CONFRONTING FAILURE

Approaches to Building Confidence and Resilience in Undergraduate Researchers

Edited by Lisa A. Corwin and Louise K. Charkoudian
with Jennifer M. Heemstra

Council on Undergraduate Research

CONFRONTING FAILURE

Approaches to Building Confidence and Resilience in Undergraduate Researchers

Edited by Lisa A. Corwin and Louise K. Charkoudian
with Jennifer M. Heemstra

Council on
Undergraduate Research

ISBN: 978-0-941933-14-8 (PDF)
ISBN: 978-0-941933-15-5 (ebook)
doi: 10.18833/cf/20

Council on Undergraduate Research
267 Kentlands Blvd. • No. 4021
Gaithersburg, MD 20878
Tel: 202/783-4810
www.cur.org

Design by Rebecca Silber Design, Milwaukee, WI
About the cover: Photo by Jacob Ode, Trollhättan, Sweden

Produced in the United States of America

Table of Contents

Introduction

Lisa A. Corwin, Louise K. Charkoudian, and Jennifer M. Heemstra

Abstract. The coeditors of *Confronting Failure* discuss the background and chapter overview of the book.
doi: 10.18833/cf/2

Innovation, technology development, data accumulation, and interconnectivity are all rapidly increasing in our modern world (Friedman 2017). Across disciplines, these advances have led to exciting developments such as novel vaccine mechanisms (Le et al. 2020), innovative ways to search for and provide information (Cao, Liang, and Li 2018), and creative uses of media and artistic expression (Kaimal et al. 2020). However, at the same time as such advances, and in some cases due to increasing connectivity and technological advancements, problems are becoming more complex. Challenges related to climate change are increasing in multitude and magnitude (Cardinale et al. 2014; Daszak et al. 2020; Pachauri et al. 2014), viral pandemics have more potential to spread and may be more lethal (Madhav et al. 2017), issues with data storage and security abound (Wang et al. 2010). The increasing complexity of our world in addition to novel advancements also make researchers more prone to encounter challenges and failures while they search for lasting and tenable solutions. Today, more than ever, we are in need of a future generation of researchers and innovators who respond adaptively to challenge and failure and who display resilience when faced with setbacks.

Although the need for resilient individuals may be becoming more pressing, it is not new. Across STEM, the humanities, and the arts, resilience and adaptive coping in the face of failure have been recognized as valued, and even necessary, skills (Harsh, Maltese, and Tai 2001; Henry et al. 2019; Manalo and Kapur 2018; Sawyer 2019; Simpson and Maltese 2017). In some disciplines, failure is seen as an epistemic experience; that is, it is viewed as generating and contributing to the learning that happens within the discipline. This is reflected in the title of Simpson and Maltese's 2017 article describing interviews with STEM professionals: "'Failure Is a Major Component of Learning Anything': The Role of Failure in the Development of STEM Professionals." Indeed, entrepreneurs across disciplines recognize the role of failure in their personal development (Lattacher and Wdowiak 2020), and professors who learn from rejections and resubmit grants more quickly after a failed attempt tend to be awarded more grants (Yin et al. 2019). There can be little doubt that, when taken as a learning opportunity, failure is a valuable experience even for those who society brands as being highly successful (Lin-Siegler et al. 2016).

Yet, we must acknowledge that although failures can be epistemic and often lead to productive and innovative courses of action, failing can be a difficult experience (Shepherd and Cardon 2009). In particular, novices in a particular field may feel discouraged or fearful when they fail. This is especially true for undergraduate students who perceive failures to be high-stakes (Nelson et al. 2013) or who may be coping with other psychological or personal challenges (Cooper et al. 2020). Failing can prompt students' decisions to leave their chosen field (Chen 2009) and may be especially influential in the departure of PEERs (persons excluded due to race or ethnicity, Asai 2020; Riegle-Crumb, King, and Irizarry 2019). Considering this, it is imperative that we, as educators and researchers, strive to understand undergraduates' experiences with failure and support them in developing the resilience necessary to both persist and succeed in tackling the challenges of the future.

Across the disciplines, engaging students in undergraduate research provides an ideal opportunity to expose students to failure in an environment that offers potential for support and scaffolding. Research, because of the nature of exploring the unknown, presents opportunities for students to grapple with unexpected challenges and results, iterate to make progress, and cope with ambiguity and surprise (Auchincloss et al. 2014). This stands in contrast to more prescriptive pedagogies in which the goal is for students to move toward a common understanding, specific answer or result, or "correct" response (Buck, Bretz, and Towns 2008). In addition, undergraduate research provides opportunities for experts in a field to mentor and guide novices in coping with failure. Furthermore, undergraduate research can happen across contexts such as part of a class (i.e., course-based undergraduate research experiences or CUREs), as a one-on-one mentored experience, or via cohort models, which all provide opportunities for experts in a field to mentor and guide novices in coping with failure (Dolan 2016; Laursen et al. 2010; Wei and Woodin 2011).

The potential for undergraduate research to serve as a context from which students can learn and be supported in adaptively coping with failure has led to several productive avenues of investigation. Investigations of STEM CUREs have elucidated how "formative frustration" and opportunities to fail and iterate lead to successful learning outcomes (Gin et al. 2018; Lopatto et al. 2020) and resulted in students seeing the research as more "authentic" (Goodwin et al. 2021). Extensive qualitative work on mentored undergraduate research has continually found that students report developing the ability to persevere through challenges and cope with setbacks as important outcomes (Harsh et al. 2011; Hunter, Laursen, and Seymour 2007; Laursen et al. 2010; Thiry et al. 2012). Beyond undergraduate research contexts, failure has also been used as a pedagogical tool in mathematics (e.g., productive failure, Kapur 2008). Yet, generally speaking, research addressing how undergraduate students cope with research failure and develop resilience within this context is sparse.

This book seeks to address this gap by bringing together a network of researchers, practitioners, and innovators who have thought about, experienced, and leveraged failure in research-based settings. Importantly, the impetus for this work arose from the interest of the Council on Undergraduate Research (CUR) in building the skill set of undergraduate researchers to nurture their personal and professional success, as well as a collaborative essay written by the book's coeditors (Corwin, biology; Charkoudian, chemistry; and Heemstra, chemistry) in collaboration with Shayla Shorter (biology) and Meredith Henry (psychology; Henry et al. 2019). This work explored how theory and constructs from psychology and the social sciences interact to influence how students approach challenges and respond to failures. Beginning with the commonly recognized and widely explored concept of Growth Mindset (Dweck 2006), the article explains how having a growth mindset is correlated with approaching challenges with a mastery goal orientation (Pintrich 2000) and how this, in turn, results in individuals being more likely to attribute failures to controllable, changeable causes (Weiner 1985) and practice adaptive coping strategies (Skinner et al. 2003). This article provided the first step from which we, as coeditors, in collaboration with contributors to this book and CUR staff, began to pose more pointed questions about undergraduates' experiences of failure when engaging in research.

Elucidating Undergraduate Researchers' Failure Experiences: Posing Questions

Although undergraduate students might enter college with a general understanding/appreciation of the value of a growth mindset, many students remain unprepared to embrace failures and challenges as learning experiences (Marra et al. 2012; Bennett 2017; Simpson and Maltese 2017). Thus, there is a clear need to build networks of support nodes within the context of undergraduate education. Given the premise that undergraduate research experiences provide fertile ground to address a range of relevant constructs such as mindset, goal orientation, fear of failure, attributions, and coping responses (Henry et al. 2019), the following six pressing questions face undergraduate educators, administrators, and educational researchers:

1. ***What type of research failures exist?*** The broad definition of failure as the gap between an expected or desired result and what one ultimately experiences (Cannon and Edmondson 2015) supports the notion that failure experiences are ubiquitous. Failure can be viewed as a concept beyond disengagement from a task (Cacciotti 2015) or error (Tulis, Steuer, and Dresel 2016). In the context of undergraduate STEM research, failure can manifest itself as an unexpected result, an ambiguous dataset, or a technical failure. In the arts and humanities, failure might be encountered as the inability to generate a proper search term or a researchable question. Identifying types of failures undergraduates experience in research as well as the contexts in which these experiences occur are central to building requisite support structures to turn a potentially devastating outcome such as attrition to a potentially empowering one such as challenge-seeking (Henry et al. 2019).
2. ***How do undergraduates respond when they encounter research failures?*** How students respond to stressors such as failures varies from student to student and across contexts (Skinner et al. 2003; Henry et al. 2019; Lazarus 1993). Adaptive coping strategies (such as support seeking) help a student move beyond the stressor and maintain well-being, whereas maladaptive strategies (such as social withdrawal) inflame threats to the student's well-being and prevent progress beyond the stressor. Understanding undergraduate coping strategies is essential to developing target interventions and practices to support adaptive coping in the face of undergraduate research failures.
3. ***How can we support adaptive responses to failure?*** Given the potential relationship between adaptive coping strategies and the ability to navigate obstacles, seek challenge, and preserve (Henry et al. 2019), supporting adaptive responses to failure in undergraduate research represents a high-impact node of intervention. This requires an understanding of how these skills manifest across contexts (Henry et al. 2021). For example, we must understand what practices are effective in helping students develop adaptive coping, whether these practices are translatable across contexts (or are context-specific) and whether there is disparate impact across different student populations. The increasing interconnectivity and complexity of our world and rapidly evolving landscape of student demographics across higher education underscores the importance of developing effective supports to encourage adaptive responses to failure.
4. ***How do we prepare students for failure and help them develop resilience prior to when failures occur?*** Given the ubiquity of failure in undergraduate research, there is no need to wait and respond to failure. Instead, we can help students prepare for the inevitable (and hopefully positive)

failure experience. Pre-failure strategies can include nurturing a growth mindset, mastery approach, goal orientation, and challenge-engaging disposition (Henry et al. 2019); building structures in courses to learn from and respond to failure; and normalizing failure as a critical part of the undergraduate research experience.

5. ***What structures and supports need to be in place at institutional, programmatic, and course-based levels?*** When undergraduate students matriculate, they enter both a community (e.g., faculty, staff, peers) and structure (e.g., curriculum, programs, advising, services) within higher education. Each of these aspects of undergraduate education represents a powerful opportunity to support students in confronting failure. Thus, it is imperative that we understand how each context can be optimally leveraged to support increasingly diverse individuals and how we can weave efforts across these institutional, programmatic, and course-based levels to provide a strong tapestry of support.
6. ***How do we build instruction on coping with failure and developing resilience more explicitly into the curriculum?*** Aligning course goals, instructional activities, and assessment provides students with a clear sense of expectations for mastery. Given that developing noncognitive skills such as adaptive coping and learning from failure is a valuable goal for undergraduate research experiences, instructional practices and assessment should be brought into alignment. How can we best do this? Perhaps exercises such as learning reflections, individual development plans, or metacognition-based assignments should become a norm in undergraduate research experiences (Tanner 2012). Exactly what these look like and how they are best integrated into research should be based on research conducted by key stakeholders such as educational researchers, instructors, psychologists and students (for a brief review of metacognition literature, see Tanner 2012).

Overview of the Book

Given the ubiquitous nature of failure in undergraduate research experiences, it is perhaps unsurprising that the six questions posed above can, and should, be addressed across a range of contexts, within numerous disciplines and within a variety of learning environments. Thus, authors were invited from a range of disciplines—from geosciences (Williams, chapter 1) to drama (Yorke, chapter 17)—to capture how failure manifests and can be productively supported in a range of research experiences. Whether the learning environment is a STEM research lab (e.g. Hall and Ketcham, chapter 16) or CURE (Hyman and Harsh, chapter 2; Townsend, chapter 3; Beason-Abmayr and colleagues, chapter 4), a humanities summer undergraduate research experience (SURF; Jasinski, chapter 11), a library (Meals, chapter 9), or the stage (Yorke, chapter 17), students can benefit from support when they experience a gap between an expected/desired result and their lived experience (i.e., when they "fail"; Cannon and Edmondson 2015). These voices and disciplinary contexts set the stage for addressing failure from different vantage points and lenses, with the common focal point of nurturing undergraduate success through leveraging failure as an opportunity to build confidence and resilience.

Furthermore, this book presents work across different educational contexts, including different institutional types, classroom and non-classroom environments, and programmatic and individual efforts. It represents efforts from institutions both private (Williams, chapter 1) and public (Olcott et al., chapter 13), comparable two-year institutions (Townsend, chapter 3) and four-year contexts (Hyman and Harsh, chapter 2), minority-serving institutions (e.g., Haeger and Oehlman, chapter 12), and authors from across the country (West Coast: Sell et al., chapter 15; East Coast: Goodman et al., chapter 5; Northern Midwest: Baril et al., chapter 8; and South: K. L. Carter and J. L. Carter, chapter 7). This work is being done at different organizational levels within institutions of higher education. The authors describe broad programmatic efforts that aim to serve all first-year students at an institution (Waterman, chapter 10), practices enacted to support undergraduate researchers across disciplines (Jasinski, chapter 11), approaches taken in individual courses (upgrading, K. L. Carter and J. L. Carter, chapter 7), and specific practices embedded within the broader practice of undergraduate research such as mentoring (Dunbar-Wallis and Henry, chapter 14) and understanding by design (Greenwell, chapter 6). It is hoped that the range of disciplines, contexts, and levels of organization presented here will ignite a diversity of new ideas for readers who aim to institute or enhance similar practices at their institution, in their course, or for their research mentees.

Importantly, because this is an emerging area of research, we intentionally sought to be inclusive of research and ideas at multiple stages of development and from individuals who span a range of areas of expertise. Thus, this collection includes many types of contributions from practitioners, researchers, and administrators. Some authors present perspectives that explain their personal views developed from reading the literature on how to best support student coping and resilience. Other authors describe their experiences teaching, researching, or mentoring framed as case studies that highlight evidence-based best practices. Still others present original research on courses taught by themselves or others that detail outcomes of deliberate interventions and investigations. By including chapters from authors with various views, perspectives, and forms of evidence, this collection of work invites a community of scholars across disciplines to further test, revise, elaborate upon, or challenge the findings presented here. We urge readers to consider how this work can be used as a starting point from which to drive forward movements that seek to better understand and design practices that support students when confronting failure.

References

Asai, David J. 2020. "Race Matters." *Cell* 4: 754–757. doi: 10.1016/j.cell.2020.03.044

Auchincloss, Lisa C., Sandra L. Laursen, Janet L. Branchaw, Kevin Eagan, Mark Graham, David I. Hanauer, and Erin Dolan. 2014. "Assessment of Course-Based Undergraduate Research Experiences: A Meeting Report." *CBE– Life Sciences Education* 1: 29–40. doi: 10.1187/cbe.14-01-0004

Bennett, Jessica. 2017, June 24. "On Campus, Failure Is on the Syllabus." *New York Times,* https://www.nytimes.com/2017/06/24/fashion/fear-of-failure.html. Accessed December 28, 2018.

Buck, Laura B., Stacey Lowery Bretz, and Marcy H. Towns. 2008. "Characterizing the Level of Inquiry in the Undergraduate Laboratory." *Journal of College Science Teaching,* 1: 52–58.

Cacciotti, Gabriella. 2015. "Fear of Failure in Entrepreneurship: A Review, Reconceptualization, and Operationalization." PhD diss., University of Warwick, England. Accessed December 28, 2018.

Cannon, Mark D., and Amy C. Edmondson. 2005. "Failing to Learn and Learning to Fail (Intelligently): How Great Organizations Put Failure to Work to Innovate and Improve." *Long Range Planning* 38: 299–319. doi: 10.1016/j.lrp.2005.04.005

Cao, Gaohui, Mengli Liang, and Xuguang Li. 2018. "How to Make the Library Smart? The Conceptualization of the Smart Library." *The Electronic Library.* doi: 10.1108/EL-11-2017-0248

Cardinale, Bradley J., J. Emmett Duffy, Andrew Gonzalez, David U. Hooper, Charles Perrings, Patrick Venail, Anita Narwani, Georgina M. Mace, David Tilman, David A. Wardle, et al. 2012. "Biodiversity Loss and Its Impact on Humanity." *Nature* 486: 59–67. doi: 10.1038/nature11148

Chen, L. H., Chia Huei Wu, Ying Hwa Kee, Meng-Shyan Li, and Shang-Hsueh Shui. 2009. "Fear of Failure, 2× 2 Achievement Goal and Self-Handicapping: An Examination of the Hierarchical Model of Achievement Motivation in Physical Education." *Contemporary Educational Psychology,* 4: 298–305.

Cooper, Katelyn M., Logan E. Gin, M. Elizabeth Barnes, and Sara E. Brownell. 2020. "An Exploratory Study of Students with Depression in Undergraduate Research Experiences." *CBE–Life Sciences Education* 19(2): ar19. doi: 10.1187/cbe.19-11-0217

Daszak, Peter, J. Amuasi, C. G. das Neves, D. Hayman, T. Kuiken, B. Roche, C. Zambrana-Torrelio, et al. (Eds.). 2020. *Workshop Report on Biodiversity and Pandemics of the Intergovernmental Platform on Biodiversity and Ecosystem Services.* IPBES Secretariat, Bonn, Germany, doi:10.5281/zenodo.4147317

Dolan, Erin L. 2016. "Course-Based Undergraduate Research Experiences: Current Knowledge and Future Directions." Commissioned Paper, pp. 1–34. Washington, DC: National Academies of Sciences, Engineering, and Medicine. Retrieved February 12, 2020, from https://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_177288.pdf

Dweck, Carol S. 2006. *Mindset: The New Psychology of Success.* New York: Ballantine.

Friedman, Thomas L. 2017. *Thank You for Being Late.* New York: Picador USA.

Gin, Logan E., Ashley A. Rowland, Blaire Steinwand, John Bruno, and Lisa A. Corwin. 2018. "Students who Fail to Achieve Predefined Research Goals May Still Experience Many Positive Outcomes as a Result of CURE Participation." *CBE–Life Sciences Education* 17(4): ar57. doi: 10.1187/cbe.18-03-0036

Goodwin, Emma C. , Vladimir Anokhin, MacKenzie J. Gray, Daniel E. Zajic, Jason E. Podrabsky, and Erin E. Shortlidge. 2021. “Is This Science? Students’ Experiences of Failure Make a Research-Based Course Feel Authentic.” *CBE–Life Sciences Education* 20(1): ar10. doi: 10.1187/cbe.20-07-0149

Harsh, Joseph A., Adam V. Maltese, and Robert H. Tai. 2011. “Undergraduate Research Experiences from a Longitudinal Perspective.” *Journal of College Science Teaching* 41(1): 84–91.

Henry, Meredith A., Shayla Shorter, Louise K. Charkoudian, Jennifer M. Heemstra, and Lisa A. Corwin, L. A. 2019. “FAIL Is Not a Four-Letter Word: A Theoretical Framework for Exploring Undergraduate Students’ Approaches to Academic Challenge and Responses to Failure in STEM Learning Environments.” *CBE–Life Sciences Education* 18(1): ar11. doi: 10.1187/cbe.18-06-0108

Henry, Meredith A., Shayla Shorter, Louise K. Charkoudian, Jennifer M. Heemstra, Benjamin Le, and Lisa A. Corwin. 2021. “Quantifying Fear of Failure in STEM: Modifying and Evaluating the Performance Failure Appraisal Inventory (PFAI) for Use with STEM Undergraduates.” *International Journal of STEM Education* 8(1): 1–28.

Hunter, Annie-Barrie, Sandra L. Laursen, and Elaine Seymour. 2007. “Becoming a Scientist: The Role of Undergraduate Research in Students’ Cognitive, Personal, and Professional Development.” *Science Education* 91(1): 36-74.doi: 10.1002/sce.20173

Kaimal, Girija, Katrina Carroll-Haskins, Marygrace Berberian, Abby Dougherty, Natalie Carlton, and Arun Ramakrishnan. 2020. “Virtual Reality in Art Therapy: A Pilot Qualitative Study of the Novel Medium and Implications for Practice.” *Art Therapy* 37(1): 16–24. doi: 10.1080/07421656.2019.1659662

Kapur, Manu. 2008. “Productive Failure.” *Cognition and Instruction* 26: 379–424. doi: 10.1080/07370000802212669

Lattacher, Wolfgang, and Malgorzata Anna Wdowiak. 2020. “Entrepreneurial Learning from Failure. A Systematic Review.” *International Journal of Entrepreneurial Behavior & Research* 26: 1093–1131. doi: 10.1108/IJEBR-02-2019-0085

Laursen, Sandra, Annie-Barrie Hunter, Elaine Seymour, Heather Thiry, and Ginger Melton. 2010. *Undergraduate Research in the Sciences: Engaging Students in Real Science.* New York: Wiley.

Lazarus, R. S. 1993. “Coping Theory and Research: Past, Present, and Future.” *Psychosomatic Medicine* 55: 366–388. doi: 10.1097/00006842-199305000-00002

Le, T. Thanh, Zacharias Andreadakis, Arun Kumar, R. Gómez Román, Stig Tollefsen, Melanie Saville, and Stephen Mayhew. 2020. “The COVID-19 Vaccine Development Landscape.” *Nature Reviews Drug Discovery* 19: 305–306. doi: 10.1038/d41573-020-00073-5

Lin-Siegler, Xiaodong, Janet N. Ahn, Jondou Chen, Fu-Fen Anny Fang, and Myra Luna-Lucero. 2016. “Even Einstein Struggled: Effects of Learning about Great Scientists’ Struggles on High School Students’ Motivation to Learn Science.” *Journal of Educational Psychology* 108: 314–328. doi: 10.1037/edu0000092

Lopatto, David, Anne G. Rosenwald, Justin R. DiAngelo, Amy T. Hark, Matthew Skerritt, Matthew Wawersik, Anna K. Allen et al. 2020. “Facilitating Growth through Frustration: Using Genomics Research in a Course-Based Undergraduate Research Experience.” *Journal of Microbiology & Biology Education* 21(1): e40. doi: 10.1128/jmbe.v21i1.2005

Madhav, Nita, Ben Oppenheim, Mark Gallivan, Prime Mulembakani, Edward Rubin, and Nathan Wolfe. 2017. "Pandemics: Risks, Impacts, and Mitigation." In D. T. Jamison et al. (Eds.), *Disease Control Priorities: Improving Health and Reducing Poverty,* pp. 315–345. 3rd ed. Washington, DC: International Bank for Reconstruction and Development/The World Bank.

Manalo, Emmanuel, and Manu Kapur. 2018. "The Role of Failure in Promoting Thinking Skills and Creativity: New Findings and Insights about How Failure Can Be Beneficial for Learning." *Thinking Skills and Creativity* 30: 1–6. doi: 10.1016/j.tsc.2018.06.001

Marra, Rose M., Kelly A. Rodgers, Demei Shen, and Barbara Bogue. 2012. "Leaving Engineering: A Multi-Year Single Institution Study." *Journal of Engineering Education* 101: 6–27. doi: 0.1002/j.2168-9830.2012.tb00039.x

Nelson, Krista L., Danielle N. Newman, Janelle R. McDaniel, and Walter C. Buboltz. 2013. "Gender Differences in Fear of Failure amongst Engineering Students." *International Journal of Humanities and Social Science,* 3(16): 10–16.

Pachauri, R. K., M. R. Allen, V. R. Barros, J. Broome, W. Cramer, R. Christ, J. A. Church, et al. 2014. "Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change." pg. 151. IPCC.

Pintrich, Paul R. 2000. "Multiple Goals, Multiple Pathways: The Role of Goal Orientation in Learning and Achievement." *Journal of Educational Psychology* 92: 544–555. doi: 10.1037/0022-0663.92.3.544

Riegle-Crumb, Catherine, Barbara King, and Yasmiyn Irizarry. 2019. "Does STEM Stand Out? Examining Racial/Ethnic Gaps in Persistence across Postsecondary Fields." *Educational Researcher* 48(3): 133–144. doi: 10.3102/0013189X19831006

Sawyer, R. Keith. 2019. "The Role of Failure in Learning How to Create in Art and Design." *Thinking Skills and Creativity* 33: ar. 100527. doi: 10.1016/j.tsc.2018.08.002

Shepherd, Dean A., and Melissa S. Cardon. 2009. "Negative Emotional Reactions to Project Failure and the Self-Compassion to Learn from the Experience." *Journal of Management Studies* 46: 923–949. doi: 10.1111/j.1467-6486.2009.00821.x

Simpson, Amber. and Adam Maltese. 2017. "'Failure Is a Major Component of Learning Anything': The Role of Failure in the Development of STEM Professionals." *Journal of Science Education and Technology* 26: 223–237. doi: 10.1007/s10956-016-9674-9

Skinner, Ellen A., Kathleen Edge, Jeffrey Altman, and Hayley Sherwood. 2003. "Searching for the Structure of Coping: A Review and Critique of Category Systems for Classifying Ways of Coping." *Psychological Bulletin,* 129: 216–269. doi: 10.1037/0033-2909.129.2.216

Tanner, Kimberly D. 2012. "Promoting Student Metacognition." *CBE–Life Sciences Education* 11: 113–120. doi: 10.1187/cbe.12-03-0033

Thiry, Heather, Timothy J. Weston, Sandra L. Laursen, and Annie-Barrie Hunter. 2012. "The Benefits of Multi-Year Research Experiences: Differences in Novice and Experienced Students' Reported Gains from Undergraduate Research." *CBE–Life Sciences Education* 11: 260–272. doi: 10.1187/cbe.11-11-0098

Tulis, Maria, Gabriele Steuer, and Markus Dresel. 2016. "Learning from Errors: A Model of Individual Processes." *Frontline Learning Research* 4(2): 12–26. doi: 10.14786/flr.v4i2.168

Wang, Qian, Cong Wang, Kui Ren, Wenjing Lou, and Jin Li. 2010. "Enabling Public Auditability and Data Dynamics for Storage Security in Cloud Computing." *IEEE Transactions on Parallel and Distributed Systems* 22: 847–859. doi: 10.1109/TPDS.2010.183

Wei, Cynthia A., and Terry Woodin. 2011. "Undergraduate Research Experiences in Biology: Alternatives to The Apprenticeship Model." *CBE–Life Sciences Education* 10: 123–131. doi:10.1187/cbe.11-03-0028

Weiner, Bernard. 1985. "An Attributional Theory of Achievement Motivation and Emotion." *Psychological Review* 92: 548–573. doi: 10.1037/0033-295X.92.4.548

Yin, Yian, Yang Wang, James A. Evans, and Dashun Wang. 2019. "Quantifying the Dynamics of Failure across Science, Startups and Security." *Nature* 575: 190¬–194. doi: 10.1038/s41586-019-1725-y

CHAPTER 1

Failing Forward: Helping Undergraduate Researchers in Geosciences Cultivate Strong Science Identities and Growth Mindsets

Nekesha B. Williams

Abstract. This chapter highlights a few socio-psychological factors that may contribute to fear of failure in undergraduate students, specifically those who are underrepresented minorities (URM). Socio-psychological factors such as stereotype threat, poor science identity, and mindset are defined, with a discussion as to how each may contribute to fear of failure in URM students. Recommendations are made to help mentors work through these fears and build resiliency in the face of fear.

doi: 10.18833/cf/3

Geoscience as an interdisciplinary field of study is at the forefront of addressing complex issues such as climate change. Therefore, educating and preparing the 21st-century geoscience workforce to tackle these complex problems requires not only scientific competency but also a culturally diverse (Daily and Eugene 2013; Gibbs 2014) and emotionally intelligent workforce (Hesseln 2020; MacCann et al. 2020). However, despite various efforts (e.g., organizational structure, leadership, federal funding), geoscience remains one of the least diverse of the science, technology, engineering, and mathematics (STEM) fields (Marín-Spiotta et al. 2020; Núñez, Rivera, and Hallmark 2020). Increasing diversity in the geosciences will require relevant academic departments to understand the fears of underrepresented minority (URM) students and the influence of the fear of failure on making academic and subsequently career decisions.

This chapter discusses potential factors contributing to the fear of failure in URM students pursuing degrees in geosciences and other STEM fields as well as provides recommendations for supporting URM student in productively confronting these fears. Some of the factors that may contribute to fear of failing in URM students include stereotype threats, negative science identities, and fixed mindsets. In this chapter, failure is defined as the inability to achieve an "expected or desired" outcome (Cannon and Edmonson 2005). For students, this can include achieving low grades, conducting failed experiments, repeating a class, changing academic programs, and/or dropping out of college (Naijimi et al. 2013).

Background

Students pursuing geoscience degrees are introduced to physical, natural, and even social sciences for a well-rounded education. A well-trained student in this field obtains a strong knowledge foundation; field and technical competencies (American Geosciences Institute 2022; BLS 2022); and a range of skills such as systems thinking (Lally et al. 2019), problem-solving, critical thinking, written and oral communication, and more (Bureau of Labor Statistics 2022). All these skills take persistent practice, yet poor performance during training (practice) can be cited as a reason to leave the field due to a lack of "talent" or "giftedness" (Smith et al. 2012; MacPhee, Farro, and Canetto 2013; Leslie et al. 2015; Oktavia and Ridlo 2020). The belief that talent is innate and not developed can lead students to predict or anticipate failure, thus creating anxiety in these students (ACHA 2019). The apparent anxiety in such students may be rooted in the uncertainty about future success in their chosen degree program. Therefore, understanding fear, the ways in which fear manifests itself in a student—in particular, fear of failure—is critical to the recruitment and retention of a diverse student body to the geosciences.

There are various socio-psychological factors that influence students' ability to achieve academic success and hinder their personal and professional growth. Some of these factors include fearing failure (Bledsoe and Baskin 2014), facing stereotype threats (Spencer, Logel, and Davies 2016), having poor science identity (Chen et al. 2021) and possessing fixed mindsets (Dweck 2006; Blackwell, Trzesniewski, and Dweck 2007; Henry et al. 2019). Although fear of failure is ubiquitous for students, there may be some components of this issue that are more prominent or unique to URM students.

Fear of Failure

Fear of failure is the "persistent and irrational anxiety about failing to measure up to the standards and goals set by oneself or others" (APA n.d.). Although failure is a part of life and occurs daily, for some students fear of failing is paralyzing and manifested through their behavior. Bledsoe and Baskin (2014) explored the cognitive, emotional, and physiological aspects of fear in the classroom. The authors reported that fear, including fear of failure, can manifest itself in various behaviors, including missed classes, frequent illnesses, little or no class engagement, and missed assignments (Bledsoe and Baskin 2014). Poor academic performance for URM students in particular has large ramifications that can include loss of financial support to complete their educational pursuits (Ramirez et al. 2018). Additionally, Ramirez and colleagues (2018) shared that failure can lead to poor self-concept, embarrassment, insecurities about career pathways, and "fear of letting others down." The fear of disappointing family and friends is significant (Inman and Mayers 1999; Parker 2013). The fear of failing due to low grades in coursework poses a stereotype threat to URM students (McGee 2018). Therefore, much pressure exists, specifically for URM students, to achieve traditional metrics of success (such as high grades) and to do so consistently (McGee 2018). When a specific metric of success is not achieved, some URM students believe that they are confirming the negative stereotype that students of color, specifically Black/African American and Latinx students, are not good at STEM courses (Aronson, Fried, and Good 2002; Gonzales, Blanton, and Williams 2002).

Stereotype Threats

Stereotype threat is "the expectation of being judged based on a negative group stereotype" (Beasley and Fisher 2012). Studies have shown that stereotype threats not only increase the stress and anxiety of stigmatized groups but also can lead to underperformance (Spencer, Logel, and Davies 2016) and unfortunately attrition from academic programs (Beasley and Fisher 2012). The results from these studies are disconcerting as attempts to diversify geosciences continue to fall short despite efforts such as fellowships, community outreach, and institutional changes (Stokes et al. 2007; Bernard and Cooperdock 2018; Kortsha 2022; Núñez, Rivera, and Hallmark 2020). Although it is important to provide targeted opportunities for URM students to engage in high-impact activities in preparation for graduate school and careers in geosciences, administrators and educators may need to take a closer look at socio-psychological factors like stereotype threats, as well as its impact on students' performance and consequently retention in academic programs.

