ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Paper ID #49763

Mindset Matters: Exploring Grit and Attitudes in Engineering and CS Undergrads in an NSF S-STEM funded program

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Mindset Matters: Exploring Grit and Attitudes in Engineering and CS Undergrads in an NSF S-STEM funded program

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The Project-Based Work Studio (PWS) is designed to increase the participation of women and under-privileged students in computer science, engineering, and technology disciplines. Its focus is on recruiting, supporting, and helping students graduate by fostering a hands-on and supportive learning environment. The PWS employs a Project-Based Learning method, giving students opportunities for real-world projects and faculty mentorship, beginning in their freshman year. Research on successful STEM programs identifies three key strategies for student retention: (1) early research involvement, (2) active learning in introductory courses, and (3) participation in STEM learning communities. The PWS research, classified as "efficacy research," targets two participant groups: (1) mostly first-year students who join the seminar course for a long-term study and (2) those who leave the program. The first cohort (N=10) joined in Fall 2021, followed by the second cohort (N=9) in Fall 2022.

Our methods included analyzing both qualitative and quantitative data from 2021 to 2024, using tools like the e-journal submissions, focus groups and survey tools that included Student Attitudes toward STEM survey (S-STEM), the Mindset Assessment Profile (MAP), and the Grit scale in both fall and spring semesters. The MAP evaluates a student's growth or fixed mindset, while Grit assesses their passion and persistence in achieving long-term objectives. We predict that students with higher grit and mindset scores will display more favorable attitudes toward science and mathematics.

Preliminary results show that students' mindset scores remained relatively unchanged throughout the program. However, grit scores improved, with an increase in the perseverance subscale despite a decline in the passion subscale. To explore the relationship between mindset and grit, students were divided into three groups based on their mindset scores: 1) Fixed mindset (scores < 24) (N=5), 2) Mixed mindset (25 < scores < 32) (N=9), and 3) Growth mindset (scores > 32) (N=6). The analysis revealed clear relationships between grit and a growth mindset. Students with a growth mindset had higher overall grit scores, including both passion and perseverance subscales. They also exhibited a more positive attitude toward math, though the influence of mindset on attitudes toward science and 21st-century skills was less evident.

Qualitative insights were gathered through e-journals and focus group interviews to capture the students' experiences in more depth. These interviews explored students' perspectives on how their mindset and grit evolved throughout the program, including their challenges, motivations, and reflections on perseverance. This allowed for a deeper understanding of how students perceived their own growth in grit and mindset over time. Students shared stories of overcoming personal and academic obstacles. Qualitative methods also revealed factors influencing passion and perseverance, including faculty support, project involvement, and personal academic goals.

In conclusion, these findings underscore the role that grit and mindset play in shaping students' attitudes toward their degree programs and suggest areas for monitoring and supporting student retention. This poster will discuss these results in detail, integrating both the quantitative analysis and qualitative findings from the focus groups and e-journals.

Introduction

The Project-Based Work Studio (PWS) is a National Science Foundation (NSF) S-STEM-funded program aimed at increasing the participation and retention of women and underrepresented students in computer science, engineering, and technology disciplines. The need for such initiatives is underscored by national trends in STEM education and workforce participation. According to the Bureau of Labor Statistics (BLS), employment in STEM fields has grown 79% since 1990, with computer science and engineering accounting for the majority of STEM jobs [1]. Despite this growth, women and underrepresented minorities remain significantly underrepresented—with women comprising only 24% of the computing workforce and 12% of engineers [2]. This persistent gender and diversity gap presents challenges to workforce equity and innovation, making programs like PWS essential in fostering an inclusive STEM pipeline.

One of the key factors influencing student retention in STEM fields is the development of non-cognitive skills such as growth mindset and grit. Research has demonstrated that a growth mindset—the belief that intelligence and ability can be developed through effort—strongly correlates with persistence and success in STEM disciplines [3-5]. Similarly, grit, defined as perseverance and passion for long-term goals, has been identified as a predictor of STEM retention [6-7]. Prior studies have indicated that students who exhibit higher levels of perseverance in the face of academic challenges are more likely to complete their STEM degrees [8]. However, recent findings suggest that while perseverance may increase over time, passion for STEM subjects may decline, raising important questions about the long-term sustainability of student engagement in demanding STEM fields [9].

