military students as a single, monolithic group, we focus our research on those undergraduate students who are military veterans and/or current servicemembers in U.S. Reserves or National Guard. Due to the nature of the military rank structure and the common requirement for military officers to earn undergraduate degrees prior to being commissioned as officers, military veterans and current servicemembers enrolled in common (non ROTC) undergraduate degree programs at civilian institutions of higher education are likely to have served or serve as *enlisted servicemembers.* Specifically, we focus our research on enlisted veteran and current service members enrolled as undergraduate students in engineering because they represent substantial—but as yet untapped—human potential for strengthening and diversifying the civilian engineering workforce.

Enlisted veteran and servicemembers collectively embody the diversity (i.e., gender, race, ethnicity, ability, and social class) present within U.S. society while further possessing unique assets, skills, and mindsets (e.g., technical knowledge and interests, hands on skills, teamwork experiences, leadership, self-discipline, and maturity) gained during their military enculturation, training, and service. Importantly, these assets, skills, and mindsets are increasingly aspired to in engineering education and highly sought after within the civilian engineering workforce. At the same time, however, levels of participation, persistence, and performance of military veteran and servicemembers in undergraduate engineering programs remain dishearteningly low [7]. The experiences of enlisted veterans and service members are such that their military service often comes before—or increasingly while—they pursue an undergraduate education within non-military affiliated programs offered by civilian institutions. Resultantly, enlisted veteran and current service members are met with varying levels of support, recognition, and positive affect within civilian programs and institutions. Furthermore, these military students must rapidly adapt to changing contexts, meshing and/or switching between ingrained military identities and emerging civilian/ professional ways of knowing and being that manifest within alternating military and academic contexts.

Other types of military students, such as ROTC and service academy cadets, experience military enculturation and training as a purposeful and integral part of their undergraduate education. Many cadets have no former enlisted military experience and pursue their undergraduate degrees for the purpose of being commissioned as a "career" military officer serving on active duty or in the active Reserves, rather than for becoming a professional in their undergraduate discipline (e.g., engineering). Similarly, current military officers who are sent to graduate school by their military component remain "in" the military during their graduate studies and return to formal military service directly upon completion of their graduate degree.

In sum, we argue that veteran and current servicemembers are a critical segment of the military student population that deserves research attention aimed at understanding their experiences and critiquing current institutional structures that impede their participation, belonging, and success in engineering degree programs. We believe that this group, among all military student groups, stands to benefit from concerted efforts by the engineering education community and are likely candidates for attaining improved levels of support within civilian institutions of higher learning. Of all military student groups, we argue that student veterans and servicemembers enrolled in engineering at civilian institutions offer substantial potential to help build a robust and diverse U.S. civilian engineering workforce and, therefore, are a critical sub-population for study.

Positionality

While not a member of the military community, the first author has experienced the effects of marginalization as a woman in an undergraduate chemical engineering program. She considers herself lucky to have had a plethora of female mentors in science, technology, engineering, and math (STEM) that allowed her to be successful in her education. In addition, her experience as a math educator for K-12 students has increased her awareness of the importance of JEDI in STEM and engineering education and the positive results of diversity in peoples' perspectives in engineering. The first author is interested in increasing inclusion in engineering education by studying the experiences of different marginalized and underserved groups in engineering.

The second author is a White woman, professional mechanical engineer, and an 11-year veteran of the U.S. Army. Notably, her engineering education book-ended her military service. She earned her bachelor's degree in mechanical engineering as a cadet at the U.S. Military Academy and completed her master's degree in mechanical engineering as a nontraditional civilian student after leaving military service. The tensions she has experienced between her veteran and civilian professional identities (both engineering and academic) and her personal experiences transitioning between military, industry, and academic environments catalyzed her interests in understanding the experiences of diverse military students and critically examining the educational structures that may inhibit military student access, participation, and persistence in engineering.

Research Questions

While empirical research related to *military students* (as defined in this work) in engineering education is relatively new, work in this area is increasing. This narrative literature review seeks to synthesize and describe the current state of this body of research and to provide insights into

important new directions for future research. To meet these objectives, this review is guided by the following research questions (RQ):

Within the engineering education literature related to U.S. military undergraduates (i.e., veterans and current servicemembers) enrolled in engineering degree programs at civilian institutions of higher learning:

1. What are the research designs and methodological approaches (i.e., participant populations, methods, theories, and perspectives) used and how are they studied or employed?
2. What are the emerging findings from this body of literature?
3. What opportunities exist for future research?