Stereotype threats can lead to failure for students who are aware of the negative perceptions/beliefs about their academic abilities. Steele (1997) synthesizes a body of work that assesses the effect of stereotype threats on women and African Americans. This author states that stereotype threats can weaken students' intellectual performance (Steele 1997). Thames and colleagues (2013) found that African Americans performed worse on testing under stereotype conditions compared to individuals of the same racial group who were in a non-threatening situation. If URM students believe that their classrooms and campus hold negative beliefs about their intellectual abilities and/or that their presence in these programs are solely "diversifying" the programs, the attainment of low grades may be viewed as evidence of this perception, which can impact self-esteem, self-efficacy, and even sense of belonging (Inzlicht and Good 2006).

Science Identity, Self-Concept, and Sense of Belonging

An individual's identity can be described as the set of characteristics that are unique to that person and helps distinguish them from others. Identity, in essence, defines what makes a person who they are and influences how that person shows up in the world, perceives and processes experiences, and engages the world (Vincent-Ruz and Schunn 2018). It is more of an internal construct that includes emotions (Stets 2005). Identity is multifaceted and intersectional and adds complexity to individuals (Hazari, Sadler, and Sonnert 2013). Identity also contributes to an individual's self-concept, which can evolve through experiences and engagement through community or cultural environment (external) (Vignoles et al. 2016). Therefore, an individual's experiences within community or environment, positive or negative can have an influence on an individual's self-concept in any given area of life (Archer et al. 2010; Rüschenpöhler and Markic 2020).

Turnbull et al. (2020) showed instructors and peers have an impact on students' science self-concept. Additionally, Betz and colleagues (2021) found that students who participated in undergraduate research opportunities experienced increased STEM identity and enhanced academic self-concepts. Students who possess positive academic self-concepts not only achieve academic success, but also hold a sense of belonging in the field (Rainey et al. 2018; Chen et al. 2021). Therefore, helping URM cultivate a positive "geoscience" identity may increase performance in their courses. Additionally, holding a positive view of their abilities may also help students separate failure from their identities (Ballen et al. 2017).

Fixed versus Growth Mindset

According to the mindset theory proposed by Carol Dweck, individuals may hold a "fixed" or "growth" mindset with regards to learning and intelligence (Dweck 2006). Individuals with a fixed mindset ". . . believe that their basic qualities, like their intelligence or talent, are simply fixed . . . that talent alone creates success." This translates to one holding the belief that they are either intelligent or unintelligent. In contrast, persons with a growth mindset believe that ". . . their most basic abilities can be developed through dedication and hard work—brains and talent are just a starting point" (Dweck 2006). Mindset may have an impact on students' academic performance and sense of self efficacy

(Mangels et al. 2006). Specifically, the mindset that students hold about themselves can impact their academic performance, which can lead to success (achievement of goals) or failure. Also, the mindset (perspective) that one holds about intelligence can then be projected onto others (externalization). In this regard, the externalization (verbally or behaviorally) of a fixed mindset may pose a stereotype threat. Hwang, Reyes, and Eccles (2016) found that white students and students from high socioeconomic backgrounds held fixed mindsets about intelligence compared to students from lower socioeconomic backgrounds and URM students. Canning and colleagues (2019) identified larger racial achievement gaps in courses taught by faculty members who possessed fixed mindsets regarding academic abilities compared to colleagues with a growth mindset.

Instructors and peer groups are key factors that contribute to students developing positive science identities and self-concept (Rainey et al. 2018; Betz et al. 2021) that, as discussed above, can influence students' response to failure. Additionally, instructors and peers are a part of the "local" and "global" STEM community. Therefore, it can be inferred that if these groups have tightly held fixed mindsets, this can have a significant effect on an individual's sense of belonging, thus promoting STEM as an exclusive field where access is only granted to those with "innate talents." This is a fallacy that must be addressed to recruit and retain a competent, culturally diverse, and emotionally intelligent STEM workforce.

Strategies for Mentors and Educators

Positionality

As an educator and researcher, I am not only interested in building the knowledge foundations and increasing the proficiencies of my students with regard to geoscience content, but I am invested in the recruiting and retention of diverse individuals in the field of geoscience. Over the years, I have worked with URM and non-URM students at the high school and undergraduate levels. I have mentored students in research and taught courses for students at various academic levels. These activities have taken place at Minority-Serving Institutions (MSI) and Primarily White Institutions (PWI), and I am currently a faculty member at a Hispanic-Serving Institution (HSI). I am a Black woman, I attended college as a first-generation student, and I am an immigrant who has lived in the United States for almost 30 years. The U.S. educational system has been quite formative in my own experiences, and I recognize that my academic and cultural background shapes/informs my perspectives. Nonetheless, I aim to communicate lessons learned in the most truthful manner and provide some guidance that educators and researchers may find useful as they endeavor to provide support for URM students in the geosciences. In the sections below, an approach to mentoring undergraduate URM researchers in the geosciences is outlined.

Strategy 1: Confirm Science Identities for Enhanced Academic Self-Concepts

At some point, instructors may have heard a student say, "I don't know. I'm just not good at science," or "I'm not really a 'science person.'" URM students at primarily white or majority institutions may often ask themselves this question (Whittaker and Montgomery 2012). These questions may arise due to failure or fear of failure. The fear of failure can lead one to question beliefs about oneself and personal abilities. Therefore, it is in these moments that mentors and educators must help students cultivate a strong and positive science identity when success seems uncertain. A simple strategy that can be used to help students when they question their scientific identities and/or science self-concepts is to be candid about one's own failures in science. Another strategy that is more inclusive would be to highlight URM professionals in geoscience. This can be delivered through "Scientist Spotlights" assignments, which includes reading the biographies of URM geoscientists and/or publications authored by URM geoscientists (Schinske et al. 2016). The American Geophysical Union (AGU) profiles geoscientists from various disciplines, which can be used for such assignments (Guertin 2019). An additional resource is "Black in Geoscience," which highlights individuals of African descent in various geoscience disciplines (Black in Geoscience 2022). It is also important to confirm for URM students that their creativity, talents, and perspectives are needed, valued, and will make significant contributions to their communities and society (Carter et al. 2021; Thoman et al. 2015).

Values affirmation intervention (VAI) is another strategy that can be used to confirm positive science identities in students and reduce fear of failure. Integrating VAI into classrooms have been found to reduce stereotype threats, which can lead to academic success (Harackiewicz et al. 2016). When working with student researchers, informal value affirmation exercises initiated by research mentors can occur by asking the students the following questions:

1. Why did you choose to pursue this field? What problem(s) are you motivated to understand or solve?
2. Who inspires you and why?
3. How do you intend to share your knowledge?

By asking these questions, being attentive to students' responses, and affirming their person (identities), mentors can ground students and shift their thinking from self-depreciation to recognizing their significance in their chosen field, thus fostering a sense of belonging to the field (Estrada et al. 2019; Smith et al. 2021).

Strategy 2: Cultivating a Growth Mindset

Mindset interventions have been effective in improving students' performance in courses (Fink et al. 2018). Shifting students' beliefs about their abilities and competencies can lead to increased recruitment and retention in STEM fields (Lisberg and Woods 2018; Sisk et al. 2018). Cultivating a growth mindset in URM students will require identifying and negating the fallacies they hold about themselves. It is also important to reframe failure by emphasizing that a part of the learning process involves mistakes, missteps, poor decisions and/or poor planning. Students must know that research is both a noun and a verb, and that, as a verb, there are actions/skills that must be developed with practice (Kapur 2016; Gin et al. 2018). Failing a test is not forever. A failed experiment is not permanent. Failure is temporary and can be changed through engagement with the challenge (Fink et al. 2018). Students should be encouraged to hold a "teachable spirit." A teachable spirit can be defined as a willingness or passion to learn and grow. It also denotes a willingness to be flexible or adaptive in the learning process. On a similar note, it is also important that mentors recognize that some students may enter their labs having not yet developed some particular skill set(s) (e.g., diving); however, that should not be a determinant in accepting or rejecting students from their labs. Students are novices with hopes of becoming experts. Mentors must hold a growth mindset for their students to help them become resilient individuals in the face of challenges (Canning et al. 2019). It is also important for mentors to recognize that "talent" can be developed over time (Gamage et al. 2021).

Shifting students' focus from failure to problem-solving allows them to develop critical thinking skills, which is vital to all fields of study. Providing a scaffolded research experience for students creates a space for error/failure at low stakes (Gin et al. 2018). For instance, scaffolding of laboratory skills can start off as repeating a method that is completely new to students. Additionally, it can also mean having students work with "play samples." In this case, students will be practicing laboratory skills on samples (i.e., sediment samples) that are not linked to the actual research, so there is no concern about "wasting samples." Once the students gain fluency in the desired technique, they will then work with the "real samples." Through this process, students will be able to increase their self-efficacies and change their mindsets about learning and intelligence (McIntee et al. 2018).

Suggested language for mentors coaching students through failure and/or fear of failure include the following:

1. "Okay, that didn't work, let's get back to the drawing board and build on what we have learned."
2. "Let's retrace our steps, so we can figure out what went wrong."
3. "We will figure this out."

Adopting an iterative process for undergraduate researchers can help reduce the stigma around failure. Normalizing failure is important, and encouraging students to reflect on their learning is the key to increasing student resiliency (Goodwin et al. 2021). Increased resiliency in turn can contribute to the formation of a positive science identity, which can then potentially lead to retention in geoscience and STEM programs in general (Ferguson and Martin-Dunlop 2021). Additionally, normalizing failure can potentially remove stereotype threats, as URM students can "see" that everyone fails, and failure is not endemic to a particular social or ethnic group.

Strategy 3: Practice Strength-Based Mentoring and Appreciative Advising

Mentorship and academic advising are critical to the academic success of students (Snowden and Hardy 2013; Zaniewski and Reinholz 2016). There are various mentorship and advising models that are used; however, the use of a particular mentorship or advising model should be based on the individual student. Two strategies that can be used for URM students in the geosciences include strength-based mentoring and appreciative advising.

Strength-based mentoring focuses on the strengths of students rather than on their deficits. Gardner (1999) defines intelligence as ". . . a biopsychological potential to process information that can be activated in a cultural setting to solve problems or create products that are of value in a culture." Gardner's Theory of Multiple Intelligences suggests that each person possesses a set of intelligences (Gardner 1999). By adopting the strength-based mentorship model, mentors can help mentees to identify their strengths. Mentors can coach students on how to use their particular strengths by providing opportunities to further develop their scientific skill sets and/ or apply community cultural knowledge to a collaboratively defined research project. Doing this will support the development of a strong science identity/ self-concept in URM students and perhaps reduce stereotype threats (Puritty et al. 2017). In such cases, students see themselves as "assets." Individuals who can make meaningful contributions to projects both scientific and non-scientific ways (Soria and Stubblefield 2015).

To be clear, using a strength-based mentorship model does not mean that a student's knowledge gaps are overlooked. Instead, the mentor affirms the student's strength and works with the individual to fill in the gaps while leveraging their strengths. In doing so, students may become resilient in the face of failure because their self-perceptions are not tied to incidences of low performance or failure. Instead, they have a clear view of their capabilities and will be open to "try again" when challenges or failure occurs rather than give up, thus cultivating a growth mindset in students.

Practicing appreciative inquiry advising (AIA) can also be an effective strategy in helping students deal with failure (Hutson and Bloom 2007) and foster optimism in students (Bloom and Martin 2002). A component of the AIA is "positive questioning" (Hutson and Bloom 2007). Taking this approach can allow a mentor and mentee to identify the root of issues in a safe and collaborative environment and not fall into the error of presumptions in the form of advisors/mentors always know best (Whitney and Trosten-Bloom 2003). Both students and mentors/advisers can then co-create a plan to address poor performance in academics and/or progress in research efforts. The AI approach to advising can also help students develop their emotional intelligence so they can deal with setbacks (Parker et al. 2004; Bushe and Kassam 2005). Bushe and Kassam (2005) states that the success of AI lies in focusing on transforming an individual's way of thinking. Therefore, effective AI advising to students will include having students correctly identify, understand, and address their primary emotions surrounding failure, then following up with strategies to move forward in a productive and healthy manner (Hutson 2010).

The goal is to prevent students from getting "stuck"—that is, holding a fixed mindset with reference to scientific ability (Bartels and Herman 2011).

Some key questions/prompts that can be used to coach students through failure and /or fear of failure based on AIA include the following:

1. What can we learn from this moment?
2. What do you think would be the next best action that will move you closer to your goals or help you to achieve your goals?
3. Let's put our heads together to determine what resources may be helpful with these challenges.

Practicing strength-based mentoring and appreciative advising has the potential to reduce fear of failure in URM students by helping students develop strong science identities/self-concepts. Additionally, through the process of positive questioning, students are able to reframe failure and address any fears of failure by cultivating a growth mindset. Learning is an iterative process; therefore, "coming back to the drawing board" allows students to explore alternative pathways to success.

Conclusion

Fear is pervasive among student groups. However, the socio-psychological factors underlying the fear of failure for URM students are unique to them. Educators who have a desire to be a better mentor must understand the root causes to their underlying fears and the pressures associated with failure. Such mentors can also help students form positive science identities, as well as cultivate growth mindsets. In doing so, this may not only lead to increased recruitment of URM students in geosciences but also increased retention in these programs (Martin-Hansen 2008; Seyranian et al. 2018; Núñez et al. 2020). Finally, although the framework presented in this chapter focused on URM students interested in geosciences, the strategies discussed above are relevant to URM students in other STEM and non-STEM disciplines. Tibbetts et al. (2017) in their review identified social-psychological interventions such as values affirmation interventions as being effective for broadening participation in life sciences. With reference to shifting in mindsets from fixed to growth in order for students to productively address fear of failure, Klein et al (2017) discusses the need for adopting a growth mindset by medical educators to train students to learn from their mistakes. Finally, studies by Soria and Stubblefield 2015 and Lehr and colleagues (2021) demonstrates that strength-based mentoring and advising can be applied to STEM and non-STEM fields.

Diversity in the geosciences and other STEM fields matter. In a global society facing ever increasing complex issues, there is a need for individuals with varying experiences and perspectives working collaboratively to devise viable solutions to these problems. To achieve this, we must collectively work toward creating inclusive academic environments and effectively train a diverse group of students who are scientifically competent and resilient when faced with challenges.

Acknowledgments

The author would like to thank the editors for their comments and suggestions, which strengthened this chapter, as well as Regina Easley and Kathryn Bailey for their feedback.

References

American College Health Association (ACHA). 2019. *American College Health Association-National College Health Assessment II: Undergraduate Student Reference Group Data Report Spring 2019.* Silver Spring, MD: American College Health Association.

American Geosciences Institute. 2022. "A Subset of Data That Highlights Significant Disparity between Skill Appraisal and Student Preparation." Accessed January 10, 2022. https://www.americangeosciences.org/sites/default/files/hrh/JointGeo_SkillsInfographic_Final_0.pdf

American Psychological Association (APA). n.d. "Fear of Failure." *APA Dictionary of Psychology.* Accessed February 2, 2022. https://dictionary.apa.org/fear-of-failure.

Archer, Louise, Jennifer Dewitt, Jonathan Osborne, Justin Dillon, Beatrice Willis, and Billy Wong. 2010. "'Doing' Science Versus 'Being' a Scientist: Examining 10/11-Year-Old School Children's Construction of Science through the Lens of Identity." *Science Education* 94: 617–639. doi: 10.1002/sce.20399

Aronson, Joshua, Carrie B. Fried, and Catherine Good. 2002. "Reducing the Effects of Stereotype Threat on African American College Students by Shaping Theories of Intelligence." *Journal of Experimental Social and Psychology* 38: 113–125. doi:10.1006/jesp.2001.1491

Ballen, Cissy J., Carl Weiman, Shima Salehi, Jeremy B. Searle, and Kelly R. Zamudio. 2017. "Enhancing Diversity in Undergraduate Science: Self-Efficacy Drives Performance Gains with Active Learning." *CBE–Life Science Education* 16: ar56. doi:10.1187/cbe.16-12-0344

Bartels, Jared M., and William E. Herman. 2011. "Fear of Failure, Self-Handicapping, and Negative Emotions in Response to Failure." Poster Presented at Annual Meeting of the Association for Psychological Science (APS), Boston, May 28, 2011.

Beasley, Maya A., and Mary J. Fisher. 2012. "Why They Leave: The Impact Stereotype Threat on the Attrition of Women and Minorities from Science, Math and Engineering Majors." *Social Psychology of Education* 15: 427–448. doi: 10.1007/s11218-012-9185-3

Bernard, Rachel E., and Emily H. G. Cooperdock. 2018. "No Progress on Diversity in 40 Years." *Nature Geoscience* 11: 292–295. doi: 10.1038/s41561-018-0116-6

Betz, Amy R., Brenee King, Bette Grauer, Beth Montelone, Zelia Wiley, and Linda Thurston. 2021. "Improving Academic Self-Concept and STEM Identity through a Research Immersion: Pathways to STEM Summer Program." *Frontiers in Education* 6: ar674817. doi:10.3389/feduc.2021.674817

Black in Geoscience. 2022. *Stories: Meet Black Geoscientists.* Accessed March 4, 2022. https://blackingeoscience.org/stories/

Blackwell, Lisa S., Kali H. Trezesniewski, and Carol Sorich Dweck. 2007. "Implicit Theories of Intelligence Predict Achievement across an Adolescent Transition: A Longitudinal Study and an Intervention." *Child Development* 78(1): 246–263. doi: 10.1111/j.1467-8624.2007.00995.x

Bledsoe, T. Scott, and Janice J. Baskin. 2014. "Recognizing Student Fear: The Elephant in the Classroom." *College Teaching* 62: 33–41. doi:10.1080/87567555.2013.831022

Bloom, Jennifer L., and Nancy Archer Martin. 2002. "Incorporating Appreciative Inquiry into Academic Advising." *The Mentor: Innovative Scholarship on Academic Advising* 4. https://journals.psu.edu/mentor/article/view/61701/61346

Bureau of Labor Statistics. n.d. "U.S. Department of Labor, Occupational Outlook Handbook, Geoscientists." Accessed January 10, 2022. http://www.bls.gov/ooh/life–physical–and-social-science/geoscientists.htm

Bushe, Gervase R., and Aniq F. Kassam. 2005. "When Is Appreciative Inquiry Transformational? A Meta-Case Analysis." *Journal of Applied Behavioral Science* 41: 161–181. doi: 10.1177/0021886304270337

Canning, Elizabeth A., Katherine Muenks, Dorainne J. Green, and Mary C. Murphy. 2019. "STEM Faculty Who Believe Ability Is Fixed Have Larger Racial Achievement Gaps and Inspire Less Student Motivation in Their Classes." *Science Advances* 5(2): eeau4734. doi: 10.1126/sciadv.aau4734

Cannon, Mark D., and Amy C. Edmondson. 2005. "Failing to Learn and Learning to Fail (Intelligently): How Great Organizations Put Failure to Work to Innovate and Improve." *Long Range Planning* 38: 299–319. doi: 10.1016/j.lrp.2005.04.005

Carter, Samantha C., Elizabeth M. Griffith, Theresa A. Jorgensen, Karin, G. Coifman, and W. Ashley Griffith. 2021. "Highlighting Altruism in Geoscience Careers Aligns with Diverse US Student Ideals Better Emphasizing Working Outdoors." *Communications Earth and Environment* 2: 213. doi: 10.1038/s43247-021-00287-4

Chen, Susie, Kevin R. Binning, Shannon T. Brady, Erica M. McGreevy, Laura Betancur, Lisa B. Limeri, and Nancy Kaufmann. 2021. "Am I a Science Person? A Strong Science Identity Bolsters Minority Students' Sense of Belonging and Performance in College." *Personality and Social Psychology Bulletin* 47: 593–606. doi: 10.1177/0146167220936480

Daily, Shaudra Bryant, and Wanda Eugene. 2013. "Preparing the Future STEM Workforce for Diverse Environments." *Urban Education* 48: 682–704. doi: 10.1177/0042085913490554

Dweck, Carol S. 2006. *Mindset: The New Psychology of Success.* New York: Random House.

Estrada, Mica, Gerald R. Young, Jill Nagy, Emily J. Goldstein, Avi Ben-Zeev, Leticia Márquez-Magaña, and Alegra Eroy-Reveles. 2019. "The Influence of Microaffirmations on Undergraduate Persistence in Science and Career Pathways." *CBE–Life Sciences Education* 18: ar40. doi: 10.1187/cbe.19-01-0012

Ferguson, Danielle, and Catherine Martin-Dunlop. 2021. "Uncovering Stories of Resilience among Successful African American Women in STEM." *Cultural Studies of Science Education* 16: 461–484. doi: 10.1007/s11422-020-10006-8

Fink, Angela, Michael J. Cahill, Mark A. McDaniel, Arielle Hoffman, and Regina F. Frey. 2018. "Improving General Chemistry Performance through a Growth Mindset Intervention: Selective Effects on Underrepresented Minorities." *Chemical Education Research and Practice* 19: 783–806. doi: 10.1039/C7RP00244K

Gamage, Kusali, James McCall, Hugh Daigle, and Chammi Miller. 2021. "Supporting STEM Transfer Students through Cross-Institutional Undergraduate Research Experiences." *Journal of Geoscience Education* 69: 326–341. doi: 10.1080/10899995.2021.2005510

Gardner, Howard. 1999. *Intelligence Reframed: Multiple Intelligences for the 21st Century.* New York: Basic Books.

Gibbs, Kenneth Jr. 2014, September 10. “Diversity in STEM: What It Is and Why It Matters.” *Scientific American.* Accessed October 15, 2021. https://blogs.scientificamerican.com/voices/diversity-in-stem-what-it-is-and-why-it-matters/

Gin, Logan E., Ashley A. Rowland, Blaire Steinwand, John Bruno, and Lisa Corwin. 2018. “Students Who Fail to Achieve Predefined Research Goals May Still Experience Many Positive Outcomes as a Result of CURE Participation.” *CBE–Life Sciences Education* 17: ar57. doi.org/10.1187/cbe.18-03-0036

Gonzales, Patricia M., Hart Blanton, and Kevin J. Williams. 2002. “The Effects of Stereotype Threat and Double-Minority Status on the Test Performance of Latino Women.” *Personality and Social Psychology Bulletin* 28: 659–670. doi:10.1177/0146167202288010

Goodwin, Emma C., Vladimir Anokhin, MacKenzie, J. Gray, Daniel E. Zajic, Jason D. Podrabsky, and Erin E. Shortlidge. 2021. “Is This Science? Students’ Experience of Failure Make a Research-Based Course Feel Authentic.” *CBE–Life Sciences Education* 20: ar10. doi: 10.1187/cbe.20-07-0149

Guertin, Laura. 2019, December 9. “AGU19 Spotlight-Scientist Spotlights and Profiles Online.” *Blogosphere.* American Geosphysical Union (AGU). https://blogs.agu.org/geoedtrek/2019/12/09/agu19-scientist-spotlight/

Harackiewicz, Judith M., Elizabeth A. Canning, Yoi Tibbetts, Stacy J. Priniski, and Janet S. Hyde. 2016. “Closing Achievement Gaps with a Utility-Value Intervention: Disentangling Race and Social Class.” *Journal of Personality and Social Psychology* 111: 745–765. doi: 10.1037/pspp0000075

Hazari, Zahra, Phillip M. Sadler, and Gerhard Sonnert. 2013. “The Science Identity of College Students: Exploring the Intersection of Gender, Race, and Ethnicity.” *Journal of College Science Teaching* 42(5): 82–91. http://www.jstor.org/stable/43631586.

Henry, Meredith A., Shayla Shorter, Louise Charkoudian, Jennifer M. Heemstra, and Lisa A. Corwin. 2019. “*FAIL* Is Not a Four-Letter Word: Theoretical Framework for Exploring Undergraduate Students Approaches to Academic Challenge and Responses to Failure in STEM Learning Environments.” *CBE–Life Sciences Education* 18: ar11. doi: 10.1187/cbe.18-06-0108

Hesseln, Hayley. 2020. “How Women in STEM Can Use Emotional Intelligence to Become Resilient Leaders.” *Linkedin.* Accessed October 15, 2021. https://www.linkedin.com/pulse/how-women-stem-can-use-emotional-intelligence-become-leaders-hesseln

Hutson, Bryant. 2010. “The Impact of an Appreciative Advising-Based University Studies Course on College Student First-Year Experience.” *Journal of Applied Research in Higher Education* 2(1): 3–13.

Hutson, Bryant L., and Jennifer Bloom. 2007. “The Impact of Appreciative Advising on Student Success.” *Esource for College Transition* 5(1): 4–5. https://sc.edu/nrc/system/pub_files/ES_5-1_Sep07.pdf

Hwang, NaYoung, Marcela Reyes, and Jacquelynne S. Eccles. 2019. “Who Holds a Fixed Mindset and Whom Does It Harm in Mathematics.” *Youth and Society* 51: 247–267. doi: 10.1177/0044118X16670058

Inman, W. Elliot, and Larry Mayes. 1999. “The Importance of Being First: Unique Characteristics of First Generation Community College Students.” *Community College Review* 26(4): 3–22. doi: 10.1177/009155219902600402

Inzlicht, Michael, and Catherine Good. 2006. "How Environments Can Threaten Academic Performance, Self-Knowledge, and Sense of Belonging." In *Stigma and Group Inequality: Social and Psychological Perspectives,* edited by Shana Levin and Colette Van Laar, 129–150. Mahwah, NJ: Lawrence Erlbaum Assoc.

Kapur, Manu. 2016. "Examining Productive Failure, Productive Success, Unproductive Failure, and Unproductive Success in Learning." *Educational Psychologist* 51: 289–299. doi: 10.1080/00461520.2016.1155457

Klein, Jill, Clare Delany, Michael D. Fischer, David Smallwood, and Stephen Trumble. 2017. "A Growth Mindset Approach to Preparing Trainees for Medical Error. *BMJ Quality & Safety* 26: 771–774. doi 10.1136/bmjqs-2016-006416

Kortsha, Monica. 2022. "Increasing Diversity in Geosciences." Jackson School of Geosciences, University of Texas at Austin. Accessed February 22, 2022. https://www.jsg.utexas.edu/news/2020/11/increasing-diversity-in-geosciences

Lally, Diane, Cory T. Forbes, Karen S. McNeal, and Nicholas A. Soltis. 2019. "National Geoscience Faculty Survey 2016. Prevalence of Systems Thinking and Scientific Modeling Learning Opportunities." *Journal of Geoscience Education* 67: 174–191. doi: 10.1080/10899995.2019.1565286

Lehr, Jane L., Daniel Almeida, Dominic J. Dal Bello, Jeff Jones, Lizabeth L. Thompson, Eva Schiorring , Fred W. DePiero, and Christina Sholars Ortiz. 2021. "Mentoring and Advising Students in an S-STEM Project: Strengths Training from a Social Justice Perspective in Engineering and Computer Science as Context-Initial Implementation." *2021 ASEE Virtual Annual Conference.* American Society for Engineering Education. 1–11. https://peer.asee.org/37499

Leslie, Sarah-Jane, Andrei Cimpian, Meredith Meyer, and Edward Freeland. 2015. "Expectations of Brilliance Underlie Gender Distributions across Academic Disciplines." *Science* 347: 262–265. doi: 10.1126/science.1261375

Lisberg, Anneke E., and Brett C. Woods. 2018. "Mentorship, Mindset and Learning Strategies: An Integrative Approach to Increasing Underrepresented Minority Student Retention in a STEM Undergraduate Program." *Journal of STEM Education* 19(3): 14–20.

MacCann, Carolyn, Yixin Jiang, Luke E. R. Brown, Kit S. Double, Micaela Bucich, and Amirali Minbashian. 2020. "Emotional Intelligence Predicts Academic Performance: A Meta-Analysis." *Psychological Bulletin* 146: 150–186. doi:10.1037/bul0000219

MacPhee, David, Samantha Farro, and Silvia Sara Canetto. 2013. "Academic Self-Efficacy and Performance of Underrepresented STEM Majors: Gender, Ethnic, and Social Class Patterns." *Analyses of Social Issues and Public Policy* 13(1): 347–369. doi: 10.1111/asap.12033

Mangels, Jennifer A., Brady Butterfield, Justin Lamb, Catherine Good, and Carol Dweck. 2006. "Why Do Beliefs About Intelligence Influence Learning Success? A Social Cognitive Neuroscience Model." *Social Cognitive Affective Neuroscience* 1(2): 75–86. doi: 10.1093/scan/nsl013

Marín-Spiotta, Erika, Rebecca T. Barnes, Asmeret Asefaw Berhe, Meredith G. Hastings, Allison Matteis, Blair Schneide, and Billy M. Williams. 2020. "Hostile Climates Are Barriers to Diversifying the Geosciences." *Advances in Geosciences* 53: 117–127. doi: 10.5194/adgeo-53-117-2020

Martin-Hansen, Lisa. 2018. "Examining Ways to Meaningfully Support Students in STEM." *International Journal of STEM Education* 5: ar53. doi: 10.1186/s40594-018-0150-3

McGee, Ebony. 2018. "'Black Genius, Asian Fail': The Detriment of Stereotype Lift and Stereotype Threat in High-Achieving Asian and Black STEM Students." *AERA Open* 4(4): 1–16. doi: 10.1177/2332858418816658

McIntee, Farron, Kendra R. Evans, Abigail J. Fusaro, Melanie Hwalek, Ambika Mathur, and Andrew L. Fieg. 2018. "Developing Undergraduate Scientists by Scaffolding the Entry into Mentored Research." *Scholarship and Practice of Undergraduate Research* 2(1): 4–14. doi: 10.18833/spur/2/1/5

Naijimi, Arash, Gholamreza Sharifirad, Mehdi Mohammed Amini, and Sayyed Davood Meftagh. 2013. "Academic Failure and Student Viewpoint: The Influence of Individual, Internal, and External Organizational Factors." *Journal of Education and Health Promotion* 2: 22. doi: 10.4103/2277-9531.112698

Núñez, Anne-Marie, Jessica Rivera, and Tyler Hallmark. 2020. "Applying an Intersectionality Lens to Expand Equity in the Geosciences." *Journal of Geoscience Education* 68(2): 91–114. doi: 10.1080/10899995.2019.1675131

Oktavia, Zaini, and Saiful Ridlo. 2020. "Critical Thinking Skills Reviewed from Communication Skills of the Primary School Students in STEM-Based Project-Based Learning Model." *Journal of Primary Education* 9: 311–320. doi: 10.15294/jpe.v9i3.27573

Parker, Ashley Dawn. 2013. "Family Matters: Familial Support and Science Identity Formation for African American Female STEM Majors." PhD diss., University of North Carolina at Charlotte.

Parker, James D. A., Laura J. Summerfeldt, Marjorie J. Hogan, and Sarah A. Majeski. 2004. "Emotional Intelligence and Academic Success: Examining the Transition from High School to University." *Personality and Individual Differences* 36(1): 163–172. doi: 10.1016/S0191-8869(03)00076-X

Puritty, Chandler, Lynette R. Strickland, Eanas Alia, Benjamin Blonder, Emily Klein, Michel T. Kohl, Earyn McGee, Maclovia Quintana, Robyn E. Ridley, Beth Tellman and Leah R. Gerber. 2017. "Without Inclusion, Diversity Initiatives May Not Be Enough." *Science* 357: 1101–1102. doi: 10.1126/science.aai9054

Rainey, Katherine, Melissa Dancy, Roslyn Mikelson, Elizabeth Stearns, and Stephanie Moller. 2018. "Race and Gender Differences in How Sense of Belonging Influences Decisions to Major in STEM." *International Journal of STEM Education* 5: ar. 10. doi: 10.1186/s40594-018-0115-6

Ramirez, Jeffrey, Janalee Isaacson, Deborah Smith, and Brenda Senger. 2018. "Teaching Life Lessons: When Millennials Fail." *Building Healthy Academic Communities Journal* 2(1): 49–59. doi:10.18061/bhac.v2il.6360.

