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Board 370: Relationship between Mindset and Grit on Undergraduate Engineering Student Retention

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Relationship between *mindset* and *grit* on undergraduate engineering student retention

Introduction

The Bureau of Labor Statistics (BLS) reports that employment in STEM occupations has grown 79% since 1990, from 9.7 million to 17.3 million in 2018. Forty-five percent of STEM employment is from information technology (IT) and 19% is related to engineering [1]. The workforce in IT and engineering is predominantly male; less than 28% of the total IT workforce and only 12% of engineers are female [2]. By the time students reach college, 1 in 5 young men plan on majoring in engineering or computing while only 1 in 17 young women declare the same [3]. Since 1990, the percentage of female computing professionals dropped from 35% to about 24% today, and if that trend continues, the share of women in the nation's computing workforce will decline to 22% by 2025 according to Girls Who Code [4]. These statistics provide the motivation for a program called *Project-based Work Studio (PWS)* developed at a mid-sized Appalachian primarily undergraduate university supported by an NSF S-STEM grant to build a more proportionate female workforce in computer science, engineering, and technology by focusing on recruiting, retaining, and graduating low-income female students.

The PWS model is based on a Project-Based Learning approach to help students develop technical and professional skills through real-world project experiences under faculty mentorship building a successful pipeline to the workforce from the college. The PWS program supports 2-cohorts of incoming students (2021 N=10 and 2022 N=9) through scholarships, coursework, and projects mentored by faculty from computer sciences and engineering. Students have participated in a 1-credit hour course each semester focusing on building and supporting students' growth mindsets and recognition of the importance of grit through the examination of two books, Carol Dweck's *Growth Mindset: A New Psychology of Success* and Duckworth's *Grit.*

The following sections describe this work. We begin with a brief rationale for this PWS to provide hands-on learning opportunities to support student persistence in the field. Then, we describe our intervention, which includes academic and social student support, as well as our participants, who primarily come from central Appalachia. After these descriptions, we provide details about our research methodologies that include both qualitative and quantitative data and analysis. We conclude with suggestions for future work and further improvements that we are implementing to build more inclusive and supportive environments for computer science and engineering students.

Rationale

The research was conducted on how female and low-income students function in a cooperative, learner-based studio environment and advance understanding of the role different levels of mentorship (peer, senior members, assistants, and faculty) play in the PWS model and how it impacts the performance of female members of the cohorts. By working together in a team-based environment, the PWS built strong connections among the PWS scholar cohort. The PWS is developing well-rounded students who are afforded hands-on experiences, and the opportunity to work in multi-disciplinary team environments and gain exposure to real-life projects in computer science, engineering, and technology. These experiences, combined with professional development and mentorship, will enable scholars to become strong members of the STEM workforce upon graduation.

This research is designed to measure the effectiveness of the PWS approach in student retention, developing their growth mindsets and grit, and advancing job placement of students, especially women in STEM. For our research, we utilize the "persistence framework," which demonstrates the interconnectedness of confidence: belief in one's ability, motivation as the intention to take action towards a goal, learning as acquiring new knowledge and/or skills, and professional identification as one's feelings of being a scientist [5]. As shown in Figure 1, this framework provides an integration of research in both psychology and education to guide both the development and implementation of efforts to increase the persistence of college students in the STEM fields [6]. More persistence of workforce deficit [7].

