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Differences in the Self-Perceptions of Resilience, Grit, and Persistence among First-Year Engineering Undergraduates*

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There is a significant demand for science, technology, engineering, and mathematics (STEM) graduates to meet impending workforce needs. However, some research studies seem to indicate that academic and personal challenges deter students from persisting toward degree completion. Resilience and grit are often seen as critical attributes to counter these challenges. By understanding the roles of resilience, grit, and persistence in engineering undergraduates' experiences, institutions can develop, implement, and improve mechanisms that assist in student retention. This work examines the potential differences in the self-perceptions of resilience, grit, and persistence among first-year engineering undergraduates. For this study, we developed an online survey compiled from existing validated scales and administered the survey to first-year engineering undergraduates at a large Midwestern university. An analysis of variance (ANOVA) was performed on a sample of 167 students to determine differences between groups based on sex, grade point average, race, and citizenship. Results indicate that students' resilience and grit may extend beyond their academic experiences. There were also differences among participants' self-perceptions across race and sex when evaluating self-assessment of resilience and among citizenship status when evaluating grit. However, there was no statistical significance found when evaluating persistence contrary to findings from other studies. Additional qualitative research (e.g., interviews) is recommended to understand additional underlying factors of these findings. This study warrants the need for institutions to collectively address the role of resilience, grit, and persistence in the experiences of first-year engineering undergraduates. As a result, this work may assist in identifying strategies that help address the needs of engineering students and support their matriculation into the STEM workforce.

Keywords: engineering undergraduates; persistence; resilience; grit; underrepresented minorities; minoritized populations

1. Introduction

There is great demand for science, technology, engineering, and mathematics (STEM) graduates to meet impending workforce needs [1, 2]. In the United States, approximately 50% of the students entering college as engineering majors complete degree requirements [3]. Existing research examines the retention and persistence levels of engineering students by identifying and promoting strategies that have been shown to improve the performance of women and students of color [4]. When exploring the characteristics of individuals pursuing engineering careers, existing studies focus on persistence, resilience, or other potential factors that drive attraction, retention, and success in STEM careers [3, 4]. Resilience is defined as being successful in school settings despite adversities, persisting in the face of obstacles, or bouncing back from hardship [5, 6]. Qualitative research studies conclude that students' past experiences are potential drivers of resilience [7, 8], but do not consider the roles of grit or persistence in combination with resilience. Grit is the tendency to pursue long-term, challenging goals with perseverance and passion [9]. Studies that explore grit have been conducted on individuals pursuing higher education and concluded that grit was positively correlated to motivators of necessity for males but not females [10]. To our knowledge, there is minimal research that has concurrently examined the relationship of resilience, grit, and persistence to engineering students' experiences. Ohland, Sheppard, Lichtenstein, Eris, Chachra, and Layton (2008) suggest that levels of persistence and engagement factor into students' ability to persevere in STEM fields [4]. Despite the importance of resilience, grit, and persistence to an individual's academic success, the empirical relationship between these three constructs has not been studied in relation to the characteristics of specific undergraduate engineering majors and students' cultures.

In this article, we propose that assessing students' self-perceptions of their persistence, resilience, and grit can provide insights about the retention of engineering undergraduates and the need for institutions to address the needs of various students. The research question guiding this study is *what are the differences in the self-perceptions of resilience, grit, and persistence of first-year engineering under-*

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graduates? In the following sections, we discuss our study of first-year engineering undergraduates' self-perceptions of resilience, grit, and persistence, and explore potential statistical significance among the sample demographics. First, we provide a research overview of student outcomes and the resilience, grit, and persistence of engineering undergraduates. Then, we discuss the methods used to conduct the study and analyze the data. Next, we present the study's findings and differences among participants' self-perceptions about resilience and grit across race, sex, and citizenship. Additionally, we discuss the need to examine resilience and grit in addition to persistence. In sum, we provide a discussion of the findings that emerged and some brief conclusions.