Rüschenpöhler, Lilith, and Silvija Markic. 2020. "How the Home Environment Shapes Students' Perceptions of Their Abilities: The Relations between Chemistry Capital at Home and Students' Chemistry Self-Concept." *International Journal of Science Education* 42: 2075–2094. doi: 10.1080/09500693.2020.1812010

Schinske, Jeffrey N., Heather Perkins, Amanda Snyder, and Mary Wyer. 2016. "Scientist Spotlight Homework Assignments Shift Students' Stereotypes of Scientists and Enhance Science Identity in Diverse Introductory Science Class." *CBE–Life Science Education* 15: ar47. doi: 10.1187/cbe.16-01-0002

Seyranian, Viviane, Alex Madva, Nicole Duong, Nina Abramzon, Yoi Tibbetts, and Judith M. Harackiewicz. 2018. "The Longitudinal Effects of STEM Identity and Gender on Flourishing and Achievement in College Physics." *International Journal of STEM Education* 5: ar40. doi: 10.1186/s40594-018-0137-0

Sisk, Victoria F., Alexander P. Burgoyne, Jingze Sun, Jennifer L. Butler, and Brooke N. Macnamara. 2018. "To What Extent and Under Which Circumstances Are Growth Mindsets Important to Academic Achievement? Two Meta-Analyses." *Psychological Science* 29: 549–571. doi: 10.1177/0956797617739704

Smith, Eric N., Christopher S. Rozek, Kody J. Manke, Carol S. Dweck, and Gregory M. Walton. 2021. "Teacher-Versus Researcher-Provided Affirmation Effects on Students' Task Engagement and Positive Perception of Teachers." *Journal of Social Issues* 77: 751–768. doi: 10.1111/josi.12417

Smith, Jessi L., Karyn L. Lewis, Lauren Hawthorne, and Sara D. Hodges. 2012. "When Trying Hard Isn't Natural: Women's Belonging with and Motivation for Male-Dominated STEM Fields as a Function of Effort Expenditure Concerns." *Personality and Social Psychology Bulletin* 39: 131–143. doi: 10.1177/0146167212468332

Snowden, Michael, and Tracy Hardy. 2012. "Peer Mentorship and Positive Effects on Student Mentor and Mentee Retention and Academic Success." *Widening Participation and Lifelong Learning* 14: 76–92. doi: 10.5456/WPLL.14.S.76

Soria, Krista M., and Robin Stubblefield. 2015. "Building a Strengths-Based Campus to Support Student Retention." *Journal of College of Student Development* 56: 626–631. doi:10.1353/csd.2015.0056

Spencer, Steven J., Christine Logel, and Paul G. Davies. 2016. "Stereotype Threat." *Annual Review of Psychology* 67: 415–437. doi: 10.1146/annrev-psych-073115-103235

Steele, Claude. 1997. "A Threat in the Air: How Stereotype Shape Intellectual Identity and Performance." *American Psychologist* 52: 613–629. doi:10.1037/0003-066X.52.6.613

Stets, Jan E. 2005. "Examining Emotions in Identity Theory." *Social Psychology Quarterly* 68(1): 39–74. http://www.jstor.org/stable/4148780.

Stokes, Philip J., Gregory S. Baker, Jason P. Briner, and Dara J. Dorsey. 2007. "A Multifaceted Outreach Model for Enhancing Diversity in the Geosciences in Buffalo, NY." *Journal of Geosciences* 55: 581–588. doi: 10.5408/1089-9995-55.6.581

Thames, April D., Charles H. Hinkin, Desiree A. Byrd, Robert M. Bilder, Kimberley J. Duff, Monica Rivera Mindt, Alyssa Arentoft, and Vanessa Streiff. 2013. "Effects of Stereotype Threat, Perceived Discrimination, and Examiner Race on Neuropsychological Performance: Simple as Black and White?" *Journal of the International Neuropsychological Society* 19: 583–593. doi: 10.1017/S1355617713000076

Thoman, D. B., Elizabeth R. Brown, Andrew Z. Mason, Allen G. Harmsen, and Jessi L. Smith. 2015. "The Role of Altruistic Values, Motivating Underrepresented Minority Students for Biomedicine." *Bioscience* 65: 183–188. doi: 10.1093/biosci/biu199

Tibbetts, Yoi, Judith M. Harackiewicz, Stacy J. Priniski, and Elizabeth A. Canning. 2017. "Broadening Participation in the Life Sciences with Social-Psychological Interventions." *CBE–Life Sciences Education* 15: es4. doi: 10.1187/cbe.16-01-0001

Turnbull, Steve Martin, Kane Meissel, Kirsten Locke, and Dion R. J. O'Neale. 2020. "The Impact of Science Capital on Self-Concept in Science: A Study of University Students in New Zealand." *Frontiers in Education* 5: ar27. doi: 10.3389/feduc.2020.00027

Vignoles, Vivian L., Ellinor Owe, Maja Becker, Peter B. Smith, Matthew J. Easterbrook, Rupert Brown, et al. 2016. "Beyond the 'East-West' Dichotomy: Global Variation in Cultural Models of Selfhood." *Journal of Experimental Psychology: General* 145: 966–1000. doi: 10.1037/xg0000175

Vincent-Ruz, Paulette, and Christian D. Schunn. 2018. "The Nature of Science Identity and Its Role as the Driver of Student Choices." *International Journal of STEM Education* 5: ar48. doi: 10.1186/s40594-018-0140-5

Whitney, Diana, and Amanda Trosten-Bloom. 2003. *The Power of Appreciative Inquiry: A Practical Guide to Positive Change.* San Francisco: Berrett-Koehler Publishers.

Whittaker, Joseph A., and Beronda L. Montgomery. 2012. "Cultivating Diversity and Competency in STEM: Challenges and Remedies for Removing Virtual Barriers to Constructing Diverse Higher Education Communities of Success." *Journal of Undergraduate Neuroscience Education* 11(1): A44–A51.

Zaniewski, Anna M. and D. Reinholz. 2016. "Increasing STEM Success: A Near-Peer Mentoring Program in the Physical Sciences." *International Journal of STEM Education* 3: ar14. doi: 10.1186/s40594-016-0043-2

CHAPTER 2

Planning to Fail: Teaching Strategies to Navigate Failure-Related Research Challenges in an Introductory Biology CURE

Oliver Hyman and Joseph A. Harsh

Abstract. This case study provides a classroom-tested framework that can be used in a large enrollment introductory biology laboratory course to troubleshoot technical issues related to the failure of a commonly used research technique in biology: polymerase chain reaction. This framework provides a highly structured, predictable, and scalable set of activities that introduce first-year undergraduate STEM students to failure in a research context and help them build confidence and resilience to overcome a technical obstacle to completing a research project.

doi: 10.18833/cf/1

Despite its documented benefit to students, coping with failure in scientific research is rarely explicitly taught in undergraduate science, technology, engineering, and mathematics (STEM) education (Corwin et al. 2018; Goodwin et al. 2021; Henry et al. 2019, Simpson and Maltese 2017; Traphagen 2015). This is especially true for large-enrollment, introductory courses, where restraints on content, expertise, and time can present significant barriers to providing students with opportunities for failure and iteration (Spell et al. 2014). Course-based undergraduate research experiences (CUREs) offer one route to address this shortcoming (Gin et al. 2018; Goodwin et al. 2021), but even within these frameworks, there is still a need for techniques that help normalize failure in research and teach students strategies for overcoming the failure-related challenges associated with authentic scientific inquiry (Henry et al. 2019). One way to address these obstacles is by *embedding predictable failure* into CUREs and explicitly providing students with the time and tools for troubleshooting and coping with the obstacles to achieving a specific research outcome.

This strategy has been successfully incorporated into a large-enrollment (greater than 600–800 students/term), two-semester CURE for introductory biology students at James Madison University (JMU;

Hyman et al. 2019). Students in these laboratory courses use molecular techniques (e.g., polymerase chain reaction [PCR], gel electrophoresis) that often fail for predictable reasons, providing opportunities for structured, scalable teaching interventions to address these failures. Prior work has suggested that engaging with failure in a CURE setting does not diminish students' positive outcomes when they are given the chance to iterate (Gin et al. 2018). In accordance with these findings, three generalizable instructional practices were used to help students navigate their failure-related research challenges in these courses. These instructional practices include providing (a) opportunities for *iteration* within the normal class schedule, (b) writing prompts for students to *reflect* upon their respective challenges and promote metacognition (Tanner 2012; see Corwin et al. forthcoming for the employed metacognitive prompts), and (c) a low-risk entrance into research by not penalizing students for failing to achieve a specific research outcome. These course design features and teaching activities were intended to not only contribute to the success of student research projects but also to support the development of students' understanding of the role of failure in science and ability to cope with the "messy" but tractable nature of scientific research. The following paragraphs provide the context for these courses, details for how "predictable failure" is used to help students navigate research challenges, and evidence of the effectiveness of this approach.

Context

Students pursuing a degree in the biological or health sciences at JMU are required to complete the sequential introductory biology courses Foundations of Biology I (BIO140) and Foundations of Biology II (BIO150). Students typically enroll in these courses in their first or second year, concurrently taking the conceptually independent lecture (150 minutes weekly) and laboratory (one 3-hour session weekly) course components. The first semester course (BIO140) also fulfills requirements for other select science programs (e.g., geology) and general education science coursework for non-STEM majors (e.g., communications, music). In total, BIO140 and BIO150 typically enroll approximately 500 and approximately 300 students per semester, respectively. The primary goal of the BIO140 and BIO150 laboratories is to engage all introductory biology students in an early research experience through the use of CUREs. The defining features of CUREs were used (authentic community practices, discovery, relevance, collaboration, and iteration) as outlined by Corwin (né Auchincloss) and colleagues (2014) as well as recommendations drawn from studies on apprenticeship-like undergraduate research to guide the design of these research courses. A one-year, two-semester, DNA barcoding-focused series of CUREs was ultimately developed (see Hyman et al. 2019 for a detailed account and lesson plans).

Students in these laboratory courses address open-ended research questions using a technique called DNA barcoding. DNA barcoding uses tools from molecular biology and bioinformatics to enable non-experts to determine the taxonomic identity of living specimens from short (approximately 500 base pair) DNA sequences called "barcodes" (Hebert et al. 2003). The DNA barcoding workflow requires extracting DNA from fresh, frozen, damaged, or processed samples of organic material. Following extraction, barcoding regions of the sample's genome are amplified by PCR, visualized via gel electrophoresis, and subsequently sequenced using taxa specific primers (Stoeckle 2003). These DNA sequences are then cross referenced to known sequences from curated databases to determine the taxonomic identity of the unknown sample.

DNA barcoding is amenable to student-driven research in large-enrollment, introductory biology courses because it has a robust, repeatable, and reliable workflow that allows novices to generate high-quality data that can address a variety of questions. Despite this robustness, DNA barcoding will often fail for predictable reasons, especially during DNA extraction and PCR amplification (see Table 1). In fact, a significant proportion (approximately 50 percent) of the students in each of these classes (BIO140/150) initially fail to amplify DNA extracted from their samples on their first attempt at PCR.

This "predictable failure" of PCR has been leveraged in the labs as an opportunity to teach introductory students—many of whom may not have encountered failure in prior confirmatory "cookbook" laboratory exercises—how to troubleshoot technical challenges in the labs and cope with undesirable research outcomes.

TABLE 1. A List of Some of the Most Common Causes of PCR and Gel Electrophoresis Failure and How Students Are Taught to Identify and Address Them

Issue uncovered by students (during wk. 4 lab on gel electrophoresis)	Potential underlying cause(s)[a]	Activity to address issue and when students complete this activity
No bands in any gel lanes, including ladder lane	Failure to properly stain or run gel	Rerun gel electrophoresis: Gel Electrophoresis 2 (wk. 6)
Negative control lane in gel contains band (ladder also present)	DNA contamination of PCR master mix	Rerun PCR: DNA extraction and PCR 2 (wk. 5)
Positive control lane and sample lanes in gel lack bands (ladder also present)	Improper PCR conditions or reagents in PCR master mix	Rerun PCR: DNA extraction and PCR 2 (wk. 5)
Ladder present, both controls work, but student sample lane(s) in gel lack band(s)	Low-quality DNA extract	Re-extract samples, measure extract quality and rerun PCR: DNA extraction and PCR 2 (wk. 5)
	Poorly matched primers	Try alternative primer set in PCR 2: DNA extraction and PCR 2 (wk. 5)

[a]This list is not comprehensive. See Hyman et al. 2019 for detailed lesson plans.

BIO140: Experiencing Failure and Iteration

In the BIO140 laboratory course students use DNA barcoding to determine the taxonomic identity of plants, invertebrates, and fungi collected from forest edges and interior habitats of the campus arboretum, with the ultimate goal of characterizing how habitat type and degradation can influence species diversity (Hyman et al. 2019). Student-generated species diversity data are compiled in a publicly available database for long-term biodiversity trends in these habitats. Many students in these labs initially fail to successfully amplify DNA from the organism they collect. In response, the BIO140 lab incorporates several activities that teach students how to use controls to identify where their DNA amplification most likely failed (extraction vs. PCR vs. gel electrophoresis) and provide time for students to re-extract and reamplify their DNA as a second attempt to generate a DNA barcode from their sample (see Figure 1; detailed lesson plans can be found in Hyman et al. 2019). These experiences help students understand that although things don't always go to plan in scientific studies, there often is time to reflect, regroup, and try again (iterate) in a more informed way.

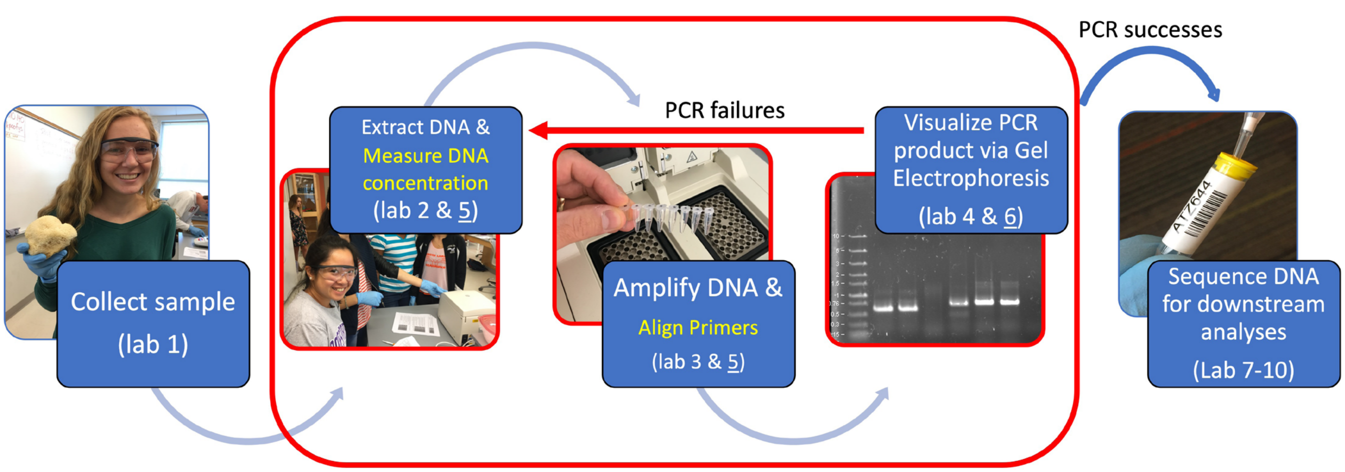
BIO150: Leveling Up—Troubleshooting Failure and Iterating with Intention

BIO150 is the second one-semester course in the students' one-year, course-based, DNA barcoding research experience. BIO150 is designed to imitate authentic inquiry-driven scientific research and provide a greater number of students with the experience of designing their own research project from start to finish. This course leverages students' prior knowledge using DNA barcoding in BIO140 to enable student teams to design and execute their own DNA barcoding-based research projects. Students develop a research question and write a mock grant proposal. Upon project approval, students use the DNA barcoding workflow to generate original DNA sequence data that address their research questions and then share their findings with classmates through written manuscripts and oral presentations. Student projects typically involve product testing (e.g., Sushi mislabeling) or biodiversity assessments (e.g., insect species diversity in wild raspberries).

Similar to BIO140, many students in BIO150 labs initially fail to successfully amplify DNA from the samples they collect. In response, BIO150 builds upon the lessons taught in BIO140 by including additional activities that teach students how (a) to determine the appropriateness of their PCR primers by aligning them in the genome of their target taxa, (b) to measure the purity and concentration of their DNA extracts on a nanodrop spectrophotometer, and (c) to optimize sample DNA concentrations for PCR amplification. Students also are provided with alternative DNA extraction techniques and primers to choose from if they decide to re-extract and/or re-PCR amplify their samples (see Figure 1). Similar to BIO140, students are given additional time in class to apply these techniques toward troubleshooting and reamplifying their samples. These experiences help students "level-up" their understanding of how to troubleshoot "failure" by accessing new tools, knowledge, and methodologies.

As previously mentioned, students in both BIO140 and BIO150 are provided with two extra lab periods to attempt to re-extract and reamplify samples (see Figure 1). Students who have successfully amplified their samples in the first attempt also attend these labs to help teammates rerun failed samples—providing everyone with extra time in the lab to learn these techniques and practice iteration,

FIGURE 1. Flowchart of Student Progress through the "Planned PCR Failure" Labs



Students in these labs are tasked with successfully amplifying DNA from an unidentified organism whose DNA will ultimately be sequenced for identification via DNA barcode-based analyses. Students who fail to successfully amplify DNA on their first round of PCR (by lab no. 4) participate in a structured series of labs that provide them with tools, tips, and time to troubleshoot their failed PCR reactions and reattempt amplifying DNA from their samples (see Hyman et al. 2019 for in-depth descriptions and sample lesson plans). These labs provide students with an opportunity to experience failure and provide instructors with a predictable and scalable way to incorporate lessons about failure into a large enrollment introductory biology course. Underlined lab numbers indicate labs dedicated to reattempting failed PCR reactions. The yellow font indicates additional, higher experience-level activities that are unique to the second course (BIO150) in the DNA Barcoding laboratory course series.

troubleshooting, and dealing with failure. Lastly, students in both courses also respond to a set of metacognitive prompts (see Corwin forthcoming) that help them reflect upon any failure or research related challenges they've faced and what they've gained from it. Overall, these activities increase students' rate of successful DNA amplification, and thereby project success, from approximately 50 percent after their first PCR to approximately 85 percent after their second iteration. Students who cannot successfully isolate DNA from their sample(s) are provided with a "safety net" of backup DNA sequences to use for subsequent downstream analyses to help maintain motivation without fear that the whole semester will be lost.

Evidence of Effectiveness

Our research team has conducted a large-scale background study on how these sequential DNA barcoding laboratory courses benefit students. As part of this multifaceted study, both quantitative and qualitative data have been collected documenting the short- and intermediate-term impact of these research courses on a variety of student outcomes. This chapter briefly discusses findings from two sub-studies from the larger project that demonstrate the positive contributions of the aforementioned failure-related design considerations to the development of students' coping skills.

In the first study, in collaboration with Corwin and others (forthcoming), a formal examination was conducted of how students cope with challenges and failure in the research setting. Data were collected from 668 students in 19 sections of BIO140L (n = 339) and BIO150L (n = 329) in the form of five open-ended prompts to document their feelings, behaviors, and learning after experiencing a challenge or failure in their research tasks (see Corwin et al. forthcoming for the employed metacognitive prompts). Survey data regarding students' academic and demographic background were also collected. Students' qualitative responses relating to encountered challenges, coping mechanisms, and outcomes were initially characterized using an open-coding approach with a-priori and emergent codes, which were converted to binary variables and quantitatively analyzed using mixed models. Most students in the sample (65 percent) reported facing a predictable technical challenge that they largely navigated using coping strategies predicted to be adaptive in STEM contexts, with differences observed between groups (gender, major). These findings lend empirical support to how the course design features (i.e., scaffolded instruction, incorporated time for iteration, and the use of planned activities that expose students to appropriate levels of challenge and failure) contributed to students' coping skills and understanding of the culture of science. Results of this work also suggest that incorporating predictable failure into coordinated research courses has the potential to support students' developmental trajectory in coping with scientific obstacles.

The second study used a mixed-methods approach to gather retrospective data from former participants to assess how the courses helped prepare them for later academic activities (e.g., coursework, undergraduate research). Survey data across a range of themes concerning perceived outcomes and course experiences were collected from former course participants (n = 148: 85 percent biology/biotech majors, 61 percent female, 68 percent third-year/fourth-year students, 26 percent underrepresented minority (URM)) that completed BIO150L on average approximately 3 semesters earlier. Insight gained from the surveys guided the design of follow-up, semi-structured interviews, conducted with a subset of 18 survey respondents (100 percent biology majors; 67 percent female; 56 percent third-year/fourth-year students; 16 percent URM), for a deeper exploration of previous survey responses. Closed-response survey items were descriptively analyzed and qualitative data from the surveys and interviews were coded and examined using directed content analysis to identify and illustrate patterns. Analyses discussed here address the self-identified intermediate-term outcomes conferred to former participants relating to their ability to navigate scientific challenges and their reflections on how those outcomes came about.

Eighty-one percent of former students surveyed reported that they felt the research courses positively contributed to their comfort in coping with scientific challenges, with the remaining 19 percent identifying a neutral effect. In addition, after technical (35 percent) and scientific communication (22 percent) skills, 20 percent of survey respondents identified that gains in their ability to deal with challenges and failure were the most valued outcome in preparing them for later academic pursuits: "My extractions in BIO 140 and 150 didn't work the first time. But the second time it did. And affirmation, I am really able to do this. [The classes] helped me to know that failure, especially in science, is not necessarily a bad thing" (Student A, biology major, female, third-year student). Interview data lend further insight as to how former students perceived the research courses helped them learn to deal with scientific challenges and failure. Most former students (83 percent) described how encounters with predictable DNA barcoding problems in BIO140L and/or BIO150L afforded useful avenues to practice coping skills. In conjunction with navigating technical issues, over half of the students (56 percent) highlighted opportunities for iteration: "In 140 my PCR did not amplify so I learned a lot about why. I had to try again and they let you try again. There's like two tries for PCR and two tries for gels so that really helped me and like having to deal with problems that I didn't really expect. So now when that happens in other labs it's like… I'm better at problem solving now because of that" (Student B, biology major, third-year student, male). One third (33 percent) of participants in the study noted that the experience "normalized" scientific failure for them in light of the regular technical challenges observed within their classroom. These results suggest that the exposure to appropriate challenges and opportunities for iteration are favorably viewed by students and can contribute to their self-efficacy, a key affective construct that contributes to one's persistence and performance in the sciences (Trujillo and Tanner 2014)—especially for members of traditionally underrepresented groups (e.g., Estrada et al. 2011).

Taken together, these studies support how embedding planned failure, iteration, scaffolded instruction, and self-reflection positively contribute to the intermediate-term abilities of students in the DNA barcoding CURE to respond to scientific challenges and failure. More broadly, the findings are consistent with prior work examining the potential benefits of deliberately designing research-oriented courses to productively expose students to scientific challenges (and failure).

Conclusion

Although there are undeniable benefits to traditional "cookbook" labs with fail-safe research outcomes, these often come at the cost of disabusing students that scientific studies invariably successfully arrive at foregone conclusions—a far cry from the messy reality of scientific research. Our "predictable PCR failure" framework (see Figure 1) provides a relatively straightforward way to teach first-year students about the obstacles that often arise in scientific research and how to overcome them. We hope that this framework will be useful to other instructors interested in scalable methods to teach undergraduates about the value of research-related failure, reduce failure-related anxiety, and begin to model the resilience and growth mindset required for successful scientific inquiry into the grand challenges facing the world (Henry et al. 2019; Simpson and Maltese 2017).

Acknowledgments

Andrea Pesce, Elizabeth Doyle, Amanda Cass, and Raymond Enke made significant contributions to development and coordination of the BIO140 and BIO150 lab courses. Bruce Nash, Jason Williams, Sharon Pepenella, and Dave Micklos at the Cold Spring Harbor DNA Learning Center also provided invaluable expertise and resources for the development of these courses. The College of Science and Mathematics (CSM) at James Madison University and 4-VA provided financial support for the development of these courses. The authors would like to acknowledge Rachel Boyce, Julie Cumins, Sarah Coleman, Joey DeTrane, Charlotte Stewart, and Brett Chappell for their contributions to the assessment of the DNA Barcoding CUREs and also are grateful to the study participants for sharing their experiences and perspectives. The studies discussed above were conducted with approval from the Internal Review Board for Human Subjects at James Madison University (no. 19-0255) and the University of Colorado, Boulder (no. 17-0540).

References

Auchincloss, Lisa Corwin, Sandra L. Laursen, Janet L. Branchaw, Kevin Eagan, Mark Graham, David I. Hanauer, Gwendolyn Lawrie, et al. 2014. "Assessment of Course-Based Undergraduate Research Experiences: A Meeting Report." CBE–*Life Sciences Education* 13: 29–40. doi: 10.1187/cbe.14-01-0004

Corwin, Lisa, Michael Ramsey, Elizabeth Woolner, Stevie Ellis, Nina Gustafson, and Joseph A. Harsh. Forthcoming. "Two Sequential Research-Based Courses Afford Students Opportunities to Develop Scientific Coping Skills." *CBE–Life Sciences Education.*

Corwin, Lisa A., Christopher R. Runyon, Eman Ghanem, Moriah Sandy, Greg Clark, Gregory C. Palmer, Stuart Reichler, et al. 2018. "Effects of Discovery, Iteration, and Collaboration in Laboratory Courses on Undergraduates' Research Career Intentions Fully Mediated by Student Ownership." *CBE–Life Sciences Education* 17(2): ar20. doi: 10.1187/cbe.17-07-0141

Estrada, Mica, Anna Woodcock, Paul R. Hernandez, and P. W. Schultz. 2011. "Toward a Model of Social Influence That Explains Minority Student Integration into the Scientific Community." *Journal of Educational Psychology* 103(1): 206–222. doi: 10.1037/a0020743

Goodwin, Emma C., Vladimir Anokhin, MacKenzie J. Gray, Daniel E. Zajic, Jason E. Podrabsky, and Erin E. Shortlidge. 2021. "Is This Science? Students' Experiences of Failure Make a Research-Based Course Feel Authentic." *CBE–Life Sciences Education* 20(1): ar10. doi: 10.1187/cbe.20-07-0149

Gin, Logan E., Ashley A. Rowland, Blaire Steinwand, John Bruno, and Lisa A. Corwin. 2018. "Students who Fail to Achieve Predefined Research Goals May Still Experience Many Positive Outcomes as a Result of CURE Participation." *CBE–Life Sciences Education* 17(4): ar57. doi: 10.1187/cbe.18-03-0036

Hebert, Paul D. N., Alina Cywinska, Shelley L. Ball, and Jeremy R. DeWaard. 2003. "Biological Identifications through DNA Barcodes." *Proceedings of the Royal Society of London. Series B: Biological Sciences* 270: 313–321. doi: 10.1098/rspb.2002.2218

Henry, Meredith A., Shayla Shorter, Louise Charkoudian, Jennifer M. Heemstra, and Lisa A. Corwin. 2019. "FAIL Is Not a Four-Letter Word: A Theoretical Framework for Exploring Undergraduate Students' Approaches to Academic Challenge and Responses to Failure in STEM Learning Environments." *CBE–Life Sciences Education* 18(1): ar11. doi: 10.1187/cbe.18-06-0108

Hyman, Oliver, Elizabeth Doyle, Joseph Harsh, Joanna Mott, Andrea Pesce, Bejan Rasoul, Kyle Seifert, and Ray Enke. 2019. "CURE-All: Large Scale Implementation of Authentic DNA Barcoding Research into First-Year Biology Curriculum." *CourseSource.* doi: 10.24918/cs.2019.10

Simpson, Amber, and Adam Maltese. 2017. "'Failure Is a Major Component of Learning Anything': The Role of Failure in the Development of STEM Professionals." *Journal of Science Education and Technology* 26: 223–237. doi: 10.1007/s10956-016-9674-9

Spell, Rachelle M., Judith A. Guinan, Kristen R. Miller, and Christopher W. Beck. 2014. "Redefining Authentic Research Experiences in Introductory Biology Laboratories and Barriers to Their Implementation." *CBE–Life Sciences Education* 13(1): 102–110. doi: 10.1187/cbe.13-08-0169

Stoeckle, Mark. 2003. "Taxonomy, DNA, and the Barcode of Life." *BioScience* 53: 796–797. doi: 10.1641/0006-3568(2003)053[0796:TDATBC]2.0.CO;2

Tanner, Kimberly D. 2012. "Promoting Student Metacognition." *CBE–Life Sciences Education* 11: 113–120. doi: 10.1187/cbe.12-03-0033

Traphagen, Stephen. 2015, May 13. "Teacher: The Important Conversations We Are Too 'Scared' to Have." *Washington Post,* https://www.washingtonpost.com/news/answer-sheet/wp/2015/05/13/teacher-the-helpful-conversations-we-are-too-scared-to-have/

Trujillo, Gloriana, and Kimberly D. Tanner. 2014. "Considering the Role of Affect in Learning: Monitoring Students' Self-Efficacy, Sense of Belonging, and Science Identity." *CBE–Life Sciences Education* 13: 6–15. doi: 10.1187/cbe.13-12-0241

CHAPTER 3

Redesigning Failure: Preparing Research Students for the Inevitable

Heather M. Townsend

Abstract. This case study highlights a first attempt at implementing a course-based undergraduate research experience (CURE) and the challenges that occurred surrounding the concept of failure. It describes an introduction to the importance of CUREs, what failure is, possible solutions to confronting failure, and a brief reflection. High-impact practices such as CUREs are unique opportunities that introduce students to realistic experimental scenarios (what it feels like to be a scientist), including the potential failure inherent in the scientific process. In this case study, the author discusses her experiences with student failure and the actions taken to further prepare students for this unintended yet beneficial outcome.

doi: 10.18833/cf/8

The term *high-impact practices* (HIPs) refers to pedagogical techniques that improve the educational experience for students by facilitating deep learning and engagement. HIPs include techniques such as first-year seminars, internships, learning communities, undergraduate research, and community-based learning. These techniques are shown to reduce attrition, improve student grades, and increase students' sense of partnership with the course and other students (Kuh 2008). Kuh reported that engaging students in experiences that actively involve them increases discussion with the student's peers outside of class and increases competency in STEM-associated careers. Similarly, Brownell and Swaner (2009) noted further gains with HIPs that included a student's overall satisfaction with their educational experience. Additional research has shown that students benefit from being directly involved in undergraduate research experiences (Brownell et al. 2015; Corwin, Graham, and Dolan 2015; Hanauer and Dolan 2014; Shortlidge, Bangera, and Brownell 2016).

Course-based undergraduate research experiences (CUREs) are a HIP that engage an entire class on research connected to class learning objectives. Important aspects of CUREs have been noted by many (Auchincloss et al. 2014; Ballen et al. 2017; Brownell and Kloser 2015; Dolan and Weaver 2021; Dolan 2016; Gin et al. 2018; Govindan, Pickett, and Riggs 2020) and include iteration, collaboration, discovery, relevance to an external community, and data production. CUREs provide research and laboratory competencies with the goal of engagement outside of the general laboratory learning outcomes (Dolan 2016). Students gain communication and collaboration skills through CUREs, as they are, by definition, required to effectively share information about their work and results with fellow classmates (Swanson et al. 2016). Authenticity and inclusion further strengthen the experience a student receives with this HIP (Munn et al. 2017; Rowland at al. 2016; Bangera and Brownell 2014). Research has found evidence that participation in CUREs leads some students to change their intended majors or careers (Corwin et al. 2018; Harrison et al. 2011; Lopatto 2007). Participation in a CURE can also help with persistence in STEM, especially for minorities and underrepresented students (Estrada et al. 2017; Rodenbusch et al. 2016).