In subsequent sections of this paper, we describe the processes used to locate and analyze current literature related to U.S. military students in engineering and discuss important findings from the research.

Method

Our review of the research literature related to military student experience in engineering takes the form of a *narrative overview* style literature review. Narrative reviews are comprehensive and descriptive syntheses of available published research on a topic of (potentially wide) interest that are written in a readable, narrative form. Narrative reviews are uniquely suited for certain purposes, such as educating readers on the origins and historical development of emerging ideas and for cultivating thought and debate about emerging research topics and approaches [8].

The literatures used in this review were collected from August 2021 to April 2022. First, a preliminary literature search was conducted for papers with titles that included the words "military" and/or "veterans" and "engineering" by mining references from an unpublished grant proposal for research with military students [9]. This process was repeated as each subsequent paper was located until no new references were found. Next, EBSCOHost was used to search the following databases: ERIC, Academic Search Ultimate, and APA PsychInfo in tandem with Google Scholar. Finally, a search was conducted on ASEE's PEER database. Key words for searching these databases were developed by selecting common key words from the previously obtained literature, as well as through consultation with a university librarian whose expertise is in educational research. Key words included "military", "veteran", "student", "engineering education", and "undergraduate student".

Once the literature search was completed, literature was selected to be included in this review based on the following inclusion criteria:

1. Studies were written in English.
2. Studies were published in journals, peer-reviewed conference proceedings, or dissertations.
3. Studies were conducted with military students defined as those who are U.S. military veterans and/ or servicemembers currently serving in the U.S. military Reserve and/or National Guard components.

4. Studies were conducted with U.S. *military students* enrolled in post-secondary engineering education specifically, rather than post-secondary STEM education generally.
5. Studies were conducted at civilian institutions of higher education.
6. Studies were empirical in nature.

Literature was excluded from this review based on the following exclusion critera:

1. Participants were service academy cadets.
2. Participants were ROTC cadets.
3. Participants were graduate students.

These inclusion and exclusion criteria were developed based on the capabilities of the authors as unilingual English speakers and the scope of the research questions. For example, because the context and goals of undergraduate and graduate engineering programs differ substantially, we included only studies that were conducted within undergraduate engineering education contexts. For example, engineering bachelor's degrees are considered professional degrees that lead to employment as practicing engineers, while engineering graduate degrees often focus more on research and often lead to academic or other research focused employment. Because the motivation for this literature review comes from a desire to increase participation of military students in careers as engineers, we chose to focus this work exclusively on the experiences of military students, as defined herein, in undergraduate engineering.

The first author conducted database searches and made an initial determination whether to include or exclude each article based on the inclusion criteria. The first author consulted with the second author whenever the selection process was unclear and, in those cases, the two authors jointly decided whether the article should be included. For example, a dissertation by Sheppard [10] was located and initially included in this review. However, after some discussion, the authors jointly agreed to exclude it from the review since the study participants included veterans who were either undergraduate students, graduate students, or professional engineers and some findings were derived specifically from the graduate student data. Thus, it was difficult to pull undergraduate specific findings from the article. Conversely, a conference paper by Mobley and colleagues [11] that's participants were not military students, but "institutional agents" (certifying officials, staff, advisors, and other institutional employees that work with military students in some capacity) was ultimately included in this review due to its focus on undergraduate *military students* in an engineering context.

Before searching the ASEE PEER database, 68 papers were initially located during the preliminary and EBSCOHost database searches. Careful application of the inclusion/exclusion criteria resulted in a dataset of 17 papers. A subsequent search of the ASEE PEER database, using the terms "veteran" & "military" & "student" & "undergraduate," resulted in a total of 232 ASEE conference papers to consider. Because there was no way to exclude author biographies during the ASEE PEER search, the authors noted that approximately the first 3.5 pages of search results were about military students; the articles included on later pages either did not include the terms "military" or "veteran" (instead including only "student" and/or "undergraduate") or, if they did, these terms appeared only in the author biographies while the papers themselves

covered a different topic. In the end, the ASEE PEER database search resulted in an additional five papers that met the inclusion/exclusion criteria. In total, 22 papers were included in the review. A summary of the papers included in this review is shown in Table 1.