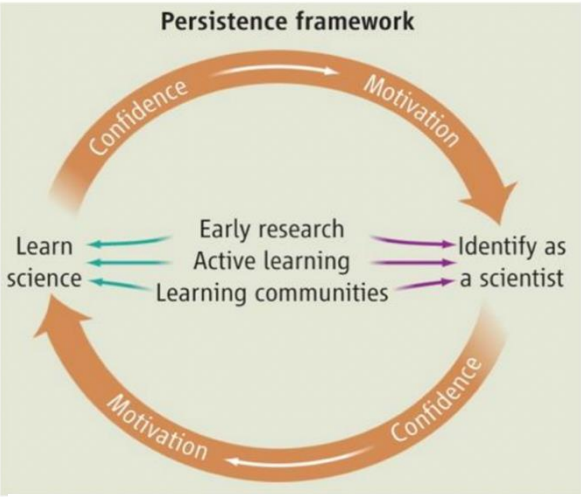

Figure 1. Persistence framework

The PWS program is structured around three evidence-based strategies for STEM retention: (1) Early engagement in research and hands-on learning opportunities (2) Active learning experiences in introductory STEM courses (3) Participation in STEM learning communities with faculty mentorship [10]. These strategies align with the Persistence Framework [11], which posits that confidence, motivation, learning, and professional identity are interconnected factors that influence student persistence in STEM fields. As shown in Figure 1 (Persistence Framework), this study integrates research from both psychology and education to examine how PWS students develop mindset and grit over time.

Using a mixed-methods approach, we analyze both quantitative (Mindset Assessment Profile, Grit Scale, and S-STEM Survey) and qualitative (focus groups, e-journals, and interviews) data collected during Year 3 (2023-2024). Our goal is to examine how student mindset and grit evolve over time, how these factors correlate with STEM attitudes and academic persistence, and what programmatic interventions may be necessary to further support student retention and success in engineering and computer science.

Theoretical Framework

Mindset theory, introduced by Dweck (2000), differentiates between fixed and growth mindsets and their impact on learning. Students with a fixed mindset view intelligence as static, leading them to avoid challenges, while those with a growth mindset believe intelligence can be developed, resulting in higher resilience in the face of difficulty [5, 6]. Dweck (2000) explains that there are two theories of intelligence that she refers to as mindsets. This theory describes how people believe that their intelligence can change and grow, specifically explaining how our beleifs impact how we approach challenges and respond to criticism. Those with a growth mindset believe that our basic qualities are thing we cultuivate through our own efforts, strategies, and help from others. They believe that a person's potential is unknown and it is impossible to forsee what can be accomplished with training and education, but cherished qualities can be developed over time. In contrast, those with a fixed mindset believe their intelligence is a fixed trait. Those who follow that mindset strive to prove themselves over and over because they believe they only have a certain amount of intelligence, personality and moral character, so they need to continually prove themselves.

Studies have shown that fostering a growth mindset can improve STEM retention, particularly among women and underrepresented students [12,13]. Blackwell, Trzesniewski, & Dweck (2007) found that students with a stronger growth mindset demonstrated higher academic performance and lower dropout rates in STEM fields [4]. Further, Yeager & Dweck (2012) emphasized that educators' mindsets influence student persistence, as students who perceive their professors to have a fixed mindset may internalize these beliefs, negatively impacting their academic trajectory [14].

Grit, a construct developed by Duckworth et al. (2007), comprises perseverance of effort and passion for long-term goals [6]. Research indicates that grit is a stronger predictor of academic success than IQ, particularly in rigorous disciplines such as engineering and computer science [7]. In STEM education, grit is associated with students' ability to persist through coursework challenges [8]. However, some studies have found a decline in passion subscale scores as students progress through their programs, suggesting that academic workload may erode initial enthusiasm [9]. Hunter (2020) found that students with higher perseverance scores were more likely to complete their degrees, even when passion waned [8].