Cookbook labs common in science education (that perhaps we have even written) are often littered with information, essentially shouting at students how to do something, why they do something, and what exact results they should obtain (guilty as charged). If students do not achieve the expected, they attribute that to either human error or instrument malfunction (Dolan and Weaver 2021). While these labs teach students to follow instructions, they do not truly teach students to conduct scientific inquiries. Science is an iterative and open discipline. Discoveries and insights are far from guaranteed. In fact, learning from negative results (that is, when our findings do not support our starting hypothesis) is one of the most central elements in science. When students engage in CUREs, their experience is far from predetermined. CUREs require that students construct, devise, elaborate, comprehend, and analyze experiments on their own. Students take ownership of the samples they collect (Dolan and Weaver 2021), the analysis they run, and the results they find. CUREs enable students to engage with failure, ambiguity, and the unexpected at a higher level (Gin et al. 2018; Shortlidge, Bangera, and Brownell 2016).

Even more significantly, CUREs require critical scientific thinking. In many CUREs, students guide the experimental process from concept to analysis. When the research "goes wrong"—that is, the results are the opposite of what they expected, or students do not find that anything happened at all—they are required to determine why. Was human error to blame? Were the samples contaminated? This level of critical thinking generates scientific reasoning skills in a way that pre-packaged labs simply cannot.

I incorporated a CURE in a microbiology course after attending a Summer Institute at the University of Texas. Since implementing this HIP, I have seen notable effects in students' educational outcomes. At a community college, students are often first-generation college students, and many come from minority backgrounds. It is important for inclusion and equity to implement CUREs and research experiences at the community college level (Hewlett 2009; Hewlett 2016; Lloyd and Eckhardt 2010; Hurtado et al. 2008; Jones, Barlow, and Villarejo 2010) as this opportunity engages and connects all students. For many of these students, science existed in books, not their lives. I felt that a CURE was the answer to the question of "how do we allow for an inclusive opportunity for students that would not otherwise participate in research?"

A CURE in the Classroom

The CURE that I implemented focuses on a series of experiments to assess the antimicrobial properties of spices. After conducting a literature review of the topic, students would select a spice and test its effectiveness on six species of bacteria. To determine effectiveness, students inoculate petri dishes with bacteria and then apply various dilutions of spice-soaked disks to the plates. After a week, they measure the clear zone (zone of inhibition, or ZOI) around the disk, which is the area that bacteria could not grow due to spice inhibition. The larger the zone, the more effective a spice was at inhibiting bacterial growth. Smaller zones imply that the spice was less effective at controlling growth of that bacterial species. Groups gather results from their spice, compare to other groups, and present their findings.

This CURE is not intended to produce ground-breaking results; rather, to immerse them in the scientific process. Allowing students the freedom to engage in self-regulated learning can be challenging to professors as well as students (Govindan, Pickett, and Riggs 2020). It requires acceptance of uncertainty. This alone may be the most challenging part of this technique. This type of experimental process puts more control in the students' hands and less control in the hands of the instructor. As my first semester rolled out, I started to realize that I was not as prepared as I had thought.

The Meaning of Failure in Science

In hindsight, the significance of failure in the scientific process is obvious as confirmed by reflections of multiple STEM professionals (Simpson and Maltese 2017). But as someone used to prepackaged labs, I had not built failure into my plan. I went confidently into the semester thinking that I was prepared for this new endeavor, and it would run smoothly. I had given the CURE careful thought and consideration.

For results, I assumed that students would measure the ZOI and collect data similar to the published data they found. In some instances, the spice may not be as effective, hence there would be minimal or no ZOI. The size of the ZOI was not important to me. Students assumed that they would each get a large ZOI around their disks (i.e., the spice was effective at microbial death) since their literature search indicated such.

I quickly realized that although I had prepared students to engage in scientific research, I had not adequately prepared students for possible instances of failure. I had intended for students to feel like scientists. Yet, I had neglected to realize how rarely the significance of failure is included in their science education. I had not recognized that the absence of expected results (no ZOI, less than desired zone, etc.), an invalid hypothesis, or lab errors would lead to great disappointment in the course and a perception of failure.

On data collection day, one group had absolutely no ZOI and was devastated. I saw the excitement quickly fade, and they immediately started blaming themselves. They did not account for ambiguity, and not obtaining results (a clear, large ZOI) felt like failure to the students. I realized that I needed to teach a lesson central to science: a negative finding is still a finding. Here, no evidence of inhibition meant that their spice was not an effective antimicrobial agent. This indeed was still a result! I had done a poor job preparing them for this potential outcome. I attempted to realign their thinking by pointing out some antibiotics are only effective against certain bacteria. Physicians do not prescribe antibiotic X to treat bacteria Y, because they have learned that X does not effectively combat Y. Scientists could only learn which antibiotics were effective on which bacteria by finding out in which circumstances they were *not* effective.

I used these cases of negative findings (that is, that a given spice did not have expected anti-microbial properties) to encourage students to think more deeply about scientific experimentation. What could lead to null findings? It is possible that spice A does not inhibit bacteria B. But what if the null results were not because of a true lack of antimicrobial properties? What else could lead to null results? Could the spice have been contaminated? Could the chemicals have been denatured in some way to make the spice ineffective? There were multiple opportunities for reflection at this moment as students tried to develop other plausible explanations as to why this could have occurred. Example justifications (as described in their final poster presentations) included "another possible explanation could be the variation in Cinnamomum species used last semester. The different species could contain varying amounts of cinnamaldehyde," "it could be possible that cumin only has antimicrobial properties when used in an oil concentration," "it is possible that the changes in efficacy could be due to using a different form of the spice such as fresh garlic cloves or pre-chopped garlic with added preservatives," and "we determined that the spice itself was contaminated and should have been tested before beginning the experiment." This reflection component was an integral part of the acceptance of failure. From this, students then devised alternative experiments to test their suspicions. This indicated that not only was the failure important but also that it inspired their learning during the CURE to critically think of the next step in the scientific process. This iteration step is critical in the success of their CURE.

What Is Failure?

"Failure" occurs when there is a disconnect between intended achievement goals and what essentially happens (Henry et al. 2019). The word failure can have many different meanings in a student's experience. They most commonly associate that word with their success in a course (perhaps with a passing grade), however students in this class perceived getting null results and/or contamination as failure.

Failure is a normal component to being a successful scientist (Henry et al. 2019). Lopatto (2007) reported that failure is a valuable skill for students to encounter and be further successful in circumnavigating scientific barriers. Professional scientists are able to recognize that null results are still results and are also able to acknowledge that human error is inevitable (Simpson and Maltese 2017). Reflecting on those times where I failed in research, like accidentally ruining samples from six months of collections (a true story of my graduate days), I realize those "failures" only made me a better scientist in the end.

How we, as faculty, prepare, handle, and engage with students for the possibility of failure could have profound influences on their future after school (Henry et al. 2019; Harrison et al. 2011). The struggles that come with failure are inevitable (Henry et al. 2019). However, undergraduate students are generally not prepared to address failure. It is also important to note that there are differences in students' responses to failure and intervention that are influenced by their background and cultural differences (Henry et al. 2019). Students from less privileged backgrounds may be particularly unprepared for this aspect of science, making this process even more important. As an instructor at a community college, I understand this relevance to my population of students and strive to foster these connections.

Authenticity in Research and Perceptions of Failure

Goodwin and colleagues (2021) conducted research exploring how students viewed and perceived "authentic research experiences." Student buy-in is critical for these experiences to be seen as authentic. But what comes with an "authentic" research experience is more than just a beaker and a petri plate; research is commonly riddled with failure at many levels. Goodwin et al. also found that students who experienced failure in a CURE felt as if they conducted real research. Students' perception of failure may have been the result of instructors leading with discussions about the normalcy of failure. This suggests that failure is ultimately an essential part of their CURE. Experiencing failure may be key in students feeling like they are conducting authentic research (Goodwin et al. 2021), but perhaps only if mentors set them up for the possibility first. When scaffolded and supported, failure can be an integral part of growth and learning, especially in the STEM fields. I intended for students to feel as if they participated in real, authentic, scientific inquiry.

The CURE I implemented was successful in achieving the learning objectives both specific to this class and those of a HIP generally. Using both quantitative and qualitative feedback from students involved in this course, I found that 91 percent indicated that they made large or very large gains in terms of "becoming part of a learning community." More essential to the goals of understanding failure, 87 percent indicated that they made large or very large gains in terms of their "tolerance for obstacles faced in the research process." In an end-of-semester reflection paper, one student reported that "… no results is still results so it was not the worst thing that could happen," whereas another noted "the most difficult parts were the most rewarding ones in the end. I am leaving this class with newfound knowledge, skills, and confidence in myself." These assessments help to confirm the process of the CURE and benefits of failure even more.

Learning from Failure

My "failure" as the instructor was in not preparing students, and myself, for the potential variety of experimental results that students perceived as failure. After my first semester, I needed to reframe how I prepared possible (and expected) scenarios of "failure." It is important that students in a CURE know that real science involves setbacks (Dolan and Weaver 2021). The next semester I changed some aspects to ensure that students were prepared for the unknowns that could occur:

- I recruited former students (and not just the ones that got As) that had completed a CURE with me to discuss their experiences conducting research and encountering ambiguous or unclear results. Based on answers in my assessment, it was meaningful for students to hear from former students who may have struggled and ways that they coped. Gin and colleagues (2018) found that when students see other students struggle with problems, it helps them with their own confidence.
- I prepared students for ambiguity from the start. Students were much more receptive to (and accepting of) the absence of a large ZOI when they knew their unexpected result was still important to the research. I introduced this at the beginning of the semester, as well as on the day they were analyzing their results.
- As failure is perceived by students as the gap between expected and desired results, I needed to reframe what "desired" meant. My intention was for them to collect and analyze data, not to obtain groundbreaking results. I defined what failure in research meant, and explained that failure and results are not the same.
- I conveyed that getting specific results was not a determinant of their grade. Students are often trained that their grade in their course correlates to them getting the "right" answers (Govindan, Pickett, and Riggs 2020), so explaining that the scientific process remained more important was critical. This CURE involves participating in a research project that is not overly important (i.e., I do not need the results as part of my own research, it does not equal life or death of a patient, etc.). This in a way takes the pressure off them—if an experiment fails, and anticipated results are not achieved, it is not calamity.
- I shared my own experiences with "failure" in science. By normalizing failure and being transparent about our own struggles, we can help students to see obstacles as challenges and gain confidence (Gin et al. 2018, Lin-Siegler et al. 2016).
- I allowed students time to overcome failure. Being able to trouble-shoot and repeat or redesign a project is important since that is a standard process in a lab setting (Auchincloss et al. 2014, Dolan and Weaver 2021). I needed to allow more time for reflection and iteration of their project based on a failure (Corwin et al. 2018, Govindan, Pickett, and Riggs 2020, Gin et al. 2018)

Discussion

CUREs provide a significant benefit for students, especially those at community colleges. They create a sense of equity and equality for a diverse population. They reach every student, not just a select few privileged with personal and educational resources. Hewlett (2018) noted the importance of undergraduate research experience especially at community college to connect to the diverse culture of learners. This reason alone reminds me of the importance CUREs bring to the demographic of students I teach.

CUREs create a true research community among community college science learners in a class. For many of them, this will be their only research opportunity while in college, and I am proud to have facilitated it. Integrating a CURE greatly enhanced students' engagement with course materials in my microbiology course, as well as increased their excitement (especially on results day). Students left the course with the necessary course content, better lab and research skills, understanding of science as a process, and a true sense of accomplishment as noted in their written reflections at the end of the semester.

Although my first implementation of a CURE may be described as a failure in some ways—my failure to prepare students for null results, students' sense of failure from having received them—I have accepted these failures as part of the process. I have learned from them and adjusted the class CURE framework accordingly. Accepting failure is a part of the process of both science and science education. Reframed, "failure" is a type of success that promotes academic growth for both students and faculty.

In closing, each semester brings new challenges, yet new rewards. With each new "failure" comes a chance for me to not only assist my students to grow but myself as well.

References

Auchincloss, Lisa Corwin, Sandra L. Laursen, Janet L. Branchaw, Kevin Eagan, Mark Graham, David I. Hanauer, Gwendolyn Lawrie, et al. 2014. "Assessment of Course-Based Undergraduate Research Experiences: A Meeting Report." *CBE–Life Sciences Education* 13(1): 29–40. doi: 10.1187/cbe.14-01-0004

Ballen, Cissy J., Jessamina E. Blum, Sara Brownell, Sadie Hebert, James Hewlett, Joanna R. Klein, Erik A. McDonald, et al. 2017. "A Call to Develop Course-Based Undergraduate Research Experiences (CUREs) for Nonmajors Courses." *CBE–Life Sciences Education* 16: mr2. doi: 10.1187/cbe.16-12-0352

Bangera, Gita, and Sara E. Brownell. 2014. "Course-Based Undergraduate Research Experiences Can Make Scientific Research More Inclusive." *CBE–Life Sciences Education* 13: 602–606. doi: 10.1187/cbe.14-06-0099

Brownell, Jayne E., and Lynn E. Swaner. 2009. "High-Impact Practices: Applying the Learning Outcomes Literature to the Development of Successful Campus Programs." *Peer Review* 11(2): 26–30.

Brownell, Sara, and Matthew Kloser. 2015. "Toward a Conceptual Framework for Measuring the Effectiveness of Course-Based Undergraduate Research Experiences in Undergraduate Biology." *Studies in Higher Education* 40: 525–544.

Brownell, Sara E., Daria S. Hekmat-Scafe, Veena Singla, Patricia Chandler Seawell, Jamie F. Conklin Imam, Sarah L. Eddy, Tim Stearns, and Martha S. Cyert. 2015. "A High-Enrollment Course-Based Undergraduate Research Experience Improves Student Conceptions of Scientific Thinking and Ability to Interpret Data." *CBE–Life Sciences Education* 14: ar21. doi: 10.1187/cbe.14-05-0092

Corwin, Lisa A., Christopher R. Runyon, Eman Ghanem, Moriah Sandy, Greg Clark, Gregory C. Palmer, Stuart Reichler, Stacia E. Rodenbusch, and Erin L. Dolan. 2018. "Effects of Discovery, Iteration, and Collaboration in Laboratory Courses on Undergraduates' Research Career Intentions Fully Mediated by Student Ownership." *CBE–Life Sciences Education* 17: ar20. doi: 10.1187/cbe.17-07-0141

Corwin, Lisa A., Mark J. Graham, and Erin L. Dolan. 2015. "Modeling Course-Based Undergraduate Research Experiences: An Agenda for Future Research and Evaluation." *CBE–Life Sciences Education* 14: es1. doi: 10.1187/cbe.14-10-0167

Dolan, Erin L. 2016. "Course-Based Undergraduate Research Experiences: Current Knowledge and Future Directions." Commissioned paper, pp. 1–34. Washington, DC: National Academies of Sciences, Engineering, and Medicine.

Dolan, Erin, and Gabriela Weaver. 2021. *A Guide to Course-Based Undergraduate Research: Developing and Implementing CUREs in the Natural Sciences.* New York: Macmillan Learning.

Estrada, Mica, Myra Burnett, Andrew G. Campbell, Patricia B. Campbell, Wilfred F. Denetclaw, Carlos G. Gutiérrez, Sylvia Hurtado, et al. 2016. "Improving Underrepresented Minority Student Persistence in STEM." *CBE–Life Sciences Education* 15: es5. doi: 10.1187/cbe.16-01-0038

Gin, Logan E., Ashley A. Rowland, Blaire Steinwand, John Bruno, and Lisa A. Corwin. 2018. "Students Who Fail to Achieve Predefined Research Goals May Still Experience Many Positive Outcomes as a Result of CURE Participation." *CBE–Life Sciences Education* 17: ar57. doi: 10.1187/cbe.18-03-0036

Goodwin, Emma C., Vladimir Anokhin, MacKenzie J. Gray, Daniel E. Zajic, Jason E. Podrabsky, and Erin E. Shortlidge. 2021. “Is This Science? Students’ Experiences of Failure Make a Research-Based Course Feel Authentic.” *CBE–Life Sciences Education* 20: ar10. doi: 10.1187/cbe.20-07-0149

Govindan, Brinda, Sarah Pickett, and Blake Riggs. 2020. “Fear of the CURE: A Beginner’s Guide to Overcoming Barriers in Creating a Course-Based Undergraduate Research Experience.” *Journal of Microbiology & Biology Education* 21(2): 1–8. doi: 10.1128/jmbe.v21i2.2109

Hanauer, David I., and Erin L. Dolan. 2014. “The Project Ownership Survey: Measuring Differences in Scientific Inquiry Experiences.” *CBE–Life Sciences Education* 13(1): 149–158. doi: 10.1187/cbe.13-06-0123

Harrison, Melinda, David Dunbar, Lisa Ratmansky, Kimberly Boyd, and David Lopatto. 2011. “Classroom-Based Science Research at the Introductory Level: Changes in Career Choices and Attitude.” *CBE–Life Sciences Education* 10: 279–286. doi: 10.1187/cbe.10-12-0151

Henry, Meredith A., Shayla Shorter, Louise Charkoudian, Jennifer M. Heemstra, and Lisa A. Corwin. 2019. “*FAIL* Is Not a Four-Letter Word: A Theoretical Framework for Exploring Undergraduate Students’ Approaches to Academic Challenge and Responses to Failure in STEM Learning Environments” *CBE–Life Sciences Education* 18: ar11. doi: 10.1187/cbe.18-06-0108

Hewlett, James. 2009. “The Search for Synergy: Undergraduate Research at the Community College.” In *Undergraduate Research at Community Colleges,* 9–18. Washington, DC: Council on Undergraduate Research.

Hewlett, James. 2016. “Undergraduate Research at the Community College: Barriers and Opportunities.” In *The Power and Promise of Early Research,* ed. Desmond H. Murray, Sherine O. Obare, and James H. Hageman, 137–151. Washington, DC: American Chemical Society. doi: 10.1021/bk-2016-1231.ch008

Hewlett, James A. 2018. “Broadening Participation in Undergraduate Research Experiences (UREs): The Expanding Role of the Community College.” *CBE–Life Sciences Education* 17: es9. doi: 10.1187/cbe.17-11-0238

Hurtado, Sylvia, Nolan L. Cabrera, Monica H. Lin, Lucy Arellano, and Lorelle L. Espinosa. 2009. “Diversifying Science: Underrepresented Student Experiences in Structured Research Programs.” *Research in Higher Education* 50: 189–214. doi: 10.1007/s11162-008-9114-7

Jones, Melanie T., Amy E. L. Barlow, and Merna Villarejo. 2010. “Importance of Undergraduate Research for Minority Persistence and Achievement in Biology.” *Journal of Higher Education* 81: 82–115. doi: 10.1080/00221546.2010.11778971

Kuh, George D. 2008. *High-Impact Educational Practices: What They Are, Who Has Access to Them, and Why They Matter.* Washington, DC: Association of American Colleges and Universities.

Lin-Siegler, Xiaodong Ahn, Janet N. Chen, Jondou Fang, Fu-Fen Anny Luna-Lucero, Myra. 2016. “Even Einstein Struggled: Effects of Learning About Great Scientists’ Struggles on High School Students’ Motivation to Learn Science.” *Journal of Educational Psychology* 108: 314–328. doi: 10.1037/edu0000092

Lloyd, Patrick M., and Ronald A. Eckhardt. 2010. “Strategies for Improving Retention of Community College Students in the Sciences.” *Science Educator* 19(1): 33–41.

Lopatto, David. 2007. “Undergraduate Research Experiences Support Science Career Decisions and Active Learning.” *CBE–Life Sciences Education* 6: 297–306. doi: 10.1187/cbe.07-06-0039

Munn, Maureen, Randy Knuth, Katie Van Horne, Andrew W. Shouse, and Sheldon Levias. 2017. "How Do You Like Your Science, Wet or Dry? How Two Lab Experiences Influence Student Understanding of Science Concepts and Perceptions of Authentic Scientific Practice." *CBE–Life Sciences Education* 16: ar39. doi: 10.1187/cbe.16-04-0158

Rodenbusch, Stacia E., Paul R. Hernandez, Sarah L. Simmons, and Erin L. Dolan. 2016. "Early Engagement in Course-Based Research Increases Graduation Rates and Completion of Science, Engineering, and Mathematics Degrees." *CBE–Life Sciences Education* 15: ar20. doi: 10.1187/cbe.16-03-0117

Rowland, Susan, Rhianna Pedwell, Gwen Lawrie, Joseph Lovie-Toon, and Yu Hung. 2016. "Do We Need to Design Course-Based Undergraduate Research Experiences for Authenticity?" *CBE–Life Sciences Education* 15: ar79. doi: 10.1187/cbe.16-02-0102

Shortlidge, Erin E., Gita Bangera, and Sara E. Brownell. 2016. "Faculty Perspectives on Developing and Teaching Course-Based Undergraduate Research Experiences." *BioScience* 66(1): 54–62. doi: 10.1093/biosci/biv167

Simpson, Amber, and Adam Maltese. 2017. "'Failure Is a Major Component of Learning Anything': The Role of Failure in the Development of STEM Professionals." *Journal of Science Education and Technology* 26: 223–237. doi: 10.1007/s10956-016-9674-9

Swanson, Hollie I., Ok-Kyong Park Sarge, Thushani Rodrigo-Peiris, Lin Xiang, and Vincent M. Cassone. 2016. "Development of a Course-Based Undergraduate Research Experience to Introduce Drug-Receptor Concepts." *Journal of Medicine Education and Curricular Development* 3: 57–66. doi: 10.4137/JMECD.S31233

CHAPTER 4

Navigating a Pathway to Success in Undergraduate Research

Beth Beason-Abmayr, Elizabeth Eich, and Daniel J. Catanese Jr.

Abstract. This chapter describes a series of course-based undergraduate research experiences (CUREs) in introductory through advanced laboratory courses in biosciences with a shared learning goal for students to "experience that not all experiments work as planned." Student reflection data and survey results show that students develop mindsets and attitudes that prepare them to confront and cope with research failures as they progress through the laboratory program. Techniques are shared for embracing failure in teaching laboratory settings to build confidence and resilience in undergraduate researchers.

doi: 10.18833/cf/15

A meta-analysis of undergraduate courses reports that active learning increases student performance in science, engineering, and mathematics (Freeman et al. 2014). This type of learning environment requires students to take on new roles and accept greater responsibilities, which may differ greatly from more traditional classrooms. A recent study by Cavanagh and colleagues (2016) suggests that student "buy-in" to active learning impacts student engagement in learning and course performance. The teaching laboratory environment, where students perform experiments and analyze results, is naturally conducive to active learning and student engagement. Joshua R. Eyler (2018) discusses the research in psychology, evolutionary biology, and neuroscience about how learning occurs and considers the importance of curiosity, sociality, emotion, authenticity, and failure in effective teaching and learning. He concludes the following about the value of failure for students' learning: ". . . if we design courses that provide students with opportunities to fail when the stakes are low and then give them the support and guidance to gain understanding from these instances, we are creating environments where students can learn more effectively" (Eyler 2018, 173).

The undergraduate laboratory program in biosciences at Rice University offers a variety of course-based undergraduate research experiences (CUREs) at the introductory, intermediate, and advanced levels. Students interested in the biosciences come from a diverse pool, including first-generation students, transfers from community colleges or other institutions, women, and groups historically underrepresented in science. Although students are encouraged to participate in independent research during their undergraduate career at Rice, research is a requirement only for the BS degree, not for the BA degree. To ensure that all students experience research at some point during their undergraduate education and to improve diversity and persistence of potential and declared majors in biosciences, consistent with Bangera and Brownell (2014), existing laboratory courses were transformed into CUREs, and entry-level CUREs were created (Brewer and Smith 2011; Graham et al. 2013; National Academies of Sciences, Engineering, and Medicine 2015). As most of the required and elective laboratory courses are CUREs, all undergraduates majoring or minoring in biosciences earn course credit for participating in research. By taking a deliberate approach to develop science communication skills, encourage students to see themselves as scientists, and engage students with research topics that they find relevant and interesting, the gap between CUREs and more traditional undergraduate research experiences can be bridged, and the preparation of students for future research experiences and careers can be improved (Burmeister, Dickinson, and Graham 2021).

Collaboration and Iteration: Essential for Student Engagement

The CUREs incorporate different aspects of the five key elements that make up the essential elements that contribute to outcome achievement in CUREs (Auchincloss et al. 2014):

1. ***Scientific practices.*** Students read scientific literature, ask questions, propose hypotheses, design experiments, choose and modify methods, generate and analyze data, communicate findings, etc.
2. ***Discovery.*** Experimental outcomes are unknown to the instructor as well as the students.
3. ***Relevant research.*** The work has meaning beyond a specific course.
4. ***Collaboration.*** Students work with their peers, and instructors serve as facilitators and mentors.
5. ***Iteration.*** Students repeat and build on their own work and that of others.

Corwin, Graham, and Dolan (2015) reviewed published studies of CUREs and research internships to identify student learning outcomes. Focusing on six activities that students typically perform in CUREs, they constructed a CURE model showing connections between these activities and short, medium, and long-term outcomes that make CUREs effective for student learning. This model served as a guide as the authors examined CURE design and evaluated the roles of collaboration, iteration, and ownership in helping students cope with failure.

Dolan (2016) defines CUREs as "learning experiences in which *whole classes of students address a research question or problem with unknown outcomes or solutions that are of interest to external stakeholders*" (3; emphasis in original). The laboratory courses, which are unique, stand-alone labs not associated with a lecture course, emphasize scientific process rather than discipline-specific content. In the Biosciences Department, non–tenure-track, full-time teaching faculty develop the CUREs and "coach" students as they undertake a research project. The course instructors are free from the pressures and conflicts faced by research faculty who must balance mentoring of students in an apprenticeship experience with generating publishable data and securing funding to support their research. Additionally, since projects are selected with the pedagogical goals in mind, there is a great deal of flexibility and freedom with the choice of research topics for students to explore. Instructors, research faculty, and graduate students collaborate to bring a diversity of projects into the CUREs each semester. Because of this approach, students not only communicate their findings with each other but also disseminate their findings to future students who may continue the project and to the research labs with a vested interest in the outcomes. At the introductory level, the entire class pursues one or two projects; at the intermediate level, each section focuses on a different project; at the advanced level, each team within a section works on a project. For example, in the advanced CURE, which focuses on purification and characterization of proteins, student teams in the fall 2021 semester could "choose" one of three different recombinant proteins to attempt to purify. For any given research project in the intermediate and advanced CUREs, students have autonomy to ask their own questions, address a specific problem, and test their own hypotheses—so even if an entire section is working on the same research topic or multiple teams choose the same project, each team's project and approach are unique.

Students show greater enthusiasm and engagement when they see the work they are doing as *relevant* and important to the research pursuits in the department. Working on a research question/problem that each team defines for itself promotes a sense of responsibility and shared ownership (Scager et al. 2016). Students work in teams of three to four for an entire semester to achieve a shared research goal; this *collaboration* is strengthened because they are working together on challenging tasks toward a common goal. When experiments fail or results are unexpected, the mentors encourage students to work as a team and think about where things may have gone wrong and what the results may mean. These CURE courses all share a common learning goal for students to "experience that not all experiments work as planned." These "desirable difficulties" (Bjork and Bjork 2011) give students numerous opportunities to use goal-oriented, "deliberate practice" (Ericsson, Krampe, and Tesch-Romer 1993) to enhance their learning rather than repetitive practice of skills that produced unexpected results. Deliberate practice is characterized by "striving, failure, problem solving, and renewed attempts" (Brown, Roediger, and McDaniel 2014, 183–185), which help novice learners become experts. Students work together to solve problems, interpret data, develop protocols, and propose future experiments. Depending on the level of the CURE, students experience different types of *iteration* as they repeat and/or modify procedures and troubleshoot experiments.

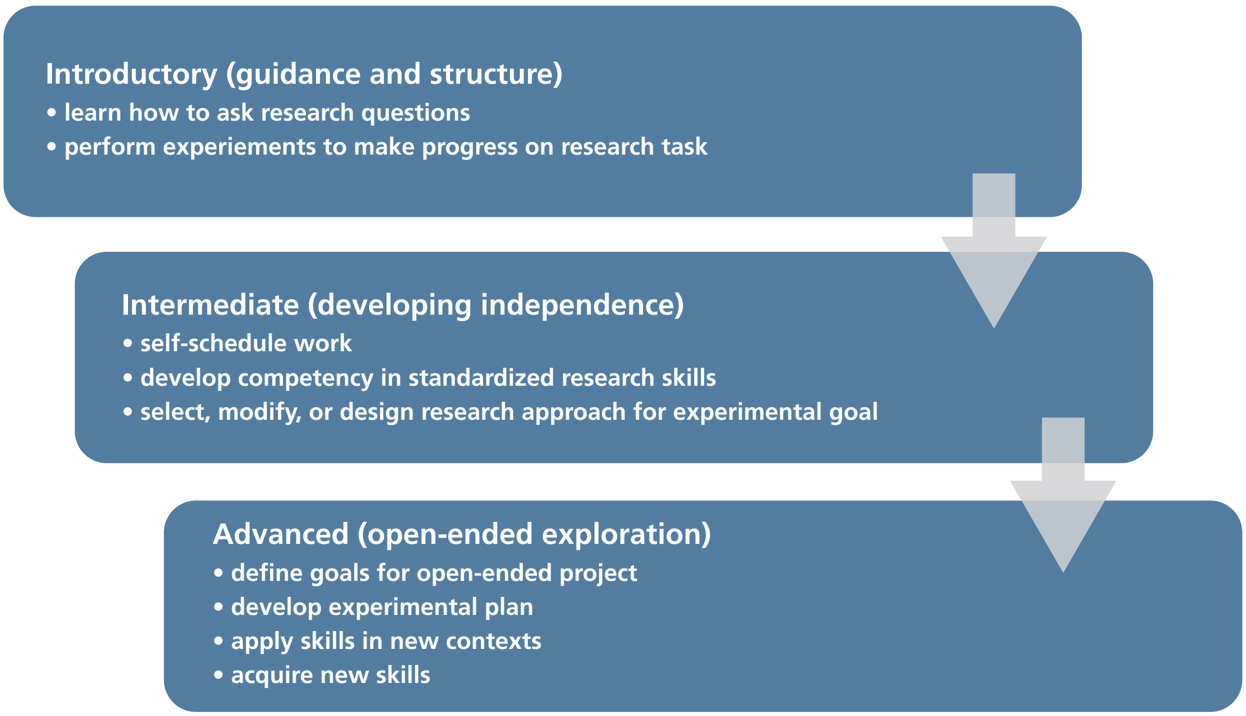
Several projects have been chosen that can be vertically integrated at different levels of CUREs; this approach increases the relevance of their work since they know that future students will be continuing the work that they started. As projects progress and use different methods, the projects shift among courses to match the experimental design and methods to student level. For example, first-year students in the introductory CURE shared in a reflection assignment how much they appreciated working on a "real" research project rather than just learning a bunch of laboratory techniques. They also showed enthusiasm and interest in their project because it had been started by students in the intermediate CURE—they successfully completed their project goals and took great pride in knowing that their work would be continued at the "next step" by students taking intermediate or advanced CUREs. To the authors' knowledge, this is the first example of CUREs with ongoing and evolving projects that flow among multiple courses. Other strategies to progress projects through CUREs include multiyear projects (Martin, et al. 2021) or multisite data collection (Bieser et al. 2020; Jordan et al. 2014).

Methods

Course Context: Scaffolded CUREs Give Students Opportunities to Fail

The intentionally scaffolded laboratory program introduces, builds, and reinforces research and communication skills so the undergraduates can become "expert-thinkers." Students in CUREs at all levels use multiple *scientific practices,* including both informal and formal means of verbal and written communication. All the research projects contain different flavors of discovery depending on the level of the CURE (see Figure 1). Scaffolding development of skills and independence in these CUREs creates an environment where students are excited about "doing science."