Table 1
Summary of Included Papers

Citation		**Research Design**	**Participants**	
Author/Year	**Methods**	**Theory/Framework**	**Gender/ Race/ Ability**	**Military Status**
Brawner et al. (2016) [12]	Qualitative	Status negotiation and enactment (Identity)	Majority male Majority White Able-bodied	Veterans
Cooper et al. (2016) [13]	Quantitative	Self-efficacy Engagement	Majority male Majority White Disability	Veterans, some having a disability
Lim et al. (2016) [14]	Qualitative	Identity Formation Acculturation theories and models Berry's Acculturation model	All male Majority White Able-bodied	Veterans
Main et al. (2016) [15]	Qualitative	Schlossberg Transition Theory 4S transition model	Majority male Majority White Able-bodied	Veterans
(Stringer & McFarland, 2016) [16]	Qualitative	Mumford's Model of Leader Characteristics on Leader Performance	Not stated, Female veteran participant Able-bodied	1 veteran; non-veteran engineering students
Brawner et al. (2017) [17]	Qualitative	Transition theories (discussed but no specific theory stated)	Majority male Majority White Able-bodied	Veterans or currently serving
Mobley et al. (2017) [1]	Qualitative	Cognitive Information Processing Theory	Majority male Majority White Able-bodied	Veterans
Atkinson et al. (2018) [18]	Qualitative	Identity and transition theories (discussed but no specific theory stated)	All female Majority White Able-bodied	Veterans or currently serving
Janeiro et al. (2018) [19]	Mixed Methods	No specific theory stated or discussed	Not stated Not stated Able-bodied	Veterans
Mobley et al. (2018) [20]	Qualitative	Grounded Theory Framework	Majority male Majority White Able-bodied	Veterans or currently serving

Salzman et al. (2018) [21]	Qualitative	No specific theory stated or discussed	Not stated Not stated Able-bodied	1 veteran TA; non-veteran engineering students
Brawner et al (2019a) [22]	Qualitative	Intersectional identity Multiple-dimensional identity theory	All male All Black or African American Able-bodied	Veterans or currently serving
Brawner et al. (2019b) [23]	Qualitative	Transition theories (discussed but no specific theory stated)	Majority male Majority White Able-bodied	Veterans or currently serving in the Navy and Marine Corps
Hood et al. (2019) [24]	Quantitative	Professional Social Responsibility Development Model	Majority male Majority White Able-bodied	Veterans or first-year engineering students
Main et al. (2019) [25]	Qualitative	Situational and Team Leadership theories	Majority male Half white, 2 Black, 2 AAPI, 1Hispanic /Latinx, 1 Mixed Race Able-bodied	Veterans or currently serving
Mobley et al. (2019a) [11]	Qualitative	Grounded Theory Framework	Not stated	Majority served or have family who served
Mobley et al. (2019b) [26]	Qualitative	Multi-dimensional identity theory Constellations of identity framework	Majority male Majority White Able-bodied	Veterans or currently serving
Mobley et al. (2019c) [27]	Qualitative	Veteran Critical Theory Multiple Identity Theory	Not stated Not stated Able-bodied	Veterans or currently serving
Sheppard et al. (2019) [28]	Qualitative	Schlossberg Transition Theory	2 male, 1 female 1 Hispanic, 1 White, 1 Asian, Disability	Veterans with service-connected disabilities

				exceeding 30%
Dalhberg et al. (2020) [29]	Mixed Method	Integrative Approach for Curriculum Development Framework Constructivist Learning Theory	Majority male Not stated Able-bodied	Veterans and non-veterans
Mobley et al. (2020) [30]	Qualitative	No specific theory stated or discussed	Majority male Majority White Able-bodied	Serving in the Reserves or National Guard
Camacho et al. (2021) [31]	Qualitative	Turner's theory of liminality	Majority male Majority White Able-bodied	Veterans or currently serving

The articles included in this review were analyzed using qualitative content analysis [32] and a coding grid that included the following a priori categories: participant populations, methods, theories, and key results and conclusions. From these categories, the literature was further organized into major subcategories within each category. For example, within the methods category, articles were categorized as either: (1) qualitative and (2) quantitative and mixed methods. Using these subsets allowed for more meaningful analysis of key results and conclusions and for themes to be developed within each subset as they relate to the research questions. These themes are presented and discussed in the Findings and Discussion sections of this paper.