2. Background

2.1 Outcomes for Engineering Undergraduates

Multiple research studies have examined engineering student outcomes with the aim of understanding retention in engineering majors. The focus of such studies relies on identifying individuals with the motivation and capacity to succeed in engineering and finding ways to encourage students to complete such degrees by improving policies and institutional practices [16]. Curricular factors, such as the perception of course work overload, may greatly influence how students navigate and select majors [17]. Astin [18–20] proposed the input-environment-outcome (I-E-O) model as a guideline for studying college outcomes and student involvement. In this model, inputs are defined as demographics, social and academic experiences, and family backgrounds of undergraduates. The environment consists of higher education institutional aspects that can affect the student, such as administrative policies and practices, facilities and physical structures, teaching practices, and peer associations. Together, the inputs and the environment affect the outcomes, which include the undergraduates' characteristics, skills, knowledge, beliefs, values, and behaviors after college. In sum, Astin's work aimed to understand the amount of physical and psychological energy that a student devotes to the academic experience. Self-concept, identity, beliefs, and drive for achievement are some examples of affective or non-cognitive outcomes identified by Astin, Panos, and Creager (1967) [18]. A review of the research on the impact of college on students [21] identifies several factors that affect students' outcomes, such as institution type, college major, and pedagogical approach. While such studies present valuable insight into the engineering undergraduate experience, the roles of persistence, resilience, and grit of these individuals are not studied collectively. Ohland et al. (2008) evaluated the persistence, engagement, and migration of engineering students to other majors [4]. Their conclusion suggested the need for a deeper understanding of engineering students to identify programming to ensure retention and commitment. In addition, they identified a need to develop policies that allow students from non-engineering majors to migrate in. In this work, students' perceptions of their own resilience, grit, and persistence are examined using self-efficacy theory as a lens.

2.2 Resilience, Grit, and Persistence, and their Relationship to Student Experiences and Outcomes

Defined as the ability to recover from hardship, resilience has been studied using quantitative and qualitative methods. Arat and Wong (2018) studied resilience and positive youth development in an attempt to understand ethnic minority youth [7]. The study included interviews of Indian and Pakistani youth and concluded that further research on resilience determinants could provide insight regarding individual-based or socioenvironmental factors. Arat and Wong's study suggests the possibility of an underlying interplay between individuals' traits and socioenvironmental factors. A qualitative study by Ferguson (2016) suggested that the experiences outside of school for 8 African American women in STEM were more important than those that take place in school in identifying the underlying factors in their resilience and persistence [8]. Furthermore, Ferguson (2016) reported that all participants self-reported themselves as resilient [8].

Resilience and grit can be situated in broader contexts in regard to persistence in STEM majors. For example, Ohland et al. (2008) proposed that "engagement is a precursor to persistence" (p. 259), and results indicate that persistence and engagement vary more according to the institution rather than the discipline. In addition, resilience and grit may play a role in the development of community among students, especially minoritized populations. Mondisa & McComb (2015) propose that persistence in STEM majors may be influenced by elements of social community, "an environment in which like-minded individuals engage in multidirectional interactions that facilitate social support" (p. 152). With the intention of understanding and predicting success, Duckworth, Peterson, Matthews, and Kelly (2007) studied grit and found that it was not correlated to IQ but rather to the Big Five Conscientiousness model [9]. The Big Five model has provided a descriptive framework for much of the contemporary empirical work on traits that predict success, and conscientiousness has been

related more robustly to job performance [9]. Duckworth's (2007) findings showed that achieving a long-term goal or difficult goals is not solely based on one's talent but also consistency and determination of the sustained and focused application of talent over time. Additionally, grit has been identified as a characteristic trait of first-generation students [22]. Other studies have concluded that in minority communities such as Latina/o, immigration status affects community members' levels of grit [23]. To our knowledge, grit has not been studied in correlation with other constructs of interest in this study such as persistence and resilience.

Various studies aim to understand persistence in STEM majors, and various conclusions have been reached. Griffith (2010) concluded that female and minority students are more likely to persist in STEM majors in institutions where the demographic majority looks like them [24]. Jones, Ruff, and Paretti (2013) studied the impact of engineering identification and stereotypes on engineering undergraduate women's achievement and persistence and concluded that neither gender identification nor gender stereotype were related to their persistence levels [25]. It was reported by African American women at various levels of higher education that their persistence was influenced by experiences outside of school [8]. Other researchers, like Estrada, Woodcock, Hernandez, and Schultz (2011), have suggested a social influence framework that includes self-efficacy, identity, and values to aid the gaps of persistence in STEM majors [26]. Research studies seem to indicate the need to have a deeper understanding of persistence and other constructs that may influence the attraction and retention of engineering undergraduates. Finally, a recent systematic literature review of first-year engineering students concluded that there is no substantial literature that studies the impact of program design on engineering program outcomes [27].

3. Theoretical Framing: Self-Efficacy Theory

In this work, self-efficacy theory is used as a lens to examine how students perceive their own resilience, grit, and persistence. The American Psychological Association (APA) defines self-efficacy as "an individual's belief in his or her capacity to execute behaviors necessary to produce specific performance attainments" [11]. Perceived self-efficacy can influence coping behaviors, and the study concluded that those who have a sense of collective efficacy will mobilize their efforts and resources to cope with external obstacles to the changes they seek, and those convinced of their inefficacy will cease trying even though changes are attainable through concerted effort [12]. Self-efficacy can also affect entrepreneurial intentions influencing stated occupational interests and occupational choice among college students [13]. Bandura (1977) identifies four information cues regarding the development of self-efficacy: enactive mastery – repeated performance accomplishments; vicarious experiences through modeling; verbal persuasion – convincing people of your capabilities; and physiological state – the perception of state [14]. Self-efficacy beliefs can also be strong predictors of individuals' levels of accomplishments [15]. As stated by the APA, self-efficacy may play a role in undergraduates' experiences, as it "reflects confidence in the ability to exert control over one's motivation, behavior, and social environment" [11]. Thus, self-efficacy was used as a lens for interpreting and discussing study findings to help us understand how students perceive their own sense of beliefs about their personal resilience, grit, and persistence abilities.