FIGURE 1. Three levels of CUREs



Scientific practices and discovery are scaffolded in different levels of course-based undergraduate research experiences (CUREs). As students progress through the laboratory program, instructors provide decreasing amounts of guidance and structure to foster independence and development of research skills.

Students majoring in biosciences choose a major concentration in biochemistry, cell biology and genetics, integrative biology, or ecology and evolutionary biology. The offerings of laboratory course sections or enrollment numbers have varied slightly to meet demand within an academic year; typical enrollments are described in Table 1.

Students are assessed on both individual and team assignments that emphasize written, oral, and visual communication of their research project; homework and quizzes that focus on content and skills; and engagement in lab activities. Assignments have been designed that allow for assessment of both collaboration and individual contributions that emphasize iteration and progress over achievement of specific experimental outcomes. Lab citizenship scoring guidelines (see Appendix 1) emphasize an individual's contribution to a collaborative environment, including safe practices and consideration of others in the lab space. A group contract assignment (see Appendix 2) further codifies how teams establish expectations for members. Collaboration and individual contributions are assessed through self-evaluation reflections (see Appendix 3) and through direct observations in weekly meetings. Students self-schedule laboratory work with different amounts of guidance at each course level to give students time for repeating or troubleshooting experiments. Students report their activities through weekly surveys of progress (see Appendix 4) or an experimental plan and timeline (see Appendix 5). Opportunities to practice or revise communication assignments are built into the course structure with either multiple communication modes (poster, oral presentation, and paper) or through drafts with revisions. Laboratory notebook rubrics (see Appendix 6) emphasize documentation and correction of errors. Research progress report rubrics (see Appendix 7) for the final course assignment emphasize interpretation of appropriate data and their relationship to expectations rather than specific findings that fit known outcomes.

TABLE 1. CURE offerings in biosciences at Rice University

Level	Sections	Students per section	Curricular integration	Can be used as a prerequisite for independent research
Introductory	1	16	Recommended; limited to first-year students; satisfies university writing seminar requirement	yes
Intermediate[a]	5	18	Required for three biosciences major concentrations; satisfies pre-health requirement	yes
Advanced[a]	2	16–20	Required for one major concentration; elective for two major concentrations and one extra-departmental major	

Note: CURE = course-based undergraduate research experience.

[a]Offered both fall and spring semesters

Study Design

A study was initiated to understand how exposing students to authentic research in these courses increased research independence and creativity and promoted retention of research-specific knowledge. Because failure is a natural part of the research process, the authors analyzed a subset of the data to reveal its role in students' achievement of the shared course learning goal. All study participants were students enrolled in CUREs at the introductory, intermediate, or advanced level. Student participation in the study was optional, and the course grade was not dependent on participation. Students were given the option to "opt out of the study." Participation in this study lasted for the duration of the course and did not entail any activities different from the regular activities students engaged in as part of a given course. Analysis of the data did not take place until after final course grades were determined. Student names and any personal identifying information were removed. All protocols were approved by the Institutional Review Board of Rice University (Protocol FY2017-294). The authors evaluated student reflections and analyzed Laboratory Course Assessment Survey (LCAS) results (see Corwin et al. 2015 for the development and validation of this survey). Reflection assignments were submitted through the institutional learning management system (Canvas LMS) several times throughout the semester; these formative assessments were low stakes assignments that contributed to the engagement/participation portion of the course grade. These reflections, which were either guided questions or open-ended prompts (see Table 2), encouraged students to practice metacognition and help them learn to think like scientists (Tanner 2012). Because the reflections were not anonymous, and students were allowed to select aspects of the courses they felt comfortable sharing, there may be bias toward positive experiences. The LCAS was used to measure students' perceptions of three course design features of CUREs: (1) opportunities for collaboration, (2) opportunities for making discovery and recognizing relevance, and (3) opportunities for iteration.

TABLE 2. Student reflections.

MID-COURSE REFLECTIONS PROMPT EXCERPTS **How does a researcher know when they have enough valid data to make a conclusion? How does your answer relate to your project in [intermediate CURE]? [M]** **Comparing before you took [intermediate CURE] and now, how would you describe your confidence level in learning a new method or applying a method you know in a new situation? [M]** **Write a "one page" (~500 words) that describes clearly what you found to be most interesting or challenging in this course so far and why. [A]**
"We keep conducting the same experiments each week, but our sample keeps getting stuck in the well (happened 2 times). This trend led us to the conclusion that the cell debris might impact the migration of the DNA in the gel, so we will centrifuge the sample this week. This demonstrates how consistent results, even if they are failures, can lead to conclusions." [M1]
". . . we have failed to create primers even though we hypothesized that our primers would work well given the Zuker algorithm and the ideal length amplicon they would create. However, they did not work, which suggests we either picked wrong primers or are doing something incorrectly in our PCR procedure, or we need to update our PCR conditions somehow. Our next plan is to update our PCR procedure by modifying magnesium concentrations. If this does not work, we might make the conclusion that it is in fact our primers that are faulty. Therefore, our next step after that one might be to end up adjusting the primers that we use to see if that changes anything." [M2]
". . . through requiring us to figuring out the specifics of methods (with instructor help) with general guidelines and logical reasoning for those guidelines given, I feel a lot more confident in being able to figure out the details of methods on my own and figuring out which parts are essential versus which parts can be modified as needed. I'm a lot less terrified about messing up new methods because I've realized it's fairly easy to correct mistakes." [M3]
". . . Before taking this class, I used to be afraid of making mistakes in labs, but I've now learned through the different competencies and cooperation with my team members that science isn't simply a quest for success but rather a journey of growth." [M4]
". . . I realize that it is ok to not know how to do something, not know where something is located, or make mistakes, as long as we correct them and document them." [M5]
". . . This challenging and unplanned series of events was important for me because it emphasized how messy real scientific endeavors can be. Things don't always go according to plan. And even well-established protocols can sometimes fall short… I think one problem our group had was that we just assumed that we wouldn't run into severe roadblocks when actually performing our experiment. . . . From now on, we've arranged a plan for that …" [A1]
". . . Being able to truly claim ownership of my work has had a tremendous impact on my confidence in my ability to do meaningful work as an independent scientist in the future and it is for this reason that I think the pedagogical approach employed in [advanced CURE] has been most important aspect about my experiences in lab. Additionally, I appreciate the fact that we were allowed to fail and make mistakes. Equally, if not more importantly, is that when mistakes were made, it was up to us to fix them. This is significant because it allowed me to gain a healthier and more productive mindset towards mistakes. . . . I now realize that mistakes are often more common than successes, that they are inevitable, and what makes a great scientist is not how little mistakes they make, but how they adjust when mistakes inevitably occur. [A2]

PROMPT EXCERPTS, END-OF-COURSE REFLECTIONS An important part of your development as a scientist and a team player is being able to evaluate not only your strengths but also those areas where you need to improve. Write an essay (minimum of 500 words) in which you reflect upon your work throughout the semester, describing specific examples of your growth. [I] Please reflect about your experiences throughout this lab and share your thoughts about how this new approach to this lab course has prepared you to become an independent researcher. [I] Which of these facets [framing, methodology, evaluation, synthesis, or communication] do you think [intermediate CURE] hit most for you? Describe when/how you advanced in this facet because of [intermediate CURE]. [M] Now that you've completed this advanced lab course, do you feel prepared to move on to independent research? [A] What is something specific that you did, observed, or learned that shows that you successfully accomplished one or more of the course learning goals? [A]
". . . I also had a strong and positive mindset about our work. This was easy for me because the rest of my group was also very cooperative. I would say that overall, each member was very positive and helpful rather than negative, which made working together feel easier. Even if something were to go wrong we would never blame it on an individual member." [I1]
"…We learned how to deal with problems in experiments by experiencing them ourselves in a low-risk environment. This new approach gives greater laboratory skills and confidence because it enables the student to react to novel situations. This approach taught us how to think about bioscience research." [I2]
"…Executing our own experiments took more time, but it exposed us to the entire experimental process, not just the experimental phase of the labs. We had to turn problems into testable questions and address those questions with our own experiments." [I3]
"…This method helped me develop as an independent researcher because it exposed me to the idea of hitting road blocks: when coming up with methods, we would think that our plan is working and fine until we hit a dead end, and need to start over (something that I had previously never done before)." [I4]
"…I struggled with the lack of direction, but in the end, I feel it really helped me to grow as a student and researcher. I was able to make my own mistakes throughout lab, and I learned more from my mistakes and failures than I would have had I just followed step by step lab protocols. The skills of critical thinking and resilience will be vital for my future research." [I5]
"In my particular project during [intermediate CURE], there was a lot of rinse-and-repeat, and we didn't actually even end up finding any oil body retaining mutants. Before this course, I would have thought that I wouldn't have been able to make any conclusions, that this was a total loss. But [intermediate CURE] taught me that that is just a part of science and there are so many faceted conclusions to be made even just about our methodology and whether or not our procedures were working the way we wanted them to." [M6]

continued

Table 2, continued

"…Research has always been daunting for me. I have always felt fear with failure, fear with the unknown nature of research, and the daunting task of taking up a project on my own. However, [advanced CURE] has shown me that this process is not scary, but rather exciting. It is exciting conducting experiments in the hope of positive results. It is exciting to study something that I am passionate about in the hopes of applying it to [a] real world setting. Individual research is exciting because I am able to take it in a direction of my own. This structure (or lack of it) really forces students to think critically about research methods and analysis of our data. What is my research question/aims? What methods are required? What do these results mean? And how can I move forward? These questions are integral to an independent research project and, while difficult to answer, have shown me that research is a journey not a destination." [A3]
"…the scientific experiments we performed did not work as planned. However, this was a good learning experience because it forced me to really think about why things were not working. If something worked, we would not have asked questions…We would have just taken for granted that certain procedures work a certain way. Now, I'm getting to understand some of the reasons behind why procedures work best…Now, I'm developing an intuition about how to evaluate our methods and determine the most probable causes of unexpected results. From these experimental failures, I've also learned about how to think about future steps. Rather than just mentioning very general statements about improvement, I've learned how to think about what might have gone wrong and how to address that within the procedures." [A4]
"...we unfortunately came to possess results we were not expecting. Because of some abnormalities in the purification protocol, we are not able to make any concrete conclusions, which complicates the results and discussion of the research paper. However, I believe this is a good learning experience since nothing in life, especially in scientific research, will always work out perfectly. By analyzing the results and looking back at our experimental protocol, we can pinpoint where the experiment needs troubleshooting for future studies. Through this process, we may even uncover other findings that may not have been discovered if the experiment had worked as planned. As I reach the end of this course, I have developed a new mindset that is confident to ask questions and understand how to respond to unexpected experimental results." [A5]

Note: Prompts and responses are from introductory [I], intermediate [M], or advanced [A] CUREs as indicated.

Data Collection and Analysis

For this study, the role of failure in promoting student learning was evaluated using the frequency of collaboration and the presence of iteration with the LCAS instrument (Corwin et al. 2015). The LCAS was administered through Canvas at the end of the semester; completion of this survey counted toward the engagement/participation portion of the course grade. The total number of undergraduate students taking the CUREs were 31 students at the introductory level, 319 students at the intermediate level, and 146 students at the advanced level. All students were invited to participate in the study; thirty students completed the LCAS at the introductory level, and 306 and 139 students completed the LCAS at the intermediate and advanced levels, respectively (96 percent response rate). LCAS results are presented as percentage of students choosing each option. For qualitative evaluation of student reflections, more than 1,300 reflections were reviewed by course instructors to create a data set of 141 reflections relevant to collaboration, iteration, and failure. For selecting quotes from reflections, the authors used deductive coding with the following set of codes: mindset, goal orientation, fear of failure, attribution, and coping. three raters independently coded the data set; only quotes unanimously assigned the same codes were included in Table 2.

Data collected from the fall 2018, spring 2019, fall 2019, and spring 2021 semesters were evaluated and analyzed. Data from spring 2020 were not included as the COVID-19 pandemic forced us to shift all courses from in-person to online at mid-semester so students were not able to work in the lab. Data from fall 2020 were not included because (a) 25 percent of students in the intermediate CURE were remote and thus did not participate in labwork; and (b) since the introductory CURE was transformed to fulfill a university requirement for a first-year writing intensive seminar, students did not work on a research project during this semester.

Results and Discussion

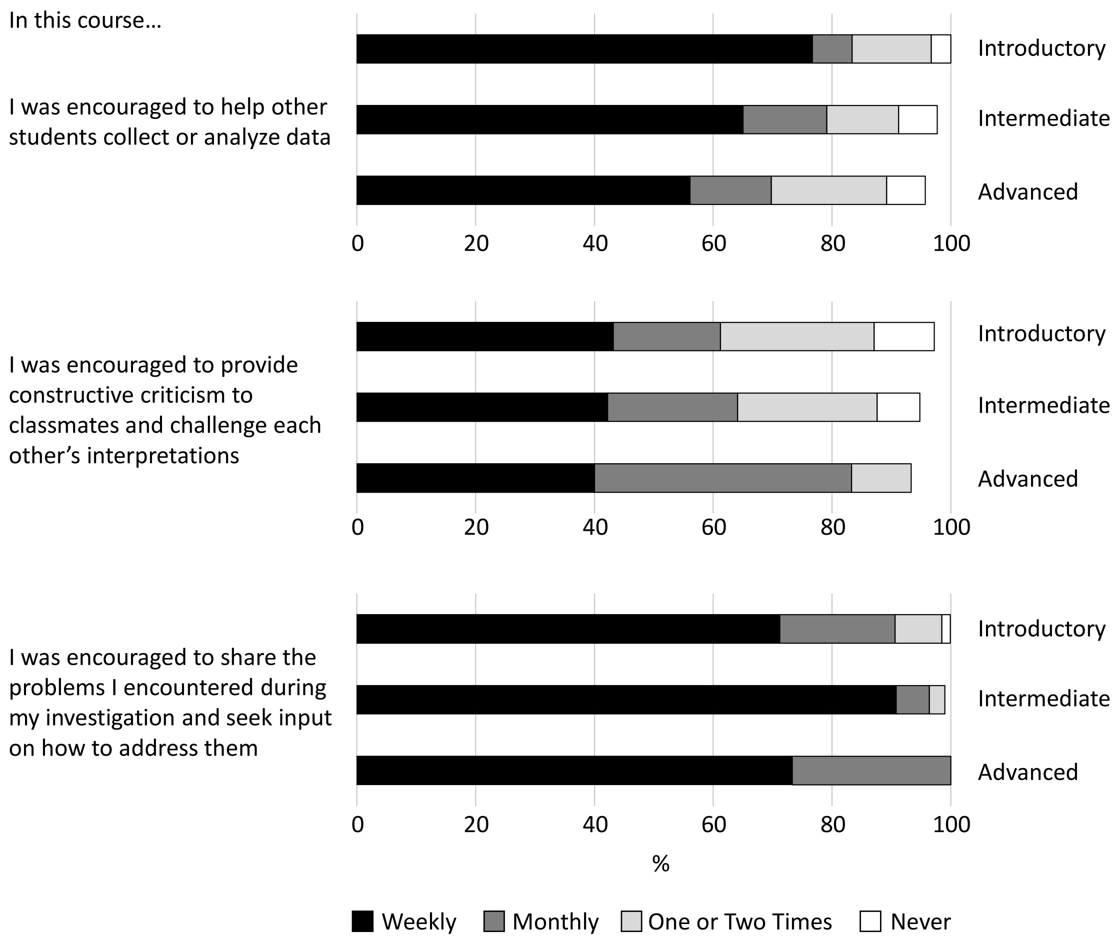
Students Experience Failure in Different Ways

The authors describe and report evidence that this CURE program can provide students space and time to identify errors and troubleshoot, make corrections and adjust the research, and report on these errors and research failures. Experiencing the reality of failure in the laboratory allows students to grow and gain the skills and resilience desired of independent researchers. The open-ended nature of the projects at all levels of these CUREs allows for differentiated experiences, as students may experience failure at different times and have different ways of coping with those failures. The authors have been intentional in how they scaffold failure in the lab courses. As described, the course structure at the introductory level has an intentional focus on the guided design of training the naïve researcher for laboratory work. At the intermediate level, students gain more independence to focus on the feasibility of their chosen procedures within the scientific process and are provided opportunities to modify and repeat their experiments. At the advanced level, students are able to execute a more extensive experimental plan and troubleshoot failure to place their work in a professional context as they operate much like independent researchers.

Students perceived opportunities to collaborate and iterate in the CUREs, and their perceptions varied slightly depending on the CURE level. Data are reported from the validated LCAS (Corwin et al. 2015) that was used to measure student perceptions of their experiences in the CUREs to evaluate the role of failure in promoting student learning. The focus was on three collaboration items (see Figure 2) and all six iteration items (see Figure 3). Although there were differences in student responses on some of these questions, many of these could have been related to the specific course structures of each CURE. These data provide evidence that the majority of students (in many instances, the great majority) believed they were given opportunities to identify, respond to, and report on errors in their laboratory course experiments in a time-appropriate manner.

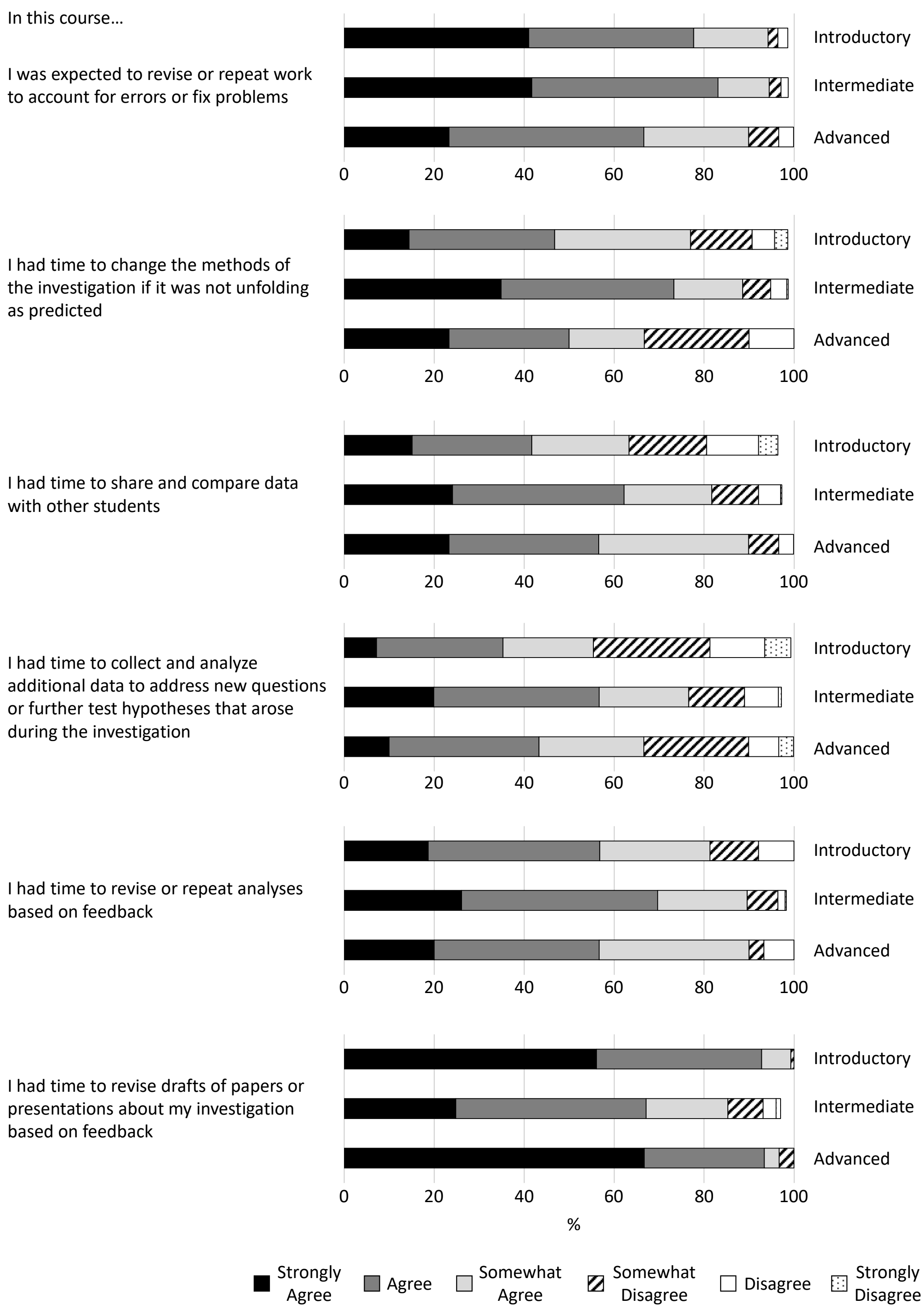
Differences were observed in student responses for the collaboration questions of LCAS (see Figure 2), which showed that students perceived they were identifying errors during team meetings and in group work. For example, the intermediate CURE is intentionally structured for students to meet as a team with an instructor on a weekly basis to identify and report on errors that may have occurred since the last team meeting. Thus, students in this CURE report more frequently sharing problems with their team (see Figure 2, Question 3). On the other hand, each class period in the introductory and advanced CUREs provides the same opportunity but in a less structured and scheduled manner (i.e., as the need arises/just in time). Figure 2 data also show that even though students work in teams in all of the CUREs, they perceived that they were gaining more independence as they progressed from the introductory to the advanced level. For example, in the introductory CURE, students collect data in teams and analyze their data as a class. In the intermediate and advanced CUREs, as students play a larger role in framing the research question, students individually are more independent in data collection and teams are working separately on analysis of their own data. A corresponding decrease was seen in perceived collaboration in collecting and analyzing data (see Figure 2, Question 1).

FIGURE 2. LCAS collaboration



Laboratory Course Assessment Survey (LCAS) results demonstrate frequent student engagement and collaboration at all levels of the course-based undergraduate research experiences (CUREs). Each question "asks students to evaluate the frequency with which they engaged in activities related to collaboration" (Corwin et al. 2015). Data collected from the fall 2018, spring 2019, fall 2019, and spring 2021 semesters. N = 30 (introductory), 306 (intermediate), and 139 (advanced). Data that do not add up to 100 percent include non-answers, "I don't know," and "I prefer not to respond," which are not individually shown.

FIGURE 3. LCAS iteration



Laboratory Course Assessment Survey (LCAS) results demonstrate most students perceive the intentional iterative aspects of the course-based undergraduate research experiences (CUREs). Questions "ask students to rate their agreement with statements about whether they had time or direction to repeat aspects of their work . . ." (Corwin et al. 2015). Data collected from the fall 2018, spring 2019, fall 2019, and spring 2021 semesters. N = 30 (introductory), 306 (intermediate), and 139 (advanced). Data that do not add up to 100 percent include non-answers, "I don't know," and "I prefer not to respond," which are not individually shown.

An important aspect of any CURE is having the opportunity to repeat an experiment—that is, iteration (Wiggins et al. 2021). *Iteration* is defined as the ability to respond to failure, as learning what does not work may help in finding what does. Differences were observed in Figure 3 data, which are questions related to student perceptions of responding to errors and reporting on them. Some of these data were consistent and marked high across all three CUREs, but they also demonstrated likely differences in the flexible schedule that students are afforded to adjust their research to achieve project goals; students are given more guidance at the introductory and intermediate levels, as they develop an "experimental plan" at the advanced level. There are instances where an aspect of iteration is emphasized in one course but not the others. For example, the student perception of additional data (see Figure 3, Question 4) and the time to change methods (Figure 3, Question 2) that were higher in the intermediate CURE is a tradeoff for the perception of more time to revise drafts and get feedback (Figure 3, Question 6) that was observed and provided in the introductory and advanced CUREs. The advanced CURE also showed a higher perception for time to share and compare data, which may be due to students gaining confidence in analyzing their data and feeling more independent in that analysis as they progressed through the program (Figure 3, Question 3). This shows that students have the opportunity to respond to different types of failure at different times in their progression through these CUREs.

Students Embrace Failure

Due to students perceived opportunities to collaborate and iterate, they not only experienced but also embraced failure. Because CUREs provide students more opportunities to explore open-ended questions, they also open up opportunities to embrace failure. It was anticipated that students in the CUREs would encounter failures such as human/user errors and equipment failures (also commonly experienced in traditional labs) as well as systematic errors, unexpected results, and conflicting results. Although the initial goal was for students to have exposure to failure as a natural part of scientific work, students actually embraced failure as contributing to their learning and development as scientists. In reflecting on factors that impact student responses in failure scenarios (Henry et al. 2019), the authors highlight the pedagogy and instructor techniques that they believe created the environment that prompted students to embrace failure.

Mindset

Rather than attempting to "get the right answer" as in a traditional teaching laboratory setting, the students have opportunities to "pursue the answer" and learn that it is okay to not have the "right" answer. Helping students frame a mindset for pursuit of an answer is at the foundation of these CUREs. Within the first two class meetings, instructors explicitly acknowledge that the research questions do not have predetermined answers. Because even instructors don't know what the outcomes will be, students are more comfortable with not knowing the answer and are motivated to try more challenging approaches to investigate their research question/problem. Students' reflections on the CUREs showed how mindset influenced responses to failures because they found ways of "turning problems into testable questions" (see Table 2, Quote I3) and recognized that "science isn't simply a quest for success but rather a journey of growth" (see Table 2, Quote M4).

Goal Orientation

Each of the research projects in these CUREs has an external audience invested in the outcomes. However, research outcomes are not linked to course scores. Not only does this structure allow them to orient their goals toward mastery of the experimental techniques rather than the outcome (see Table 2, Quotes M4, I5, M6, A4), it also means that they share motivations with their peers and can collaborate around their investment and ownership in the research. Student reflections included comments about ownership of the experimental questions, failure, and outcomes (see Table 2, Quotes A2, A3) and research plans that included an expectation of failure/mistakes (Table 2, Quotes M2, A1). The realization that failure is a valuable part of science demonstrates an orientation toward inquiry and exploration rather than support for a specific hypothesis. The CURE structure employs two techniques to enable this. First, instructors must be open about and follow through on the promise that experimental outcomes will not impact grades. Student mindset and trust in their instructor are important for students to engage in this process (Cavanagh et al. 2018; Wang et al. 2021). Second, the CURE promotes student interactions and reliance as part of teams. Because research outcomes are not tied to grades, students are not punished for team-member mistakes so interactions with team members can focus on project management and mastery as opposed to score and performance-related outcomes, as demonstrated in Table 2, Quote I1. All of these CUREs initially establish team identity by requesting team names. Team meetings, group contracts, and resources on successful teams (Rock and Grant 2016; Rock, Grant, and Grey 2016; gcccmu 2020; Brunt 1993; Tuckman and Jensen 1977) are used in various CUREs.

Fear of Failure

Dissociating experimental outcomes from course scores also worked to reduce fear of failure. This study's findings and observations agree with a study by Goodwin et al. (2021) that looked at student perception of authenticity of a research experience in a CURE; although all the students experienced failure during the course, they were not graded on the success of their experiments and rarely seemed discouraged. Additionally, structures were put in place to normalize the reporting and discussing of mistakes or "failure" outcomes. Student reflections often used the word failure in conjunction with fear synonyms (see Table 2, quotes I2, M3, M4, A3); however, the association between fear and failure was almost always situated in the past. They described how experiencing these CUREs had allowed them to move beyond the fear. The techniques instructors employed to normalize discussion of failures included weekly conversations during team meetings or class discussions with the instructors. Talking about failure throughout the course can help students become more comfortable with failure and accept it as part of scientific discovery. Creating a laboratory environment where failure is seen as a valuable opportunity for learning is essential for students to overcome their fear of failure (Eyler 2018, pp. 208-210; Steuer and Dresel 2015). Anecdotally, the students shared that they could better accept failure in the lab since there was not an expected or known experimental outcome. Unlike a completed research study, students' main findings may still need additional data support or troubleshooting. Restructuring the written assignments as a scientific poster and/or progress report gave students assignment structures that allowed for reporting of failed approaches or incomplete conclusions.

Attribution

Student quotes showed an understanding that mistakes happen and "even well-established protocols can sometimes fall short" (see Table 2, Quote A1), but they also recognized the value of failure in opening up new questions for the research project and in their own learning (see Table 2, Quote A4, M1). In each of these examples, students do not attribute failure to excessive difficulty of tasks or their own abilities; instead, they attribute failure to factors that they can modify or improve by asking different questions or adjusting their approach. Not only is discussion of failure normalized in formal course reports, but the teaching assistants selected for the courses are undergraduates who share their own failures and responses with students. Instructors use a technique of focusing on the value of record keeping to identify and troubleshoot errors to create an environment where learning from mistakes is valued, as demonstrated in student reflections (see Table 2, Quote M5).

Coping

Some students in the introductory and intermediate CUREs indicated that the idea of "hitting roadblocks" during laboratory work was a novel experience (see Table 2, Quote I4, M6). This aligned with the expectation that students may not have experience coping with failures in experimental work. Seeing failure as an opportunity for exploration allowed students to reframe failure as a positive experience: "If something worked, we would not have asked questions…" (see Table 2, Quote A4). Students also referenced coping with failure as helping them to develop "resilience" (see Table 2, Quote I5), to see failure as a natural part of science (see Table 2, Quotes M6, A2), and to see failure as beneficial to scientific exploration (see Table 2, Quote A5). The most important aspect of the pedagogy that allowed students to embrace coping with failure was purposeful selection of research projects; these were either selected directly by instructors before the CURE began or students selected projects with instructor mentoring. The scope of the project must include a reasonable goal given the timeframe of the course but also allow time for troubleshooting to be built into the schedule. Building this troubleshooting into the CUREs was accomplished through more structured techniques in the introductory and intermediate CUREs, occurring in class discussions and team meetings moderated by the instructors, and on an ad hoc basis in the advanced CURE.

Students Gain Confidence and Build Resilience

It has been shown that the CURE participants gain confidence as they experience failure and subsequently build resilience to improve their research skills and become more independent. When students performed experiments that yielded either no results, unexpected findings, or findings that differed from previous experiments, they worked as a team to understand the experimental outcome and formulate a path forward, *turning a potentially negative experience into a positive one through exposure to an authentic research process.* Eyler (2018, 215) describes this experience as "failing better . . . a kind of cycle where we continually fail and then learn from that failure in order to refine our understanding." Even though students may fail at achieving their research goals, they can still successfully achieve course learning goals. Gin and colleagues (2018) reported that when students face research challenges in CUREs, they experience increased opportunities for iteration, collaboration, and autonomy, all of which contribute to the development of research self-efficacy. The CUREs provide "safe" and nurturing environments where a student can accomplish the following failure-related learning outcomes:

- Respond to questions that require troubleshooting of experimental methods or data collection.
- Use laboratory notes and observations to evaluate the success of experiments and identify potential errors when outcomes are unanticipated.
- Make corrections or alterations after missteps in experimental procedures, adjusting their schedule or research plan appropriately.
- Observe how other students report errors in papers, posters, or presentations.

The findings discussed here support a study by Corwin and colleagues showing that collaboration and iteration positively impacted the students' sense of ownership (Corwin et al. 2018). Student teams collaborate in brainstorming, problem-solving, troubleshooting, analyzing and interpreting data, and communicating their findings. The undergraduates seem to enjoy how the labs have been modified to focus on participation in science rather than simply learning techniques to achieve a known outcome. Positive impacts were observed on student engagement and teamwork. Students appreciate CUREs in which they tackle open-ended research questions and experience failure; they especially value the responsibility of designing and executing their own experiments and analyzing the results, since often in their independent research labs, they are generally following a graduate student or postdoctoral scholar and doing what they are told to do to advance a project. In the CUREs, the students have autonomy to drive the scientific process and make the daily decisions on what to do next. Their engagement in the lab has increased, and they use the language of inquiry in their reflections, using words such as "framing," "evaluation," "dissemination," or "synthesis" as they describe their experiences (see OURI n.d.).

