Exploring the Relationships Between Resilience and Student Performance in an Engineering Statics Class: A Work in Progress

Dr. Peter H. Carnell P.E., University of Georgia

Peter Carnell is a Senior Lecturer at the University of Georgia. He has been a licensed professional engineer for over 20 years and seeks ways to bring his work experience into the classroom. He has taught at UGA for 4 years and prior to that taught at Georgia Tech for 8 years. His areas of interest include mechanics, design and engineering education.

Dr. Nathaniel J Hunsu, University of Georgia

Nathaniel Hunsu is currently an assistant professor of engineering education at the University of Georgia. He is affiliated with the Engineering Education Transformational Institute and the school electrical and computer engineering at the university. He holds a Bachelor's degree in electronic and computer engineering from the Lagos State University in Nigeria, a Masters in Project management from the University of Sunderland, and a PhD in Educational Psychology from Washington State University. His research interests include learning and cognition, students' engagement, and the assessment of learning and students engagements, in engineering classrooms. His expertise also include the development and validation of measurement inventories, systematic reviews and meta-analysis, and quantitative research designs.

Davis F Ray, The University of Georgia

Passionate about bringing lasting change to the built environment, I desire to learn more about sustainable systems through an economic lens that will enable clean solutions for the future. I am currently studying for my BS in mechanical engineering, and in the coming years, I will be pursuing my MS in environmental economics to build on my understanding of economic theory and its application to sustainable business models, specifically in the renewables sector. Moving towards this, I serve as an Undergraduate Researcher within the Engineering Education Transformations Institute, a funded educational development program that seeks to promote diversity and improve transdisciplinary collaboration within the college. Specifically, I serve on the Resilience in Engineering Education Project team aimed to investigate the effects that students' resilience and professional skills have on exam performance in technical courses.

Dr. Nicola W. Sochacka, University of Georgia

Nicola W. Sochacka is the Associate Director of the Engineering Education Transformations Institute (EETI) in the College of Engineering at the University of Georgia. Dr. Sochacka's research interests span interpretive research methods, STEAM (STEM + Art) education, empathy, diversity, and reflection. She holds a Ph.D. in Engineering Epistemologies and a Bachelor of Environmental Engineering from the University of Queensland.

Exploring the relationships between resilience and student performance in an engineering statics class: A work in progress

Abstract

Prior studies have identified the importance of resilience to success both in life and in the workplace. Resilience is also a valued professional skill for academic achievement and student retention in cognitively demanding disciplines such as engineering. However, only limited efforts have been made to characterize how resilience impacts the academic engagement, performance, and retention of engineering students. This study is the first in a program of studies that will map academic resilience, through the measurement of "protective factors" such as optimism and adaptability, with academic performance, as well as identify students at risk of dropping out of their engineering major. In this exploratory study, we examined differences in a group of engineering students on four resilience measures. Participants included 111 engineering students enrolled in six sections of statics taught by one instructor. Participants completed the Psychometric Project Resilience Scale (PPRS) survey online as well as the academic performance requirements for the course. The 50-item instrument surveyed students on five constructs indicative of resilience: adaptability; self-sufficiency; self-control; optimism; and persistence. Learning performance was based on three mid-examinations intended to assess students' knowledge of the course. The psychometric properties of the instrument used to assess resilience factors were examined and student groups were compared on resilience and performance measures. Results of the study showed that transfer students seemed to struggle more with resilience and academic performance. Differences between gender and race groups in terms of resilience and academic performance were insignificant. Implications of study findings and direction for future studies of resilience among engineering students are discussed.