4. Methods

In this exploratory study, we collected quantitative data to examine the differences in first-year engineering undergraduate students' self-perceptions of their resilience, grit, and persistence. Prior to conducting the research, the University of Michigan Institutional Review Board approved this study as Exempt. A survey instrument was developed using items from existing validated scales, and data was collected using an online Qualtrics survey to maintain the anonymity of participants. Participants received no financial compensation for completing the survey. Exploratory and confirmatory analyses were conducted to analyze the data.

4.1 Recruitment and Selection of Participants

The study participants are first-year engineering undergraduates at the University of Michigan. The survey was distributed to five course instructors during the fall and winter semesters of 2017 and 2018. There are approximately 14 types of ENGR 100 courses with approximately 60–100 students in each course. The ENGR 100 course is a required first-year course for engineering undergraduate majors. Depending on the time the survey was taken by participants, they may have not declared their specific engineering major. The instructors solicited were colleagues of the second author who taught the course. Instructors were asked to share a link to the study's Qualtrics survey with their students via the online component of their course websites.

4.2 Characteristics of the Sample Population

A total of 188 responses were eliminated from the data: 9 were students who were not first-year engineering undergraduates and 12 were students who did not complete the survey in its entirety. The total sample is n = 167. The ages of the respondents ranged from 17 to 19 years old with a mean age of 18.28 (SD = 0.52). Of these responses, 61.08% (n = 102) were males and 38.92% (n = 65) were females. In terms of grade point average (GPA), 53.95% (n = 82) reported a GPA less than or equal to 2.50 and 46.05% (n = 70) reported above 2.50.

The racial makeup of the sample is 66.47% White/Non-Hispanic, 23.95% Asian, 1% Black or African American, 8.38% Hispanic or Latino, and 1% people who selected multiple racial categories or American Indian or Alaska Native, Native Hawaiian, or Pacific Islander. The University is classified as a predominately White institution. The sample population's racial makeup is similar to the racial makeup of the University's student enrollment, according to the Office of Diversity, Equity, and Inclusion of the University of Michigan [28]. Given the large proportion of White/Non-Hispanic responses compared to all other groups, analyses were conducted with two groups: ''White/Non-Hispanic'' and ''Other,'' which is equivalent to all the remaining racial categories (i.e., American Indian or Alaska Native, Asian, Black or African American, Hispanic or Latino, and Native Hawaiian or Pacific Islander). The population is comprised of 94.54% United States citizens and 1.80% United States permanent residents. Neither United States citizens nor residents comprise 4.79% of the study sample.

4.3 Data Collection

An online survey instrument, referred to herein as the Resilience, Grit, and Persistence (RGP) scale, is a compilation of three existing scales. Questions from the RGP scale were adapted by combining survey items from existing validated instruments for measuring 12 items of resilience [29], 10 items of grit [9], and 16 items of persistence [30]. The RGP scale consists of a total of 45 survey items. Seven items surveyed demographics and academic information, including whether the student was a first-year undergraduate in an engineering program, sex, race, age, citizenship, academic level classification, and GPA. The remaining 38 items use a 5-point Likert scale ranging from Strongly Disagree/Not like me at all equal to zero (0) to Strongly Agree/Very much like me equal to four (4). For the ''Grit'' survey items, 1 through 6 responses were reverse coded, as per the original scale. Descriptive statistics and statistical analysis were assessed in R, a programming language and software environment for statistical computing and graphics.