Conclusion

In summary, student reflection data and LCAS results show that students taking CUREs *develop mindsets and attitudes that prepare them to confront and cope with research failures* as they progress through the laboratory program. Students from diverse backgrounds bring their unique experiences to an inclusive research community that improves the research skills of all its members (Bangera and Brownell 2014). When students prove to themselves that they can overcome their challenges in the lab, their confidence grows, and they are empowered to learn; these experiences promote independent thinking and help students think and act like scientists (Thiry et al. 2011). Students taking CUREs perceive higher levels of collaboration, relevant discovery, and iteration when compared to students taking an inquiry-based lab, and interestingly, failure was the most common explanation provided by students for why the CURE "felt like real research" (Goodwin et al. 2021). By supporting students as they encounter failure and guiding them as they respond to failure, mentors are equipping them for success in research. The research projects in the CUREs allow students at all stages of their scientific development to explore biological challenges, design experiments, generate data, communicate their findings, and contribute to a diverse team. Giving them these opportunities to take ownership of a project will likely generate greater interest in research, lead to greater persistence in STEM programs, and open a doorway for them to pursue independent research as they apply to summer programs, internships, and postgraduation programs (Graham et al. 2013; Bangera and Brownell 2014; Rodenbusch et al. 2016),

The following reflection from a student in an advanced CURE inspired us to evaluate the value of failure in helping students succeed in undergraduate research:

> I truly believe that the main contribution that my involvement with Rice Biosciences lab courses has had on my development has been towards my mentality, confidence, and attitude towards work as an independent scientist. Of the goals explicitly outlined in the syllabus, Goal 4: Experience that not all scientific experiments work as planned and formulate a path forward, was the one that I felt my experience most closely aligned with. My time in Rice Biosciences labs, overall, has been characterized as a general trend toward the acceptance of mistakes and setbacks as a natural part of scientific investigation. I think this final semester is the semester where this realization was truly internalized. I no longer view mistakes as setbacks, but rather as one fewer mistake between myself and the desired outcome. With regards to takeaways to my work in off-campus research … the primary takeaway will be my mentality as an independent researcher. I feel completely confident in my ability to conduct experiments and learn new techniques on my own. Most important, however, I know now that I am capable of troubleshooting and working past mistakes and setbacks. The realization is an interesting one because, at the onset of my time as a researcher, I had always anticipated the day would come where I would become a better scientist and no longer fail experiments. . . . . I don't think that the answer to instances of setbacks and failures is to "hide" them, but I think there's something to be said about evaluating them as something that carries a less strong connotation. If we look at mistakes as alternative results, for example, it is much easier to view them as inevitable checkpoints that must be encountered on the way to the desired result. All this to say that my time in the Rice Biosciences labs has prompted a lot of introspection on my part over what work as an independent scientist truly entails. I can say that I've come through with much healthier expectations for what a career as an independent scientist has in store for me and confidence that it is a career that I am capable of doing meaningful work in.

Acknowledgments

The development and continued enhancements of the CUREs were supported by institutional grants from the Rice Office of Undergraduate Research and Inquiry, curricular funds from the Biosciences Department, and the Council on Undergraduate Research's Transformations Project through the National Science Foundation's Division of Undergraduate Education (NSF-DUE Award #1625354). The authors would like to thank all of the participating undergraduate students who contributed their ideas and feedback through reflections and LCAS answers. They also thank the faculty and graduate students in the Biosciences Department that provided ideas and materials for the open-ended research projects. Beth Beason-Abmayr created and teaches the introductory and advanced CUREs, and Daniel J. Catanese Jr. teaches the intermediate CURE that was created and initially taught by Elizabeth Eich.

References

Auchincloss, Lisa Corwin, Sandra L. Laursen, Janet L. Branchaw, Kevin Eagan, Mark Graham, David I. Hanauer, Gwendolyn Lawrie, et al. 2014. "Assessment of Course-Based Undergraduate Research Experiences: A Meeting Report." *CBE–Life Sciences Education* 13: 29–40. doi: 10.1187/cbe.14-01-0004

Bangera, Gita, and Sara E. Brownell. 2014. "Course-Based Undergraduate Research Experiences Can Make Scientific Research More Inclusive." *CBE–Life Sciences Education* 13: 602–606. doi: 10.1187/cbe.14-06-0099

Bieser, Kayla, Danielle Hamill, Melanie Hwalek, Julieta Merke, Kenneth Saville, Jamie Siders, Joyce Stamm, et al. 2020. "Fly-CURE: A Consortium of Undergraduate Genetics Laboratory Courses Mapping and Characterizing Drosophila EMS Mutants." TAGC 2020. Poster. doi: 10.6084/m9.figshare.12133542.v1

Bjork, Elizabeth Ligon, and Robert A. Bjork. 2011. "Making Things Hard on Yourself, but in a Good Way: Creating Desirable Difficulties to Enhance Learning." In *Psychology and the Real World: Essays Illustrating Fundamental Contributions to Society,* 56–64. New York: Worth Publishers.

Brewer, Carol A., and Diane Smith, eds. 2011. *Vision and Change in Undergraduate Biology Education: A Call to Action: Final Report of a National Conference.* Washington, DC: American Association for the Advancement of Science.

Brown, Peter C., Henry L. Roediger III, and Mark A. McDaniel. 2014. *Make It Stick: The Science of Successful Learning.* Cambridge, MA: The Belknap Press of Harvard University Press.

Brunt, J. 1993. "Facilitation Skills for Quality Improvement." Madison, WI: Quality Enhancement Strategies.

Burmeister, Alita R., Katie Dickinson, and Mark J. Graham. 2021. "Bridging Trade-Offs between Traditional and Course-Based Undergraduate Research Experiences by Building Student Communication Skills, Identity, and Interest." *Journal of Microbiology & Biology Education* 22: e00156-21. doi: 10.1128/jmbe.00156-21

Cavanagh, Andrew J., Oriana R. Aragón, Xinnian Chen, Brian A. Couch, Mary F. Durham, Aiyana Bobrownicki, David I. Hanauer, and Mark J. Graham. 2016. "Student Buy-In to Active Learning in a College Science Course." *CBE–Life Sciences Education* 15: ar76. doi: 10.1187/cbe.16-07-0212

Cavanagh, Andrew J., Xinnian Chen, Meghan Bathgate, Jennifer Frederick, David I. Hanauer, and Mark J. Graham. 2018. "Trust, Growth Mindset, and Student Commitment to Active Learning in a College Science Course." *CBE–Life Sciences Education* 17: ar10. doi: 10.1187/cbe.17-06-0107

Corwin, Lisa A., Christopher R. Runyon, Eman Ghanem, Moriah Sandy, Greg Clark, Gregory C. Palmer, Stuart Reichler, Stacia E. Rodenbusch, and Erin L. Dolan. 2018. "Effects of Discovery, Iteration, and Collaboration in Laboratory Courses on Undergraduates' Research Career Intentions Fully Mediated by Student Ownership." *CBE–Life Sciences Education* 17: ar20. doi: 10.1187/cbe.17-07-0141

Corwin, Lisa A., Christopher Runyon, Aspen Robinson, and Erin L. Dolan. 2015. "The Laboratory Course Assessment Survey: A Tool to Measure Three Dimensions of Research-Course Design." *CBE–Life Sciences Education* 14: ar37. doi: 10.1187/cbe.15-03-0073

Corwin, Lisa A., Mark J. Graham, and Erin L. Dolan. 2015. "Modeling Course-Based Undergraduate Research Experiences: An Agenda for Future Research and Evaluation." *CBE–Life Sciences Education* 14: es1. doi: 10.1187/cbe.14-10-0167

Dolan, Erin L. 2016. "Course-Based Undergraduate Research Experiences: Current Knowledge and Future Directions." Commissioned Paper. Washington, DC: National Academies of Sciences, Engineering, and Medicine. https://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_177288.pdf

Ericsson, K Anders, Ralf Th Krampe, and Clemens Tesch-Romer. 1993. "The Role of Deliberate Practice in the Acquisition of Expert Performance." *Psychological Review* 100: 363–406.

Eyler, Joshua. 2018. *How Humans Learn: The Science and Stories Behind Effective College Teaching. Teaching and Learning in Higher Education.* Morgantown: West Virginia University Press.

Freeman, Scott, Sarah L. Eddy, Miles McDonough, Michelle K. Smith, Nnadozie Okoroafor, Hannah Jordt, and Mary Pat Wenderoth. 2014. "Active Learning Increases Student Performance in Science, Engineering, and Mathematics." *Proceedings of the National Academy of Sciences* 111: 8410–8415. doi: 10.1073/pnas.1319030111

gcccmu. 2020. "Overcoming Unconscious Bias on Your Team." Accessed October 15, 2021. https://www.youtube.com/watch?v=y5ShTBRw8xY

Gin, Logan E., Ashley A. Rowland, Blaire Steinwand, John Bruno, and Lisa A. Corwin. 2018. "Students Who Fail to Achieve Predefined Research Goals May Still Experience Many Positive Outcomes as a Result of CURE Participation." *CBE–Life Sciences Education* 17: ar57. doi: 10.1187/cbe.18-03-0036

Goodwin, Emma C., Vladimir Anokhin, MacKenzie J. Gray, Daniel E. Zajic, Jason E. Podrabsky, and Erin E. Shortlidge. 2021. "Is This Science? Students' Experiences of Failure Make a Research-Based Course Feel Authentic." *CBE–Life Sciences Education* 20: ar10. doi: 10.1187/cbe.20-07-0149

Graham, Mark J., Jennifer Frederick, Angela Byars-Winston, Anne-Barrie Hunter, and Jo Handelsman. 2013. "Increasing Persistence of College Students in STEM." *Science* 341: 1455–56. doi: 10.1126/science.1240487

Henry, Meredith A., Shayla Shorter, Louise Charkoudian, Jennifer M. Heemstra, and Lisa A. Corwin. 2019. "*FAIL* Is Not a Four-Letter Word: A Theoretical Framework for Exploring Undergraduate Students' Approaches to Academic Challenge and Responses to Failure in STEM Learning Environments." *CBE–Life Sciences Education* 18: ar11. doi: 10.1187/cbe.18-06-0108

Jordan, Tuajuanda C., Sandra H. Burnett, Susan Carson, Steven M. Caruso, Kari Clase, Randall J. DeJong, John J. Dennehy, et al. 2014. "A Broadly Implementable Research Course in Phage Discovery and Genomics for First-Year Undergraduate Students." *MBio* 5: e01051-13. doi: 10.1128/mBio.01051-13

Martin, Allison, Adam Rechs, Thomas Landerholm, and Kelly McDonald. 2021. "Course-Based Undergraduate Research Experiences Spanning Two Semesters of Biology Impact Student Self-Efficacy but Not Future Goals." *Journal of College Science Teaching* 50: 33–47.

National Academies of Sciences, Engineering, and Medicine. 2015. *Integrating Discovery-Based Research into the Undergraduate Curriculum: Report of a Convocation.* Washington, DC: National Academies Press. doi.org/10.17226/21851

Office of Undergraduate Research and Inquiry (OURI), Rice University. n.d. "Student Learning Outcomes." https://ouri.rice.edu/student-learning-outcomes-0

Rodenbusch, Stacia E., Paul R. Hernandez, Sarah L. Simmons, and Erin L. Dolan. 2016. "Early Engagement in Course-Based Research Increases Graduation Rates and Completion of Science, Engineering, and Mathematics Degrees." *CBE–Life Sciences Education* 15: ar20. doi: 10.1187/cbe.16-03-0117

Rock, David, and Heidi Grant. 2016, Nov. 4. "Why Diverse Teams Are Smarter." *Harvard Business Review.* Accessed October 15, 2021. https://hbr.org/2016/11/why-diverse-teams-are-smarter

Rock, David, Heidi Grant, and Jacqui Grey. 2016, Sept. 22. "Diverse Teams Feel Less Comfortable — and That's Why They Perform Better." *Harvard Business Review.* Accessed October 15, 2021. https://hbr.org/2016/09/diverse-teams-feel-less-comfortable-and-thats-why-they-perform-better

Scager, Karin, Johannes Boonstra, Ton Peeters, Jonne Vulperhorst, and Fred Wiegant. 2016. "Collaborative Learning in Higher Education: Evoking Positive Interdependence." *CBE–Life Sciences Education* 15: ar69. doi: 10.1187/cbe.16-07-0219

Steuer, Gabrielle, and Markus Dresel. 2015. "A Constructive Error Climate as an Element of Effective Learning Environments." *Psychological Test and Assessment Modeling* 57: 262–275.

Tanner, Kimberly D. 2012. "Promoting Student Metacognition." *CBE–Life Sciences Education* 11: 113–120. doi: 10.1187/cbe.12-03-0033

Thiry, Heather, Sandra L. Laursen, Anne-Barrie Hunter. 2011. "What Experiences Help Students Become Scientists? A Comparative Study of Research and Other Sources of Personal and Professional Gains for STEM Undergraduates." *Journal of Higher Education* 82: 357–388. doi: 10.1080/00221546.2011.11777209

Tuckman, Bruce W., and Mary Ann C. Jensen. 1977. "Stages of Small-Group Development Revisited." *Group & Organization Studies* 2: 419–427. doi: 10.1177/105960117700200404

Wang, Cong, Andrew J. Cavanagh, Melanie Bauer, Philip M. Reeves, Julia C. Gill, Xinnian Chen, David I. Hanauer, and Mark J. Graham. 2021. "A Framework of College Student Buy-in to Evidence-Based Teaching Practices in STEM: The Roles of Trust and Growth Mindset." *CBE–Life Sciences Education* 20: ar54. doi: 10.1187/cbe.20-08-0185

Wiggins, Benjamin L., Haley Sefi-Cyr, Leah S. Lily, and Caroline L. Dahlberg. 2021. "Repetition Is Important to Students and Their Understanding during Laboratory Courses That Include Research." *Journal of Microbiology & Biology Education* 22: e00158-21. doi: 10.1128/jmbe.00158-21

APPENDIX 1. Lab citizenship

"Lab citizenship" measures your contribution to lab maintenance, responsibility, help, and consideration of others in equipment use.

Respect others' time and space.

- Submit reflections and weekly progress surveys on time.
- Be on time for weekly meetings with your instructor and be prepared to discuss your project and progress as a group at those meetings. Being prepared and on-time helps keep the meeting schedule for all teams.
- Let instructors or teammates know well in advance if you need to cancel or postpone a lab session or appointment.
- Place your backpacks in the cubbies by the front door or under bench kneeholes or tables. Many students are using equipment throughout the lab. Backpacks in the walkways or in the aisle are a tripping hazard.

Respect that others are using the same supplies and equipment that you are.

- Return items to their correct storage. If someone hands you a chemical, ask where it should be returned so you can store it properly and promptly.
- Leave the lab ready for the next person to use.
    - Clean the bench when you are finished—throw away disposables, such as weigh paper, and clean the equipment, like the balance or centrifuge.
    - Turn off equipment that you turned on or someone turned on for you, such as spectrophotometers, centrifuges, microscopes, etc.
    - Decontaminate (if necessary) and rinse out glassware before placing in the dish bin.

- Use equipment safely and considerately. Ask questions when you are training to use equipment so that you can use it independently in the future. Avoid cutting corners that jeopardize safety or proper outcomes.
- Autoclave in groups to maximize efficiency for all groups. Always use an autoclavable bin —a flask that breaks without an appropriate bin means the autoclave will shut down for cleaning and repair. The TAs will control the autoclave schedule for each day.

- When equipment is already in use, ask instructors for help rather than harming another student's experiment by stopping or overloading equipment.
- When using part of a set of supplies, leave the remainder in a condition that can be used by others. Close pipette tip boxes when not in use. Tape and date partial sleeves of unused petri dishes.

Be responsible for the safety of yourself and others.

- Wear face masks while in the lab. Wear safety glasses and gloves when handling chemical hazards or biohazards. Be conscientious of gloves with the Bunsen burner. Keep in mind that others may be working with hazards even when you are not—always wear long pants and closed-toe shoes in the lab.

- Keep food, drinks, gum, and makeup out of the lab.
- Dispose of waste appropriately. This includes emptying tip waste and sorting the biohazard trash, glass waste, and regular trash correctly.
- If you observe accidents or unsafe behavior, report these to an instructor or TA who can correct the situation following safety protocols.
- Help your peers troubleshoot and understand concepts when allowed.
- Remember that this is a safe place to fail—Do not be afraid to ask questions!

APPENDIX 2. Group Contract Assignment

Introduction

This class is structured on group work and team assignments. In order to help establish strong group work, the expectations of the assigned groups will be defined by a contract generated by each team. You will need to use the resources provided in class and your previous experiences with group work to cover important issues and predict possible conflicts that may arise. Creating a detailed class contract will allow you to begin working in your groups quickly and efficiently and prevent any issues that can accompany group work from occurring. If any issues do arise, such as a team member not completing her/his assigned work or not attending meetings, the contract can be used to outline consequences for members who are negatively influencing the group dynamics and environment.

Objective

As a group, create a contract that will be used by your team to ensure each group member will have strong teamwork and productive meetings and to serve as a reference in case of conflict management. Sections can be divided amongst group members, but the whole group must agree to the final product.

Important topics that need to be considered include:

- How will the group communicate? What communication issues could arise and how will your group take measures against them?
- How are responsibilities divided amongst the group? How will group contributions be quantified?
- What tasks must be accomplished before every class? When must these tasks be completed so the rest of the group has access to your work (timelines, for example)?
- What will be the consequences if a person does not complete their tasks, or does not do their task to the standards set by the group? What will be the penalty and how will it be assessed?
- How will the group prepare for the exams and large group projects?
- When the group has meetings, how can those meetings be conducted (online, in person, etc.)? How will those meetings be formatted? How will the group make sure that meetings stay on topic and achieve their goals?
- And any other topics your group would like to have established in writing.

As a team, you will prepare your contract as a doc/docx file and upload your document in Canvas; "sign" the cover page next to your name—you can use an electronic signature or just type your name with the date/time. The cover page should include:

- Course name, number, and semester (e.g., Fall 2020)
- Group Contract for "team name"
- Team members' names with a line for a signature next to each name

Assignment will be evaluated for effort and participation points. The instructor will give you feedback about your group contracts.

APPENDIX 3. Lab Citizenship: Self-Evaluation

An important part of your development as a scientist and a team player is being able to evaluate not only your strengths but also those areas where you need to improve. In this assignment, please review our guidelines in Laboratory Citizenship. ***Write an essay (minimum of 500 words)*** in which you

- reflect upon your work throughout the semester, describing specific examples of your growth
    - ***Contribution:*** Did you contribute useful ideas to help your group move forward? Did you work effectively by doing your share of the work?
    - ***Group dynamics:*** Did you work effectively to ensure the success of the group by stepping up when needed or sitting back and allowing another member to take a turn? Did you also listen to and respect the ideas of your fellow group members?
    - ***Attitude:*** Did you have an overall positive attitude and work with other group members to resolve conflicts and problem solve when necessary?
    - ***Attendance:*** Did you attend group meetings? If you couldn't attend, did you work on your own to make up for the absence?
- suggest a grade for Lab Citizenship (just a letter grade, not a number) and explain why you think you earned that grade

I will take your self-evaluation into account when assigning grades for Laboratory Citizenship.

APPENDIX 4. Weekly or biweekly progress surveys

Early in semester (week 3)

1. As you prepare to start your project, what previous research have you looked at?
2. What do you think is the first step to start your project? What reagents do you need?

Middle of semester (weeks 4–12)

1. What did you specifically do this week toward your project?
2. What do you specifically plan to do next week?
3. Provide the citation for a research paper that you have recently looked up. In 2-3 sentences, why is this paper important and/or interesting for your project?
4. [asked in Weeks 6 and 10] Are you making progress in your project? If not, what is hindering your progress?
5. [asked in Weeks 7 and 11] What are your main conclusions at this point in your project?

Late in semester (weeks 13–14)

1. What did you specifically do this week toward your project?
2. With [one or two] week(s) to go in the semester, what do you specifically plan to do to finish your project? What is left, if anything?
3. What are your main conclusions for your project?

APPENDIX 5. Experimental plan and timeline

Complete this assignment as a team.

All team members need to contribute, and all receive the same score. *As a team, create a Google doc in Canvas on your Group Home Page—make sure you share this document with Dr. Beason and the TAs. For this assignment, download your Google doc as a Word doc and submit as a doc/docx file in Canvas by the specified due date/time.*

Purpose

This assignment will help you organize your thoughts about your project and help you to plan and outline your work in the lab. With review by your lab instructor, the experimental plan and timeline will also help ensure that your project is well planned and manageable.

Format

There is no page limit for this assignment. Include a page with citations for references to support your plan at the end of the document.

Content

It is helpful to organize the content around two main points: experimental plan and timeline.
Note: please use these headings to organize your document.

1. **Experimental Plan:** Include a reasonably detailed overview for the purification and characterization of the protein for your project.
    - Although you do not need to give a detailed protocol with "exact steps" (i.e., volumes, times, etc.), you should specify buffers and specialized materials/reagents that you will need.
    - Include a list of reagents/equipment/supplies you need.
    - Cite references for established procedures as well as for the purification protocols you are adapting for your study.
    - Specify exact names of any commercial products.
2. **Timeline:** Outline a preliminary schedule for when you will perform a given experiment. Other considerations as you are planning include:
    - How many times you will need to repeat the experiment
    - Extra time needed if you run into problems / have to troubleshoot
    - Access to the lab

APPENDIX 6. Lab notebook rubric

Team name ______________________________

1. Entries are recorded in pen, and the notebook never leaves the research area.
2. Table of Contents is updated weekly with detailed entries.
   - Lists pages where procedures start and stop
   - Lists pages where protocols/methods are described
   - Lists pages that contain important data
   - Lists pages where you summarize sections of work or make conclusions
3. Page labels identify page number and date for every page of an entry.
   - Each page is numbered (front-only)
   - Date is recorded at the beginning of each page and entry
   - Date is recorded on every page of multi-page entries
   - Correct date format where month is abbreviated or spelled out
4. Introductions, Summaries, and Conclusions.
   - Indicated by headings to help locate them.
   - Separate projects into major steps.
   - Used throughout notebook to help track progress toward project goal.
   - Summaries are given for daily activities that do not require conclusions.
5. Experimental procedure and details
   - Person(s) performing the work identified.
   - Experiments are recorded in past tense and in the order completed. **It is a real-time record!**
   - Steps of the procedure are outlined, drawn, flow-charted, and/or referenced with a previous page of the notebook.
   - Type, brand, serial #, or location of specialized equipment (pipettors, balances, centrifuges, incubators, autoclave, etc.) is provided within the procedure.
   - Gel loading order, plate layouts, etc. are noted.
   - Contents of solutions (concentration, pH) are provided or solutions are identified using a published name with specified formulation.
   - Temperature / time / speed of incubations/centrifugation are recorded.
   - Commercial sources and lot numbers of biological materials / reagents / specialized supplies / kits / software versions are recorded.
6. Data and observations reported.
   - Qualitative observations (color, cloudiness, compactness of a pellet, formation of bubbles, etc.) are noted.
   - Numerical data presented in text or tables; written with precision and accuracy.
   - Hand-drawn diagrams and graphs of results are made in the notebook.
   - Printouts of graphs or photographs taped into notebook; labels are present.
7. Locations (even if temporary) and labels of samples/tubes/bottles/plates.
8. Blank space (5+ lines) is indicated as void ("X" or line through).

9. Corrections.

- X or line used to void mistakes
- Corrections are nearby or page of correction is indicated
- Information is never obliterated ("scratched-out")
- No pages are removed

APPENDIX 7. Research progress report rubric (advanced CURE)

Criteria

TITLE (< 15 words)

- Effective
- Contains relevant keywords
- Accurate / clear / logical

ABSTRACT

- Establishes importance and context for research
- Identifies the research question/hypothesis
- Briefly describes the experimental approach
- Reports qualitative and quantitative data highlights
- Gives a statement about major conclusion(s) / significance of the research
- Writes clearly and concisely in a single paragraph (about 250 words)

INTRODUCTION

Establishes the importance of the research project within the context of established research (concise background with relevant references from the primary literature; clear statement of goals/objectives)

- How is the problem addressed currently?
- What are limitations of current methods?
- What is the motivation for the research?
- What is the problem or gap in understanding that the project will address?
- What is the purpose/hypothesis/research question for the study?
- What methods were used in the study?
- Optional: What were the key findings?

Writes at an appropriate depth for the target audience

MATERIALS AND METHODS

- Describes methods accurately at an appropriate depth / content (omits implicit information)
- Presents methods in logical order with appropriate subheadings
- Excludes procedural details that do not affect the experimental outcome (i.e., lab-specific information)
- Provides sources and exact names for specialized materials (biologicals, commercial products, etc.)
- Cites references for established procedures

PRELIMINARY FINDINGS

Results and Discussion

- Opens by reorienting reader to research goal / significance
- Excludes raw data and analytical tools; accurately reports all relevant data using appropriate data displays and text
- Describes all of the data in text, referencing figures and tables as supporting material
- Includes properly formatted and labeled images/graphs of major results with declarative titles and informative captions that allow figures to stand alone
- Includes tables (if appropriate) with clear organization and professional formatting (use of rule lines, title placement, headings with correct units, numerical alignment)

- Considers precision and accuracy when reporting numerical values
- Acknowledges source of any data generated by another team
- Interprets data accurately, making comparisons to expectations and/or describing how data support claims
- Draws distinct conclusions that are supported by data
- Compares data with results from published studies and cites relevant/appropriate research articles from the primary literature

Conclusions and Next Steps

- Describes approaches taken to overcome challenges and problems
- Specifies limitations / questions that still need to be answered / results that need confirmation
- Suggests potential avenues to continue / improve the project
- States implications / applications of the project outcome(s)

REFERENCES

- Cites both within text (using #) and in References section (complete citation)
- Follows Instructions to Authors for formatting and uses consistent formatting in citations
- Includes a minimum of 10 references, with at least 6 from the primary research literature

COMPREHENSIBILITY AND STYLE

- Follows Instructions to Authors for formatting and organizing paper
- Writes clearly and concisely with excellent sentence construction and uses correct terminology
- Divides information into paragraphs with topic sentences that allow for coherent, logical flow
- Uses correct verb tense and defines scientific jargon
- Proofreads for errors in spelling, grammar, language use, and punctuation and checks for formatting errors in paper

CHAPTER 5

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

Sara G. Goodman, Melissa M. Goodwin, Noveera T. Ahmed, Kristin Picardo, and Michelle Erklenz-Watts

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 reperceive 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 *reperceiving* (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 reevaluation 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 reperceive 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 themself, 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.

References

Allchin, Douglas. 2012. "Teaching the Nature of Science through Scientific Errors." *Science Studies and Science Education* 96: 904–926.

Blackwell, Lisa S., Kali H. Trzesniewski, and Carol Sorich Dweck. 2007. "Implicit Theories of Intelligence Predict Achievement across an Adolescent Transition: A Longitudinal Study and an Intervention." *Child Development* 78: 246–263.

Canning, Elizabeth A., Katherine Muenks, Dorainne J. Green, and Mary C. Murphy. 2019. "STEM Faculty who Believe Ability Is Fixed Have Larger Racial Achievement Gaps and Inspire Less Student Motivation in Their Classes." *Science Advances* 5: eaau4734.

Carlone, Heidi B., and Angela Johnson. 2007. "Understanding the Science Experiences of Successful Women of Color: Science Identity as an Analytic Lens." Journal of Research in Science Teaching: *The Official Journal of the National Association for Research in Science Teaching* 44: 1187–1218.

CMind. 2021. *The Tree of Contemplative Practices* [Illustration]. Florence, MA: Center for Contemplative Mind in Society. https://www.contemplativemind.org/practices/tree

Cooper, Katelyn M., Logan E. Gin, Barierane Akeeh, Carolyn E. Clark, Joshua S. Hunter, Travis B. Roderick, Deanna B. Elliott, et al. 2019. "Factors That Predict Life Sciences Student Persistence in Undergraduate Research Experiences." *PloS One* 14: e0220186.

Cooper, Katelyn M., Logan E. Gin, M. Elizabeth Barnes, and Sara E. Brownell. 2020. "An Exploratory Study of Students with Depression in Undergraduate Research Experiences." *CBE–Life Sciences Education* 19: ar19. doi: 10.1187/cbe.19-11-0217

Corwin, Lisa A., Christopher R. Runyon, Eman Ghanem, Moriah Sandy, Greg Clark, Gregory C. Palmer, Stuart Reichler, Stacia E. Rodenbusch, and Erin L. Dolan. 2018. "Effects of Discovery, Iteration, and Collaboration in Laboratory Courses on Undergraduates' Research Career Intentions Fully Mediated by Student Ownership." *CBE–Life Sciences Education* 17: ar20. doi: 10.1187/cbe.17-07-0141

Deiglmayr, Anne, Elsbeth Stern, and Renate Schubert. 2019. "Beliefs in 'Brilliance' and Belonging Uncertainty in Male and Female STEM Students." *Frontiers in Psychology* 10: ar1114. doi: 10.3389/fpsyg.2019.01114

Downing, Virginia R., Katelyn M. Cooper, Jacqueline M. Cala, Logan E. Gin, and Sara E. Brownell. 2020. "Fear of Negative Evaluation and Student Anxiety in Community College Active-Learning Science Courses." *CBE–Life Sciences Education* 19: ar20. doi:10.1187/cbe.19-09-0186

Dunlosky, John, and Janet Metcalfe. 2008. *Metacognition.* Thousand Oaks, CA: Sage, 2008.

Dweck, Carol S. *Mindset: The New Psychology of Success.* New York: Random House, 2006.

Dweck, Carol S. *Self-Theories: Their Role in Motivation, Personality, and Development.* New York: Psychology Press, 2000.

Dweck, Carol S., and Ellen L. Leggett. 1988. "A Social-Cognitive Approach to Motivation and Personality." *Psychological Review* 95: 256–273. doi: 10.1037/0033-295X.95.2.256

Gin, Logan E., Ashley A. Rowland, Blaire Steinwand, John Bruno, and Lisa A. Corwin. 2018. "Students who Fail to Achieve Predefined Research Goals May Still Experience Many Positive Outcomes as a Result of CURE Participation." *CBE–Life Sciences Education* 17: ar57. doi: 10.1187/cbe.18-03-0036

Hall, Eric, Elizabeth Bailey, Simon Higgins, Caroline Ketcham, Svetlana Nepocatych, and Matthew Wittstein. 2021. "Application of the Salient Practices Framework for Undergraduate Research Mentoring in Virtual Environments." *Journal of Microbiology & Biology Education* 22: ev22i1-2287.

Henry, Meredith A., Shayla Shorter, Louise Charkoudian, Jennifer M. Heemstra, and Lisa A. Corwin. 2019. "*FAIL* Is Not a Four-Letter Word: A Theoretical Framework for Exploring Undergraduate Students' Approaches to Academic Challenge and Responses to Failure in STEM Learning Environments." *CBE–Life Sciences Education* 18: ar11. doi: 10.1187/cbe.18-06-0108

Kabat-Zinn, Jon. 1994. *Wherever You Go, There You Are: Mindfulness Meditation in Everyday Life*. New York: Hyperion.

Killpack, Tess L., and Laverne C. Melón. 2016. "Toward Inclusive STEM Classrooms: What Personal Role Do Faculty Play?" *CBE–Life Sciences Education* 15: es3. 10.1187/cbe.16-01-0020

Lin-Siegler, Xiaodong., Janet N. Ahn, Jondou Chen, Fu-Fen. A. Fang, and Myra Luna-Lucero. 2016. "Even Einstein Struggled: Effects of Learning about Great Scientists' Struggles on High School Students' Motivation to Learn Science." *Journal of Educational Psychology* 108: 314–328. doi: 10.1037/edu0000092

Lopatto, David, Anne G. Rosenwald, Justin R. DiAngelo, Amy T. Hark, Matthew Skerritt, Matthew Wawersik, Anna K. Allen, and Consuelo Alvarez. 2020. "Facilitating Growth through Frustration: Using Genomics Research in a Course-Based Undergraduate Research Experience." *Journal of Microbiology & Biology Education* 21(1): e40. doi: 10.1128/jmbe.v21i1.2005

Nelms, April A., and Miriam Segura-Totten. 2019. "Expert–Novice Comparison Reveals Pedagogical Implications for Students' Analysis of Primary Literature." *CBE–Life Sciences Education* 18: ar56. doi: 10.1187/cbe.18-05-0077

Nunes, Krystal, Sherry Du, Riya Philip, Mohammed Majd Mourad, Zainab Mansoor, Nicole Laliberte, and Fiona Rawle. 2022. "Science Students' Perspectives on How to Decrease the Stigma of Failure." *FEBS Open Bio* 12: 24–37.