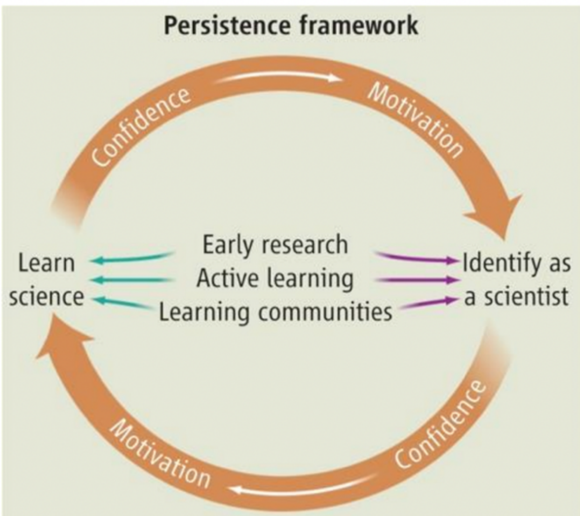

Figure 1. Persistence framework

Of the three million students who enter US colleges intending upon pursuing a STEM degree, less than half persist until graduation [8]. For those considered under-represented such as women, and racial and ethnic minorities, the exit rate is especially high even though these students make up 68% of all college students in the US [9]. STEM initiatives that seek to improve persistence, and therefore improve retention in the STEM fields, must be careful to address both learning (as skill acquisition) and professional identity development. Research about highly successful STEM programs have revealed that three interventions are widely recognized for retaining STEM students: **(1) early research experiences, (2) active learning in introductory courses, and (3) membership in STEM learning communities** [7]. This program provided students access to all three and our research efforts focused on the success/challenges of each. The PWS research, categorized as "efficacy research," focused on two groups of participants: (1) particularly, the students who leave the program and (2) and the longitudinal experiences of the first-year students who participate in the seminar course. Despite our real-time intervention attempts, we anticipate that program attrition would be inevitable and focused our research on better understanding contributing factors to inform mitigation.

Mindset

The first psychosocial belief guiding this work is the role of our intelligence beliefs and whether individuals believe that our intelligence is fixed/unchangeable (fixed mindset) or malleable/ changeable (growth mindset) [10]. Much research has found that individuals with a more fixed mindset tend to give up when they face challenges or obstacles. In contrast, individuals with a more growth mindset tend to view challenges as an opportunity to improve [11-13]. More recent research has focused on the role of mindset on STEM academic performance, particularly because STEM students face unprecedented academic challenges. Cromley found that a stronger growth mindset was linked with lower rates of attrition in a biology course [14] and Lytle and Shin found that a more growth mindset served as a key predictor for STEM interest and engagement among first-year undergraduate STEM students [15]. Beyond students' mindsets, their perception of their professors' mindsets may influence their mindsets and persistence to overcome challenges. Students who perceive that their educator endorses more of a fixed mindset may also experience negative impacts on their mindset [16]. The intelligence beliefs related to mindset are measured with an 8-item Likert scale developed by Dweck that includes statements like "You have a certain amount of intelligence, and you really can't do anything about it" [10].

Grit

The psychosocial parameter called grit describes an individual's perseverance and passion for longer-term goals [17]. As a relatively newer construct, grit has shown great promise in predicting an individual's academic achievement. Duckworth and other researchers have shown that grit is a better predictor of educational outcomes and success over traditional measurements like IQ [17-18]. More recent research has connected grit with mindset and STEM retention/success. Hunter found that those students considered higher in grit were able to remain interested in their courses and be retained in STEM [19]. Grit consists of two dimensions that were measured in this study: perseverance of interest and passion or consistency of interest [17]. Perseverance of interest entails an individual's ability to keep working towards long-term goals while consistency/passion of interest captures an individual's ability to maintain their interest and pursue similar activities over time. Perseverance of interest has been shown to be a more reliable predictor of academic outcomes than consistency/passion of effort [20]. The 8-item Likert Grit Scale was used in this study which consists of two factors: perseverance of effort and consistency/passion of interest.

The following research questions were addressed with our preliminary study after our first year of work. For students enrolled in the program:

RQ1 *What is the relationship between mindset/grit and STEM retention/success? And how do students describe their mindset/grit when they face academic challenges?*
RQ2 *What is the relationship between their mindset/grit and reason for leaving the program? And what reasons do students provide for leaving the program?*
RQ3 *What are the internal and external challenges that students face throughout the program?*

Intervention & Participants

Participants

The PWS program selected 10 students in fall 2021 as the first cohort and another 9 students in fall 2022 as the second cohort among the academically talented high school candidates with financial needs pursuing engineering or computing-related degrees. The first cohort (N=10) of participants included 8 females, 3 first generation, 2 Pell-eligible, 2 underrepresented minorities, and 1 neurodiverse. The second cohort (N=9) of participants included 8 females, 3 first generation, 6 Pell-eligible, and 1 underrepresented minority.

Course description
The PWS offered a one-credit required seminar course per semester for students in years one (2021-2022) and two (2022-2023). The series consisted of lectures and hands-on activities, promoted professional development, and prepared students for real-world projects. (See Tables 1 and 2.) Weekly seminars for PWS scholars included speakers from University service offices (such as Financial Aid, tutoring services, Career Resources, etc.) and industrial partners who addressed issues, ranging from gender segregation and cultural mismatch of women to navigating and succeeding in the current engineering culture [21]. Orienting scholars enabled them to become socialized in the discipline and familiar with the range of PWS support services available. In addition, this orientation supported a better understanding of the project portfolio, working in a team environment, and preparing for internships and summer jobs. In Year 1, most topics were covered through lectures and activities by faculty and mentors. In each session, scholars shared their stories from their PWS projects to support learning from one another. As a culminating semester program with family members, mentors, and community partners in attendance, final group presentations enhanced teamwork and communication skills with industry partners improving students' understanding of the importance of career development in the early stages. The fall seminar will consist of social events, lectures, and hands-on activities; final group presentations (topics selected by scholars) will enhance teamwork and communication skills.