Student persistence in STEM is influenced by multiple factors, including confidence, motivation, learning strategies, and professional identity development [10]. Research highlights three key interventions that enhance STEM retention:

1. Early research opportunities improve students' confidence in their abilities and connect them to faculty mentors, reinforcing a growth mindset.
2. Active learning strategies in STEM courses increase engagement and resilience in problem-solving.
3. STEM learning communities provide social and academic support, mitigating the impact of stereotype threat and imposter syndrome among underrepresented students.

The PWS program incorporates these evidence-based practices to foster academic persistence, professional identity, and mindset development among participants. By examining the evolution of grit, mindset, and STEM attitudes in Year 3, this study contributes to the ongoing discourse on effective retention strategies in engineering and computer science education.

Methodology

Using a mixed-methods approach, we analyze both quantitative (Mindset Assessment Profile, Grit Scale, and S-STEM Survey) and qualitative (focus groups, e-journals, and interviews) data collected during Year 3 (2023-2024).

The study included two cohorts of students. Cohort 1 (N=10, entered Fall 2021) consisted of 8 female and 2 male students. Among them, 3 were first-generation college students, 2 were Pell-eligible, and 2 identified as underrepresented minorities in STEM. Their academic interests spanned across various engineering and computer science disciplines, with a majority pursuing degrees in electrical, biomedical and mechanical engineering and computer science. Cohort 2 (N=9, entered Fall 2022) included 7 female and 2 male students. Of these, 3 were first-generation college students, 6 were Pell-eligible, and 1 identified as an underrepresented minority. Similar to Cohort 1, students in this group primarily majored in computer science, biomedical, electrical and mechanical engineering.

Students were selected based on academic merit and financial need. Many of these students came from central Appalachia, a region historically underrepresented in STEM disciplines, making the PWS program's support structures essential in fostering retention and success.

Project Work Studio Support

The PWS program is a cohort-based model that provides financial, academic, and professional development support through a one-credit-hour seminar course and hands-on research projects [15]. These research projects are designed to give students early exposure to real-world engineering and computing challenges, fostering both technical and professional skills. Students engage in faculty-mentored interdisciplinary projects, collaborating on topics such as machine learning applications, renewable energy solutions, cybersecurity, and biomedical engineering innovations. The projects are structured to provide progressive levels of responsibility, where students start as observers, transition to active participants, and eventually take leadership roles as they advance in the program. This hands-on experience is a key component in reinforcing problem-solving skills, teamwork, and resilience, aligning with the framework outlined in Cartwright, Snyder Yuly, & Yoo (2023) [15]. Students work in faculty-mentored interdisciplinary teams, engaging in real-world engineering and computing challenges.

Research Questions

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?*

Findings and Discussion

The findings from the Year 3 assessment provide valuable insights into the relationship between mindset, grit, and STEM attitudes in the PWS program. The study sought to examine how these factors evolved over time and their impact on student retention. The key results highlight the stability of mindset scores, the increase in perseverance subscale scores, the decline in passion subscale scores, and the differing attitudes toward STEM fields based on mindset classification. We also combined findings from the ongoing program assessment to see if the experiences and perceptions of students in the program supported or contrasted their mindset findings.

Stability in Mindset Scores

Despite programmatic interventions, overall mindset scores remained relatively stable across time and within cohorts. This suggests that while students may engage in growth mindset-oriented activities, deeply ingrained beliefs about intelligence and ability may be resistant to short-term change. However, students classified as having a growth mindset continued to show higher engagement in coursework and were more likely to persist in their STEM fields.

Grit: Increased Perseverance but Declining Passion

A notable trend in the data was the increase in perseverance of effort while passion for STEM subjects declined over time. This aligns with research suggesting that as students progress through rigorous academic programs, they develop stronger persistence to overcome challenges but may simultaneously experience a decline in intrinsic enthusiasm [16]. This pattern was most pronounced among students in more technically demanding disciplines, such as engineering and computer science, where coursework intensity can be a factor in diminishing initial excitement.

To further explore the relationship between mindset and grit, students were categorized into three groups based on their mindset scores:

1. Fixed mindset (scores < 24) (N=5),
2. Mixed mindset (25 < scores < 32) (N=9), and
3. Growth mindset (scores > 32) (N=6).