O'Keefe, Paul A., Hae Yeon Lee, and Patricia Chen. 2021. "Changing Students' Beliefs About Learning Can Unveil Their Potential." *Policy Insights from the Behavioral and Brain Sciences* 8: 84–91.

Ortiz Alvarado, Nancy Berenice, Marisol Rodríguez Ontiveros, and Edgardo Arturo Ayala Gaytán. 2019. "Do Mindsets Shape Students' Well-Being and Performance?" *Journal of Psychology* 153: 843–859.

Packard, Becky Wai-Ling. *Successful STEM Mentoring Initiatives for Underrepresented Students: A Research-Based Guide for Faculty and Administrators.* Sterling, VA: Stylus, 2015.

Paunesku, David, Gregory M. Walton, Carissa Romero, Eric N. Smith, David S. Yeager, and Carol S. Dweck. 2015. "Mind-Set Interventions Are a Scalable Treatment for Academic Underachievement." *Psychological Science* 26: 784–793.

Prunuske, Amy J., Janelle Wilson, Melissa Walls, and Benjamin Clarke. 2013. "Experiences of Mentors Training Underrepresented Undergraduates in the Research Laboratory." *CBE–Life Sciences Education* 12: 403–409.

Rattan, Aneeta, Krishna Savani, Dolly Chugh, and Carol S. Dweck. 2015. "Leveraging Mindsets to Promote Academic Achievement: Policy Recommendations." *Perspectives on Psychological Science* 10: 721–726.

Shanahan, Jenny Olin, Elizabeth Ackley-Holbrook, Eric Hall, Kearsley Stewart, and Helen Walkington. 2015. "Ten Salient Practices of Undergraduate Research Mentors: A Review of the Literature." *Mentoring & Tutoring: Partnership in Learning* 23: 359–376.

Shapiro, Shauna L., Linda E. Carlson, John A. Astin, and Benedict Freedman. 2006. "Mechanisms of Mindfulness." *Journal of Clinical Psychology* 62: 373–386.

Stefan, Melanie. 2010. "A CV of Failures." *Nature* 468: 467.

Sternberg, Robert J. 1998. "Metacognition, Abilities, and Developing Expertise: What Makes an Expert Student?" *Instructional Science* 26: 127–140.

Thiry, Heather, Sandra L. Laursen, and Anne-Barrie Hunter. 2011. "What Experiences Help Students Become Scientists? A Comparative Study of Research and Other Sources of Personal and Professional Gains for STEM Undergraduates." *Journal of Higher Education* 82: 357–388.

Thiry, Heather, Timothy J. Weston, Sandra L. Laursen, and Anne-Barrie Hunter. 2012. "The Benefits of Multi-Year Research Experiences: Differences in Novice and Experienced Students' Reported Gains from Undergraduate Research." *CBE–Life Sciences Education* 11: 260–272.

Vandermaas-Peeler, Maureen, Paul C. Miller, and Jessie L. Moore, eds. 2018. *Excellence in Mentoring Undergraduate Research.* Washington, DC: Council on Undergraduate Research.

Walton, Gregory M., Christine Logel, Jennifer M. Peach, Steven J. Spencer, and Mark P. Zanna. 2015. "Two Brief Interventions to Mitigate a 'Chilly Climate' Transform Women's Experience, Relationships, and Achievement in Engineering." *Journal of Educational Psychology* 107: 468–485. doi: 10.1037/a0037461

Yeager, David S., and Gregory M. Walton. 2011. "Social-Psychological Interventions in Education: They're Not Magic." *Review of Educational Research* 81: 267–301.

Yeager, David Scott, and Carol S. Dweck. 2012. "Mindsets That Promote Resilience: When Students Believe That Personal Characteristics Can Be Developed." *Educational Psychologist* 47: 302–314.

CHAPTER 6

Confronting Failure by Facilitating Transfer: Mentoring Undergraduate Research in Literary Studies with an Understanding-by-Design Framework

Amanda M. Greenwell

Abstract. This case study outlines the use of "Understanding by Design" (UbD; Wiggins and McTighe 1998) to structure a course-based undergraduate research experience in literary studies. After demonstrating how UbD is an apt model for mentoring undergraduate students through potential failure as they navigate messy and recursive discipline-specific research processes, it details pedagogical strategies and scaffolded assignments that align with the responsive teaching and metacognition UbD espouses for deep, transferable learning. Although the case study draws examples from a Literature for Young Adults course to illustrate its points, the strategies discussed are applicable to other course-based and independent study projects.

doi: 10.18833/cf/11

Successful mentorship of undergraduate research in literary studies does not just mean that students produce a solid research paper by the end of their time in academia. It also means that they learn to "become active participants in the scholarly community by following multiple lines of interpretations, synthesizing conflicting positions, and ascertaining their own position in relation to the larger debates of a text, an author, or a field of study" (Lee-Keller 2009, 17). However, as Brock et al. (2010) point out, literature students in college classrooms often "witness [by way of their readings and instructor lectures] the end result of the research process without the instructive, but sometimes messy, mechanisms" that lead to it (125). When instructors ask them to perform work that has been made essentially invisible to them (Baldus 2009, 87; Grobman and Kinkead 2010a, x), they may very well fail.

It is not surprising, then, that scholars who teach undergraduate researchers in English studies note trends in students' failures that correspond to faulty understanding of the scope and aims of a project (Wilson 2003, 77), underdeveloped or misconstrued notions about the use of secondary source material (Baldus 2009, 83; Bankert and Van Vuuen 2008; Wilson 2003, 77), and inexperience with the sheer amount of time investment required for strong literary studies research (Manarin, McGrath, and Carey 2016, 15). Even though such misconceptions tend to result from lack of exposure and lack of concerted mentorship rather than lack of ability, upper-level students can be embarrassed to admit they require further guidance because they assume these are things they should just "know" (Bankert and Van Vurren 2008).

Strong mentorship, therefore, requires that mentors empower students to understand and navigate disciplinary expectations to develop the savviness, resilience, and confidence they need to succeed. It also requires that they renegotiate students' very understandings and experiences of failure as students engage in the "messy" mechanisms (Bankert and Van Vurren 2008; Brock et al. 2010, 125; Brookbank and Christenberry 2019, 6) that characterize literary studies research. In a discipline that values complexity (Wilder and Wolfe 2009, 174) and in which the best scholars' processes consist of "twists and turns" impossible to anticipate with specificity in advance (Bankert and Van Vuuren 2008), undergraduates must be mentored through the halts and redirects that are endemic to the practice. Thus, this chapter distinguishes between (1) those discipline-specific moments that occur when researchers encounter a "twist" that sets them back and requires they decide how to "turn" to accommodate it, and (2) "discipline-invalid" moments that occur when a novice researcher exhibits faulty understanding of their task and its attendant processes in literary studies.

It is important to acknowledge, of course, that moments of the first type may turn into moments of the second if the "turn" taken by the researcher is based on a misconception about the aims of the discipline. Considering that possibility, this chapter relies in part on the definition of failure of Henry et al. (2019) as "the inability to meet the demands of an achievement context with the result of not achieving a specific goal" (2), since students who fail in literary research do exhibit an inability to perform scholarship in the context of literary studies. However, it is important to consider how that "inability" manifests, especially in students who have heretofore been successful in other disciplinary, context-specific endeavors: those who have progressed to upper-level courses or experiences requiring independent literary research specifically because their performance in earlier coursework has deemed them "ready." In addition, it is unwise to conflate adequate task completion with true, transferable understanding (Jackson 2020; Tinberg 2015). Thus, this chapter defines failure as "unqualified performance arising from the gap between superficial or basic knowledge of goal-oriented task expectations and successful, meta-cognitive enactment of those expectations."

This chapter focuses on how using the methodology Understanding by Design (UbD; Wiggins and McTighe 1998) allows for honoring this gap between knowledge and enactment while at the same time working to close it. UbD uses a backward-design template, in which an educator first determines the end result and method for assessing that result and then designs learning experiences that provide students the opportunity to build the knowledge and hone the skills they will need to "own" and exhibit the end result (Wiggins and McTighe 1998). After demonstrating how UbD is an apt model for mentoring undergraduate literary studies researchers as they navigate discipline-specific processes, this chapter details the process of employing UbD to mentor undergraduate research in an upper-level literary studies course where students create researched critical analysis papers. Some examples from a Literature for Young Adults course illustrate the discussion, but the pedagogical strategies discussed here are applicable to other undergraduate research projects.

Understanding by Design: A Lens for Mentoring Literary Studies Researchers through Failure

For Wiggins and McTighe, the end result of any unit or course of instruction is a discrete set of "enduring understandings" (EUs): key insights that stay with students beyond the course, specifically because they have practiced them or investigated them in ways that endure. EUs are big, discipline-specific concepts, and Wiggins and McTighe (1998, 11) maintain that only when educators "involv[e] students in 'doing' the subject" will learners gain the ownership that allows them to transfer these understandings to new situations. Without referencing UbD, Reed Wilson (2003) makes a strikingly similar point about engaging undergraduate students in literary studies research: "the best way to teach is to invite them wholeheartedly into our world" (77), so that they "really learn what it means to pass from 'knowledge' to 'understanding'" (78). One reason that UbD is so well matched for mentoring students through this passage is that it is designed to account for potential failure during the journey and thus provides a useful method for incorporating proactive attention to its presence as part of the teaching approach. Strong EUs can explicitly correct certain common misconceptions students have about the subject matter (Wiggins and McTighe 1998, 11), and leading students to true understanding requires nuanced attention to the processes by which individual students master those insights.

In the words of Wiggins and McTighe (1998), that process works "more like trial and error than follow the leader" (135), and so rigidly linear instructional planning does not make room for the recursive, iterate processes—the revisiting and reconceptualizing—necessary for deep understanding. Since literary studies scholarship processes are also recursive and iterative (Brookbanks and Christenberry 2019, 6; Lee-Keller 2009, 18), planning to make room for rethinking and doubling back honors a "messy" process and affords the time and opportunity to draw distinctions between the discipline-specific and discipline-invalid setbacks students experience. That is, UbD helps mentors "mind the gap" in failure—that between superficial knowledge and metacognitive enactment of goal-oriented expectations—while at the same time clarifying that encountering the twists and turns in the messy path entailed by such enactment should not be confused with failure.

Finally, UbD's focus on fostering metacognition (Wiggins and McTighe 1998) both attends to these clarifications and avoids the conflation of task completion with understanding. It fosters a student's ability to self-direct, to recognize their own strengths and weaknesses, and to meta-talk their choices in relation to discipline-specific terms and practices so they make their thinking processes legible to the instructors coaching them. A strong test of transference is whether students can discuss, or meta-talk, their discipline- and genre-specific moves in ways that confirm they are doing the authentic work of the field and developing strong conceptual knowledge (Tinberg 2015; Wiggins and McTighe 1998, 66–69; Yancey et al. 2018). Through the process, UbD advocates for coaching in the form of individualized, qualitative feedback on both graded and ungraded student work (Wiggins and McTighe 1998, 156)—especially student work created in moments when misconceptions might interfere with their understanding and enactment.

The course illustrated in this chapter employs three EUs to guide literary studies research:

1. Strong literary studies researchers conceive original scholarly arguments about primary texts that respond to ongoing critical conversations in the field's scholarship.
2. Strong literary studies researchers employ sources in various and nuanced ways.
3. Strong literary studies researchers employ a recursive, iterative process for idea conception and research practices, a process that requires discipline-savvy metacognition to navigate successfully.

Detailed below are the formative assignments and iterative instruction by which the course engages students and layers these understandings, as well as comments about how attentive feedback (Sommers

1982), especially when aligned with UbD concepts, allows a mentor to confront and redirect failure at each of these instructional stages.

Initiating EU 1: Finding an Entry into the Critical Conversation with a Dual-Inquiry Project Proposal

One UbD principle (Wiggins and McTighe 1998) for fostering student progress toward EUs is to resist the temptation to give students everything they need to know before they begin work on a project. Instead, mentors should seek to "engage students in inquiry and inventive work as soon as possible" (164). Scholars in many disciplines have linked active learning to student motivation and success (Andres 2019; Freeman et al. 2014), such as through experiences in disciplinary research processes (Grobman and Kincaid 2010a, xxiii; Knutson et al. 2010). In undergraduate research in literary studies, this principle is crucial: if information about research is imparted via lecture right from the start, mentors risk losing student motivation and confirming the sage-on-stage mentality that keeps students in passive roles (Morrison 2014) in relation to scholarship they are positioned only to consume rather than create.

Using a project proposal assignment with a dual-inquiry model helps students move beyond stubborn misconceptions about research being limited to "reporting back" what others have said. The proposal assignment overtly differentiates two key lines of inquiry followed in literary studies research:

- ***Ask my scholarly self.*** What do I want to examine about the text I've chosen?
- ***Ask other scholars.*** What have *other people* argued about my text, texts like it, and/or issues relevant to my text, and how might their ideas help me conceptualize unique answers to my own questions?

These questions help clarify the complicated—and to students, sometimes confusing—directives that tend to populate handbooks about literary research. For instance, the *MLA Guide to Undergraduate Research in Literature* urges students to "create new knowledge, not to report on what [they] already know" (Brookbank and Christenberry 2019, 18) yet also "learn how to participate in the scholarly conversation" (Brookbank and Christenberry 2019, 9) in part by "us[ing] secondary sources to support [their] claims about the primary source at hand" (Brookbank and Christenberry 2019, 7). Students often ask how their ideas can be "new" if they need to "support" them with secondary sources. Although the notions embedded in this concept of "support" will be discussed later in this chapter, the two inquiry questions listed above limn the foundational notion of the "scholarly conversation," referring to a careful balance among several voices that will sound throughout the students' process and in their final product: their own and those of the scholars with whom they are conversing.

To further concretize the idea for students, the notion of rhetorician Kenneth Burke (1941) can be useful: critical conversations conceived as never-ending, heated *parlor* discussions (110–111). Since 'parlor' is somewhat removed from most contemporary student experiences, the image can be modified to something like the following:

> Think about entering the critical conversation the same way you enter a conversation with friends or coworkers who are talking about the latest info making the rounds among the group. You walk over, listen for a bit, get a handle on what they're saying, and only then do you add your two cents or provide new info or a new angle they haven't considered. Perhaps you even pose a new question, like "hey, has anyone considered whether [some related thing] happened? Because if so, then maybe . . .". Your contribution matters because you're not barging in to drop knowledge someone has already offered; it matters because it adds nuance or new info or another angle of consideration to an ongoing discussion: it fits (even if it disrupts!).

By requiring students to pose questions that assert the productive coexistence of their point of view with those of other scholars, the dual-inquiry proposal anchors this "scholarly conversation" concept right from the start of their process.

In addition, the research proposal also asks students to do some meta-talk about these questions, telling the mentor why they are interested in these questions and why they think such questions are useful as a starting point for the project. Metacognition—or thinking about one's thinking patterns and processes (Beaufort 2007; Berthoff 1990)—is one hallmark of understanding, according to Wiggins and McTighe (1998, 67). Asking students to articulate and comment upon on their thought processes at several points throughout an experience helps them develop a stronger sense of purpose behind the choices they make (Yancey et al. 2018, 43), which in turn positions them to be more likely to internalize their processes and transfer them—and the ability to reflect on them—to future situations (Taczak and Robertson 2017). Furthermore, asking students to write about the origin and value of their questions positions them in a dialogue with the mentor about their process.

That dialogue can only be carried on via instructor feedback tailored to the coaching needs of each student (Wiggins and McTighe 1998, 156), and that means focusing on the work placed by the writer on the page as well as on the writer (Sommers 1982), all in concert with academic and disciplinary expectations (Henderson et al. 2021). Since the dual-inquiry proposal requires that students differentiate between their work on the project and the work of others who have been carrying on the critical conversation they are entering, the mentor's feedback can respond to the extent to which they do so. Students are ready to move forward when they can articulate these types of questions specific to their chosen topic and text and can write clearly about their significance. The following examples of questions and meta-talk engage the demands of the proposal well:

- ***Ask my scholarly self.*** What does the textual representation of puberty in [a popular middle-grade graphic novel] convey about the physical adolescent body and the emotional state of adolescence? How do these ideas intersect with American cultural understandings and stereotypes about teens, and to what effect? I am interested in this line of inquiry because puberty seems to be talked about as both magical and scary, and this book uses humor to do both. I started thinking about that when we were talking about how adults sometimes view adolescents as full of possibility but also as kind of terrifying, so I think I may be able to write about how this book embraces these ideas about adolescents.
- ***Ask other scholars.*** Has anyone written about puberty in middle-grade graphic novels? What do they say? If not, what have scholars written about graphic novels and representation of the body? Or, how do graphic novels for adolescents visually engage gender and sexuality? If no one has written about graphic novels these ways, I will look into scholarship on similar topics that focuses on conventionally printed novels.

In this case, feedback can be congratulatory. The students can be commended for articulating their own focused inquiry question and connecting it to a concept from class that may very well help them reconstruct the critical conversation they are entering; they also can be applauded for posing several questions of the research that will help them figure out the novelty of their idea, whether they need to refine it to contribute to the extant scholarship, and what entry point—puberty in middle-grade graphic novels, graphic novels and the body, and/or the body/puberty in middle-grade novels in general—is best for joining the conversation. Clarifying the strengths of the proposal in feedback (rather than writing a brief "great job!") will help students anchor their investigation and revision work going forward (Daiker 1989; DePeter 2020).

But most students need further coaching as they attempt this feat (often for the first time), and in that case, mentoring kicks into another gear to account for the type of failure at play. Often, all students have at least identified a general topic that interests them, and so feedback can emphasize that they have begun the process with a sense of ownership and investment—two attitudes crucial to the deep learning they will engage as the project develops (Grobman 2009; Lee-Keller 2009, 19; Mandarin, McGrath, and Carey 2016, 15). The meta-talk portion of the assignment contains the nuance that helps differentiate how to deliver the rest of the feedback. In some cases, students may articulate in their meta-talk a phrase or even whole line of inquiry that is important to their questions proper, which the mentor can point out. In other cases, the mentor can provide specific coaching about rooting their project in literary analysis. For instance, students sometimes use as their unique question something outside of the scope of the course, such as "How does fantasy literature affect children who read it?" In that case, feedback can prompt them to move from human subject study (an important way to consider how literature works in the real world but not one that fits the course's timeframe or methodologies) to literary analysis. But a mentor can also point out that this question could become one of their "ask other scholars" questions if they wish to include the information it yields in their argument, perhaps to make clear that fantasy literature matters, and therefore it should be studied. Feedback of this type (and the resulting office-hours conversation sometimes sparked by it!) can often prompt students to revise their main question to focus on the ways they wish to engage in original analysis of their chosen primary text—such as "How do the transformative masks in Nnedi Okorafor's *Akata Witch* function, especially in relation to genre, culture, identity, and adolescence?" This literary studies project can now advance, and researching what other scholars have studied about the impact of fantasy literature on real readers can still help this student frame their argument about the significance of masks in Okorafor's work for its implied audience.

Other common failures that require a "mind the gap" response tend to be due to intersections of a researcher's orientation and the project's scope—as for instance, when students respond with, on the one hand, a predetermined argument that seems to preclude any possibilities for exploratory research that might challenge their current understanding; or, on the other, vague questions and doubt about their project's viability that suggests they may be unclear about their direction and uncertain about moving into the research stage. The first student might have been in love with *The Hunger Games* since middle school, only reads empowerment into its narrative, and is set on writing about how amazing this story is for young readers. A second student might express interest in writing about a minor character of color in a children's fantasy novel but is uncertain whether that is enough to support a whole paper and has not yet articulated a true inquiry question or questions for scholars aside from "do people study fantasy?". The first student needs to be nudged to step away from a certain subject standpoint so as to truly engage in inquiry; the second needs encouragement and a schema by which to understand how the project has potential as an academic exploration, even if it needs refinement.

In both cases, the same kernel of feedback can be provided: pointing them to a particular scholar's work. But the language in which that kernel is couched can be specific to each student's orientation to the EU about building a unique argument within a critical conversation. Feedback to the first student can run along the following lines:

> Keep your mind open to critiques of these texts as well, which may help you hone or redefine your argument as you explore its context. Check out Ebony Elizabeth Thomas's book *The Dark Fantastic* (2020): It will help you think more about the way discriminatory, disempowering conceptions of race figure into that series as well as popular Anglo-American fantasy in general.

Such feedback can function as a warning away from the failure risk of myopic embrace and a push toward the critical consideration necessary for literary studies scholarship; it also introduces a perspective that the student might not have considered. The second student might benefit from this note:

> Your thinking here reminds me of Ebony Elizabeth Thomas's important consideration of Black characters in popular fantasy: check out her book *The Dark Fantastic* (2020), and you'll see how

can follow specific lines of inquiry that root an argument like the one you're thinking about—and you will also likely find that her work will help you locate and reconstruct the critical conversation you are entering.

Such feedback provides not a warning but a green light, along with some extra guidance about an intellectual model for the work. The meta-talk is significant in opening the conversation: the student's expression of doubt about the viability of the topic opens the door for the mentor to provide a small push. If a student does not offer enough meta-talk to determine an appropriate response, feedback can also encourage the student to engage in a stronger dialogue with the mentor about personal processes, decision-making, and questions (Cohn and Stewart 2016).

Essentially, the dual-inquiry proposal deliberately builds in space for students to fail, since it both tests whether students can differentiate their lines of inquiry and exhibits where they are in their thinking processes so feedback can be tailored accordingly. Consistent with the practice of instructors who have assigned to such formative early work either a no-stakes or low-stakes grade (Fike 2011, 49; Lee-Keller 2009, 18), the mentor can offer students an opportunity to revise and resubmit their pieces so that failure at this early stage results not in rejection but in opportunity.

Layering EU 2: Source Work in Literary Studies Research

The proposals are initial avenues for exploration: they contain questions that students would like to pursue. At the research stage, a common setback for novice literary studies researchers can appear: the challenging task of using discipline-specific avenues to select and employ sources. Kimberly Baldus (2009, 83) comments on how even upper-level students often do not think beyond "'plugging in' scholars' ideas" to satisfy a source requirement, and Bankert and Van Vurren (2008) note that even when students seem otherwise ready for individual research projects, they "often fail to understand the nature, organization, and scope of the resources they must use." Such occurrences can widen the gap apparent in failure: it arises from a disconnect between superficial knowledge about source use and enactment of discipline-specific research practices.

To help address this gap, mentors can elicit some anonymous self-assessment pertaining to students' research experience levels (which encourages honesty) and share the results with the class (which demonstrates to students that they are not alone in their concerns about the process). That motivating and relieving sense of solidarity (Balster et al. 2010; Lopatto 2013; Rand 2016; Tapp 2015) opens a conversation about their understandings and experiences in their previous research projects. The main failure-risk misconception that tends to arise is that they rely on the far too vague notion that they should be using outside sources to "support" their argument—a term first encountered in late elementary school and never abandoned. The use of "support" for outside-source-use shorthand is ubiquitous; even the *MLA Guide to Undergraduate Research* employs the term uncritically in its introduction (Brookbank and Christenberry 2019, 7). One way to mentor students through this potentially discipline-invalid concept of source use is to interrogate this term and replace it with discipline-specific language (listed below), illustrated by examples, that speaks to the moves strong literary researchers make with their sources.

To reorient students to outside source use, a combination of direct instruction, constructivist student work, and coaching can be effective, consistent with the UbD approach for particularly complex or "new" concepts (Wiggins and McTighe 1998, 156). The direct instruction involves naming and illustrating source integration moves that many students may not have had articulated to them. For instance, literary studies researchers employ sources to do the following:

- Provide context for the critical conversation they are entering, including reviewing or locating trends, debates, and/or gaps in the scholarship on their text or texts like it.

- Borrow (or even create) lenses or frameworks to apply to their text(s).
- Locate an insight made by other scholars only in passing, or notice a gap—something not yet mentioned—in the conversation, and use it as a springboard for deeper discussion.
- Take care of complex points or premises so a new argument can build upon what has already been said.
- Provide evidence to bolster a particular portion of their argument or contextualize an explanation.
- Provide a counterargument against which to emphasize their own ideas.

In each case, the mentor can offer examples related to the scholarship read in class, either recalling articles that demonstrate these moves or noting how students have already applied a concept from an outside reading to a primary text in earlier class discussions. Eliciting examples from the students themselves can enhance interaction and help them discover that they have already seen or enacted these strategies, and encouraging students to have their own projects in mind as the discussion continues can help them consider approaches specific to their inquiries.

The list offered above is not exhaustive and can be modified for other course content or independent projects. One additional concept emphasized in the course on which this case study draws, which is more specific to the field of young adult literature or contemporary literature, is that relevant and important outside sources for a student project should include those directly about a chosen text if there are some to be consulted. However, if there is no extant scholarship on this text, that does not mean a student must abandon their topic. Model texts can exhibit to students how to perform a "move" specific to a particular subfield of study (Bunn 2013; Charney and Carlson 1995; Gallagher 2014), so Angel Daniel Matos's 2016 article "Queer Consciousness/Community in David Levithan's *Two Boys Kissing:* 'One the Other Never Leaving'" is useful to demonstrate how a scholar might approach employing a variety of source material for an argument about a text that has not yet received scholarly attention. It provides a wonderful touchstone during discussion of research methods, since it exhibits several of the moves previously mentioned.

Engaging EU 3: An Iterative, Metacognitive Practice for Researching and Writing

Once students have been introduced to the various and nuanced use of sources by scholars within the literary studies paradigm, they are ready for a metacognitively-oriented lesson about that mainstay of research methods instruction: database use. The mentor can conduct this work alone or collaborate with a research librarian but should not limit the session to nuts-and-bolts logistics. Although those are important and certainly feature in instruction, the key EU emphasized by this activity is that the research process in literary studies is recursive and messy, thus requiring strong metacognition to navigate with success. To illustrate these practices, the mentor can revisit research design concepts as they model testing key terms, managing search parameters, switching databases, and reviewing titles and abstracts. The mentor can emphasize a trial-and-error approach (McDorman 2004; Traga Philippakos 2021) by eliciting key terms from the "ask other scholars" questions included in the research proposals, riffing on the students' suggestions and modeling how dead ends—which some less discipline-savvy students might consider to be failures—are actually part of the process.

Furthermore, the mentor can emphasize that students will likely perform several rounds of research and that such rounds will recursively inform their project's purpose, aims, and questions. Some students in their earlier research experiences failed to grasp the notion that reading source material can (and should) cause researchers to shift directions or rephrase their own interventions: that their initial "finding" of the minimum number of peer-reviewed sources they need does not mean that they have located the sources that will help them shape their final product. Reorienting these shifts in students' minds as discipline-specific endeavors requires some attention to the emotional processes that manifest in challenging intellectual situations (Markle 2017; Rand 2016; Todd, Bannister, and Clegg 2004). Some students are unused to starting over, nor do they wish to acknowledge that a proposal that earned an "A" just a few weeks ago no longer seems viable as they peruse their database yield. However, it is precisely because they are expected to modify the contours of their first "ask my scholarly self" question as they encounter the research of the scholars responding to their second "ask other scholars" questions that a delay is advisable in inviting them into this messier stage of the process. They need the motivation (Grobman 2009; Lee-Keller 2009, 19; Manarin, McGrath, and Carey 2016, 15) that the proposal conjures to anchor them as they navigate through.

Employing this note from Brookbank and Christenberry (2019) often helps convince them that recursivity *is* the way of the discipline: "You will likely find yourself returning to some of the steps that you already took and that you will have increasingly detailed and complex questions to answer. This is a good thing; it is what is supposed to happen when one does research . . . Shifts in direction and going back to square one are perfectly normal and to be expected" (6). Clearing up this misconception by emphasizing how a return to the proposal and/or the databases may mark a *successful* process rather than a *failing* one is crucial to mentoring students through the twists and turns they might otherwise mistake for actual failure, which can cause them to give up somewhere in that gap between superficial understanding and enactment. Mentors who offer examples from personal experience can be helpful to students, following notes from Eaton et al. (2008, 162) and McDorman (2004, 41) about the important learning and even bonding that can happen when mentors acknowledge personal setbacks and moments of doubt during research processes.

It is important to note that the iterative process of database searching can still lead to failure if students do not keep discipline-specific concepts of source use in mind, but students need to experiment with their topic and their searches for a while so that they can experience and make use of the recursivity of the process. Here, to combat the common misconception some students have about the amount of time a project could require from start to finish (Manarin, McGrath, and Carey 2016), a mentor can emphasize productive recursivity and deep planning by drawing on the advice of composition theorist Donald Murray (1972/2003, 4) that the prewriting stage should take up about 85 percent of a writer's project time. Therefore, it can be helpful to give students several weeks to compile and create an annotated bibliography, which leaves them ample room to hit dead ends, lament, reorient, reconceive, re-search, and meet with mentors or librarians if they wish. Although annotated bibliographies are a mainstay in many course-based research processes (Fike 2011, 50), assigning an augmented version that aligns with the EUs about literary research helps students solidify these concepts: In addition to the conventional summary portion in each entry, students must include a "plan for use" that nods directly to one of the previously mentioned source use concepts in explicit relation to their argument as they now conceive it—or ruminates on an alternative concept that may not have been covered in class but nevertheless seems logical to their work. This portion of the assignment helps them record their metacognition as they attempt to apply concepts in practice and therefore helps mentors adjust feedback to their specific needs (Sommers 1982). Often students comment about the value of their sources, which may not have been evident to the mentor while reading only the sources' bibliographic citation and summary; such comments allow the mentor to respond with excitement to the rich thought processes in which the students are engaging as they delve into the research.

Students can also be directed to end the document with a paragraph indicating whether they think they have found sufficient sources to feel confident in entering the critical conversation and making an argument, and why—as well as whether there are other types of sources they are hoping to find. Again, the meta-talk in which they engage here is crucial, as it helps the mentor understand whether they are beginning to see a shape for their work or whether they need further guidance. In some cases, their meta-talk can even resituate a product-oriented failure (not finding a needed source) into a process-oriented success (understanding they need to find it) that can be applauded, and the mentor may even be able to point to a source that fills the gap they have identified. The mentor can also provide course-correcting feedback on anything from accurately identifying peer-reviewed sources to conversing with students about whether they should reference a particular source in the introduction or conclusion. As with the proposal, this formative assessment is low-stakes and revisable: the expectation is that students might need more coaching through this complex process, and a formative assessment works to mutual benefit as students learn and as mentors coach.

Normalizing Iterative Processes with Iterative Pedagogies: FAQs and Conferences

Adjusting instruction is paramount to the UbD process (Wiggins and McTighe 1998, 134, 153, 156), specifically because no planning will ever be a match for the nonlinear, recursive processes of learning that occur during literary studies research. Throughout the entire time in which students conceive and create their projects, two recurring pedagogical practices may help a mentor adjust on-the-fly: a live document of Frequently Asked Questions (FAQs) and regularly scheduled conferences. The FAQs are a way to extend instruction beyond class time and enact the suggestion of Wiggins and McTighe (1998) to confront misunderstandings that can contribute to failure early and often (43). When a student contacts a mentor for guidance, the mentor might consider whether the issue encountered is one that other students in the course may be experiencing. If so, the mentor can obtain permission to replicate the gist of the mentor-mentee conversation (without any identifying information) so it can be made available for everyone. Sometimes the questions that arise duplicate items already discussed in class or those that are already in the FAQs, but that does not necessarily disqualify the mentor's work with those students from appearing in the document; rather, it provides the opportunity to add explanations and examples that help students see how EUs are portable from situation to situation.

