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Successful Failure: Leveraging Mindfulness and Growth-Oriented Reframing to Build Undergraduate Research Resilience

Sara G. Goodman

St. John Fisher University, sgoodman@sjf.edu

Melissa M. Goodwin

St. John Fisher University, mgoodwin@sjf.edu

Noveera T. Ahmed

St. John Fisher University, nahmed@sjf.edu

Kristin F. Picardo

St. John Fisher University

Michelle Erklenz-Watts

St. John Fisher University, Erklenz-Watmerklenz-watts@sjf.edu

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Publication Information

Goodman, Sara G.; Goodwin, Melissa M.; Ahmed, Noveera T.; Picardo, Kristin F.; and Erklenz-Watts, Michelle (2022). "Successful Failure: Leveraging Mindfulness and Growth-Oriented Reframing to Build Undergraduate Research Resilience." *Confronting Failure: Approaches to Building Confidence and Resilience in Undergraduate Researchers*, 70-79.

Please note that the Publication Information provides general citation information and may not be appropriate for your discipline. To receive help in creating a citation based on your discipline, please visit <http://libguides.sjfc.edu/citations>.

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Successful Failure: Leveraging Mindfulness and Growth-Oriented Reframing to Build Undergraduate Research Resilience

Sara G. Goodman, Melissa M. Goodwin,
Noveera T. Ahmed, Kristin Picardo,
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Abstract. This chapter shines the light on how helping students re-perceive their experiences with failure allows them to boost confidence, well-being, and belongingness. The authors share a practice for re-perceiving failure—mindfulness-metacognition-mindset shift—which is applicable in nearly every situation where failure or difficulty can be encountered. Guidance is provided for implementing this practice within and beyond research settings.

doi: 10.18833/cf/9

Failure: A Guarantee in Undergraduate (and All) Research

It's a familiar script to anyone who has mentored undergraduate STEM researchers. After a summer of independent research on a project they co-designed with their mentor, an undergraduate student researcher is discouraged.

STEM Student Researcher: “My research didn't work.”

Mentor: “Well, what do you mean?”

Student: “Our results weren't what we thought they'd be.”

Students experiencing this kind of violation of expectation are quick to declare defeat rather than acknowledge the outcome as a useful, informative failure.

Failure, put simply, is the lack of achievement of a specific goal (Henry et al. 2019). Attributable to external circumstances, lack of preparation, current ability level, or mere belief about ability, failure is ubiquitous in everyday life. Although failures arise frequently for students in incidental ways during early coursework, students may encounter their first significant, jarring failure in the context of undergraduate (UG) research (Corwin et al. 2018, Gin et al. 2018). Especially in their early research experiences, students expect things to turn out as they anticipated when planning their work originally. Novice student researchers are used to lab experiments “working” as they’ve mostly experienced research in the form of cookbook lab procedures with predictable outcomes and results (Thiry, Laursen and Hunter 2011).

When embarking on a new UG research pathway, students carry this preexisting belief that there is a “correct” outcome to their course of inquiry, and any deviation from this outcome is a failure of the useless variety. For example, the findings from a study may not be conclusive, or may provide evidence for the opposite of the stated hypothesis. Alternatively, a method or procedure may not be suitable for the task, or a miscalculation or error in implementing a protocol may yield unusable data. Despite the frustration that can accompany these experiences, these are all common occurrences in research (Allchin 2012). In science, we actually expect things not to work!

Undergraduate Perceptions and Costs of Failure

Unfortunately, failure bears an overwhelmingly negative connotation. That is, failure is perceived as unilaterally bad, and is something to be avoided. This “failure stigma” results from the perceived narrative that unmitigated success is the path to achievement (Henry et al. 2019; Thiry et al. 2012). Students very rarely hear stories of scientists whose work has been unsuccessful in some form. It comes as a surprise to students to learn that their mentors have failed repeatedly and in a wide variety of ways. In some instances, failures are small speed bumps such as using a technique incorrectly, overlooking an important step in a procedure, or making an error in the data collection process (Gin et al. 2018). These minor failures are often recoverable but can be embarrassing. In other instances, failures can be major setbacks such as significant equipment failures, errors leading to dangerous lab situations, incorrect use of a control sample, or faulty data-recording processes (Lopatto et al. 2020). These major failures can render the data unusable, can waste costly materials, and may derail an entire project. The ways that UG researchers perceive these failures, both minor and major, can lead to a decreased or undermined sense of belonging in the field (Canning et al. 2019; Carlone and Johnson 2007; Cooper et al. 2019; Killpack and Melón 2016).