Limitations

First, we note that most of the literature discovered and analyzed in this review (14/22 papers) were written by a single group of researchers to describe differing aspects and findings of the same, broad research study (see for example [1]). Recognizing that the strong representation of a single research study in this body of work may unduly influence our review findings, the complete data set was categorized in several ways (for example, by theory and methodology) to allow for an analysis that compares and contrasts research from this broad study and other research across multiple dimensions. Despite the limitation created by this strong representation from a single research study, the articles published from this single study include participants from four universities and researchers from three universities and one professional research consulting group. Therefore the articles developed from this broad research study included substantial diversity in participant experience and researcher background and provides a foundation of empirical research with military students in engineering education. Therefore, reporting on these articles is critical for any review of the empirical literature of military student veterans and service members to date. Second, while it is possible that some relevant articles were not discovered in our searches due to missing key words or inadequate search strategies, substantial efforts were made by the research team to identity all important key words by conducting preliminary literature search and by consulting with a university librarian. Last, this review is similar to all reviews in that it is limited by researcher self-selection bias. The authors mitigated this limitation by establishing and following well-defined inclusion and exclusion

criteria, based on the goals of the research, to guide decisions about which papers to include in the study and by making inclusion decisions that were not clear cut openly and collaboratively.

Findings

Of the 22 studies included in this review, all were conducted at 4-year public or private civilian institutions within the United States. It should be noted that many of these institutions are described as having comparatively large military student enrollments and as being recognized for having strong support systems for military students [33]. All studies were published within a five-year period between 2016-2021. Seventeen studies were published in peer-reviewed conference proceedings and five studies were published in peer-reviewed journals, including the *International Journal of Engineering Education*, *Journal of Military, Veteran and Family Health*, *Social Sciences*, and *International Journal of Qualitative Studies in Education*. While each paper focused primarily on the experiences of undergraduate military students, five articles also studied populations that contained non-military affiliated participants [29], or participants whose family members had served in the military [11].

We found that the literature on U.S. military students is largely consistent in both participant demographics (able-bodied White male) and research methods (qualitative), with important distinctions in theoretical frameworks. These findings likely reflect the predominance of a single research study within this body of literature.

Participant Demographics

Race, Ethnicity, Gender, Ability

All studies except six (16/22) reported the race/ethnicity and gender demographics of the participants. All studies that reported gender used binary descriptions (i.e., female or male) of gender identity. The exception is the study by Hood and colleagues [24] that included "other" as a gender category. Data also revealed that this research is overwhelmingly conducted with military students who are White males, despite researcher's efforts to increase sample diversity using purposive and snowball sampling [14]. Two studies engaged participants who self-identified as having a disability[13], [28]. Although specific reasons for the lack of diversity among military student participants are not discussed within the studies, there are several possible reasons why military student research in engineering education does not reflect the demographics of the larger military population. Reasons could include that military students who are women, dis/abled, or not White disproportionally leave engineering or choose majors other than engineering, or that current research recruitment strategies are not adequate, or are not being applied in appropriate ways, to reach those military students from diverse racial, ethnical, gender, and ability groups or those who identify with this groups but seek to hide their military identity.

Military Status

In addition to the homogeneity in participant race/ethnicity and gender, it should also be noted that all the studies engaged military student participants that have been successful in their undergraduate engineering programs in that they were still in these programs at the time these studies were performed. These students may have vastly different experiences than those that start an undergraduate engineering program and switch to a non-engineering major or do not finish their undergraduate degrees.

As noted previously, five studies included in this review engaged with non-military participants [16], [21], [24], [29] or participants whose family members have served [11]. In developing a mechanical engineering course that introduces military technology to engineering students, Dalhberg and colleagues [29] found that both military and non-military students found the course to be beneficial to developing an understanding of mechanical engineering topics. This study suggests that introducing military technology in engineering courses can have a positive impact on military and non-military students and may be an effective way of creating inclusive environments for military students in engineering. Likewise, Salzman and colleagues [21] and Stringer and McFarland [16] found that when an undergraduate veteran with technical engineering expertise was placed in a leadership position in a lab-based class, both the veteran and the non-veteran students benefited from the veterans's knowledge and participation. Together, these studies suggest that including military students in engineering education helps all engineering students.

Hood and colleagues study of veteran students' and non-veteran first-year engineering students' perceptions of social responsibility found that both groups of students consider social responsibility to be important [24]. This suggests that social responsibility can be used in developing interventions to increase retention of both military and non-military students in engineering.