The analysis revealed notable relationships between grit and a growth mindset. Students in the growth mindset group had higher overall grit scores, demonstrating stronger perseverance and passion subscale scores than those in the mixed or fixed mindset groups. Additionally, students in this category exhibited a more positive attitude toward mathematics, suggesting that a growth mindset is particularly beneficial in math-related STEM fields. However, the relationship between mindset and attitudes toward science and 21st-century skills was less pronounced, indicating that external influences such as faculty mentorship and research experiences may play a larger role in shaping these perceptions. A notable trend in the data was the increase in perseverance of effort while passion for STEM subjects declined over time. This aligns with

research suggesting that as students progress through rigorous academic programs, they develop stronger persistence to overcome challenges but may simultaneously experience a decline in intrinsic enthusiasm [16]. This pattern was most pronounced among students in more technically demanding disciplines, such as engineering and computer science, where coursework intensity can be a factor in diminishing initial excitement. One example of this is when students were asked about what classes they were most excited about and one of growth mindset students wrote, *"I'm not excited for any of my courses. They must be done so I'm not complaining but they spark no real joy this semester."* This particular student has some health and mental health issues that have challenging to recover. While comments on the journal surveys tend to be more negative, this student continues to persist through the program and classwork.

Figure 1 below illustrates the relationship between grit scores and mindset groups, showing clear trends across perseverance, passion, and total grit scores. Students with a growth mindset exhibited the highest perseverance and total grit scores, suggesting a stronger ability to persist through challenges compared to those with fixed or mixed mindsets. Students with a growth mindset demonstrated the highest perseverance scores, reinforcing previous research that highlights a positive correlation between a growth mindset and resilience in STEM disciplines. Passion scores were notably lower across all groups, with only slight differences among mindset categories. This aligns with qualitative data suggesting that while students continue to persist, enthusiasm for STEM subjects may decline due to academic workload and external pressures. Growth mindset students maintained the highest total grit scores, while mixed mindset and fixed mindset students exhibited slightly lower but comparable scores.

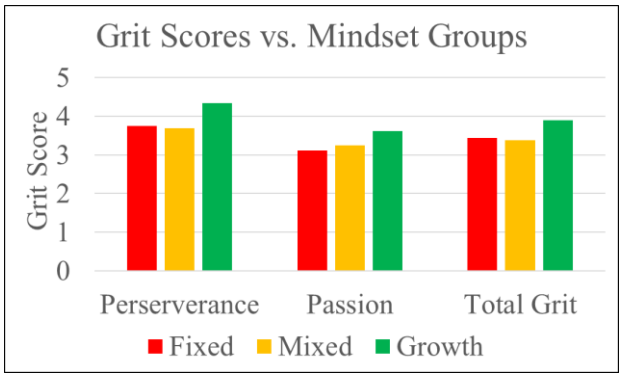

Figure 1: Grit scores vs mindset groups across the two subscales and the total grit score.

STEM Attitudes

The study found a strong correlation between growth mindset and positive attitudes toward mathematics**,** with students classified in this category consistently expressing greater confidence and enthusiasm for math-related coursework. However, the relationship between mindset and attitudes toward science and 21st-century skills was less pronounced, indicating that external factors such as faculty support and exposure to research projects may play a more significant role in shaping these perspectives. The connection between science and 21st-century skills was illustrated as the PWS program implemented a series of workshops focusing on communication, leadership, and other success skills, which very few students attended. While some students

genuinely could not attend due to scheduling conflicts, many of the students dismissed the need for them. Two students with fixed-mindsets noted, *"Truthfully, I do not care about soft skills. Bringing in companies or industry speakers would be great"* and *"Maybe one event could be a Q&A session with a panel of our mentor's and we can ask different real-life questions about their careers and experience."* This potentially illustrates concern for learning something the student feels challenged, or that they are more focused on outcomes than personal growth. Students with fixed mindsets were less interested in and less likely to attend these workshops. Students with mixed and growth mindsets were more likely to attend, but even those students did not quite see the value with one growth mindset student explaining, *"It would be beneficial for me if the topics were discussed through materials on blackboard instead of a physical meeting. It is difficult to participate in things outside of my courses due to my personal schedule."* While the student indicate the workshops' importance, they were not willing to attend activities outside their course work.