There is a big disconnect between a novice and a seasoned scientist in terms of expectations and perceptions of research outcomes, especially when those outcomes involve some form of failure. Human error is expected by the mentors but not by the students. Mentors expect results to differ from those predicted and are comfortable with the informational value of this unpredicted result (Nelms and Segura-Totten 2019; Singer and Smith 2013). Novice student researchers are inclined to see these outcomes as “wrong” or “bad” and may manage, or cope with, these negative feelings by engaging in an avoidant strategy that involves ignoring, concealing, or not reporting the failure (Henry et al. 2019). That is, UG researchers may manage their discomfort with failure by not sharing these results with their mentors (at least right away). The encounters with failure may be due to a developmental gap in expertise or an inability to properly execute some step in the process due to a number of factors (e.g., lack of or inaccurate prior knowledge, human error). Ultimately, what students perceive as a negative, wrong, or bad outcome is oftentimes just a violation of their own expectations about how something *should go*. The

misplaced belief that the goal of science is to be “right” rather than to identify the “Truth” weighs heavily on students’ beliefs about the value of their work and the implications of unanticipated outcomes (Thiry, Laursen, and Hunter 2011). Preexisting beliefs and the behaviors that result from them can disrupt the development of a science identity and undermine the potential for growth, learning and improvement (Allchin 2012; Carlone and Johnson 2007; Nunes et al. 2022). This can be further complicated by UG researchers’ reluctance to discuss those failures in service of using avoidance as a coping strategy (Henry et al. 2019). If mentors are not made aware of a problem or failure, they simply cannot help students learn to fix it, let alone to see and appreciate the value of that failure (Lopatto et al. 2020).

Students who appraise failures as reflective of their inability—or who are working in a research environment where failure is not freely discussed, celebrated, or at least evaluated—may hold tightly to this stigma and begin to view their experience in the lab as negative. Consistent with a *fixed mindset* (Dweck 2000, 2006), students who believe that intelligence and ability are static tend to perceive failure as negative and ultimately show higher rates of disengaging and quitting during challenging activities (Blackwell, Trzesniewski and Dweck 2007; Dweck and Leggett 1988; Ortiz Alvarado, Rodríguez Ontiveros, and Ayala Gaytán 2018; Yeager and Dweck 2012). They may also take these failures to signal that they are wasting their time and are not progressing, learning, or developing as a scientist in an adequate way. Cooper and colleagues (2019, 1) showed that “students who reported a negative lab environment or that they were not gaining important knowledge or skills were more likely to leave their Undergraduate Research Experiences (UREs).” In addition to quitting UREs, it is possible that these negative lab environments could lead students to question their belonging in STEM fields in general and thus contribute to the decision to change majors. However, the impact of negative UG research environments on STEM major retention is difficult to analyze because of the likelihood of *survivorship bias*. Studies investigating the impact of UREs on retention in STEM tend to sample only those UG researchers who persist in their research experiences and not those who choose to leave. These findings cannot fully reflect the effects of negative experiences, because UG researchers who quit or are driven away from UREs due to negative experiences are not represented in these studies. Because these nuanced perspectives and experiences are not often captured in the research on major and institutional retention outcomes, we can only reason that the factors that drive students out of UREs may be some of the same things that drive students out of the major or the institution.

Unsupported experiences with failure are detrimental to confidence and belongingness, and ultimately undermine the retention of undergraduate students in research environments (Cooper et al., 2019). Reducing the stigma around failure can encourage students to develop an identity as a scientist and build a sense of belonging in research spaces (Nunes et al. 2022). By validating student experiences in the warts-and-all research process, these encouraging interactions can help establish a sense of comfort in research settings (Lin-Siegler et al. 2016). Consistent with a *growth mindset*, in which students evaluate intelligence and ability as malleable, the appraisal of failure as a learning opportunity can lead to persistence in high-challenge environments (Blackwell, Trzesniewski, and Dweck 2007; Dweck and Leggett 1988; Ortiz Alvarado, Rodríguez Ontiveros, and Ayala Gaytán 2018; Yeager and Dweck 2012). Students who engaged in a high-challenge, course-based undergraduate research experience (CURE) setting and who were supported through their encounters with failure demonstrated a stronger understanding of the nature of science, including a focus on collaboration and persistence through iteration (Gin et al. 2018). These developments in comfort, efficacy, and belonging ultimately contribute to identity development as a researcher. Further, this identity development can be solidified by encouraging meaningful interactions in the lab and supporting UG researchers as their roles become more challenging and complex (Thiry et al. 2012). Increased feelings of security and belongingness can encourage UG researchers to think creatively about problem solving and take calculated risks, which lays the groundwork for scientific innovation (Nunes et al. 2022). These kinds of positive, supportive lab