Mobley and colleagues [11] engaged with "institutional agents" (as defined previously) to understand their perspectives on military student assets and challenges in engineering. While the participants in this study were not military students, many (14/24) participants had either served in the military or had family members who had served. In this study, researchers reported that institutional agents recognized the challenges that *military students* face in getting support from educational institutions due to the lack of a "one-stop-shop" of resources. The authors also found that some institutional agents did not consider engineering to be a viable pathway for military students based on the reputation engineering programs have for being long and difficult. Institutional agents described how military students, who are likely to be nontraditional and have had a substantial break in schooling, often require additional courses in subjects like math to re/acquire the prerequisite knowledge and skills needed for engineering. This finding lends an interesting contrast to military student perspectives of their own success in engineering and further complicates concerns of a pervading deficit perspective of military students in both higher and engineering education that may be impeding military student participation and persistence.

Methods

To illustrate the review findings related to empirical research methods, Table 2 presents the literature categorized by research methods (qualitative, quantitative, and mixed methods).

Table 2

Summary of Methods Employed

Methods	Studies Utilizing Method

Qualitative (18)	[1], [12], [14], [15], [16], [17], [18], [20], [21], [22], [23], [25], [11], [26], [27], [28], [30], [31]
Quantitative (2)	[13], [24]
Mixed Methods (2)	[19], [29]

Qualitative

Eighteen of the 21 papers in this review used qualitative data generation methods. Almost all of these qualitative studies used in-depth or semi-structured interviews [1], [11], [18], [21]–[23], [25]–[28], [30], [31], focus groups [12], [15], [17], or a combination of both [14], [20]. One study used written participant observations [16]. In addition, a handful of studies used Identity Circles [18], [22], [26], [27] and a key event timeline [27] to elicit deeper narratives during interviews. Specifically, Mobley and colleagues found that using these qualitative measures allowed for topics to come up in the interview that the researchers had not thought to ask about or could not ask about due to their sensitive nature, helping ground their research in an assets-based approach [27].

Quantitative and Mixed Methods

Self-report surveys were employed most often as quantitative measures. Janeiro and colleagues [19] and Dahlberg and colleagues [29] both used mixed methods approaches that combined qualitative interviews with quantitative surveys. Janeiro used this information to better understand the characteristics of military students at East Carolina University (ECU), as well as their reasons for choosing to pursue engineering at ECU [19]. Dahlberg also implemented the use of journal reflections, and participant observations with the interviews and surveys to evaluate a mechanical engineering course designed to introduce military technology to both military and non-military engineering students. Similarly, the ELEVATE program, which was evaluated using quantitative pre- and post-surveys, was developed to focus on improving self-efficacy in pre-engineering military students by providing engineering and professional development workshops and rehabilitation counseling [13]. Hood and colleagues [24] used quantitative surveys of veteran students and first-year engineering students to determine the perceptions of these students in regards to social responsibility and if it could be used to develop interventions to increase retention of veteran students in engineering.

It is interesting to note that half of the studies using quantitative methods (i.e., two papers) were related to new course/program development. Both studies [13], [29] found that students perceived the programs as useful to their future education and careers. While neither study measured changes in conceptual learning achieved by students in these courses/programs, they demonstrated the potential for further research on program development targeted at supporting U.S. military students in engineering education.

Theoretical Frameworks

Table 3 presents the literature categorized by theoretical framework (identity, transition, learning-based, leadership-based, and other) employed. As shown in Table 3, three main types of theories that have been used to understand the experiences of military students in engineering: identity, transition, and learning theories. While most of the literature on these topics do come from the same broad study, four of the papers from different researchers [13], [14], [28], [29] employed these theories as well.

Table 3
Summary of Theoretical Frameworks Employed

Theoretical Framework	Studies Utilizing Theory
Identity Theories	
Identity Formation [34]	[14]
Multiple-dimensional identity theory [35]	[22], [26], [27]
Identity (Status) negotiation and enactment [36]	[12]
Identity theories (discussed but no specific theory stated)	[18]
Transition Theories	
Schlossberg Transition Theory [37]	[15], [28]
Turner's Theory of Liminality [38]	[31]
Cognitive Information Processing as related to career decision-making [39]	[1]
General Transition (transition discussed but no specific theory stated)	[17], [18], [23]
Learning Theories	
Constructivist Learning Theory [40]	[29]
Self-efficacy and engagement [41]	[13]
Leadership Theories	
Situational and Team Leadership Theories [42], [43]	[25]
Mumford's Model of Leader Characteristics on Leader Performance [44]	[16]
Critical and ProSocial Theories	
Veteran Critical Theory [45]	[27]
Professional Social Responsibility Development Model [46]	[24]
No Theoretical Framework defined	
Grounded Theory Methodology [47]	[20], [11]
None	[19], [21], [30]