4.4 Data Analysis

A three-phase data analysis was conducted in R. Phase one consisted of exporting the survey responses from Qualtrics and assigning a numerical value of 0 to Strongly Disagree/Not really like me at all, 1 to Disagree/Not like me, 2 to Neutral/Somewhat like me, 3 to Agree/Mostly like me, and 4 to Strongly Agree/Very much like me. The grit scale contains 10 items, out of which items 1 to 6 were reversed coded; hence, the numerical value of 0 was attributed to Strongly Agree/Very much like me, 1 to Agree/Mostly like me, 2 to Neutral/Somewhat like me, 3 to Disagree/Not much like me, and 4 to Strongly Disagree/Not like me at all. After attributing corresponding numerical values to the responses, statistical analysis was conducted to obtain descriptive statistics. Overall descriptive statistics were obtained for each construct or factor evaluated (resilience, grit, and persistence). Phase two consisted of an exploratory factor analysis run for the 38 items in the RGP survey attributing to 3 factors: resilience, grit, and persistence. Exploratory factor analysis was applied to explore any cross-loading occurring among items' responses while providing evidence of construct validity of the self-reported survey, in order to allow the formation and fine-tuning of the RGP scale [31]. Based on item loading among factors, a smaller model was built for all items with single loading equal or greater to 0.3 following inclusion criteria outlined by Taherdoost, Sahibuddin, and Jlaliyoon (2014). Confirmatory factor analysis was then used to evaluate alternative reduced models of the RGP scale. The RGP scale reduced model goodness-of-fit was assessed with the comparative fit index (CFI) and Schwarz's Bayesian information criterion (BIC). Lastly, phase three consisted of performing an ANOVA to test differences among survey responses for each construct or factor (i.e., resilience, grit, persistence) based upon demographic categories: sex, GPA, race, and citizenship. All of the hypotheses tests were performed at a 95% confidence level.

5. Results

To analyze the survey data, we conducted exploratory and confirmatory factor analyses and an ANOVA. A total of 188 responses were received. Incomplete surveys were eliminated. Those responses from students that did not fit the first-year engineering undergraduate criteria were also eliminated. After data cleaning, the total sample size was 167 completed surveys from first-year

Table 1. Mean Values for the Constructs

Overall	Resilience		Grit		Persistence	
n	Mean	(SD)	Mean	(SD)	Mean	(SD)
167	3.03	(0.77)	2.41	(0.92)	2.57	(0.86)

Table 2. Descriptive Statistics by Demographic Category

Demographic Categories		n (%)	Resilience Mean (SD)	Grit Mean (SD)	Persistence Mean (SD)
Sex	Male	102 (61.08)	3.10 (0.77)	2.40 (0.96)	2.62 (0.91)
	Female	65 (38.92)	2.91 (0.76)	2.41 (0.85)	2.51 (0.77)
GPA	Less than or equal to 2.50	82 (53.95)	2.99 (0.79)	2.41 (0.91)	2.57 (0.84)
	Greater than 2.50	70 (46.05)	3.09 (0.76)	2.38 (0.94)	2.56 (0.88)
Race	White, Non-Hispanic	111 (66.47)	3.03 (0.75)	2.45 (0.92)	2.54 (0.85)
	Other	56 (33.53)	3.02 (0.81)	2.32 (0.91)	2.65 (0.87)
Citizenship	U.S. Citizen	156 (94.54)	3.04 (0.77)	2.40 (0.92)	2.58 (0.86)
	U.S. Permanent Resident	3 (1.80)	3.00 (0.91)	2.89 (0.57)	2.67 (0.68)
	Neither	8 (4.79)	2.90 (0.83)	2.42 (0.99)	2.48 (0.86)
Race and Sex	White, Non-Hispanic, Male	59 (35.33)	3.12 (0.76)	2.42 (0.97)	2.59 (0.91)
	White, Non-Hispanic, Female	52 (31.14)	2.94 (0.72)	2.42 (0.85)	2.47 (0.77)
	Other, Male	43 (25.75)	3.08 (0.77)	2.31 (0.92)	2.66 (0.89)
	Other, Female	13 (7.78)	2.81 (0.89)	2.38 (0.87)	2.63 (0.79)

engineering undergraduates. Responses were evaluated based on the study's constructs: resilience, grit, and persistence and as per demographic groups: sex, GPA, race, and citizenship. In other words, responses were divided among constructs and analyzed as per different demographic groups. Results include statistical significance among sex and nonwhite students for resilience and among citizenship for grit, as well as no statistical difference among any of the demographics for persistence. Descriptive statistical analyses of the study's constructs including mean and standard deviation values are displayed in Tables 1 and 2. The mean value of resilience rated the highest (3.03) followed by persistence (2.57) and grit (2.41). In particular, males rated almost higher in RGP than females. For the racial demographics, Whites/non-Hispanics rated higher in resilience and grit while the group designated as Other (all other self-reported races besides white) rated higher in persistence. These trends were also noticed when comparing the descriptive statistics of race and sex combined. Citizenship demographics displayed higher resilience for U.S. citizens and higher grit and persistence for U.S. permanent residents.

Response patterns by demographics for the RGP scale shown in Fig. 1, were plotted to allow visual examination using R (version 3.5.1) Likert package [32]. In Fig. 1, each construct response was represented individually. Responses of Strongly Disagree/Not like me at all are on the left side of each graph, while Strongly Agree/Very much like me are on the right side, and the Neutral/Somewhat like me category is in the middle for each plot. Percentages included group responses in three main groups: Disagree, Unsure, and Agree, located left, middle, and right, respectively. Fig. 1 shows that, in general, first-year engineering undergraduates' self-perceptions report resilience, grit, and persistence levels greater than 2 (Neutral/Somewhat like me).