Table 1. PWS First Semester Course

Week	***Topic***
Week 1	Introduction/Surveys
Week 2	Feelings of Belonging & Mindsets
Week 3	How People Learn
Week 4	Communication in the College Environment
Week 5	Project Introduction
Week 6	Invited Guest Speaker from local industry
Week 7	Metacognition & Study Skills
Week 8	Workplace Fundamentals / Project Review
Week 9	Mindset & Response to Failure
Week 10	Research & Ethics
Week 11	Registration & Semester Preparation
Week 12	Self-care & Stress Management
Week 13	Field Trip
Week 14	Practice Presentation & Feedback
Week 15	Project Presentation with Families/mentors Dinner

The spring seminar (see Table 2) focused on professional development by introducing attitudes and behavior appropriate to the workplace. With daily changes in technology and required skills, PWS scholars need to learn and be committed to becoming independent, lifelong learners. Field trips, arranged with industry partners, complemented classroom learning; while working with community partners help PWS scholars to learn how to serve the community through their profession.

Table 2. PWS Second Semester Course

Week	***Topic***
Week 1	Introduction
Week 2	Technology Training
Week 3	Healthy relationship building
Week 4	Time management
Week 5	Resume Writing and Job Interview Preparation
Week 6	Invited Guest Speaker from local industry
Week 7	Influencing People
Week 8	Leadership & Delegation
Week 9	Project Progress Report
Week 10	Entrepreneurship
Week 11	Accountancy & Budgeting
Week 12	Diversity & Gender issues in professions
Week 13	Health & Safety
Week 14	Field trip
Week 15	Project Presentations

Project-based Work Studio environment

Experiential learning incorporates hands-on learning and reflection on learning [23]. A principal challenge that STEM students face is the lack of hands-on experience that enables them to connect what they learn in the classroom with real-world applications. Many pedagogical methods have been proposed to fulfill this need. Examples include a Mobile Hands-On STEM (MHOS) pedagogy for large lectures in teaching electrical engineering, Project Based Learning (PBL) in teaching engineering design, Discovery Learning in Cyber Security Education [21-22], and Studios in Software Engineering education [23-27]. Research shows that unique learning environments with integrated learning studios such as the contemporary architectural studio model in North America, improve students' learning experiences [28]. In the 1990s, the University of Colorado at Boulder introduced the Studio model for their first-year engineering students, which resulted in improved retention rates (80% of students retained up to the third year of the program) [29]. More recently, the University of Michigan introduced Smart Surfaces courses based on the Architecture Design Studio model, which showed significant increases in communication, creative thinking, and critical thinking over the other courses [30].

For the last four years at our university, the Computer Sciences & Electrical Engineering Department has run a hands-on public service research studio. Prior to this S-STEM award, this has enabled seniors and graduate students to work on projects that provide engineering/technical solutions to local industries. With the support of the S-STEM award, the freshman scholars joined the PWS. Support from NSF (through this S-STEM) has provided an opportunity to: (a) ensure a consistent and diverse pipeline of well-prepared students for careers in STEM, (b) generate new knowledge on pedagogical strategies, efficacy research and (c) establish new and expand/strengthen existing university-industry-state partnerships to overcome key challenges and sustain the work. This work is expected to build a stronger and more sustainable Studio environment at the college level. Most importantly, this grant has provided the opportunity to study the effectiveness of the Studio in students' professional development and retention.

The learning of skills of the PWS follows a three-step process: observe, do, and teach. First-year students "observe" a project process, sophomores carry out (or "do") the design and prototype development process, and juniors or seniors lead (or "teach") the project and mentor junior members. In the first year, 10 students were recruited to form the first cohort, and another cohort with 9 students followed in the second year. Broadly, in the first year, PWS scholars mainly were assigned to existing projects in the college and the second cohort was primarily integrated into the projects with the first cohort as mentors. PWS scholars worked on conceptual design - identifying a need, identifying key stakeholders, developing appropriate specifications, proceeding through the concept selection phase, and generating project solutions.