Identity Theories

Under the umbrella of identity theories, current literature focuses on identity formation [14], identity salience [18], and multi-dimensional identity theory[22], [26], [27]. In the broad study conducted by Brawner and colleagues, an identity activity called a "Student Veteran Identity Circle" was developed and used in conjunction with semi-structured, in-depth interviews to better understand the identity salience of engineering status, veteran status, and other identities. The researchers found that military and engineering identity tend to be the most salient for military students, even for those students that identify as first-generation, female, or as a racial minority. The exception to that is for black male veteran students; researchers found that participants' identity as black males was equally salient to their military identities [22]. This

finding is complemented by the findings of Lim and colleagues [14] that participants viewed their military and engineering identities as highly synergistic.

Transition Theories

The literature using transitional theoretical frameworks focused on transition theories in general [17], [18], [23], and on Schlossberg's Transition theory [15], [28], Turner's Theory of Liminality [31], and Cognitive Information processing (as related to career decision making) [1] in particular. Schlossberg's Transition theory uses a "4S" transition model that describes transition experiences based on four factors 1) characteristics of the situation, 2) the self, 3) support, and 4) strategies to cope with stress [37]. Turner's Theory of Liminality focuses on the "liminal state," a time that exists between leaving one social status and entering another [38].

Researchers using this liminality-based theory found that while military service did not always influence military students' decisions to pursue engineering, participants found a strong connection between their military experience and engineering once they started their engineering education [31]. They also found that the support networks military students developed during their initial transition from the military into higher education (through family, faculty, and peer support) had a direct impact on a military student's successful transition to engineering education [31].

Those researchers using Schlossberg's Transition theory found that that cultural similarities and a synergy between character traits and technical skills learned in the military and required in engineering made military experience an advantage when pursuing engineering [15], [28]. Interestingly, they also found that even at schools that are considered to have strong veteran and military student support programs, participants had mixed feelings about utilizing these programs, either due to ease of access [28] or a participant's preference to hide their veteran identity or "self" [15].

Using the Theory of Cognitive Information Processing [39] to understand *veteran* students' decisions to study engineering, Mobley and colleagues found that while many of their participant saw a connection between their military experience and engineering, nearly half of the veteran participants had already chosen to pursue an engineering degree before entering the U.S. Armed Forces [1]. They also noted that external factors such as financial stability, and advice from mentors influenced military students' decisions to study engineering.

Learning Theories

While studies in this category employed different learning theories, both employed quantitative and/or mixed-methods approaches and can be categorized as course/program development [13], [29]. These studies reported that including military technology and military-based skills within an engineering curriculum improved the self-efficacy of military students in engineering [13], [29]. It was also found that the majority of military students that participated in a pre-engineering program called ELEVATE, continued to pursue engineering or STEM-related undergraduate programs [13].

Other theories

Three additional theories were used to understand the experiences of military students in engineering. Using Situational and Team Leadership Theories [42], [43], Main and colleagues [25] found that participants often took on leadership roles in group projects in their undergraduate programs because of their leadership experience in the military. However, participants also found that their military experienced helped them to be effective in team member roles as well. In a similar vein, Stringer and McFarland [16] used Mumford's Model of Leadership Characteristics [44] to understand the success of a Capstone project when a veteran was placed in a leadership position. Using the tenets of Veteran Critical Theory [45], Mobley and colleagues were able to collect the narratives and counter-narratives of military students in engineering education, anchoring their research process in an asset-based approach [27]. Hood and colleagues [24] created and validated the survey used in their study based on the Professional Social Responsibility Development Model, which was developed in the context of engineering [46], aligning their research with engineering education research as a whole.