Introduction

For many students, engineering statics is a critical step along the path toward becoming an engineer. The range of challenges students face when they learn statics threshold concepts has motivated a significant body of research in this area. These studies focus on: the link between statics and student persistence [1]; factors that influence student performance [2]; conceptual misunderstandings [3]; concept inventories [4]; and interventions designed to improve student learning [5]. A common thread across these studies is the focus on analytical problem solving. As Litzinger et al. [6] stated in their cognitive study of problem solving in statics: "Even as expectations for engineers continue to evolve to meet global challenges, analytical problem solving remains a central skill." Similarly, Higley et al. [5] shared the same perspective; they noted that "although non-technical skills are increasingly important to successful engineering careers in the global marketplace of today, problem-solving remains a critical skill for most young engineers." One could interpret these statements to mean that non-technical skills are subordinate to analytical problem solving. In this study, we explore another proposition. More specifically, we propose that intrapersonal skills [7], such as adaptability, self-sufficiency, persistence, and optimism, which are facets of a multi-dimensional concept called resilience, play an instrumental role in achieving success in core engineering courses. Put another way, we hypothesize that students with higher levels of resilience will be better able to navigate the cognitive challenges they encounter than students with lower levels of resilience. We hold that resilience is essential to the development and formation of the professional engineers of the future. As such, we suggest that finding ways to inculcate professional skills such as resilience, along with the kind of technical skills taught in courses like statics, may help more students to succeed through engineering degrees, be better prepared to engage with challenges in engineering workplaces, and be adaptable to the changing landscape of global engineering practice. In this paper, we describe our first efforts to explore this novel approach toward supporting student success in core engineering courses.

Literature Review

Definitions

Resilience generally refers to a process of adapting well in the face of adversity and significant stress [8]. It is often described in terms of "bouncing back" from difficult experiences [e.g., 9, 10, 11]. Resilience is a multidimensional construct [12] that is defined differently depending on the context in which it is investigated. For example, in a study of how children develop resilience, Maclean [13] discussed a wide range of factors including self-esteem, self-efficacy, locus of control, initiative, faith and morality, trust, affection, safe environment, autonomy, identity, and more. In an educational context, resilience has been defined as the "the heightened likelihood of success in school and in other life accomplishments, despite environmental adversities" [14]. Similarly, Novotný and Kreménková [12] described academic resilience to "represent a state, in which the child (from an *at-risk* group) achieves much higher educational goals than the average output common of children in similar groups." Despite the varying definitions of resilience in the literature, it is mostly conceptualized to entail exposure to adversity or risk and the attainment of positive adaptation or competence [15]. In the context of our study, we conceived "adversity" to include stressors and challenges that students face as they progress through engineering statics. While we recognize, of course, that different students face additional and diverse stresses outside of the classroom, at the current stage of our research agenda we are less focused on extracurricular stressful conditions in students' lived experiences and more focused on how they "bounce back" from adverse academic conditions, using engineering statics students as a case in point. Martin and Marsh [16] defined this focus on "students' ability to successfully deal with academic setbacks and challenges that are typical of the ordinary course of school life (e.g., poor grades, competing deadlines, exam pressure, difficult schoolwork)" as academic buoyancy.

In order to differentiate academic buoyancy from resilience, Martin and Marsh [16] argued that *academic buoyancy* might be the more appropriate construct to describe the comeback students make when they experience less debilitating, but considerably demotivating stressful situations such as "isolated poor grades and 'patches' of poor performance." Faced with such adverse academic situations, some students adopt maladaptive behaviors (e.g., self-handicapping and anxiety) that further impair their chances of succeeding in their chosen engineering majors. In contrast, resilient students would adopt adaptive behaviors, for example, persistence, planning, optimism, and self-determination, among others [8]. We argue that students with high levels of resilience are better able to come back from initial academic stresses, while those who are less resilient may decline in their academic performance, lose interest in their major, and consequently consider dropping out of their engineering program.

Measurement approaches

As noted above, resilience is most commonly defined as a process of positive adaptation following exposure to risk or adversity. However, resilience itself is never directly measured in the literature [17]. On the contrary, it is inferred from the assessment of one or more of three distinct variables: adversity; positive adaptation; or protective factors. Adversity may include life conditions or occurrences that are associated with maladjustment in critical domains [18]. Sarkar and Fletcher [15] described three approaches typically used to measure adversity in empirical studies: multiple-item checklists of negative life events; single life occurrences; and the simultaneous consideration of multiple risks to form an overall adversity estimate. In our study, we took poor grades on early assessment in the semester as an indicator of adversity. We based our conclusion on the fact that most students who withdraw from the course do so right after they receive the result of their first exam in the course.

