Board 27: Work-in-Progress: Developing Underrepresented Biomedical Engineering Students' Persistence in a First-Year Introductory Design Course

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Background

Historically, only half of declared engineering undergraduates will graduate with a bachelor's degree in engineering [1], [2]. Furthermore, underrepresented minority (URM) students and women enroll in engineering programs at much lower rates than their white male counterparts and suffer disproportionate attrition rates [1]-[3]. This lack of participation and persistence in engineering programs leads to an inequitable and unrepresentative engineering workforce [1]. The National Academies of Sciences, Engineering, and Medicine report claims this contributes to the national labor shortage as well as lost opportunities for economic gain [3].

Different engineering fields attract and support varying levels of women and URM students [1]-[5]. Women made up only 24.6% of enrolled undergraduate engineering students across engineering fields in 2019, but Biomedical Engineering (BME) awarded women 48.1% of bachelor's degrees, 43.1% of master's degrees, and 36.3% of doctoral degrees [2]. In contrast, 16.6% of bachelor's degrees across all engineering fields were awarded to URM students, compared to 13.7% in BME. Furthermore, tenure-track faculty across all engineering fields, including BME, does not mirror the composition of the workforce. The general workforce is made up of 47% women, 17% individuals who identify as Hispanic, and 11% of individuals who identify as Black and/or African American [10]. 24.7% of BME professors are women, 3.4% are Hispanic, and 2% are Black/African American [2]. These inequities need to be addressed.

In engineering, factors contributing to attrition rates have included, but are not limited to, a hostile academic environment, a limited sense of self-efficacy, and a lack of representative role models [3]. An issue specific to BME is its interdisciplinary nature, leading students to need a broader foundation of knowledge and wider array of skills [4], [5]. Prior researchers have hypothesized that developing emotion regulation skills would have an outsized impact on women, URM students, and First-Generation College Students (FGCS) in engineering, especially since so many of the cited reasons for leaving engineering fields have to do with how students perceive themselves and/or their relationships within the field [6], [7]. BME is an important field of engineering to conduct this research in as it has a higher representation of women and added challenges to degree programs because of its interdisciplinary nature [4].

Research Questions

To better understand the different factors that impact the persistence of engineering students who identify as women and/or FGCS, we asked the following research questions:

- R.1 Is there a correlation between self-regulation skills and students' sense of self-efficacy in a Biomedical Engineering introductory course?
- R.2 In what ways can self-regulation skills be further developed in lab settings?

The questions are framed within the context of an Introduction to Biomedical Engineering course as attrition rates are highest in engineering students' first and second years. There are no prerequisites for this course, and it is required of all declared BME students.

Methods

To answer R.1, 59 students in an Introduction to Biomedical Engineering course of first-year students were invited to complete a survey that consisted of:

- the Performance Failure Appraisal Inventory (PFAI) Modified for use with STEM undergraduates (15 questions) [6];
- the Situational Self-Awareness Scale (9 Questions) [8];
- the Emotion Regulation Questionnaire (ERQ) (10 Questions) [9];

- 10 questions on faculty and campus resource utilization trends.

50 students responded to the survey. 45 students reported on their campus resource utilization.

To answer R.2, all 59 students were invited via email to participate in an interview series. The interview series consisted of three sessions. In order to learn about students' self-regulation skills, they were asked about their response to facing setbacks in lab settings. The first interview session gathered detailed descriptions of the students' experiences of failure and/or setbacks in their STEM lab courses. The second interview session asked students to describe in what ways their professors and Teaching Assistants (TAs) helped to respond to and/or anticipate their needs in these moments. The final session focused on what in-class supports students felt would help them learn from and move past experiencing setbacks. Five students completed the interview series. Of these five, two identified as women and two identified as FGCS.

Findings

Survey data analysis is still in its preliminary stages, though findings suggest students who seek out campus resources are more likely to report higher levels of self-awareness and greater use of emotion-regulation strategies. Findings of preliminary thematic analysis [11] of the interview transcriptions demonstrates that students' self-regulation after setbacks in lab settings is impacted by their prior experiences and the content and relational supports available to them at the time. These findings are depicted in Figure 1.

Interview One: Describe a Setback in a Lab Setting

Each student could readily think of an experience in a lab setting where they experienced a setback. Students were not instructed to limit their responses to their BME course. In the BME lab, a student was using a breadboard for an EKG reading, but could not get a reading. The student described feeling frustrated, especially as the groups around them seemed to have moved on to the next activity without an issue. Luckily, their team was able to stay calm and retry following the directions until they were successful.