The PWS is not only a project-conceptualized space, but it is a physical collaborative shared space as well. A separate collaborative room with multiple work areas was assigned to the PWS where PWS scholars worked together, engaged in group discussion, conducted research, met with faculty mentors and senior students, and designed/implemented/tested solutions. Team presentations and critiques were scheduled throughout the semester to assess the team's progress. Learning and experimental tools included access to computer and engineering labs, programming, modeling, and simulation software licenses, and material and workshop access for 3D prototyping. The PWS equipped PWS scholars to carry on and complete the projects in a timely manner by engaging them in current STEM challenges as part of a collaborative team with peer and faculty mentorship.

Methods

Data collection

To address our research questions, Experience Sampling Methods (ESM) was used. ESM is a methodology concerned with collecting repeated points of data over a period of time and/or following events. ESM was proposed by London, Rosenthal, and Gonzalez as a method with the potential to provide more detailed experiences of women in STEM fields and to administer more tailored interventions [31]. This methodology engaged both qualitative and quantitative data as it relates to the persistence framework and mindset. Students were prompted monthly to complete an electronic journal that included both open and closed-ended questions regarding their experiences within the PWS program, as well as other relevant variables related to persistence. The open-ended questions allowed students to self-report their feelings, behaviors, and thoughts in their everyday life. The closed-ended questions evaluated more targeted experiences with brief Likert scale questions such as: "I am excited about the courses I am enrolled in?" or "I feel that I have benefitted from the PWS lessons this week?" These journal entries were set up as an assignment for students in the Professional Development seminars in the first and second years to reflect on seminar content, other course work, and personal experiences. ESM compared students enrolled in the program and those who choose to leave. ESM also permitted more fine-grained analysis for students in STEM education, as well as providing short- and long-term longitudinal questions about STEM engagement in a natural context. ESM has the potential to capture the course of engagement and disengagement within the STEM fields [31]. Research conducted by Seron, Silbey, Cech & Rubineau served as our guide to focus research efforts on the challenges associated with socialization and gender issues as students develop their professional identity, which will lead to valuable data about the challenges our students face [32].

Qualitative data was collected from students in three different ways. The first was through the ongoing journal entries. Students were made aware that none of these surveys were anonymous. This was done deliberately to provide "just in time" intervention if we were concerned about a student, as well as to triangulate the responses from their Mindset Assessment Profile and their quantitative perseverance scores. The second way was through focus groups that happened during the second semester. In groups of 2-4, we conducted focus groups to assess grit, mindset, and programmatic information. We currently have data for the first cohort focus groups. Third, we collected "just in time" information through interviews and interventions based on questions or concerns related to responses in the journals. For instance, after hearing a student had to drop or retake a class, we would sit down for a few minutes or email a student to check in with them. These were not formal interviews, but students were informed that their data may be reflected in our research.

Quantitative data was collected from students' pre-, midyear- and post-year-survey responses. Students' names were collected so that changes in students' scores over time could be monitored. Through these students, we wanted to capture their attitudes toward STEM, their mindsets regarding challenges/failures, and their grit which included both passion and perseverance sub-scores. Although the small number of participants limits the quantitative analysis that can be conducted, several surveys were given to assess and track participants' mindset and attitudes toward science. Participants' attitudes toward STEM were monitored using Student Attitudes toward Science, Technology, Engineering and Math and interest in STEM careers (S-STEM) survey.

Data analysis

Quantitative data was analyzed to capture the movement and trends in both individual students, as well as the group, throughout the program to capture shifts that may be occurring in student thinking as they move through the program with a particular emphasis and our research focus on the students who choose to leave the program. We believe that although the program is relatively small, we have the opportunity to follow up with our students and use their quantitative surveys to initial and focus attention on those students who indicate concerns. Additionally, descriptive statistics were used to provide a summarized set of findings from the survey data.

Findings

There were ten PWS students in Cohort 1 involved in the study and table 3 provide demographic information of those students.

Table 3. Cohort 1 demographic information and number associated with grit and mindset graphs.

No	Gender	Race	First Gen	Age	University Entrance Date	Current Standing (in year 2)	GPA	Major
1	F	White	No	19	FA 2019	Sophomore	3.88	Electrical Engineering
2	F	White	Yes	22	FA 2018	Senior	3.73	Electrical Engineering
3	M	White	No	19	SP 2018	Senior	4.0	Computer Science
4	F	White	No	20	FA 2019	Sophomore	3.79	Civil Engineering
5	M	White	No	19	FA 2020	Sophomore	3.18	Computer Science