environments also contribute to enjoyment, which promotes retention in UREs (Cooper et al. 2019). Working to normalize and destigmatize failure, in the many ways researchers experience it, leads to an environment where ideas are valued, where mistakes provide learning experiences, and where the serendipitous nature of STEM research results contributes to our broad knowledge base. These outcomes need to be welcomed and recognized as the gift of past “failures” that they are.

What to Do About Failure? Mindfulness, Metacognition, and Reframing Activities

Exposure to failure can generate a strong negative emotional response (Dweck and Leggett 1988). This response can lead to disengaging, responding helplessly, or outright quitting (Henry et al. 2019). How can students unlearn this link between failure and negativity, and relearn to process failure as a positive experience? The process of learning to re-perceive research failure is rooted in both growth mindset and mindfulness. Teaching student researchers to mindfully pause to reflect on a failure, then to evaluate and reframe the situation as an opportunity for learning and growth, is a process that requires effort but is also one that shifts the narrative from inability to possibility.

Mindfulness, an ancient set of practices rooted in Eastern beliefs, has gained traction in the academic and commercial worlds over the last 20 years. Briefly described, mindfulness is “the awareness gained by paying attention to the present moment, non-judgmentally” (Kabat-Zinn 1994, 4). At the core of this present-moment awareness is acknowledging that the present moment may be positive or negative in perceived valence. Sitting in the moment without attaching the judgment of “good” or “bad” but rather just observing what is real is practicing mindfulness. Mindfulness does not take on any particular or specific form. Instead, it is an ongoing practice that can occur in any number of ways that serve to bring attention into the present moment. Although meditation is a common form of this practice, mindfulness can take on other forms including reflective journaling, walking, singing, deep listening, or yoga (CMind 2021). People can practice mindfulness by engaging in deliberate instances of attention to the present moment. By pausing in the present moment, the automatic narratives or responses to a situation are inhibited, and space is created. Through mindfulness practices, one can gain clarity and experience a shift in perspective—a process defined as *re-perceiving* (Shapiro et al. 2006).

By drawing on the space created through mindfulness practice, student researchers can seize the opportunity to evaluate their own thoughts about their failure experiences and then use reframing processes consistent with a growth mindset to shift their perspectives of failure from useless to informative. This process begins with metacognition or thinking about one’s own thoughts (Dunlosky and Metcalfe 2008; Sternberg 1998). Students can consider what they knew prior to the commission of the failure, what factors contributed to their failure, and what they have learned that will better inform their decisions and actions in the future. In engaging in this metacognitive loop, UG researchers (and people at large) can use their own cognitive tools to understand their evaluations of their own behavior and abilities (Dunlosky and Metcalfe 2008; Sternberg 1998). Most importantly, students can use this process to better understand the biases and framing inherent in their appraisal of these events and can decide to deliberately reevaluate and reframe the appraisal using a growth-oriented lens.

For students struggling with a recent failure, particularly those who experience negative stereotypes, self-talk can often be riddled with questions of belonging (Deiglmayr, Stern, and Schubert 2019):

Does this failure mean I’m bad at this? Does this error mean I shouldn’t be doing this kind of work? Why am I the only one who is making these mistakes? This failure means that I’m not a “science person” or that I don’t belong in this research setting.

When students take a metacognitive time-out to evaluate the factors that contributed to the failure, as well as the lessons learned from it, failure inherently becomes a learning opportunity. This reevalua-

tion is not an outright celebration of the failure itself (although that can be useful for morale), but rather a thoughtful and deliberate identification of the value of the failure:

Yes, this is crummy. What did I learn? Why didn't I know this before I started? If I could do it over, is there something I would have done differently? How can I apply this wisdom as I move forward?

This dramatic pivot from “failure as a reflection of one’s inability” to “failure as an opportunity to learn, grow, improve and innovate” is characteristic of a shift from a fixed mindset to a growth mindset (Dweck and Leggett 1988; Paunesku et al. 2015). This reevaluation entails effort and can be difficult, particularly in the throes of a high-challenge URE (Cooper et al. 2020; Downing et al. 2020).