Positive adaptation has been conceived as adapting that is “substantially better than what would be expected given exposure to the risk circumstance being studied” [17]. In our study, we operationalized positive adaptation as how students who performed poorly early in the semester did or did not bounce back in subsequent assessment items.

The majority of resilience research focuses on the measurement of the third and final dimension, protective factors. These are those factors that protect individuals from, or enable them to recover from, the stressors they encounter [e.g., 19, 20]. These factors include optimism, perseverance, internal locus of control, self-efficacy, adaptability, and perceived social support, among others [15]. Protective factors may be viewed as intrinsic characteristics of those people identified, or extrinsic factors, such as social support, that facilitate resilience.

The Present Study

In addition to being a prerequisite for multiple junior and senior level courses at our institution, statics also serves as a gateway course for an assured place in the program—it is one of a limited number of courses that are used to determine students’ ability to continue past the third semester as part of a high-demand major management process. This added pressure, combined with the challenging nature of the course itself, leads some students to withdraw, while others stay and struggle. Although technical skills are imperative to success in a course such as statics, we believe that professional skills such as resilience may be invaluable in fostering the comeback that is essential to success in engineering statics, future coursework, and subsequent engineering careers.

In this exploratory study, the first in a series of studies within a research agenda on academic resilience, we examine the relationships between the protective factors associated with resilience and student academic performance across a semester. To facilitate our exploration, we examined how different student groups, who may respond differently to academic stressors, compared on four protective factors associated with resilience and performance on three mid-semester examinations, in order to provide us with preliminary insights into future studies of academic resilience in the professional formation of engineers.

Methods

Participants

Participants were 111 undergraduate students (83 males and 28 females) enrolled across six sections of an engineering statics course at a major southeastern public university. All six sections were taught by the same instructor. Seventy percent of the participants identified as Caucasians. Thirty percent of the participants identified as transfer students from other institutions. Participants responded to an online resilience survey early in the semester prior to getting their scores on any of three mid-semester exams that form part of the course assessment. Data from all students who consented to be part of the study were included. This included 111 students for Exam 1, 110 students for Exam 2, and 105 students for Exam 3. Participation was entirely voluntary; no items on the survey were mandatory.

Materials

Performance Measures: As part of the assessment requirements in the course, students took three mid-term examinations, in the 4^{th}, 8^{th}, and 12^{th} weeks of the semester. Each exam was scored as a percentage scale and students' scores on each exam counted toward their final grade in the course. Students also had homework grades and a final examination, but those were not included at this stage of our study. Each exam measured students' ability to bring their knowledge of physics and mathematics to bear on increasingly complex engineering problems, from particle equilibrium in two dimensions, to rigid bodies in three dimensions, and systems of rigid bodies that perform an engineering function (e.g., trusses, frames and machines).

The Instrument: The *Psychometric Project Resilience Test (PPRT)* is a five-scale resilience test comprising 50 self-report statements, with 10 items per subscale [21]. Items were measured on a 5-point Likert scale ranging from 1 to 5 (with 1 being *"very inaccurate"* and 5 being "*very accurate"*) of how well each statement was true of them. The sub-scales included five protective factors relevant to resilience—adaptability (ADT), self-control (SCTRL), self-sufficiency (SSUF), optimism (OPT) and persistence (PERS). For example, ADT1 probed participants' ability to "adapt easily to new situations," while OPT2 examined participants' propensity to "look on the bright side of life." Please refer to the Appendix for further examples of items in selected categories.

Resilience test results were shared with each student and presented as professional skills that students should be aware of and should also consciously develop during their undergraduate studies. In addition, some aggregated results were presented to the entire class with a brief discussion of how differences in traits might affect performance in statics. Care was taken to emphasize places where a perceived weakness might hide a complimentary strength. For example, low adaptability might be associated with an increased ability to adhere closely to rules and regulations. Our goal was to motivate students to think about the importance of such skills where they can make an immediate impact on their performance and development. We contend that students will be more successful the earlier they identify and embrace their strengths and find work-around strategies for their weaknesses.