5.1 Exploratory and Confirmatory Factor Analysis

With means of ensuring three constructs (resilience, grit, and persistence) in the administered RGP scale, an exploratory factor analysis on all responses was executed in R using a psych package [33]. All 38 question responses of the 167 completed surveys were used to run an exploratory factor analysis of three factors with varimax rotation in R. Table 3 shows the factor loading for each question/item and construct/factor. Questions that loaded at 0.30 or greater were assigned to that construct [34]. Multiple questions loaded on more than one construct: in those cases, the questions were assigned to the construct with the highest loading. Questions with loading below 0.30 were dropped. The remaining questions were used to build an embedded RGP model. The embedded model includes 26 questions (8 grit, 10 resilience, and 8 persistence questions). Then, confirmatory factor analysis was performed to examine the fit of the data to a three-factor model. Confirmatory factor analysis was also executed in R using a lavaan package [35]. Effectively, the CFI increased after dropping questions with loadings lower than

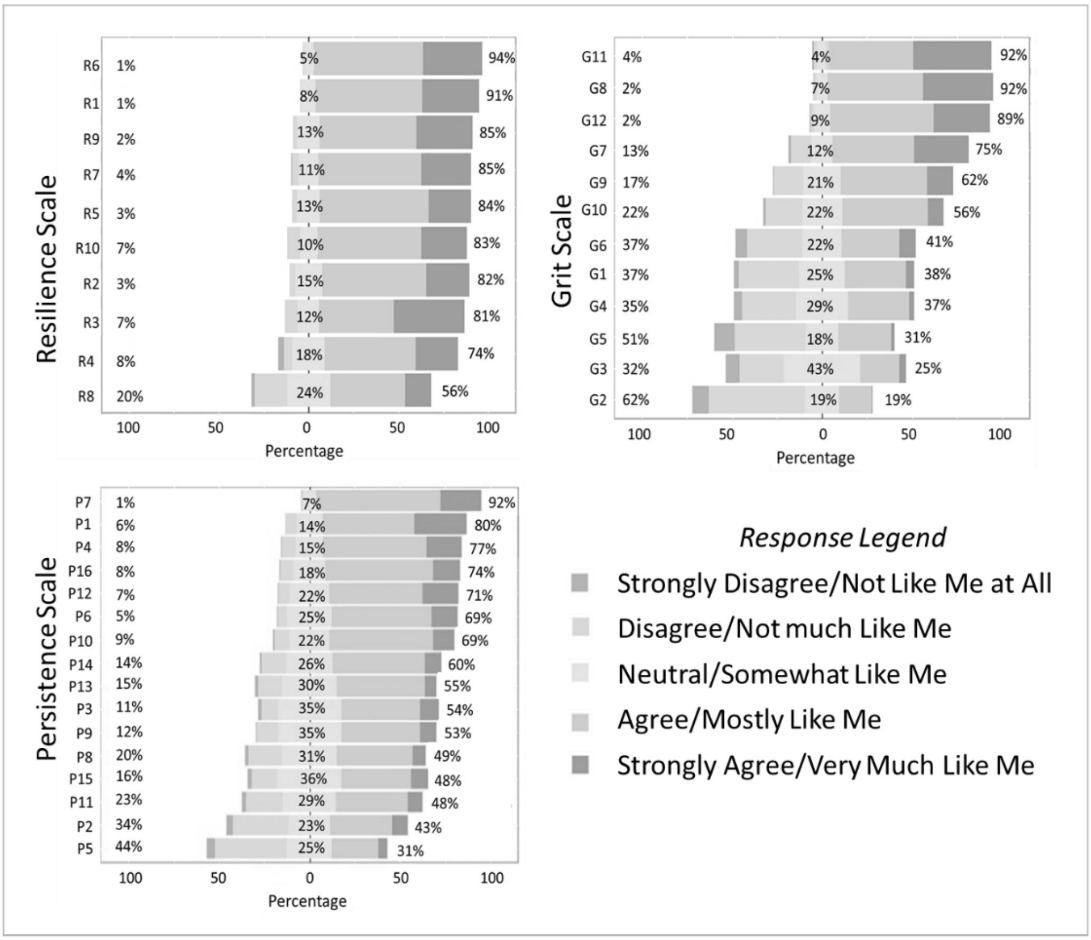

Fig. 1. Distribution of responses to resilience (R), grit (G), and persistence (P) items of the RGP scale.

0.30, and the BIC value followed the same trend as the CFI (Table 4).