Although it may seem sufficient to simply learn to re-perceive or reframe an experience, the high emotionality of failure in these circumstances is what makes the incorporation of mindfulness a necessary step. To evaluate a situation using a different lens, space needs to be made between the event itself and the affiliated emotional response. Mindfulness teaches those who practice it to create space between the stimulus (i.e., the failure) and the response (i.e., the frustration; Kabat-Zinn 1994; Shapiro et al. 2006). By creating this space, learners are afforded the latitude to make a different decision about how to perceive or evaluate the meaning of the situation. The mindful “pause” is necessary to interrupt the familiar appraisal of a failure event as negative, and to make space to make a different decision about what the failure means. In short, reframing requires a space to make a decision; mindfulness affords that space (Shapiro et al. 2006).

The Importance of Mentorship

Although much of the mindful, metacognitive work in failure reframing must be done by the student researcher themselves, this process is a learned skill set. Inarguably, in a research setting, the person best suited to teach, model, and encourage the application of this set of skills is a student research mentor. The existing literature on mentorship in UG research settings makes plain the importance of mentor involvement in student development beyond mere technical skill (Hall et al. 2021; Shanahan et al. 2015; Vandermaas-Peeler, Miller, and Moore 2018). The Salient Practices framework posited by Shanahan and colleagues (2015) outlines a list of ten best practices of mentors; these practices have since been adapted to the online mentoring environment encouraged by the COVID-19 pandemic (Hall et al. 2021). Of these ten practices, six focus on strategies related to personal development and establishing belongingness in the field of study (including providing emotional support, facilitating networking, encouraging interaction with labmates, and peer mentorship). These Salient Practices reflect priorities that underscore the importance of mentorship for teaching students how to be researchers rather than merely how to *do* research. That is, effective mentorship practices are ones that encourage the development of supporting skills like communication, autonomy, and relationship development. An entire CUR publication, *Excellence in Mentoring Undergraduate Research*, has since been devoted to the importance of mentoring in UG research; topics such as these are carefully explored (Vandermaas-Peeler, Miller, and Moore 2018). Because failure is an inherent part of the research process, effective mentorship must also include a focus on adaptive coping practices.

Beyond teaching research techniques and community-building skills, mentorship encompasses the responsibility to teach UG researchers to strategize in response to adversity or difficulty. These coping and resilience skills are notable among accomplished scientists but are not commonly incorporated as explicit teaching or mentorship practices (Henry et al. 2019). Put plainly, practicing effective failure management is an important skill for researchers, but the opportunity to learn it is lacking. Mentors are perfectly positioned to provide these failure reframing opportunities and can leverage this training to increase retention and engagement among UG researchers. Mentors can improve the lab environment

and encourage efficacy-building through the incorporation of effortful and deliberate failure management as a mentorship practice. This has the added benefit of requiring the mentor to reevaluate their own beliefs about failure, challenge, and resilience, which is yet another important factor in determining UG researcher outcomes.

The beliefs and biases held by mentors and teachers can directly impact student identity development (Carlone and Johnson 2007) and belongingness (Canning et al. 2019; Killpack and Melón 2016). These beliefs may be explicit and clearly known by the mentor or may be implicit such that the mentor is unaware of their biases (Killpack and Melón 2016). Both explicit and implicit biases can impact mentors' perceptions of their students' work, can shift expectations and resultant evaluations, and can influence beliefs about student ability overall (Killpack and Melón 2016; Canning et al. 2019). For example, some mentors may implicitly believe that certain students have "a high level of innate intelligence" (Prunuske et al. 2013, 406) that contributes to a predetermined likelihood of success; this belief is consistent with a fixed mindset (Dweck 2000, Dweck 2006). Instructors' fixed mindsets about students' STEM ability contribute to significant and pervasive racial achievement gaps, because their policies, practices, and language can send strong implicit signals to students about the kinds of students that can succeed in STEM (Canning et al. 2019). Instructors with growth mindsets saw far fewer instances of this kind of disparity because their policies, practices, and language tend to reinforce the idea that anyone can improve their abilities, and that all students can belong in the discipline (Canning et al. 2019). In a summary of mentor perspectives, Prunuske et al. (2013) report that mentors commonly characterize students who quit UG research experiences as "discovering that science was not for them" (406). These kinds of stereotype-bound beliefs about belongingness heavily influence science identity formation (Carlone and Johnson 2007) and can drive students away from growth-rich, challenging opportunities (Killpack and Melón 2016).