Coupled with the PPRT, we also administered a survey consisting of 10 questions to better understand the participants' abilities to self-assess. The first five questions directly asked students about their adaptability, self-sufficiency, self-control, optimism, and persistence. The second five questions looked at aspects of accurate self-assessment, such as "knowing your strengths and weaknesses", "knowing how you will respond emotionally," and "what motivates you." In our analyses for this study, we compared how students responded to the 50 less direct questions in the PPRT to how they responded to the five direct questions and used the root-mean-square differences as a measure of their ability to self-assess.

Procedure

Participants received a link to the PPRT survey in the third week of the class, prior to taking their first midterm exam. The survey prompt asked students to assess how well each statement on the survey was reflective of them. Statements were framed positively and negatively so that "very accurate" (5 on the Likert scale) was not consistently associated with high resilience. The survey was described as a measurement of professional skills that are crucial to their success as engineering professionals. The survey began with the prompt below:

> Please take 10 minutes to answer the following 50 questions. There are no right or wrong answers. Focus on how you currently think about these things and not how you think you should answer them.

After completing the survey, each student received a 1 through 5 score that represented their overall resilience and also their score on each of the five subscales (adaptability, self-sufficiency, self-control, optimism, and persistence). The goal was to start students thinking about skills that are valued by employers and how these skills are tools for success, much like the traditional problem-solving skills that are so often emphasized. In addition, aggregated data from across all sections was presented and discussed with students as part of whole-of-class discussions.

Analysis and Results

We conducted two phases of data analysis: first to explore the structural validity and the reliability of the instrument that was used in this study, because we found no data about the psychometric properties of the instrument before we administered it to students. Next, we conducted comparative analysis of sub-groups within our sample to explore patterns in student performance and measures of resilience.

Exploratory Factor Analysis (EFA)

We conducted an EFA using Principal Axis Factoring to extract factors on the 50-item instrument. Extracted factors were rotated based on Oblimin rotation procedure in SPSS®. When conducting factor analysis, items with similar variance in participants' responses tend to cluster together—suggesting that they are defined by a similar latent factor [22]. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.743. This suggests that the sampled data were sufficient for conducting EFA. Bartlett's test of sphericity was $\chi2$ (55) = 2701.93, $p < 0.01$, indicating that patterned relationships exists between items. Many of the items on the instrument were poorly correlated with most other items and were deleted from our analysis as recommended in the literature [23]. Items with a factor loading below a threshold of 0.4 were also deleted. In all, 18 items measuring four factors were retained for the analysis conducted in this study.

Scale Reliability

We also examined the internal reliability coefficient of the 18 items loading onto the four factors derived from the EFA. The reliability coefficient of each sub-scale is shown in Table 1. Scales are considered to have desirable internal reliability reliable at Cronbach's α = 0.70 or greater (Streiner, 2003). The reliabilities of adaptability and self-sufficiency was marginally below 0.70. The other two exceeded the threshold for good reliability. Please note that examples of the items below are given in the Appendix.

Table 1: Item mean and scale reliability

Item Designation	Mean	Std. Deviation	Cronbach's α
OPT2	3.83	1.07	
OPT4	4.00	1.10	
OPT6	4.23	0.81	0.84
OPT8	3.97	1.01	
OPT10	3.95	1.07	
PERS3	4.28	0.91	
PERS4	4.17	0.97	
PERS5	3.98	0.91	0.86
PERS6	4.12	0.87	
PERS9	3.84	0.90	
SSUF2N	2.30	0.96	
SSUF4N	3.08	0.98	0.67
SSUF10N	2.20	1.17	
ADT1	3.82	0.88	
ADT3	3.79	0.82	
ADT5	3.61	1.11	0.67
ADT7	3.46	0.99	
ADT9	3.72	1.02	

Sub-Group Comparisons

We conducted multivariate analysis of variance in order to examine sub-group differences on the four resilience factors and students' academic performance. We identified four groups for comparison based on: mode of college entry; gender; race; and students' ability to self-calibrate resilience factors.

