Title: *Failure reframed: Supporting STEM students in developing productive coping skills through scientist narratives of failures*

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Abstract: Failure is a pivotal aspect of scientific research and a regular part of academic experiences. Yet there are significant barriers to students' capability to navigate and overcome academic failure. Students' ability to persist in their chosen majors, specifically in STEM fields, depends on their academic success and their ability to face and navigate instances of failure. We are requesting funds to develop an online asynchronous workshop on failure directed at first- and second-year STEM students and support undergraduate and graduate students to be part of this innovative effort. Our goal for this project is tri-fold for CU Boulder (1) to create and present failure narratives of diverse faculty and researchers in the Natural Science Division of the College of Arts & Sciences; (2) to demonstrate to students in STEM majors how failure is a pivotal and necessary part of science, research, and academia; and (3) to help students develop individualized strategies to productively navigate potential academic and scientific failures.

Project Summary:
Background:
Persistence in Science, Technology, Engineering, and Math (STEM) undergraduate degrees, specifically for those students that identify and hold minoritized and underrepresented identities (URM) is still below those students that are not traditionally underrepresented (Hatfield et al., 2022). Hatfield and colleagues (2022) found that not meeting high grade expectations (greater than a C) in introductory STEM courses disproportionately pushes URM students away from a STEM degree compared to their White counterparts. Black and Hispanic communities show the least progress in both STEM educationally and professionally relative to their presence (Fry et al., 2021). However, when students experience failure while engaged in authentic science research, they seem to learn more about science practices and engage with science in more productive ways (e.g. Gin et al., 2018; Krishnan, 2021).

More recent work has found that students had a more positive experience in their undergraduate STEM courses when exposed to scientists of the same or similar identities (Metzger et al., 2023). This was especially true for first-generation and female students. Similarly, students' ability to identify as scientists due to science-related activities like research experiences, mentorship, peer support, etc. is an important component to their academic and professional choices and development (Huffmyer et al., 2022). In other words, when students can see themselves being scientists and experiencing the different parts of the scientific experience (the good and bad), it fosters students' persistence and accomplishment in STEM fields. Conceptually, it is also important for all students, regardless of identity, to be exposed to diverse scientists in order to understand the reach of work and presence within their field as well as to begin to diversify their cultural competencies in STEM (Posey & Lavik, 2022).

As such, this project brings together two major ideas: how failure can be used as a teaching tool in science and how students connect with scientists and science communities through aspects of their identities. We seek to understand and utilize the impact and importance of role models on students' persistence and resilience when presented with academic difficulties and as they navigate higher education. By collecting and sharing the narratives of diverse faculty and

researchers in the College of Arts & Sciences, we can further support and retain URM students in STEM by helping them craft individual strategies that emerge from supports related to their own identities. This work suits the Innovation Fund's purpose, as it incorporates CU STEM faculty stories into curriculum to improve student retention across STEM disciplines.

Participants

This work will incorporate faculty, researchers and students in the Division of Natural Sciences including the following departments: Astronomy, Atmospheric & Oceanic Sciences, Biochemistry, Chemistry, Ecology & Evolutionary Biology, Environmental Sciences, Integrative Physiology, Mathematics, Molecular/Cellular & Developmental Biology, Neuroscience, Physics, Psychology, and additional associated subdivisions.

We will also partner with existing structures (such as Course Alert) in the Division of Natural Sciences to support students who are facing academic challenges. Course Alert connects students who are struggling in their courses to resources meant to help them achieve their desired goals. We believe that the workshop could function as a resource for this program. Daniel Easton and Lily Board, part of the Academic Advising administrative team responsible for this program have already communicated their interest to work together on this project such that we develop curricula that encourages students to reflect on their struggles and take specific and measurable action to improve.

Project Goals

Our main goals for this project are derived from the above background as well as the preliminary work from an associated research project that is already engaged in collecting diverse scientist stories.

1. Collect failure narratives from diverse faculty and researchers in STEM field, *specifically* those in the Natural Science Division of the College of Arts & Sciences at CU Boulder.
2. Design an online asynchronous workshop (using available learning management tools such as Canvas and PlayPosit) that has students learn about and analyze these narratives.
3. Recruit first- and second-year students majoring in STEM disciplines in the College of Arts & Sciences to participate in the workshop through Course Alert.

Developing a Workshop

Below, we include the elements of this evidence-based workshop that already has support from the literature. Additional content (indicated in the model) will be developed from results of ongoing research.

Based on previous literature (e.g., Simpson & Maltese, 2017), we anticipate that scientists will share many constructive strategies about how they learned from failure and learned how to cope with failure as both students and scientists. We will create enough content for a two-week workshop for students to learn to develop similar skills.

Additional content will be built from the narratives of how scientists navigate failures. We anticipate that at least 50 diverse scientists from around CU Boulder will participate in the research that will generate data for our workshop. In order to ensure that students have a voice in the development of the workshop that will benefit them and their peers, we propose hiring 2 undergraduate students and 1 graduate student to help recruit and analyze the data from interviews with scientists (see proposed budget below).

Components of an Asynchronous Online Two-Week Workshop

Here, we provide the general topics for each module of our proposed student workshop. We have kept it broad as we will incorporate and compensate student voices in the detailed design.

- Module 1: How do we fail? What is failure to you? How do we approach failure in different spaces? How do we respond to or cope with failure?
- Module 2: How do scientists fail?
- Module 3: How do we and can we learn from failure? The role of instructor support.
- Module 4: Developing a personal plan to navigate future failures.

Timeline of Project Activities	Summer 2024	Fall 2024	Spring 2025	Summer 2025
Faculty recruitment	■			
Faculty and researcher interview and narrative creation	■	■		
Curriculum development of the workshop		■		
Student recruitment with Course Alert - specifically looking at first- and second-year STEM students in academic difficulty at the end of Fall 2024 semester		■		
Provide Workshop on Canvas to recruited students			■	
Monitoring of students' progress through timed module releases			■	
Assess completion of modules and students' opinion on failure narratives.			■	
Create report on student outcomes			■	
Modify workshop curricula based on student feedback			■	■
Final report on project			■	■

Budget and Justification:

Materials & Compensation	Cost per	# of individuals	Total
Undergraduate Student Research Assistant	$20/hr, 500 hours	2	$20,000
Graduate Research Assistant	$30/hr, 300 hours	1	$9,000
External Hard Drive	$60	1	$60
Participating Students Funds	-	-	$940
Total			$30,000

- Graduate Research Assistant (GRA): Will lead the initial recruitment, workshop curriculum development, and supervise undergraduate student research assistants. The graduate student will TA during these semesters and tuition fees and benefits be covered through the TA funding. This additional stipend for this project is still allowable based on CU policy.
- Undergraduate Student Research Assistants (2 students): In collaboration with GRA, students will develop the narratives of failure that will be posted on the workshop. Students will also participate in recruitment, online discussions, workshop monitoring, and additional tasks related to the project as needed but will not exceed 10 hours of work per week.
- External Hard Drive: 1 encrypted unit to securely store the scientist interviews we will have. Only GRA, undergraduate students, and Primary Authors will have access to this Hard Drive.
- Participating Students Funds: Students that participate in all of the modules of the workshop will be awarded $5-10 gift card depending on the number of completed modules.