Instructor/mentor beliefs, including mindset, send a strong message about who seemingly belongs in these spaces; it is critically important for mentors to be cognizant of this influence (Prunuske et al. 2017). Acknowledging the impact of mentor beliefs on student outcomes is an important initial step in shifting the narrative surrounding failure. Mentors are in the perfect position to shift failure perspectives in research settings and can use these practices to create a culture of belonging. There are two practical and simple ways to approach this shift: failure transparency and modeling mindful reframing.

First, mentors must be transparent about past and current failures to bring failure to the forefront of research space as a common, inevitable, necessary process (Lin-Siegler et al. 2016). Student researchers often only see the successes and perceive mentors as nearly faultless, further contributing to failure stigma (Nunes et al. 2022). To dismantle this, mentors can normalize talking about failures of all types (Walton et al. 2015). This includes experiment failures (design, execution, etc.), publication failures (rejections, revise/resubmit then reject, etc.), funding failures, and any other kind of situation that both humanizes the mentor and destigmatizes the process of not meeting a goal or objective. Mentors may consider keeping an accessible written record of these obstacles in the form of a "Failure CV" (Stefan 2010). Mentors can also highlight the commonality of research failure by sharing information about journals and archives that publish null results and nonsignificant findings, including *Positively Negative* and *The All Results Journals*. From the mentor perspective, failure is likely the rule to which success is the exception; student researchers may only be aware of the exception.

Second, and equally as important, is for the mentor to learn, teach, and continually practice the process of mindful reframing, modeling this strategy for UG researchers. Mentors can learn to mindfully pause and reframe failure by using the processes outlined above. As mentors learn this strategy, they can include it as a part of the research process so that when a student experiences a failure, the mentor can help to create space for the pause and scaffold the reframing process (Rattan et al. 2015). For example, a mentor might ask all lab members to bring an example of a recent failure to the weekly lab meeting.

The mentor can begin the meeting by presenting their own failure and modeling the process of mindful reframing, then coaching each lab member through their own reframing practices (O’Keefe, Lee, and Chen 2021). In a group setting, this has multiple benefits: not only do student researchers hear about others’ failures, helping to normalize that failure experience, but also have the added benefit of helping others troubleshoot, unpack, and reframe the experience. Ultimately, these practices can bolster belongingness and confidence for STEM students (Deiglmayr, Stern, and Schubert 2019; Walton et al. 2015). Packard (2015, 99) reminds us, “One student, one colleague, one interaction at a time,” which is pertinent advice given the often-small group or one-on-one nature of mentored UG research. The process of mindful reframing is a *practice*, which requires time, effort, support, and iteration.

How to Get Started

Mindful reframing is an effortful, ongoing practice. Fortunately, this practice does not need to be learned exclusively in a research setting to be useful in that context. The following suggestions can help develop and practice these skills.

First, engage in the practices of mindfulness, metacognition, and mindset-based reframing in other areas of life. By using this same strategy to evaluate non-research-related failures, the strategy can be further solidified so that transfer to other contexts becomes much easier. This can be done in three simple steps. First, take a mindful pause. Second, metacognitively reflect: consider thoughts, biases, knowledge, and beliefs. Finally, reevaluate the situation and shift the perspective. This process, *mindfulness-metacognition-mindset shift*, is applicable in nearly every situation in which failure or difficulty can be encountered, and every use of this process is worthwhile practice for future failures.

Further, learning better can occur through teaching. This process is straightforward; simple; impactful; and can easily be taught to students in classrooms, to collaborators, and to colleagues. Helping others to harness this mindful reframing process in situations beyond research settings can help student researchers and mentors alike to better develop these skills. Further, by sharing and spreading these processes in other spaces (especially research-adjacent spaces such as among colleagues in a department or division, with support staff in academic spaces, and so on), this mindful reframing perspective can take hold as a norm or typical practice.

Establishing a practical and useful practice in response to the experience of failure can allow for a shift from academic cultures and structures to ones that are centered on principles of growth (Yeager and Walton 2011). These growth-oriented structures encourage belongingness, engagement, and boost student confidence and well-being (Ortiz Alvarado, Rodríguez Ontiveros and Ayala Gaytán 2018; Yeager and Dweck 2012). In working toward these larger goals of inclusion and equity, we can start to dismantle the misperceptions of failure.

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