Mode of College Entry: We examined differences between transfer and non-transfer students on the resilience measures and academic performance. Transfer students often face stressful situations because of the demand of integrating into a different school culture (Laanan, 2001). We conducted MANOVA analysis to compare transfer and non-transfer students on resilience measures and exam performance. Differences between transfer and non-transfer students on the sub-scales and the composite resilience score were not significant, $F(1, 109) = 1.124$, $p < .001$; Wilk's $\Lambda = .96$, $\eta^2_p = .343$. However, we observed that transfer students rated consistently lower on all measures of resilient factor than non-transfer students (see Table 2). In contrast, differences between the groups were statistically significant across the three performance tests $F(1, 103) = 6.06$, $p < .001$; Wilk's $\Lambda = .764$, $\eta^2_p = .99$ (see Table 2).

Table 2a: Resilience factors of Transfer and Non-transfer students

	Transfer Student		Non-transfer Student	
	M	*SD*	*M*	*SD*
ADPT	18.00	3.77	18.58	2.89
OPTMS	19.67	4.34	20.13	3.82
PERST	19.55	4.44	20.74	3.26
SSUFF	7.45	2.53	7.63	2.40

Table 2b: Exam performance of Transfer and Non-transfer students

	Transfer Student		Non-transfer Student		*Effect size (d)*
	M	*SD*	*M*	*SD*	
Exam 1	61.81	14.90	74.22	11.89	- .97
Exam 2	66.32	12.45	75.33	13.13	- .70
Exam 3	64.84	11.97	77.86	11.25	- 1.14

Gender: We examined whether there were differences across genders on the resilience and performance measures. There were no statistically significant differences in all resilience factors except self-sufficiency. Female students rated as feeling more self-sufficient than male students $F(1, 109) = 19.95$, $p < .01$. There was no gender difference across the three exams. Descriptive data by gender is provided in Table 3 below.

Table 3a: Resilience factors by gender

	Female		Male	
	M	*SD*	*M*	*SD*
ADPT	17.79	2.75	18.61	3.29
OPTMS	20.32	3.92	19.88	4.00
PERST	20.64	2.95	20.30	3.90
SSUFF	9.21	2.15	7.02	2.27

Table 3b: Exam performance by gender

	Female		Male	
	M	*SD*	*M*	*SD*
Exam 1	68.54	11.94	71.25	14.70
Exam 2	71.46	12.62	73.08	13.90
Exam 3	71.89	9.91	74.75	13.80

Race: We examined whether there were differences across race on the resilience and performance measures. No statistically significant differences were found between students who identified as Whites and the other cluster of races on the three exams (please refer to Table 4a below). On the other hand, these students rated consistently lower than their White counterparts on three of the resilience factors (Table 4b below).

Table 4b: Exam performance by race

	White		Non-Whites		
	M	*SD*	*M*	*SD*	*p*
Exam 1	71.34	13.74	68.50	14.88	-.19
Exam 2	73.42	13.65	70.50	13.37	-.20
Exam 3	75.29	12.28	70.93	14.18	-.34

Table 4b: Resilience factors by race

	White		Non-Whites	
	M	*SD*	*M*	*SD*
ADPT	18.68	3.23	18.06	2.62
OPTMS	20.59	3.57	18.68	4.56
PERST	21.01	3.66	18.97	3.39
SSUFF	7.26	2.48	8.24	2.22

Initial Performance Struggle: We conducted descriptive analysis to determine whether students who performed poorly on the first exam differed on the resilience scores. Students who scored less than 62% on the first test but improved over the semester were termed "Soaring," while students with low scores on Exam 1 and whose performance faltered over the course of the semester were termed "Struggled." Students in the soaring category seemed to have also rated highly on three out of four measures of resilience (see Table 5).

Table 5: Resilience factors by initial low performance groups

		Mean	Standard Deviation	*n*
ADT	Struggled	17.62	4.89	13
	Soaring	18.10	3.31	10
PERS	Struggled	19.23	4.82	13
	Soaring	21.60	2.76	10
OPT	Struggled	19.23	5.40	13
	Soaring	21.00	2.21	10
SSUF	Struggled	7.85	2.30	13
	Soaring	6.50	2.37	10

Ability to self-calibrate resilience factors: Lastly, we examined how participants' assessment compared to their performance on the first exam. The purpose of this analysis was to explore whether there are any relationships between students' self-conception and their performance. We grouped participants based on how their responses to the items on the sub-scales (they were unaware of what those items were intended to assess) compared to their responses to direct statements about each of the five factors of resilience our study was about. We calculated the root-mean-square difference between their scores on the "indirect" and "direct" responses about adaptability, self-sufficiency, self-control, optimism, and persistence. The quintile of participants that had the greatest consistency in their responses performed markedly better on exams, as illustrated in Figure 1.