Figure 2 illustrates the relationship between attitude scores in mathematics and science across different mindset groups. Students with a growth mindset demonstrated the highest attitudes toward both math and science, while those with a fixed mindset exhibited a more pronounced disparity, with stronger attitudes toward science than math. Mixed mindset students showed relatively balanced but lower attitude scores compared to their growth mindset peers.

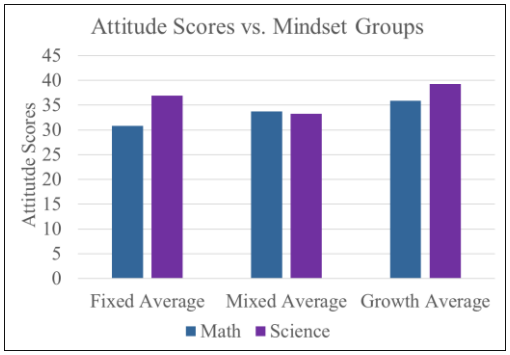

Figure 2: Math and Science attitudes across the 3 different mindset groups.

Growth mindset students had the most positive attitudes toward mathematics, reinforcing the idea that a belief in one's ability to improve can foster confidence and enthusiasm in math-related coursework. Science attitudes were slightly higher in the fixed mindset group compared to mixed mindset students, though growth mindset students still led in overall positivity toward science. One student in the mixed mindset stated, *"This semester, I am enjoying Calc I because it has been nice to learn new math and to get a start in what I will be doing in my future. I also am enjoy ENGR 217 because I've gotten the opportunity to create a resume, take a mock interview with someone from Service Wire, and learn more about the engineering profession and what is expected of me."* Another student said, *"I have struggled with hydraulics the most because the professor is hard."*

These findings indicate that while growth mindset correlates with improved attitudes toward STEM subjects, external factors such as faculty support, research engagement, and curriculum

structure may influence these perceptions. Further research should explore targeted interventions to support positive STEM attitudes, particularly in students with mixed or fixed mindsets.

Student Retention

An important aspect of this study was understanding how mindset and grit relate to student retention in STEM programs**.** The figures below illustrate differences in grit subscales (perseverance and passion) and mindset scores between students who were retained in the PWS program and those who left.

Students who remained in the program had higher mindset scores (28.23) compared to those who left (26.7) (see Figure 3). This suggests that a growth-oriented belief in intelligence and learning may contribute to persistence in STEM disciplines. While overall grit scores were lower for non-retained students, an interesting trend emerged—passion scores were slightly higher among those who left, but their perseverance scores were notably lower (see Figure 4). This supports prior research indicating that grit's perseverance component may be more critical for retention than passion alone. One student who had the lowest perseverance score in the program ultimately left, citing challenges with mentorship, burnout, and dissatisfaction with the handling of transfer credits. This highlights the importance of faculty support and academic policies in influencing student persistence. These findings reinforce the notion that both mindset and perseverance play a role in STEM retention, suggesting that interventions should focus not only on fostering passion for STEM fields but also on strengthening students' ability to persist through academic challenges.

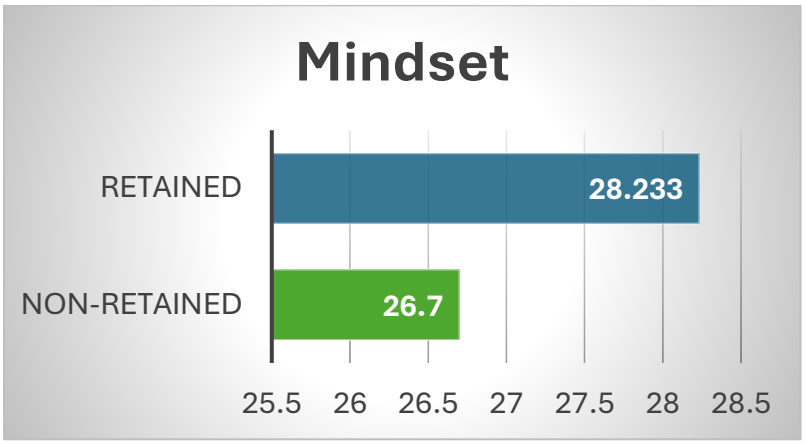

Figure 3: Comparison of mindset scores for students who were retained vs. non-retained.