6	F	White	Yes	19	FA 2021	Sophomore	3.3	Biomedical Engineering
7	F	Black	Yes	21	FA 2021	Sophomore	2.58	Computer Science
8	M	Multi-racial	No	20	SU 2021	Sophomore	2.51	Computer Science
9	F	White	No	19	FA 2021	Junior	3.6	Biomedical Engineering
10	F	White	Yes	21	SA 2021	Junior	2.67	Mechanical Engineering

Beyond our focus on grit and mindset, preliminary results include cohort 1 students having the highest interest in 21st-century skills across all 3-time samples. Engineering and technology interest had decreased mid-year but returned to close to pre-year by the end of their first academic year. Interestingly, student interest in science decreased mid-year and stayed lower than at the start of the academic year. Although the students' Mindset scores did not change dramatically, we saw a slightly lower mindset score mid-year that improved by the end of the year. This is not surprising as student's mindset and abilities in STEM have yet to be challenged prior to entering college. Qualitative data have also been collected to supplement the low-N survey data.

Below is the data collected from our 10 students on their attitudes towards science, math, engineering/technology, and 21st Century Skills across these three times. Students indicated a higher interest in math (most significantly) and 21st Century Skills. Engineering and technology interest had decreased mid-year but returned to close to pre-year by the end of their first academic year. Interestingly, student interest in science decreased mid-year and stayed lower than at the start of the academic year.

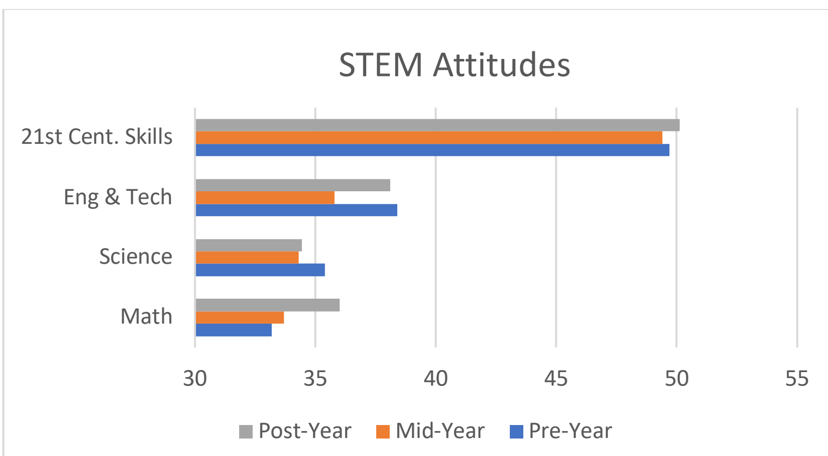

Figure 2. STEM Attitudes (S-STEM) for students at 3-time intervals (in May 2022 – post year, February 2022 – mid-year, and August 2021 – pre-year)

To address RQ1 and RQ2, data evaluating participants' mindset was collected using a questionnaire containing eight Likert-type questions from the *Implicit Theories of Intelligence* scale, called the Mindset Assessment Profile (MAP). Below is a data table for the students for their mindset at the three-time samples. Although the scores did not change dramatically, we see a slightly lower mindset score mid-year that improves slightly at the end of the year. This is not surprising as students' mindset and abilities in STEM have yet to be challenged prior to entering college. With such a small population, this is not a statistically significant result.

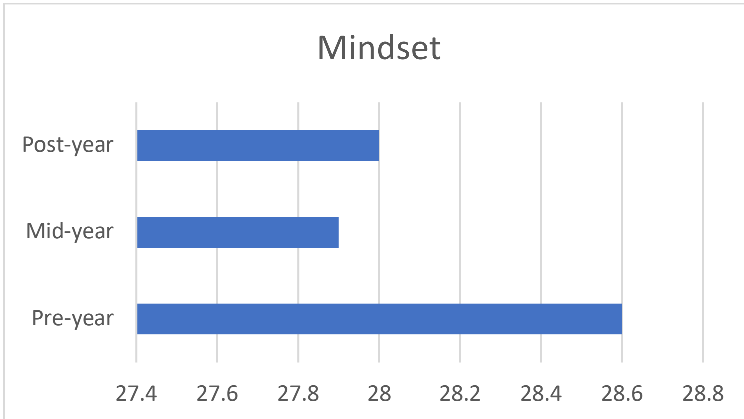

Figure 3. Mindset scores for students at 3-time intervals
(May 2022 – post year, February 2022 – mid-year, and August 2021 – pre-year)

To address student attrition, the changes to one's mindset might be a predecessor to feelings and tendencies to leave the chosen degree field, particularly as a more fixed mindset (lower score) describes an individual who would be more unwilling to take risks and face challenges. Three students indicated a lower mindset score and one of these students left the program at the end of the second semester. The other two students indicated the lowest STEM career field interests compared to the others in the cohort.