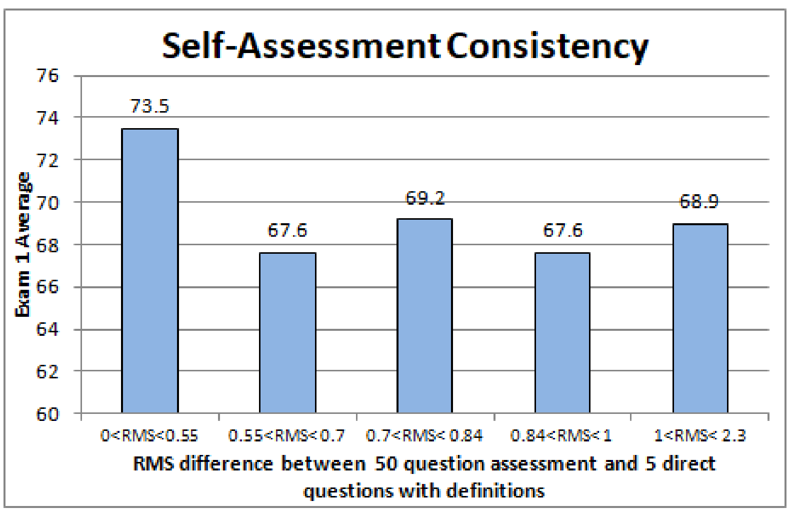

Figure 1: Self-Assessment Consistency and Exam 1 Performance

Discussion

This present study is the first of a research agenda intended to study academic resilience among engineering students. In this exploratory study, we compared groups of students that could differ in their responses to academic stress on protective factors that foster resilience and student performance. Prior to the comparison, however, we conducted a factor analysis to explore the psychometric soundness of the instrument we used in this study. We could only use four of the five sub-scales (comprised of 18 items) for our analysis. Given the exploratory nature of this analysis, the 18 items were sufficient for the intent of this study.

Although differences in the resilience factors of transfer and non-transfer students were not statistically significant, we did observe that transfer students rated consistently lower on all four measures of resilience compared to non-transfer students. This pattern is particularly interesting in light of the statistically significant differences that were found between the academic performance of transfer and non-transfer students. Although the effect sizes of group differences on the resilience factors were relatively small, effect sizes observed between the means of the groups on the three exams scores are worth investigating further. One could theorize that the transfer students were less prepared for the course and had lower prior knowledge.

The descriptive data indicated that students in the Soaring category may indeed have shown more resilience than those who struggled through the course. Soaring students rated consistently higher on all measures of protective factors of resilience except self-sufficiency. This might indicate that these students use adaptive learning strategies and are able to seek help when necessary, compared to students who felt self-sufficient despite their learning difficulties. We hope to further examine the study strategies and learning goals of these categories of students in future studies to better understand resilience-performance relationships.

There were no statistically significant differences between gender and racial groups on the three mid-term exams. However, groups differed on some resilience factors. Female students reported being more self-sufficient than males, while students who identified with other minority groups rated less on optimism and persistence. Although students of the minority ethnic groups rated lower on the mid-term exams, differences between these groups on the exams were not as pronounced as for the transfer students, considering effect size. Because academic stress may be particularly pronounced for transfer students, we hope to further examine the links between direct measures of academic stress, protective factors, and academic achievement in the future.

The self-assessment consistency results suggest that it may be equally important to help participants better understand their existing strengths and weaknesses. One possible explanation for the results in this area is that students who know themselves better are more able to play to their strengths and develop effective work-around strategies for their weaknesses.

One of the motivations for doing this work is to help us identify the relationships between academic resilience and student performance. We anticipate that this will be helpful in identifying and assisting students who might be handicapping themselves in how they respond to academic stress. We also seek to identify students who might be at risk of dropping out of engineering because they cannot adequately negotiate initial stressful situations. We hope that the findings of this study and our subsequent plan of work will be invaluable in developing more effective support for engineering students.