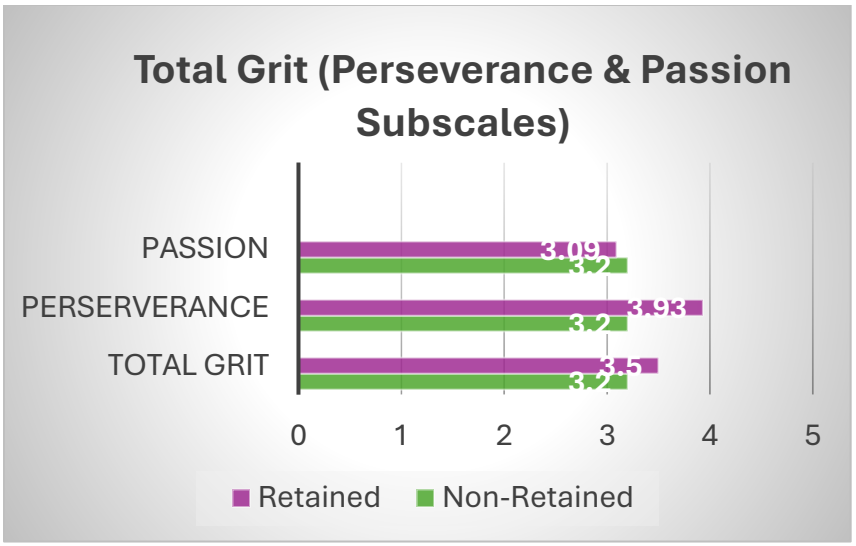

Figure 4: Comparison of grit scores (with 2 subscales) for students who were retained vs. non-retained.

Student Experiences

Ongoing student assessment through our student journal surveys and focus group interviews provided additional depth to the quantitative findings. Many students highlighted the importance of faculty mentorship and hands-on projects in sustaining their motivation despite academic challenges. For instance in a Fall 2024 journal survey, one mixed mindset student mentioned, "*Dr. Nosoudi and I have a great mentee and mentor relationship. With any lab questions, career questions, internship applications, even which courses I still need to take she has always been right there and super willing to help. I have asked her to help guide me in the right direction in the lab and asked her if there are any papers to look at and read to help better understand my project."*

However, some also noted difficulties balancing workload demands, particularly in foundational STEM courses such as calculus, physics, and computer programming. Faculty feedback was identified as a crucial element, with some students responding positively to structured support, while others expressed concerns about overly critical evaluations. An excellent example of the role that faculty play is seen in this comment by a mixed mindset student, *"I have struggled with Dynamics and PHY 213 the most. I think that Dynamics is difficult because there are so many different types of problems to do, and I don't know what method to use. I have suggested to my teacher to have a tutor or supplemental instruction for his course, but he doesn't do that. I also think I am struggling in PHY 213 because this is the teacher's first year teaching it. She does not explain it very well."* Rather than reflecting on the self, the student suggests the struggles are caused by issues with the faculty.

Student reflections on their confidence in their chosen major offer deeper insight into how mindset and grit interact with perseverance in STEM fields. A mixed mindset student wrote in Fall 2023, *"I know this is what I should be doing and I'm happy I chose BME,"* but by Spring 2024, they expressed uncertainty: *"I have felt a little regret about my major but I'm in it too far*

to go do anything else so I'm sticking it out." Similarly, a fixed mindset student initially stated in Fall 2023, *"I feel good about the major, it is just rough,"* but by Spring 2024, their concerns had shifted: *"I'm not as worried about the degree, but more worried about GPA coming out of it."* In contrast, a growth mindset student in Fall 2023 acknowledged struggles but remained optimistic: *"I am struggling a little in math and physics but I should be okay because I have a good work ethic."* By Spring 2024, their confidence had strengthened: *"I feel like I am doing well in my classes. I really like everything that I am learning about."*