As for the students' Grit, the grit survey values in and of themselves reveal little in any particular time frame, but considering how the scores change over time, it provides an opportunity to see how the participants' passion and perseverance may be wavering or strengthening. In Figure 4 below, the initial grit scores of the first cohort illustrate that the differences between a student's total grit (sum of passion and perseverance) can be quite different from either their passion or perseverance scores separately. Two students (Students 3 and 6) have relatively high perseverance even though their passion is much lower. Two students (7 and 8) have a higher passion score than perseverance at the initial time. When examining the end of the initial year grit scores, several changes can be visually observed. Several students' scores lowered. Student 3's (grey line) passion score has lowered dramatically yet their perseverance score remains the same. Students 7 and 8 who had a marked high passion at the beginning have now lowered that passion to nearly equal their perseverance. In general, when computing the average changes across the year, the total grit remained statistically unchanged (0.06 difference) yet the passion score dropped (-0.17) and the perseverance score increased (0.29). Only one student (Student 10) dropped in both categories – passion and perseverance. This student left the program and transferred to our local community college to pursue a flight mechanic degree. Our other student who left the program (but remains in the college) is student 5 who like others lowered their passion score from the beginning of the year but increased their perseverance score equivalently.

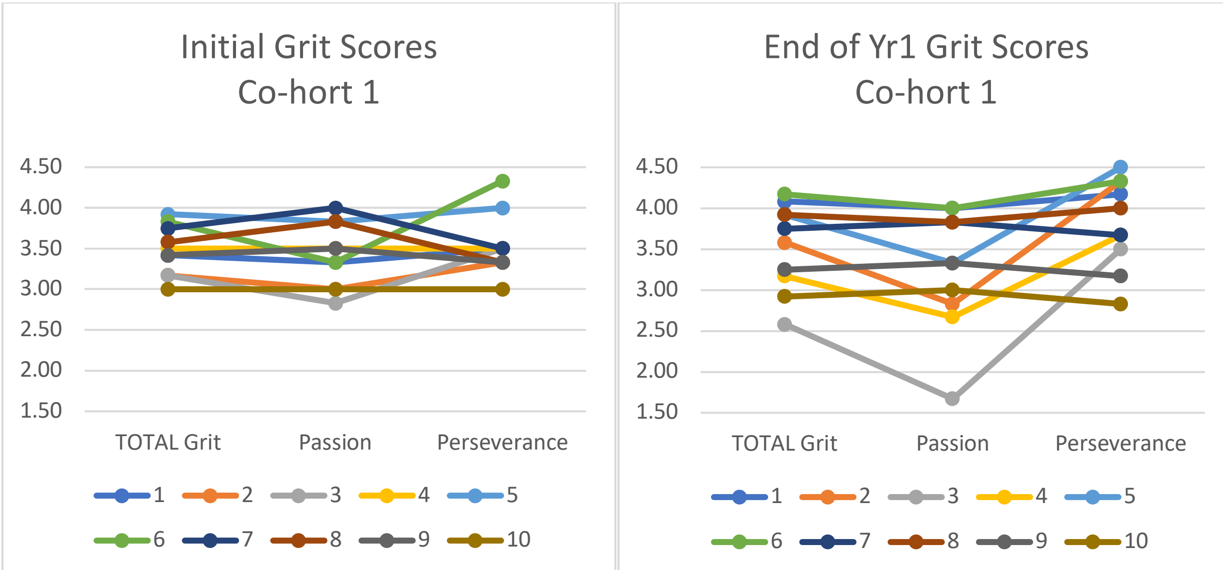

Figure 4. A snapshot of cohort 1 Grit scores including their total grit which includes 2 subscales of Passion and Perseverance.

The mindset scores of our first cohort across three times are presented in Figure 5. The student numbers remain the same as in the above figure. These values represent a snapshot of a student's feelings at the moment, which can be influenced by several factors such as stress over an upcoming exam etc., but merely provides a snapshot of their feelings about challenges and failures at the moment. Student 10 is the outlier student who dropped their mindset score by 10 points (from 31 to 21) while struggling with whether to stay in the program. Her score rebounded once more to 29 at the end of the year, after she decided to transfer to the community college. Across the cohort, there seems to be a "correction" of sorts with their initial mindset score (before the semester begins) as higher since their abilities in the challenging major have yet to be tested (August average: 28.6; February: 27.9 and May: 28.0).