Limitations and Future Direction: We could not completely utilize the 50-item resilience instrument we chose for this study because many of the items would not load together as the instrument suggests. Although we conducted our analysis using a redacted version of the instrument based on our psychometric analysis of the PPRT, we will consider using alternate test instruments with more established records of use within the extant resilience literature in future studies. Within this program of research, we intend to examine the relationships between academic resilience, student performance, and student attrition in engineering courses. We also intend to study how protective factors (both personal and institutional), motivation, academic stress factors, and students' aptitude predict academic performance, engineering identity, and future dropout.

This exploratory analysis revealed interesting patterns in the resilience and exam performance of transfer students in our study. However, we cannot make strong claims about the nature of differences between these groups of students because we did not have adequate baseline data on our participants. We will endeavor to obtain institutionally available data (e.g. SAT scores, Social Economic Status [SES] data, and relevant demographic data) in future studies. Research has shown that poor academic performance is one of many reasons why students drop out of STEM career programs [22]. Aside from transfer students who may experience high stress due to changing school cultures, students who perform poorly on initial exams may suffer from poor self-esteem and doubt their ability to succeed in engineering. Such self-doubt may result in emotional disengagement with learning tasks. Disengaged and poor-performing students are often at risk of withdrawing from engineering courses, such as statics, that they deem to be cognitively challenging. Because resilience is particularly relevant for students who experience initial poor performance, we will study the resilience/academic performance relationships of students who struggle initially in statics and either persevere or withdraw. Differentiating among those who initially struggle will help us better understand the mental attitude and coping strategies of resilient students.

References

[1] W. H. Goodridge, I. Villanueva, B. J. Call, M. M. Valladares, N. Wan, and C. Green, "Cognitive Strategies and Misconceptions in Introductory Statics Problems," in *IEEE Frontiers in Education Conference*, Madrid, Spain, 2014, pp. 1-4: IEEE.

[2] E. Anderson, R. Taraban, and D. Hudson, "A Study of the Impact of Visuospatial Ability, Conceptual Understanding, and Prior Knowledge Upon Student Performance in Engineering Statics Courses," in *American Society of Engineering Education 2009 Annual Conference & Exposition*, Austin, Texas, 2009, pp. 14.119.1 - 14.119.10, 2009.

[3] B. C. James, W. H. Goodridge, and C. Green, "Strategy, Task Performance, and Behavioral Themes from Students Solving 2-D and 3-D Force Equilibrium Problems," in *2015 ASEE Annual Conference & Exposition*, Seattle, Washington, 2015, pp. 26.1405.1 - 26.1405.15: ASEE, 2015.

[4] P. S. Steif and M. Hansen, "Comparisons Between Performances in a Statics Concept Inventory and Course Examinations," *International Journal of Engineering Education,* vol. 22, no. 5, pp. 1070-1076, 20 November 2005 2006.

[5] K. Higley, T. Litzinger, P. Van Meter, C. B. Masters, and J. Kulikowich, "Effects Of Conceptual Understanding, Math And Visualization Skills On Problem Solving In Statics," in *American Society for Engineering Education Annual Conference & Exposition*, Honolulu, HI, 2007.