Two of the studies included in this review did not explicitly define or describe their theoretical framework, but instead used Grounded Theory Methodology [35] to develop new understandings of the experiences of military students in engineering that are grounded in the data they generated [11], [20]. Three of the studies included did not explicitly define or describe their theoretical framework, nor did they use a methodological framework [19], [21], [30]. Given that empirical research on military students in engineering education is still relatively new (the oldest study in this review was published in 2016), it can be expected that some research would be exploratory, either not relying on theoretical frameworks or making use of a Grounded Theory approach to develop new theories and conceptual models for this topic [47].

Assets-based frameworks

Regardless of theories used, we note that almost all studies included in this review are grounded in an assets-based frameworks. Research that is assets-based acknowledges and looks for the strengths that students bring to their studies [48]. This perspective contrasts to the deficit-based approaches, wherein researchers view the challenges that marginalized or underserved student groups face as indications of the "lack" or weaknesses of that group's, that permeates the current base of research on military students in higher education [49]. This focus on assets-based approaches may be due to the predominantly qualitative nature of the reviewed literature, or the fact that none of the empirical research studies about undergraduate military students in engineering education are more than six years old given the recent shift towards JEDI in engineering education. No matter the cause, this research approach builds a foundation for future research that is both inclusive of and equitable to military students.

Synthesis of Research Outcomes

Our synthesis of this literature points to some key research outcomes that have implications for current teaching practice and ongoing research related to military students in engineering education. These outcomes can be organized into four main categories: factors influencing military and engineering decisions; impact of military and engineering identity; *military student* assets in engineering; and barriers to success in engineering. Table 4 summarizes these key research outcomes.

Table 4

Key Research Outcomes

Factors Influencing Military and Engineering Decisions
Students may purposefully plan to use military service as a means to fund undergraduate *engineering* education [20], [23], [30].
External Factors (i.e., desire for financial stability, mentor advice) may play a substantial role in military students' choice of engineering as a career[1], [12], [20], [22], [26], [31]
Identity
Impacts of Military and Engineering Identities
Military and engineering identity may be more salient for military students than gender or race [18], [26], [27] -except for Black Males [22].
At universities where strong support systems for veterans and military students are already in place, military students may not always utilize these programs due to issues with ease of access [28] or their preference to hide their veteran identity or "self" [15].
Military Student Strengths in Engineering
Including the study of military-specific technology into engineering courses may be one way to engage military students and non-military students together [16], [21], [29].
Military students may excel in both team leadership and team member roles in engineering courses [16], [25].
Military experience can prepare students for engineering through technical experience [18], [23], [29]; leadership and teamwork training [16], [21], [25]; and development of a goal-oriented mindset [14].
Perspectives about Military Student Fit in Engineering
Deficit perspectives and negative stereotypes of military students may exist among faculty, staff and administrators, even those connected to the military themselves, working in engineering degree programs offered within civilian institutinons [11].
Although military experience can prepare students for success in engineering, military students may not see a connection between their military service and engineering until they are enrolled within in engineering programs [1], [23].

The key research outcomes reflect the perspectives used in this set of literature, with a strong emphasis on outcomes emphasizing an asset-based framework. Understanding factors that influence military students' choices to enlist in the U.S. Armed Forces and pursue and undergraduate engineering degree, the impact of identity, and the strengths military students bring to engineering programs provides insight to colleges and universities that can then implement programs and classes to increase participation and retention of military students in undergraduate engineering programs. Specifically, the outcomes of this research suggest that creating recruitment material/programs that emphasize the value of technical military experience in an engineering program and future career can encourage military students to participate in undergraduate engineering programs [1], [15], [20], [23], [26]. Likewise, placing military students in leadership positions and creating courses that implement military-specific technology benefits both military and non-military students [16], [21], [25], [29]. Research also suggests that deficit perspectives regarding military students exist in the context of undergraduate engineering

programs, and universities may need to provide engineering-specific, military awareness training to faculty, staff and administration.

Discussion

In our review, we found that the empirical literature about military students, defined as undergraduate students who are enlisted veterans and/or current servicemembers, who are enrolled in engineering programs at civilian institutions of higher learning began less than a decade ago. While still nascent (and largely the results of a single NSF-funded study), this literature is almost exclusively framed from an assets-based perspective. The literature in this review shows that engineering education researchers are taking a disciplinary lead towards assets-based research with military students; we commend these authors for acting on calls to make engineering education research inclusive and assets-based [50]. The literature in this review also hints a "barely there" emerging use of critical theory in research with military students, as evidenced by the predominance of assets-based approaches and the single article that employs Veteran Critical Theory as its frame [27]. For some, use of critical theories may be seen as a potential next step for research in this area light of evidence of deficit thinking about military students in engineering [22].