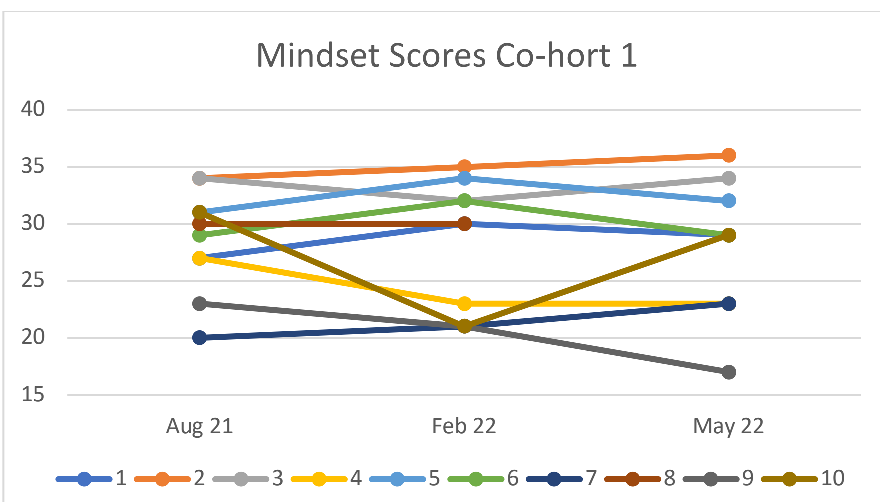

Figure 5. Mindset scores across 3-time frames of the cohort 1 group of 10 students.

Two students in the first cohort chose to leave PWS after their second semester. Both students agreed to be interviewed, but neither student responded when the assessment coordinators reached out to schedule interviews. However, we were able to gather data through GRIT scales, prior interviews, and journal entries. One of the two students who left the program was a White female student with the lowest perseverance Grit score. While the student expressed many positive aspects of the program – noting that she had become close friends with at least one other cohort member and enjoyed many of the speakers, she also expressed frustration with one of the mentors saying that he hurt her feelings. This student is now enrolled in Aviation Maintenance Technology, an associate degree program through a local community college. This student started college at 16, and at 20, Marshall University was the 4th college she attended. In our focus group interviews, she noted that she does not like the theoretical aspect of mechanical engineering, and she feels burnt out. In addition, she said the other colleges she attended did not start their mechanical engineering courses until the junior year. As a junior, she expressed frustration at being in classes with first-year students and was upset at how Marshall University handled her transfer credits. The second student who left the program was a White male student. In an email to the program director, he noted that he enjoyed the program, but it was taking too much of his time. This student noted he is pretty happy with his choice of STEM and plans on becoming a software engineer to make money. In addition, he has had an exceptional mentor experience that resulted in him getting a research project in the summer between his first and second years. He decided to leave the program after securing a job related to his major after his first year in college.

Interestingly, we have found that two of our female students who have the highest perseverance Grit scores are staying in the program after experiencing significant setbacks. The first female student had to drop a math class and had major changes in her support system, along with other personal issues since starting the program. While these issues are significant, they have not deterred her from moving forward. She has noted that she recognizes who she wants to be, and success in her field is part of that vision. She explained that she wants to be someone others can look up to and learn from, and she wants them to understand that dealing with setbacks is ok. She stated, "I can be in a crappy situation and learn from it. I recognize I am not going to be perfect at everything, but these challenges help me move forward and learn." Even with the setbacks she has had, she said her biggest challenge is picking a specialty because she likes so much of what sciences offer. In addition, she mentioned the role that her mentor has played. She explained that the PWS mentors have helped her through some personal and academic issues and have both offered to talk with her on multiple occasions. In addition, they have provided her with some amazing professional opportunities that most younger students often don't get to do – working on an academic paper, presenting at a conference, and connecting her with potential research and internship opportunities. The second female student with high Grit scores had to retake a physics class after receiving a D. This student reports that she suffers from social anxiety and stress and struggles to make friends. However, she explained that retaking the course was "worth it in the end" and said you don't learn by giving in; you learn from your mistakes." When she learned she had to retake the class, she admits there were lots of tears, and even her mom inquired if this was truly what she wanted to do. She goes on to note that taking it the second time was a great choice because she now actually gets it.