[6] T. A. Litzinger *et al.*, "A Cognitive Study of Problem Solving in Statics," *Journal of Engineering Education,* vol. 99, no. 4, pp. 337-353, 2010.
[7] J. Pellegrino, "Integration of Teaching, Learning, and Assessment: A Design-based Approach," presented at the American Society for Engineering Education Annual Conference & Exposition, Columbus, OH, 2016.
[8] A. J. Martin and H. W. Marsh, "Academic resilience and its psychological and educational correlates: A construct validity approach," *Psychology in the Schools,* vol. 43, no. 3, pp. Pages 267–281, 10 February 2006 2006.
[9] N. Galli and R. S. Vealey, "Bouncing Back from Adversity: Athletes' Experiences of Resilience," *The Sport Psychologist,* vol. 22, no. 3, pp. 316-335, September 2008 2008.
[10] G. Netuveli, R. Wiggins, S. Montgomery, Z. Hildon, and D. Blane, "Mental health and resilience at older ages: bouncing back after adversity in the British Household Panel Survey," *Journal of Epidemiology and Community Health,* vol. 62, no. 11, pp. 987-991, 2008.
[11] B. W. Smith, J. Dalen, K. Wiggins, E. Tooley, P. Christopher, and J. Bernard, "The brief resilience scale: Assessing the ability to bounce back," *International Journal of Behavioral Medicine,* Journal Article vol. 15, no. 3, pp. 194-200, September 01 2008.
[12] J. S. Novotný and L. Kreménková, "The Relationship between Resilience And Academic Performance at Youth Placed at Risk," *Ceskoslovenska Psychologie,* Feature vol. 60, no. 6, p. 14, 2016 2016.
[13] K. Maclean, "Resilience: What it is and how children and young people can be helped develop it," *eJournal of the International Child and Youth Care Network (CYC-Net),* no. 62, March 2004 2004.
[14] M. C. Wang, G. D. Haertel, and H. J. Walberg, "Toward a Knowledge Base for School Learning," *Review of Educational Research,* vol. 63, no. 3, pp. 249-294, September 1, 1993 1993.
[15] M. Sarkar and D. Fletcher, "How Should We Measure Psychological Resilience in Sport Performers?," *Measurement in Physical Education and Exercise Science,* vol. 17, no. 4, pp. 264-280, 2013/10/01 2013.
[16] A. J. Martin and H. W. Marsh, "Academic buoyancy: Towards an understanding of students' everyday academic resilience," *Journal of School Psychology,* vol. 46, no. 1, p. 30, February 2008 2008.
[17] S. S. Luthar and L. B. Zelazo, "Research on resilience: An integrative review," *In Resilience and Vulnerability: Adaptation in the Context of Childhood Adversities,* pp. 510-550, 1/1/2003 2003.
[18] A. S. Masten, "Ordinary magic: Resilience processes in development," *American Psychologist,* vol. 56, no. 3, pp. 227-238, 2001.
[19] K. M. Connor and J. R. T. Davidson, "Development of a new resilience scale: The Connor-Davidson Resilience Scale (CD-RISC)," *Depression and Anxiety,* vol. 18, no. 2, pp. 76-82, 2003.
[20] G. M. Wagnild and H. M. Young, "Development and psychometric evaluation of the Resilience Scale," *Journal of Nursing Measurement,* vol. 1, no. 2, pp. 165-178, 1993.
[21] Open Psychometric Test Resource, "50 Item Resilience Questionnaire," Accessed on: 15 July 2017Available: https://www.psychometrictest.org.uk/resilience-test/

[22] S. Takahira, D. J. Goodings, and J. P. Byrnes, "Retention and Performance of Male and Female Engineering Students: An Examination of Academic and Environmental Variables," *Journal of Engineering Education,* vol. 87, no. 3, pp. 297-304, 1998.

[23] A. G. Yong and S. Pearce, "A beginner's guide to factor analysis: focusing on exploratory factor analysis. Tutorials in quantitative methods for psychology." vol. 9 no. 2, pp. 79-94, 2013.

Appendix

Representative statements from selected subscale categories

Statement ID	Statement
ADT1	Adapt easily to new situations
ADT3	Am good at taking advice
ADT5	Can stand criticism
ADT7	Respond well to change
ADT9	Can handle opposition
OPT2	Never give up hope
OPT4	Love life
OPT6	Work on improving myself
OPT8	Feel comfortable with myself
OPT10	Look on the bright side of life
PERS3	Am a hard worker
PERS4N	Feel that work is not an important part of my life
PERS5	Finish things despite obstacles in the way
PERS6N	Put little time and effort into my work
PERS9	Accomplish a lot of work
SSUF2N	Need protection
SSUF4N	Often need help
SSUF10N	Am easily moved to tears

Notation	Description
ADT	Adaptability Subscale
OPT	Optimism Subscale
PERS	Persistence Subscale
SCTR	Self-control Subscale
SSUF	Self-sufficiency Subscale
#	Statement number within subscale (1 - 10)
N	Indicates negatively-framed statement