Despite locating a limited number of empirical studies that were conducted with military students in engineering contexts, we found that these literatures employed a rich array of (non-critical) theoretical frameworks from the social sciences, including identity-based theories, transition theories, learning theories, and leadership theories, and Grounded Theory Methodology. Coupled with this extensive use of theory, researchers employed numerous, varied, and innovative cross-sectional qualitative research approaches to help them develop nuanced interpretations of military student perceptions and experiences in engineering, as well as perceptions that institutional agents have about military students in engineering. Far less numerous were studies that described and assessed engineering course or program curricula and extracurricular activities that sought to improve military student engagement and persistence in engineering.

Our critique of this literature highlights the limited number of racial/ethnic, and gender, and ability diverse participants studied, the wholly cross-sectional nature of the current studies, the focus on the 4-year "veteran friendly" school context, and the lack of studies that explored the experiences of military student participants who left engineering or college altogether. Along with a predominance of White male participants, these literatures relied on a binary framing of gender. While current research is cross-sectional in nature, some of this research examined constructs (i.e., identity, perceptions of self and experiences) that are mutable and can change or shift over time.

While the 4-year, military supporting institutional context is likely beneficial for participant recruitment, it provides a limited view of the experiences of military students, some of whom choose to attend local community colleges or small, public state college and universities as they transition out of the military into university. While participants who have left engineering are difficult to locate and recruit, the lack of their experiences leaves a marked hole in this research literature. New research contexts (2-year colleges, small 4-year colleges that are not known for

being outwardly or particularly supportive of military students) and approaches to the recruitment of military students into research studies are needed in order fill in our current picture of their experiences.

Conclusions and Implications for Future Research

While still nascent, the literature related to military students in engineering is off to a promising start. This narrative review reports on the small but growing body of research that considers enlisted student veterans and service members as students with unique assets that can potentially improve engineering education for all students, military and civilian. Researchers can use this narrative review to help fill in the gaps and expand this literature to its full potential.

One of the most frequent recommendations for future research expressed by the authors of these review articles is to develop approaches to work with military students who have switched out of engineering majors or dropped out of college altogether, since the perspectives and experience of these military students are currently missing from the literature. This request is a difficult one, given that military students are hard to identify and contact when enrolled in school, let alone after they have left university. We suggest that one approach may be to conduct longitudinal studies with military students, starting as they begin their pre-engineering, first or second years of engineering study. Longitudinal studies may naturally provide opportunities to learn about the experiences of military students who do and do not persist in engineering education.

Along with the perspectives of military student who have left engineering, more research that uncovers the intersectional experiences and perceptions of racial/ethnic, gender, orientation, and ability diverse military students are needed. Participants who reflect the broad demographics of the military population are needed to understand the intersectional experiences of military students who are /have been marginalized along multiple dimensions of identity (i.e., military, race, gender, orientation, ability). While the current research has shown us that recruiting diverse military student participants is difficult, we believe doing so is an absolute necessity for achieving equitable research with military students. Future qualitative studies should purposely sample for racial, ethnic, gender, diversity and all studies should empower participants to self-identity diverse abilities and to represent their gender and orientation along a continuum [51], [52].

Based on our analysis, we also recommend that researchers continue to explore the deficit perspectives and potential biases that institutional agents (civilian and military-connected), across a variety of institutional types, may hold about military students in engineering. It is equally important to begin to contrast these perspectives with military students' own ideas about their fit and capabilities to succeed in engineering. Given findings that institutional agents may view engineering as a career path that is not feasible or viable for military students, deeper understandings of these perspectives, and their influences on military students' decisions to enter or persist in engineering education, may uncover new approaches for supporting military students in engineering (i.e., military assets awareness training).

Last, we see a need for the expanded use of quantitative approaches to research with military students in engineering to determine the broader impact of factors and trends revealed in existing

qualitative studies. Fortunately, by choosing to ground their research in the existing findings from the qualitative studies that are predominantly assets-based, quantitative scholars can avoid taking deficit-based approaches in their work. Given the emerging and nascent state of empirical research related to military students in engineering, future research can use these findings to design new research studies aimed at improving our understandings, developing new courses and programs, and implementing institutional changes to better serve military students in engineering education and, ultimately, increase their participation in the engineering workforce.

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