Two students shared experiences in their chemistry labs where they visually did not get the intended results. They described being able to quickly move forward as their peers also struggled to get the intended result, reassuring them that the setback was typical. However, both indicated they were instructed on what they did wrong technically but did not understand conceptually what had caused their mistake or what would fix it. They felt a disconnect between the experiment and their course understanding, which did not impact their confidence as a student, but did influence their sense of progression and cohesion in the course.

The other two students described not being able to achieve the goal of a lab, such as reaching less than a ten percent error. Another described a machine malfunction. The latter student described feeling frustrated and inept at first, but reassured about their abilities when the TA had the same difficulties. However, they did not feel they learned the actual objective of that lab or its intended tie-in with the lecture. The last student described how their inability to get the correct lab result made them fear they were letting down their lab partner, and they grew increasingly frustrated until they needed a few minutes alone to calm down and regroup. After a few minutes away, they were able to correctly follow the directions, but could not identify what error they originally made that caused the initial results. This student indicated their stress response was triggered by past lab experiences.

Interview Two: What Helped or Hurt Moving Beyond that Setback?

In interview two, each participant was asked to describe how their environment and the supports within helped in the moment of their frustration. The students discussed a great reliance on their peers and TAs. Their experience was helped if their peers and TAs normalized setbacks and encouraged them to problem solve. Their ability to move beyond the setback was hindered if their peers did not have the same difficulties or their teammates were quiet and hesitant. Students also struggled if the TA seemed more concerned with helping them do the lab correctly at the expense of understanding what was happening and why. Most cited they wanted the TA to know their name, check-in on their progress, and walk around the room. Students were afraid to go to TAs for help if they did not know the TA well or if they felt asking them a question would bother them. Furthermore, if the directions were sparse and poorly correlated to course content, it was much harder for students to problem solve and move past setbacks.

Interview Three: Describe the Ideal Lab Environment

When the students were asked what classroom supports would help them move past setbacks, they described content supports and community-building. Students were better able to identify and move past their mistakes if they understood where to look to help them make sense of the lab, whether that meant lab or course materials. They also described that the relationship with their peers and their TA drastically impacted their response to setbacks. If they felt safe to fail, they could problem-solve and move forward. If people were quiet or expectant, it prolonged the sense of failure. The students needed to feel comfortable with both their peers and their TA to be able to recover from a setback quickly.

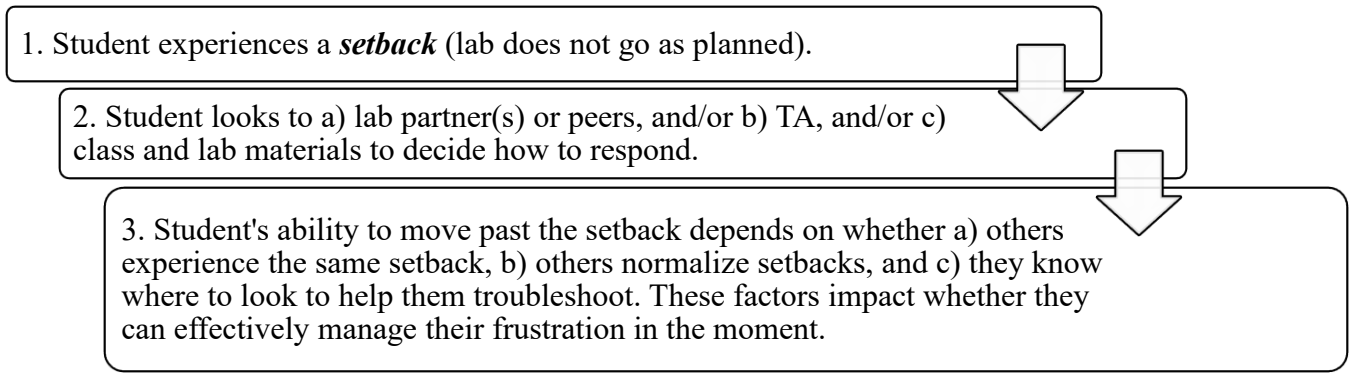

Figure 1. Student Response to Setbacks in Lab Settings Flowchart

Conclusion

To summarize, students' ability to recover from setbacks is aided by four classroom supports: when a) lab assignments are more process-oriented than outcome oriented; b) the purpose of the lab is clearly correlated to lecture content; c) teaching staff are approachable and willing to admit mistakes and confusion; and d) peers work together freely without fear of making mistakes. These are just preliminary findings thematically analyzed to better understand what classroom-level supports students need to bolster resilience and persistence. Further analysis of the surveys and interview transcripts will allow for a better understanding of the individual characteristics that help students persist, and help universities learn how to help students build the skill sets necessary to reframe setbacks as learning opportunities.

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