5.1.1 Analysis of Variance

Several ANOVAs were conducted to compare mean differences across demographics of first-year engineering undergraduates' responses (Table 5). Results indicated statistical significance among students' citizenship responses regarding grit, $F(2, 22) = 4.85$, $p < 0.05$. Also, when evaluating the combined demographic categories of "Race and Sex", a statistical significance difference was found among the "Other, Male" and "Other, Female" groups, $F(1, 18) = 9.37$, $p < 0.05$ for the resilience construct. Finally, the combined "Overall" demographic categories of Race and Sex showed statistical significance of $F(3, 36) = 3.54$, $p < 0.05$ for resilience as well.

6. Discussion

This work seems to suggest that some first-year engineering minoritized and non-domestic undergraduates have differing levels of resilience and grit, respectively, that may influence their persistence and overall college experience. First, we found that White males and females had slightly higher levels of perceived resilience than underrepresented minorities. In contrast to other research studies, this difference may suggest that individuals' ability to recover from academic challenges may differ based on race and sex/gender. Second, non-U.S. citizens had higher perceived levels of grit, which seems to suggest that students' citizenship status may impact their efforts to pursue engineering degrees. Additionally, we provide an overview of the importance of persistence as related to the study's findings as well as a brief discussion of survey fatigue as a potential study limitation.

6.1 Differences among Participants' Self-Perceptions across Race and Sex

There may be differences in academic resilience among students as related to race and sex. The resilience of engineering undergraduates may be impacted by the demographic makeup of the insti-

Table 3. Resilience, Grit, and Persistence Scale Constructs, Questions, and Factor Loadings

Construct and Question	Factor Loadings		
	Factor 1	**Factor 2**	**Factor 3**
R1: I am able to adapt to change.	**0.681**		
R2: I can deal with whatever comes.	**0.617**	0.131	
R3: I try to see the humorous side of problems.	**0.323**	–0.222	0.105
R4: Coping with stress can strengthen me.	**0.44**		0.103
R5: I tend to bounce back after illness or hardship.	**0.443**		
R6: I can achieve goals despite obstacles.	**0.709**	0.116	
R7: I can stay focused under pressure.	**0.474**	0.256	
R8: I am not easily discouraged by failure.	**0.562**	0.208	
R9: I think of myself as a strong person.	**0.628**	0.136	
R10: I can handle unpleasant feelings.	**0.424**		
G1: I often set a goal but later choose to pursue a different one.[RC]		**0.618**	–0.14
G2: New ideas and new projects sometimes distract me from previous ones.[RC]		**0.601**	
G3: I become interested in new pursuits every few months.[RC]		**0.672**	
G4: My interests change from year to year.[RC]		**0.633**	
G5: I have been obsessed with a certain idea or project for a short time but later lost interest.[RC]		**0.643**	
G6: I have difficulty maintaining my focus on projects that take more than a few months to complete.[RC]	0.248	**0.576**	
*G7: I have achieved a goal that took years of work.**	0.324	0.138	0.132
*G8: I have overcome setbacks to conquer an important challenge.**	0.426		
G9: I finish whatever I begin.	0.227	**0.441**	0.29
*G10: Setbacks don't discourage me.**	0.498	0.118	
G11: I am a hard worker.	0.348	**0.352**	0.106
*G12: I am diligent.**	0.464	0.208	
P1: Long-term purposes motivate me to surmount day-to-day difficulties.	0.288	0.244	**0.371**
P2: Even though it doesn't matter anymore, I keep thinking of personal aims that I had to give up.	–0.195	–0.166	**0.612**
P3: Once I decide to do something, I am like a bulldog: I don't give up until I reach the goal.	0.33	0.39	**0.37**
*P4: I make sure that what I set myself to obtain in several months or years is realistic.**	0.101	0.184	
P5: I often find myself thinking about older initiatives that I had abandoned.	–0.219	–0.375	**0.615**
*P6: I continue a difficult task even when others have already given up on it.**	0.456	0.232	0.279
P7: I purposefully pursue the achievement of the projects that I believe in.	0.324	0.178	**0.354**
*P8: It's hard for me to detach from an important project that I had given up in favor of others.**	0.195	0.392	
P9: The more difficult a task is, the more determined I am to finish it.	0.336	0.225	**0.45**
*P10: I remain motivated even in activities that spread over several months.**	0.335	0.306	0.27
*P11: From time to time, I imagine ways to use opportunities that I have given up.**	–0.273	0.68	
*P12: I have a high capacity to focus on daily tasks.**	0.261	0.165	
*P13: I can easily realize when to stop in the pursuit of important personal objectives.**	0.149		
P14: I often come up with new ideas on an older problem or project.	0.169	–0.204	**0.45**
P15: I keep on investing time and effort in ideas and projects that require years of work and patience.	0.398	0.178	**0.433**
P16: I keep track of the things I promised myself to acquire at some point.	0.224	0.229	**0.316**

* Indicates removed from the embedded model.