Qualitative data provides insight into RQ3. Throughout the students' journals, surveys, and interviews, the students have identified several internal and external challenges that they face. From an internal perspective, students have consistently mentioned mental health and time management as their most significant challenges. These results are not surprising. According to a Substance Abuse and Mental Health Services Administration report, 10.2 million people between 18 and 25 experience mental, behavioral, or emotional health issues [33]. This is approximately 30% of young adults, and this percentage has risen by about 8 percent in the last five years. Additionally, the state where our university is located has a higher prevalence of mental illness and lower rates of access to care [34]. Two students have expressly noted they have specific anxiety-related mental health issues; others have alluded to other anxiety-causing issues. One student noted they had family troubles, and several mentioned challenges making friends.

The second major internal issue has been various issues with time management. Time management and mental health, to some extent, go hand and hand. As one student mentioned, "I'm a bad procrastinator and it hasn't taken a toll on my grades, but definitely on my mental health." One student even asked during the first semester if there could be a session on time management in the following semester. Psychologist Damour highlighted that over 31% of girls and young women experience anxiety symptoms compared with only 13% of boys and young men [35]. In her book, she notes that the American College Health Association found that undergraduate women were 43% more likely than undergraduate men to report feeling anxiety.

Students face not just internal challenges, but external difficulties have also been noted. Almost all the students in the program have stated in one way or another that there is substantially more work than they expected in the PWS class. Students have noted that the class should be worth 3 credits, not 1, that the projects are great but extremely time-consuming, or that they didn't understand the amount of work tied in with the scholarship. Many students feel that they have additional work on top of a difficult major. One student noted, "It has been hard to focus on the project while having other work."

Another significant challenge that students have faced has to do with faculty mentor personality and criticism. Almost every one of the female participants noted that they felt excessively criticized. One student explained, "working with mentors is good, but I always feel like sometimes they only have bad things to say." Two other students specifically used the phrase "destructive criticism," referring to feedback given during practice presentations. Extensive research has shown that young men face more exposure to harsh criticism and discipline. DiPrete and Buchmann noted that boys often do not perceive schools as welcoming places or socially rewarding environments [36]. Because young women are often rewarded more or punished less for their behavior in K-12, they are not used to receiving the same type of critique males have been receiving throughout their education. Additionally, Steele, James, and Barnett report that undergraduate women in STEM are more likely to feel threatened by stereotypes that they are less capable than men in these fields [37]. Some of these women in our program may believe that because the PWS seminar is predominantly women, they are being critiqued based more on their gender than their ability.

Finally, it is possible that as first-year students, this was their first experience of being critiqued in a way that is harder than in high school. Additionally, these students are part of the Covid generation, where their last few years of high school may not have adequately prepared them for the transition into college. As such, this program is quite significant in that the facilitators, upon seeing their concerns provided by the assessment coordinators, have had the opportunity to work with both the students and faculty to make them aware of these issues.

Conclusions and Future Direction

In this study, we sought to support students who often face the greatest challenges in their first year of college through a cohort approach with both academic/collegial support and opportunities to engage in hands-on real-world projects to see the application of computer science and engineering. To research the impacts of these interventions, both qualitative and quantitative data were collected to help us understand the impact and the reasoning behind the matriculation of students who leave the program. Our research efforts were primarily focused on the role of mindset and grit on student success and matriculation by collecting a wide variety of qualitative data to help fill in the gaps that survey data often leave.

For the two students who left the program, it seems that they left for two very different reasons. The first student (Student 10) was a female student who discussed significant academic challenges and feelings of being overwhelmed by her coursework, yet she was not the only student who faced these challenges, but she is the only student whose grit scores went down in both sub-scales (passion and perseverance). Duckworth addresses the need for students/individuals facing challenges to have at least a high score in one of the categories to help offset the challenges faced when times get tough [17]. Student 10 was falling in both categories. This should be a red alert for program facilitators. The second student was a strong student with a high GPA, and he never expressed concern about his courses or his major. It appears he left the program because he did not feel that it helped him or supported him adequately to offset the time demands that the program expected of him.

Both the PWS program and its assessment have provided the opportunity to shed light on the role that grit and mindset play in recruiting and retaining female students. In addition, the assessment has provided information on real time issues students might be facing and ways to address these situations to help alert faculty to issues students are facing to develop ways that faculty and students can move forward to help retain underrepresented students in STEM fields.

PWS scholars have been working on research-based projects guided by their mentors for the first two years with outcomes of multiple publications and professional conference presentations. However, more projects by industry partners will be brought to the studio for the next two or three years. Some students may work on projects as co-ops/interns in the industry under mentorship. There will be no additional cohort in the program due to the funding limit, and the future study will be focused on the effectiveness of project-based learning and how the constructs of grit/mindset influence the success of our two cohorts.

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