There are also some interesting differences between students with differing mindsets. First, is that those individuals with a fixed mindset all indicated that they disagree that the PWS program has connected them to leaders in their fields, while all growth mindset individuals indicate that they strongly agree that they have been connected to leaders in their fields. Additionally, those with mixed or growth mindsets have indicated that they plan to go to graduate school or are unsure at this point; however all those with a fixed mindset indicated that were not planning to go to graduate school. Finally, those with fixed mindsets note that their biggest challenges are making connections or planning for their futures. For instance, one senior fixed mindset student responded to their biggest challenge by noting*, "The biggest challenge I am facing in college right now is planning toward my future and possible workplaces following graduation."* Those in the fixed mindset were more likely to indicate they wanted more help with resume writing, finding internships, and other work related issues. These same students also dismissed the workshops that created the next semester, which often addressed these same topics. Unlike the fixed mindset students, those with growth mindset indicated their challenges centered on finding balance. One growth mindset student mentioned, *"Maintaining a health stress level as I find the end of the semester very stressful with such a large amount of exams."* Those in the growth mindset rarely mentioned career oriented help, but were more interested in help in tutoring to increase their learning.

The relationship with the mentors also has some distinct differences. For the fixed mindset students, when asked about their engagement with their mentors mentioned working with their mentors about plans after graduation, talked about resumes, and researched potential jobs. While this was not an unusual topic for all the seniors, those with mixed and growth mindsets were more likely to mention class scheduling, working on their projects, or other academic advice.

These qualitative insights suggest that while students with a growth mindset exhibit resilience in the face of academic difficulties, students with mixed or fixed mindsets may experience greater uncertainty and stress over time. The progression of student attitudes aligns with the quantitative findings, reinforcing the need for interventions that support perseverance and long-term confidence in STEM pathways.

Programmatic Implications

Overall, retention rates within the PWS program remained strong, with the majority of students persisting in their STEM majors. Students who left the program often cited academic workload and misalignment with career goals rather than dissatisfaction with the program itself. This suggests that while PWS successfully supports students academically and professionally,

additional interventions targeting workload management and sustained passion in STEM may further improve long-term retention outcomes.

Conclusion and Future Work

The findings from this study reinforce the importance of fostering a growth mindset and perseverance among undergraduate STEM students. While mindset scores remained relatively stable over time, students with a growth mindset exhibited higher grit scores and more positive attitudes toward mathematics. The data also revealed that perseverance increased, even as passion for STEM subjects declined, particularly in high-rigor disciplines such as engineering and computer science. These findings underscore the complexity of student motivation and the need for targeted interventions that sustain passion while reinforcing resilience in demanding academic environments. As students progress through demanding STEM coursework, their initial enthusiasm may give way to pragmatic career considerations. Many students expressed that while they remained committed to completing their degrees, their passion shifted toward practical application rather than abstract interest.

Despite these insights, this study has several limitations. The sample size was relatively small, and the study was limited to students participating in the PWS program, which may not fully represent the broader population of STEM undergraduates. Additionally, while the study identified correlations between mindset, grit, and STEM attitudes, further research is needed to establish causal relationships. Longitudinal studies following students beyond their undergraduate education could provide deeper insights into how mindset and grit impact long-term career persistence in STEM fields.

To enhance student retention in STEM, future work should focus on strategies to maintain student enthusiasm while strengthening perseverance. Expanding faculty mentorship, incorporating growth mindset training into coursework, and offering structured interventions to support students through academic challenges may help bridge the gap between persistence and passion. Additionally, integrating research experiences earlier in the academic journey could foster deeper engagement and a stronger sense of professional identity. The observed decline in passion scores aligns with industry reports on engineering and computing professionals who cite early-career burnout as a concern. This raises important questions for educators about how to sustain student enthusiasm beyond academic coursework. By addressing these areas, STEM programs can better support diverse student populations and improve retention rates in engineering and computer science disciplines.

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