[RC] Participant responses were reverse coded for grit questions G1, G2, G3, G4, G5, and G6 due to their phrasing. When participant response is negative (e.g., Not like me at all OR Strongly Disagree), it is recorded as the opposite in order to create a cohesive set of responses.

Table 4. Confirmatory Factor Analysis Metrics

Metric	Base Model	Embedded Model
CFI	*0.614*	*0.776*
TLI	*0.59*	*0.754*
BIC	*15096.187*	*10358.998*

Table 5. Analysis of Variance per Construct and Demographic Categories

Demographic Categories		Resilience F value (p-value)	Grit F value (p-value)	Persistence F value (p-value)
Sex	Male Female	3.168 (0.092)	0.077 (0.785)	0.598 (0.452)
GPA	Less than or equal to 2.50 Greater than 2.50	1.068 (0.315)	0.007 (0.936)	0.033 (0.858)
Race	White, Non-Hispanic Other	0.028 (0.869)	0.552 (0.470)	0.423 (0.526)
Citizenship	U.S. Citizen U.S. Permanent Resident Neither	0.402 (0.673)	**4.849** **(0.018)**	0.017 (0.983)
Race and Sex	White, Non-Hispanic, Male White, Non-Hispanic, Female	2.167 (0.158)	0.007 (0.934)	0.501 (0.491)
	Other, Male Other, Female	**9.37** **(0.0067)**	0.369 (0.553)	0.293 (0.597)
	White, Non-Hispanic, Male Other, Male	0.196 (0.663)	0.895 (0.36)	0.158 (0.697)
	White, Non-Hispanic, Female Other, Female	1.117 (0.305)	0.036 (0.852)	0.397 (0.539)
	Overall	**3.539** **(0.0241)**	0.344 (0.794)	0.461 (0.712)

Bolded items are statistically significant.

tution. In contrast to existing studies [36–38] that demonstrated no significant difference in academic resilience among sex (gender), resilience and race/sex were found to be statistically significant in this study. This seems to suggest that underrepresented minority groups, classified as "Other" in our study, may be exposed to other experiences outside of school that may influence their self-perception of resilience. Thus, examining the intersectional experiences of minoritized populations like Black women may provide insights about the relationship of gender and resilience to learning outcomes, persistence, graduation, and professional self-confidence. A study presented by Ro and Loya (2015) showed women assess their engineering learning outcomes lower than men but assess their professional learning outcomes higher [39]. Additionally, an intersectional approach showed that Black women tend to rate their contextual competence and communication skills lower than their White counterparts [39]. On the other hand, there was no difference in self-assessed learning outcomes between Latinos/as and Whites, except that Latinas rated themselves higher in leadership skills. In sum, further analysis and qualitative studies are needed to identify the underlying factors for the statistical significance of our study when evaluating race and sex. Additionally, the socioenvironmental factors and individual traits of the subjects may play a fundamental role in understanding resilience among first-year engineering undergraduates.

6.2 Citizenship: A Relationship to Grit?

From the study, perceived levels of grit seem to be higher among non-U.S. citizen, first-year engineering undergraduates, which suggests that participants' backgrounds or experiences as international students may influence their grit. In our study, citizenship was classified into three categories: U.S. citizens, U.S. residents, and neither of the previous categories. Although the majority (95%) of the participants self-reported as U.S. citizens and roughly 34% reported their race as other than White, it is imperative to note that those participants from minority groups shape their personal aspirations based on their social commitments [40]. Also, we must consider an underlying factor might be that some of our participants may be first-generation students. Hodge, Wright, and Bennett (2018) reported that there is a positive relationship between an increased level of grit and the individual being the first in their family to attend college [22]. A quantitative and qualitative study among non-citizen and citizen Latina/o first-

generation college students demonstrated that immigrant status plays a role in the grit and depression of the participants [23]. The qualitative component of this study revealed that citizens use different channels for support, but non-citizens only look for support from family [23]. Such findings indicate that a qualitative study (i.e., interviews) is needed to provide a deeper understanding of the relationship of citizenship to grit. Additionally, there is a need for institutions to address the need for a sense of community among students. Our results align with Hodge et al. (2018) with no difference in grit among the participants by sex. Additionally, grit has been shown to demonstrate an incremental predictive validity of success measures [9]. Further study may be intuitive in the outcomes of first-year engineering students and their retention and graduation rates.

6.3 A Need to Examine Resilience and Grit, Not Just Persistence

Although persistence did not appear to be significant, there are potential underlying factors to investigate related to resilience and grit. Multiple studies aim to understand persistence, specifically in underrepresented minority groups and among females. Research indicates minority and female students are more likely to persist in a STEM major at institutions with a high number of STEM graduate students that look like them [24]. Hence, the environment of the institution and the STEM department can have a strong impact on students. Additionally, empowering underrepresented minorities with the skills, identities, and values of scientists and engineers can result in a sense of inclusion into these communities, enhancing their likelihood of greater persistence [26]. Recommendations provided by Estrada et al. (2011) include increasing institution accountability, creating strategic partnerships to lift students' interest, commitment, and ability to persist using the curriculum, addressing student resource disparities, and awakening the creativity in students as the framework to increase persistence in STEM careers [26]. On the other hand, a qualitative study on African American women by Ferguson (2016) suggests that factors related to or having an impact on persistence rely on their experiences outside of school [8]. Expanding our study to include interviews may provide insights about internal and external factors that affect the persistence of first-year engineering undergraduates.

Finally, we need to also consider the role of potential survey fatigue among our study participants due to the length and similar language of some of the questions. Porter, Whitcomb, and Weitzer (2004) studied multiple surveys of students and survey fatigue and concluded that survey fatigue affected non-Whites more than Whites [41]. This may be an underlying factor for which persistence was not statistically significant. Such an assumption takes us back to the demographic makeup of our participants. Conducting the study at a predominately White institution (PWI) may affect our results, since it has been shown that institutional context plays a role in undergraduates' experiences, especially for underrepresented minorities such as Hispanic non-traditional students [42]. Additional qualitative research may provide new findings and a better understanding of the lack of statistical difference among the construct of persistence and possible underlying relationships to the other constructs.

7. Limitations and Future Research

7.1 Study Limitations

This study was not without limitations. With a cross-sectional nature, this study limits the possibility of drawing full conclusions about the causative nature of effects, despite the theoretical support for these ideas. Limitations of this study include its sample size, and a lack of demographic diversity in regard to female-to-male ratio and racial makeup. All underrepresented minorities are combined together into one group given the small sample size in which the numbers of these groups are limited, despite being representative of the institution's engineering undergraduate population. Another potential limitation is that grit as a construct may have issues with predictive validity and confounding. Recent work suggests that Duckworth's Grit Scale may have some confounding items and contradictive empirical evidence [43]. Yet, for this study, grit is a useful indicator of perseverance and passion that provides insight into engineering retention with limited value due to the high levels of self-awareness required and reverse coding to positively account for undergraduates' responses.

7.2 Future Research Recommendations

Future research recommendations for this work include conducting interviews with first-year engineering undergraduates to address potential underlying factors affecting their self-perceptions of resilience, grit, and persistence. Conclusions from Ohland et al. (2008) revealed that retention of engineering undergraduates is not a major cause of persistence deficiencies. The reverse relationship remains unanswered, can the lack of persistence, resilience, or grit affect the retention rate of engineering students? Collecting more data but using the survey with reduced items as per exploratory

and confirmatory factor analysis to examine constructs, is also recommended. Additionally, the comparison of these results with studies of more diverse engineering programs may answer questions regarding the self-perceptions of underrepresented minorities. For example, comparing the results of PWIs to Historical Black Colleges and Universities and other underrepresented minority programs could potentially address the impact that an institution's context has on first-year engineering undergraduates relative to the study's constructs. Such a study could result in guidelines on how institutions can be more inclusive, increase retention rates, and promote community and success for racially minoritized populations.

8. Conclusions

In this article, we examine how first-year engineering undergraduates self-report their levels of resilience, persistence, and grit, and how possible aspects of these constructs may explain their self-beliefs, how they assess themselves, and how institutions might address the needs of various student communities. Results show that undergraduates' resilience and grit extend beyond academics. Racial identities and external experiences seem to affect undergraduates' personal aspirations and perceptions of themselves. Additionally, other studies align with ours when evaluating resilience and how racial identities and sex/gender play an important role. Recognizing that experiences for our participants are different and affected by attending a PWI must be included as we further study resilience and grit in first-year engineering undergraduates. Institutions must provide attention to the needs of underrepresented minorities in an effort to attract and retain these groups and ensure their success in engineering careers. The literature recognizes that minoritized communities refer to their family as their immediate support system. Community programs and inclusion of family may aid in the transition of students into undergraduate life. Additionally, we show how citizenship may be related to students' levels of perceived grit. Although additional qualitative research is required to understand the underlying factors of these findings, some inferences that we can make are that the sense of security or insecurity possibly related to their residential status affects the way they shape and see their goals. Again, it is important for institutions to address this issue to ensure the retention and support of first-year engineering undergraduates, as the need for engineering graduates continues to rise with dismal numbers of underrepresented minorities. Identifying these factors will not only benefit the STEM community but also the integrity and well-being of the individuals pursuing such careers.

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