The FAQs thus normalize the need for extra guidance (Wiggins and McTighe 1998, 156) that students might need as they attempt, often for the first time, to shed discipline-invalid notions of argument-creation, source-finding, and source-integration and align their processes with discipline-specific methods of researched inquiry. For students to reach understandings that are both complex and hopefully enduring, enacting the following suggestion from UbD proponents is a must: "make clear by word and deed that there is no such thing as a stupid question" (Wiggins and McTighe 1998, 164). The FAQ document supports awareness of discipline-specific practices even as it validates the struggle to meet them, and it also supports enactment of those same practices by attempting to close that gap between knowing and performing through responsive coaching (Wiggins and McTighe 1998, 8).

Peer conferences (Elbow and Belanoff 1999) can also augment the stages detailed above to foster the constructivist learning espoused by UbD: students doing the discipline. Laurie Grobman (2009) touts revision as a key component of authentic disciplinary work in English (176). Students engage in and receive peer review from each other and from the mentor as a way to rehearse the moves they are learning to make. Even if students do not receive excellent suggestions from peers during these moments, they practice employing the discourse that they are working to internalize: that pertaining to the dual-inquiry model for literary studies research, that pertaining to the nuances of source use, and that engaging the recursivity of it all.

Practicing this language with the students' peers facilitates their ability to use it in their own formative assessments and in their conferences with the mentor. When they are versed in this discourse, one-on-one conferences can cover more ground more quickly (Kittle 2008), and the mentor is able to discern more incisively the areas where students need support and adjust the approach accordingly

(Taylor 2021). Students who use the language of EUs can readily express, for instance, that although they are using two sources to frame their critical conversation, they are unsure where to place that conversation in the paper. This comment can set the stage for the mentor and student to assume a collaborative stance (Taylor 2021) and problem solve together, and such students are likely to apply their knowledge beyond the course. Students also versed in the discourse who arrive with a draft that employs sources only three times in the body of the paper to handle fairly minor points—rather than truly engaging with sources to construct a critical conversation and develop their ideas—can better follow the mentor's logic when the mentor assumes an instructor stance (Taylor 2021). In that case, the mentor can convey that what they have is sound, but they need to set up the intervention they are making into the extant scholarship. Asking probing questions about the source material may lead students to knit their work to the work of others in just a few minutes—or realize that they need to return to the databases for another round of searching. If they work on this aspect of the paper, they will leave the course with a sense of that critical conversation's importance. On the other hand, if students come in with disjointed drafts and do not exhibit use or understanding of this shared language, the conversation can review the previous stages of work, locate the source of the disconnect, and triage pedagogical intervention from there. Such students may need more time than the academic term allows to fully embed the EUs; however, they also will know that they did not follow a discipline-savvy process and that they should pursue a project differently the next time—potentially reducing the gap they must close to overcome failure and proceed on the path to success.

Conclusion: Student Success; the Learning Continuum; and Failure as Fruitful, not Finale

Wilson (2003) notes that expecting perfection from undergraduate researchers is counterproductive to mentors' aims (78), and Grobman (2009) advocates that mentors should "see all student writers as scholars-in-process" (177). As students undertake research in a field where scholarship is characterized by individual conceptions of fresh ideas formulated in original arguments about primary texts that respond to ongoing critical conversations, their trajectory through a project can waver between confidence in an argument and sudden loss of direction, moments of clarity and stretches of confusion, and elated excitement and dismayed overwhelm—often capped by doubt in their ability to pull it all together. What UbD offers to undergraduate research in literary studies is a pedagogical alignment with the complex, messy, and productive processes that characterize this field, and it thus builds—or, at the very least, begins to build—the foundation of transferable understandings needed by students to perform successful literary studies research.

Grounding literary studies students in discipline-specific research concepts—such as entering a critical conversation, understanding the various and nuanced ways that literary scholars employ sources, and engaging metacognition about their own scholarly processes—and offering students opportunities to enact them in a feedback-rich environment not only supports their success on a finished product but also provides a method by which they can navigate and redefine failure in their current and future work. The iterative UbD pedagogy discussed here thus provides space for students to revisit and build on foundational concepts in literary studies research by reflecting on their explorations, stumbles, and discoveries in relation thereto; in doing so, they learn to contribute their perspectives to the literary studies arena—or be better positioned to do so in the future.

References

Andres, Hayward P. 2019. "Active Teaching to Manage Course Difficulty and Learning Motivation." *Journal of Further & Higher Education* 43: 220–235. doi: 10.1080/0309877X.2017.1357073

Baldus, Kimberly. 2009. "Negotiating the Dynamics of Individual Research within Academic Communities." In Behling 2009, 11–28.

Balster, Nicholas, Christine Pfund, Raelyn Rediske, and Janet Branchaw. 2010. "Entering Research: A Course That Creates Community and Structure for Beginning Undergraduate Researchers in the STEM Disciplines." *CBE–Life Sciences Education* 9: 108–118. doi: 10.1187/cbe.09-10-0073

Bankert, Dabney A., and Melissa S. Van Vuuren. 2008. "Stranger in a Strange Land: The Undergraduate in the Academic Library, a Collaborative Pedagogy for Undergraduate Research." *The CEA Forum* 37(1): n.p.

Beaufort, Anne. 2007. *College Writing and Beyond: A New Framework for University Writing Instruction.* Logan: Utah State University Press.

Behling. Laura L, ed. 2009. *Reading, Writing, Research: Undergraduate Students as Scholars in Literary Studies.* Washington, DC: Council on Undergraduate Research.

Berthoff, Ann E. 1990. *Sense of Learning: The Making of Meaning.* Portsmouth, NH: Boynton/Cook.

Brock, D. Hayward, James M. Dean, McKay Jenkins, Kevin Kerrane, Matthew Kinservik, and Christopher Penna. 2010. "New Frontiers in Faculty-Student Research Projects in Literature and Journalism." In Grobman and Kinkead 2010b, 123–142.

Brookbank, Elizabeth, and H. Faye Christenberry. 2019. *MLA Guide to Undergraduate Research in Literature.* New York: MLA.

Bunn, Michael. 2013. "Motivation and Connection: Teaching Reading (and Writing) in the Composition Classroom." *College Composition and Communication* 64: 496–516.

Burke, Kenneth. 1941. *The Philosophy of Literary Form.* Berkeley: University of California Press.

Charney, Davida H., and Richard A. Carlson. 1995. "Learning to Write in a Genre: What Student Writers Take from Model Texts." *Research in the Teaching of English* 29(1): 88–125.

Cohn, Jenae, and Mary Stewart. 2016. "Promoting Metacognitive Thought through Response to Low-Stakes Reflective Writing." *Journal of Response to Writing* 2(1): 58–74.

Daiker, Donald. 1989. "Learning to Praise." In *Writing and Response: Theory, Practice, Research,* ed. Chris Anson, 103–113. Urbana, IL: NCTE.

DePeter, Ron. 2020. "How to Write Meaningful Peer Response Praise." In *Writing Spaces: Readings on Writing,* Vol. 3, ed. Dana Driscoll, Mary Stewart, and Matthew Vette, 40–51. Fort Collins, CO: The WAC Clearinghouse. https://wac.colostate.edu/books/writingspaces/writingspaces3/

Eaton, Angela, Linda Rothman, Jessica Smith, Robin Woody, Catherine Warren, Jerry Moore, Betsy Strosser, and Randi Spinks. 2008. "Mentoring Undergraduates in the Research Process." *In Stories of Mentoring: Theory and Praxis,* ed. Michelle F. Eble and Lynée Lewis Gaillett, 159–177. West Lafayette, IN: Parlor Press.

Elbow, Peter, and Patricia Belanoff. 1999. *Sharing and Responding,* 3rd ed. New York: McGraw Hill.

Fike, Matthew A. 2011. "Promoting Research in an Undergraduate Shakespeare Course." *The CEA Forum* 40(2): 43–54.

Freeman, Scott, Sarah L. Eddy, Miles McDonough, Michelle K. Smith, Nnadozie Okoroafor, Hannah Jordt, and Mary Pat Wenderoth. 2014. "Active Learning Boosts Performance in STEM Courses." *Proceedings of the National Academy of Sciences* 111: 8410–8415. doi: 10.1073/pnas.1319030111

Gallagher, Kelly. 2014. "Making the Most of Mentor Texts." *Educational Leadership* 71(7): 28–33.

Grobman, Laurie. 2009. "The Student Scholar: (Re)Negotiating Authorship and Authority." *CCC* 61(1): 175–196.

Grobman, Laurie, and Joyce Kinkead. 2010a. "Illuminating Undergraduate Research in English." Introduction to Grobman and Kinkead 2010b, ix–xxxii.

Grobman, Laurie, and Joyce Kinkead, eds. 2010b. *Undergraduate Research in English Studies,* ed., 123–142. Urbana, IL: NCTE.

Henderson, Michael, Tracii Ryan, David Boud, Phillip Dawson, Michael Phillips, Elizabeth Molloy, and Paige Mahoney. 2021. "The Usefulness of Feedback." *Active Learning in Higher Education* 22: 229–243. doi: 10.1177/1469787419872393

Henry, Meredith A., Shayla Shorter, Louise Charkoudian, Jennifer M. Heemstra, and Lisa A. Corwin. 2019. "*FAIL* Is Not a Four-Letter Word: A Theoretical Framework for Exploring Undergraduate Students' Approaches to Academic Challenge and Responses to Failure in STEM Learning Environments." *CBE–Life Sciences Education* 18: ar11. doi: 10.1187/cbe.1806-0108

Jackson, Brian. 2020. *On Transfer: Teaching Mindful Writers.* Logan: Utah State University Pres.

Kittle, Penny. 2008. *Write Beside Them: Risk, Voice, and Clarity in High School Writing.* Portsmouth, NH: Heinemann.

Knutson, Kristopher, Jennifer Smith, Mark A. Wallert, and Joseph J. Provost. 2010. "Bringing the Excitement and Motivation of Research to Students; Using Inquiry and Research-Based Learning in a Year-Long Biochemistry Laboratory: Part I—Guided Inquiry—Purification and Characterization of a Fusion Protein—Histidine Tag, Malate Dehydrogenase, and Green Fluorescent Protein." *Biochemistry and Molecular Biology Education* 38: 317–323.

Lee-Keller, Helen. 2009. "Scholarship Automatically Reminds Me of Grant Money." In Behling 2009, 11–28.

Lopatto, David. 2003. "The Essential Features of Undergraduate Research." *CUR Quarterly* 23(3): 139–142.

Manarin, Karen, April McGrath, and Miriam Carey. 2016. "Original Undergraduate Research in Classroom Contexts: Student Perceptions of a Scaffolded Approach." *CELT* ix: 11–17.

Markle, Gail. 2017. "Factors Influencing Achievement in Undergraduate Social Science Research Methods Courses: A Mixed Methods Analysis." *Teaching Sociology* 45: 105–115. doi: 10.1177/0092055X16676302

Matos, Angel Daniel. 2016. "Queer Consciousness/Community in David Levithan's Two Boys Kissing: 'One the Other Never Leaving.'" In *Gender(ed) Identities: Critical Rereadings of Gender in Children's and Young Adult Literature,* ed. Tricia Clasen and Holly Hassel, 59–74. New York: Routledge.

McDorman, Todd. 2004. "Promoting Undergraduate Research in the Humanities: Three Collaborative Approaches." *CUR Quarterly* 25(1): 39–42.

Morrison, Charles D. 2014. "From 'Sage on the Stage' to 'Guide on the Side': A Good Start." *International Journal for the Scholarship of Teaching & Learning* 8(1): ar4.

Murray, Donald. 1972/2003. "Teach Writing as a Process not Product." In *Cross-Talk in Comp Theory: A Reader,* 2nd ed., ed. Victor Villanueva, 3–6. Urbana, IL: NCTE.

Rand, Jane. 2016. "Researching Undergraduate Social Science Research." *Teaching in Higher Education* 21: 773–789. doi: 10.1080/13562517.2016.1183621

Sommers, Nancy. 1982. "Responding to Student Writing." *College Composition and Communication* 33: 148–156.

Taczak, Kara, and Liane Roberston. 2017. "Metacognition and the Reflective Writing Practitioner: An Integrated Knowledge Approach." In *Contemporary Perspectives on Cognition and Writing,* ed. Patricia Portanova, J. Michael Rifenburg, and Duane Roen, 211–229. Fort Collins, CO: The WAC Clearinghouse; Boulder: University Press of Colorado. doi: 10.37514/PER-B.2017.0032.2.11

Tapp, J. 2015. "Framing the Curriculum for Participation: A Bernsteinian Perspective on Academic Literacies." *Teaching in Higher Education* 20: 711–722.

Taylor, Laura A. 2021. "Scaffolding Literacy Learning through Talk: Stance as a Pedagogical Tool." *Reading Teacher* 74: 375–383. doi: 10.1002/trtr.1958.

Thomas, Ebony Elizabeth. 2020. *The Dark Fantastic: Race and the Imagination from Harry Potter to the Hunger Games.* New York: NYU Press.

Tinberg, H. 2015. "Metacognition Is Not Cognition." In *Naming What We Know: Threshold Concepts of Writing Studies,* ed. Linda Adler-Kassner and Elizabeth Wardle, 75–76. Logan: Utah State University Press.

Todd, Malcolm, Phil Bannister, and Sue Clegg. 2004. "Independent Inquiry and the Undergraduate Dissertation: Perceptions and Experiences of Final-Year Social Science Students." *Assessment & Evaluation in Higher Education* 29: 335–355. doi: 10.1080/0260293042000188285

Traga Philippakos, Zoi A. 2021. "Think Aloud Modeling: Expert and Coping Models in Writing Instruction and Literacy Pedagogy." *Language and Literacy Spectrum* 31(1): 1–27.

Wiggins, Grant, and Jay McTighe. 1998. *Understanding by Design.* Alexandria, VA: Association for Supervision and Curriculum Development.

Wilder, Laura, and Joanna Wolfe. 2009. "Sharing the Tacit Rhetorical Knowledge of the Literary Scholar: The Effects of Making Disciplinary Conventions Explicit in Undergraduate Writing and Literature Courses." *Research in the Teaching of English* 44: 170–209.

Wilson, Reed. 2003. "Researching 'Undergraduate Research' in the Humanities." *Modern Language Studies* 33(1–2): 74–79.

Yancey, Kathleen Blake, Matthew Davis, Liane Robertson, Kara Taczak, and Erin Workman. 2018. "Writing across college: Key Terms and Multiple Contexts as Factors Promoting Students' Transfer of Writing Knowledge and Practice." *The WAC Journal* 29(1): 42–63. doi: 10.37514/WAC-J.2018.29.1.02

CHAPTER 7

Ungrading through Portfolios: Embracing Failure in the Research Writing Classroom

Keri Lee Carter and John Lando Carter

Abstract. This case study shares the experiences of first-year undergraduate writers with a fused ungrading and portfolio approach in the research writing classroom. The authors describe how an iterative fail-reflect-learn cycle helps students recognize failure and error as a necessary part of the research process. The authors also provide examples of reflective resources and forms to aid instructors and students in the ungrading process.

doi: 10.18833/cf/12

Many first-year student writers fear failure. Students have told us, their composition instructors, that they "aren't great writers." Others express anxiety about plagiarism in research writing, not knowing what exactly it is but hoping they avoid it. The irony, however, is that the English instructor's job is to *teach* research skills as part of the writing process. Just as students should not be expected to possess skills for a course not yet taken, students should not hold themselves to that expectation either. Nonetheless, students are afraid of failing because of the often severe and absolute consequences. This can be especially true for underrepresented students who may have fewer prior experiences and resources (Feldman 2019; Muhammad 2015). Students punished for research-related offenses such as plagiarism might fail, lose financial aid, and—at worst—may quit college with a sense that they do not belong. First-year writing courses are the gateway to understanding college-level research, and it is critical that the learning environment invites students to navigate the complexities of research without high-stake penalties. Therefore, ungrading—an assessment approach that challenges traditional grading policies and procedures while empowering both students and instructors to focus on learning—invites both failure and reflection to produce meaningful growth in research-based, first-year writing courses (Blum 2020a). In requiring students to revise projects and reflect on their growth through a portfolio, we ask students to assess their own semester-long learning and embrace failures so they can grow. As Eyler (2018) notes, "failures (both small and large) tend to make up quite a bit of the terrain on the road to discovery" (172). Ungrading through portfolios can help students recognize that failure is a necessary part of the learning process in research writing.

The concept of ungrading means to decrease or remove the focus of grades and points to increase a focus on feedback (Blum 2020a). Although students and instructors may ultimately have to conclude each course within a grading system established by the higher education institution, ungrading advocates for student-teacher consensus of grades based on learning and growth. Ungrading provides a space for failure as learning while it dismantles assessment practices of privilege. Inoue (2015) argues that everything done in a classroom, including assessment, is part of a "superstructure" system where the teacher and student enact certain hegemonic conventions. When some control of the superstructure is relinquished to students, antiracist assessment is enacted, he explains. In fact, Inoue (2019) challenges instructors to consider how habits of mind such as "curiosity, openness, and engagement" makes writing students slaves of the instructors' standards, measures, and conceptions of those very habits of mind: "how do we know what those noncognitive dimensions of students' learning look like? Might they look different in different students, different groups of students, different contexts and schools, different activities?" (25). White, middle-class racial habits, according to Inoue, imbue writing classrooms both consciously and unconsciously; thus, whose habits of mind are being assessed—directly or indirectly—and to what end?

To implement ungrading, Blum (2020a) advocates for portfolio assessment because it not only forces students to reflect in iterative waves throughout their learning experience but also provides the opportunity to showcase their "total experience" in the course. As Ericsson and Pool (2016) make clear, novices need both time and many tries to truly master something, and portfolio assessment, where wins and near-wins are placed side by side, can showcase students' nonlinear, error-filled paths toward course outcomes. Further, Strommel (2020) argues that portfolios are more than a "receptacle" in which to deposit assignments; rather, they should be a "metacognitive space" for students to explore their learning (38). Students must see that failure is part of the learning process; in fact, Blackwelder (2020) advocates for students to envision their learning as a continual progression of trial and error instead of "a judgement of who they are." He adds, "If my students did not fail, they did not learn" (47). Warner (2020, 208) likens this learning to fail process as a Wile-E.-Coyote moment that students need to embrace: "Wile E. Coyote is a planner, an iterator, each failed initiative giving rise to the next."

Once we share with students that the journey through failure is, in and of itself, learning, we can begin to build an authentic partnership with them. Blackwelder (2020) notes that without ungrading, relationships with students can become dependent upon the accumulation of gradebook points. Using portfolios to implement ungrading practices allows both instructors and students alike to relinquish the power that grades have over learning. As a result, feedback, which can often be ignored by students in the hunt for points or letters, becomes central to the writing process, and discussions between instructors and students become growth-centered, thus alleviating arguments over points and deductions.

The students in our research writing classroom are typically first-year undergraduates in the course Research and Argumentative Writing, which is the second course in a first-year writing course sequence. The course objectives are focused on the understanding the research process, building information literacy, finding and using library source materials, analyzing arguments, and writing original research-based arguments. Classes traditionally reach capacity at 20 students. To fully engage students in the research writing process, projects are student-centered. For example, students read two articles on the same topic of their choice and compose a rhetorical analysis that compares and contrasts the authors' rhetorical moves. Students also write a research-based argumentative essay on a topic of their choice. The topic is approved by the instructor after the student completes a multi-topic research proposal, where students explore at least three potential ideas before settling on one. Finally, students complete a remix project where they take their research-based essay and transform the work into a new form or genre of their choice.

In utilizing ungrading, we help students embrace failure through individual assignment reflection documents (see Appendix 1), which take the place of rubrics on individual assignments, and course portfolios that include a final grade form and reflection document (see Appendix 2) at the end of the semester. The individual assignment reflection documents give students the opportunity to explore their challenges and successes on each project while practicing intensive and authentic reflection throughout the semester. Additionally, these individual assignment reflections provide us with insight into the students' mindset concerning their confidence and ability. By the end of the semester, students have continuously reflected on their work and have received feedback from us aided by the course reflection documents. Students use the feedback to continue to revise projects for the final course portfolio. At the end of the semester, students include all original and revised projects into a course digital portfolio, fill out the final document concerning the work they have completed, and write a final course reflection that aids in the conception of the final grade for the course. Students propose their final grade, and we approve it or propose an adjustment. Regardless, students have the opportunity to discuss their grade with us until a consensus is reached.

The individual assignment reflection forms are worth further consideration, as, through these, students have the opportunity to discuss successes as well as areas where they need coaching. These forms help students recognize that each paper will have weaknesses, perhaps even flat-out failures, and that finding and recognizing problems is a tool for improvement. Csikszentmihalyi (2013) reveals that many of the most creative and innovative people—across fields of study—are *problem finders,* meaning that they actively seek out errors as *opportunities* to continue tinkering, creating, and innovating. Many students in our writing courses used the reflection documents to uncover and face their struggles with writing research papers:

> "I feel like the paper was more thrown together rather than organized and planned out. I also feel like the topic was too broad."
>
> "I am a little worried about the flow of the piece. I've had to come and go from this project. I am also worried about the whole thing and if it makes sense."
>
> "I struggled with my thesis and conclusion. How could I make them stronger?"
>
> "My sentence structure is too long, or it seems like I ramble."

Students willfully acknowledged that writing a research-based argumentative paper is challenging because not only do they have to utilize and incorporate research but also balance general writing skills as novices. They also invited instructors to guide and coach them through their failures rather than focusing on a grade they may feel does not reflect effort or growth. Additionally, the reflection forms provide a space for students to recognize pitfalls with research. For example, some students wrote:

> "I am not sure if I cited my sources correctly."
>
> "I'm wondering if I conveyed the information I gathered properly and used it effectively."
>
> "Should I also be including the names [of] the articles when I'm introducing evidence every time? For example, if I used the same article, do I have to state the title of the article again?"

The statements revealed common patterns of error seen in first-year research writing courses, and these students correctly identified problems with incorporating and citing research. Further, the reflection forms started an instructor-student dialogue about what to do with failures so that they could become opportunities for growth. Once the students received specific feedback about their inquiries, they were able to revise the papers for the final portfolio and were invited, once again, to reflect on the changes they made as well as their improvements and continuous struggles.

On the other hand, some students failed to recognize their failures in the first research-based essays. For instance, one student self-plagiarized her first essay by using research she collected for and writing from her communication studies speech course. The student's topic changed rapidly and drastically from the topic identified in her proposal planning document and other writings completed leading up to the paper. Through emails, we discussed the issue with the student and recognized the student's articulation of the connection between speech and writing. A conversation ensued about the concerns and challenges of trying to convert a speech and speech outline into an essay as well as the concept of self-plagiarism. We expressed to the student the importance of consulting with instructors about changing the topic of a paper and using work from another course. The student expressed gratitude about the opportunity to rework the essay, deciding ultimately to revert to an original topic from her planning document. She successfully completed the course, and in her final portfolio, she noted that the course helped improve her research writing skills. More importantly, her work and new paper illustrated an alignment with her actual understanding of the skills she claimed were areas of growth. The mismatch too often seen among student self-evaluation, reflection, and evidence of learning was not present.

Another student indicated on the reflection form that he felt "proud but also worried" about his paper. Although he did note that he had trouble finding research and integrating internal citations on his reflection document, he did not elaborate on this point in the commentary section. This student had unintentionally plagiarized portions of his paper by copying from websites and online student papers, and he did not include citations in many places. The student's worry about his paper was born out of a concern that he did not fully understand how to incorporate research and make the paper his own. When the student did incorporate research with citations, they were often lengthy quotes. Again, this opened up an opportunity to discuss with the student about how his ideas were valued and why he did not need to use the words of other students online. We discussed the idea of "common knowledge," reviewed how to paraphrase, and found sources to support many of his original ideas in the paper. Although the student's final paper still contained issues such as awkward introductions to quotes and avoidance of paraphrasing, the paper showed a better understanding of incorporating research and synthesizing information without plagiarism.

The process of self-discovery and back-and-forth dialogue between instructor and student in the ungrading portfolio class allows students to fail in the process of topic generation as well. For example, one student wanted to write about the military banning transgender people. Through dialogue with the teacher and help examining the literature, the student returned to class to discuss his topic. When asked if and how he was going to pursue the transgender debate concerning the military, the student replied that he did some research using the tools provided; this included reliable source-vetting information and specific library search guides. The student then noted that he had changed his mind based on that new information from credible sources. The student embraced the failed attempt at a first topic and pivoted to research about the Army and Marines' restrictions on visible tattoos and the need to loosen these restrictions. The time to revise, research, and return to brainstorming in a portfolio ecosystem allows students to fail in the exploratory phases of research. Topic generation often results in failure for the paper and perhaps the course because of a lack of options for a student who may face time restrictions. Sawyer (2013, 173) notes that thinking happens in a zigzag pattern, and great ideas often come from generating "boatloads of ideas" and letting most of them stay unused. Blum (2020a, 56) notes that "[c]heating, shortcuts, cramming—all those make sense if the only goal is points or winning." Thus, ungrading challenges the compulsion for correctness and quickness found with traditional grading approaches by allowing students to try and try again without the pressure of gaining or losing points.

In a research-based writing class, instructors must also normalize failure in information literacy by sharing the difficulties of research in the world of instant information. If the difficulty of information literacy in the context of academia and daily information consumption is not discussed, students will be unable to apply research strategies beyond the classroom. The study of Wineburg and McGrew (2019) about the research habits of fact checkers, historians, and students reveals the need for transparency concerning lateral versus vertical reading habits. Wineburg and McGrew (2019) explain that *lateral reading* means a researcher should not actually read a text immediately from top to bottom or scan up and down the page. Instead, the goal of lateral reading is to experience a deeper interaction by asking questions about the text to gain better insight into the text's relevance and reliability. The researcher will ignore the main text; open new tabs on the computer; and investigate "behind the scenes" information such as who sponsors or funds the information, how the author is an expert on the subject matter, and if the sources referenced are trusted by experts. Opening a dialogue about this process and creating a space to talk about being duped by fake news encourages students to own research failures and have greater awareness and acumen moving forward. In one class activity to launch a discussion about fake news, students read the NPR piece by Domonoske (2016), which summarizes the work of Wineburg and McGrew, and focuses on students' ability to spot fake news. In a discussion post about the article, one student wrote that high school research strategies did not allow her to fail, thereby rendering her ill-equipped to navigate the many ambiguities involved in research. She stated:

> [T]he skills they do teach us are becoming outdated. From my whole school career, the things I was taught was to never use Wikipedia and only use cites that end with .gov, .org, and .edu. And it wasn't until halfway through high school, they told me to only use articles from Opposing Viewpoints from Gale for my argumentative essays. Because they were the most reliable to use and the work cited in MLA was already done for me. No one taught me what to look for on websites and how to know which is reliable. We were never taught to fact check the facts.

An ungrading approach provides the time and space to make errors in research and then recover rather than shield students from errors or try to limit their research to a prescribed set of rules that often do not reflect the reality of source evaluation outside of the classroom in everyday life. According to Blum (2020a, 57), "Grades encourage a fear of risk-taking. Grades seem so consequential that students believe they can't take a chance on anything unproven….Yet mistakes are information and contribute to learning." Therefore, ungrading encourages growth in information literacy by allowing room for source exploration without the fear of getting it wrong the first time.

The ungrading research-writing classroom culminates in a final grade form and reflection document (see Appendix 2) that invites students to explore their growth, challenges, setbacks, and accomplishments. As stated previously, students turn in a digital portfolio that includes the originals and revisions of all major writing assignments, the completed grade sheet form that considers all work for the semester, and overall reflections on their progress. Space at the bottom of each section allows students to elaborate on reasons for an anomaly that may, in a traditional grading classroom, be seen as a failure instead of a catalyst for growth. In other words, when life happens, students should have the opportunity to acknowledge and overcome a barrier to learning. Students were told that they did not have to disclose deeply personal information but were encouraged to use the space to describe how they counteracted or moved forward from any obstacles. Although many students experience hardships during academic terms, they will continue to face barriers long after a course is finished. Instructors who not only acknowledge that life circumstances can interrupt learning but also give students the grace and time to recover reinforce a focus on learning and progress. Therefore, the final grade form provides a space for students to validate their progress in their own words, which supports a more equitable and inclusive learning experience. Sorensen-Unruh (2020, 141) agrees, stating that ungrading not only provides students with agency but also promotes social justice. Chu (2020) further explains that traditional grading gives those who already possess access and opportunity more access and opportunity, thus widening the gap for diverse learners concerning race, gender, socioeconomics, and so on (163). Ungrading and the final grade sheet, consequently, disrupt this access and opportunity gap.

A common worry of instructors considering an ungrading approach is that students will give themselves flawless scores. However, a clear grading sheet that guides students in proving progress along with the portfolio of revision encourages honest reflection and evaluation. One student wrote about his misunderstanding of discussion board response expectations; in a midterm progress report, the instructor clarified the expectations, and the student improved to meet the standard throughout the rest of the course. The final grade form allowed the student to explain his misunderstanding of the issue and showed how he fixed the problem; we encouraged the student to amend his portfolio grade to a higher grade based on his proof of progress versus an averaging of past mistakes. His failure followed by instructor feedback allowed for clarity, compromise, and—more importantly—deeper learning.

On the final grade form, students reflected upon their writing throughout the semester, and many used the word *struggles* to describe their experiences. One student stated about the grade: "[T]here was one major mistake with one of my assignments, but this mistake and the other smaller mistakes that were made gave me the opportunity to learn and showed me where I have room for growth and improvement." Another student noted the opportunity to revise: "I saw I missed a few things when I turn[ed] in my second assignment (lack of counterargument and having low research for some paragraphs). I was able to resolve these issues and learned that it is probably better to summarize or rephrase when writing, especially if it's long quotes!" Students also commented that they felt decreased anxiety regarding the fear of failure. One student stated, "I know if I was to get a grade on my research-based paper when I first turned it in, it would've been a very low score. And that score would [have] made me worry about my grade the rest of the semester . . . I would only focus on this grade rather than learning in this class or fixing my mistakes and grow as a writer." Instead of the constant worry over grades, the ungrading portfolio approach allowed students to propose an accurate self-reported grade that illustrated end-game growth, not an averaging of past attempts.

Blum (2020a) reminds us that current assessment practices frequently defeat the best of instructors' intentions in promoting learning, in establishing meaningful connections with students, and in giving students useful feedback. The evidence is clear. Novices in any learning context need time and repeated tries to zig and zag toward true mastery of learning outcomes, according to Ericsson and Pool (2016, xxii), who note that the lengthy and meandering road toward expertise can take a decade or more. Moreover, those attempts must be housed within a safe and encouraging learning environment where errors are celebrated as opportunities (Reeves 2016). Portfolios, then, provide students with a picture of their journey toward mastery by serving as a collection of low or no-stakes chances of trying, failing, and trying again differently, thereby allowing aspiring researchers to enter an iterative fail-reflect-learn cycle.

Acknowledging strengths while facing failures head-on in a portfolio approach is what helps students develop the tenacity and resilience needed to face future challenges within and beyond the classroom, whether it is writing the next research paper or vetting an internet article. When ungrading is fused with a portfolio approach, students can embrace failure and grow without fear in the research writing classroom.

References

Blackwelder, Aaron. 2020. "What Going Gradeless Taught Me About Doing the 'Actual Work.'" In Blum 2020b, 42–52.

Blum, Susan. 2020a. "Just One Change (Just Kidding): Ungrading and Its Necessary Accompaniments." In Blum 2020b, 53–73.

Blum, Susan, ed. 2020b. *Ungrading: Why Rating Students Undermines Learning (and What to Do Instead).* Morgantown: West Virginia University Press.

Chu, Gary. 2020. "The Point-less Classroom: A Math Teacher's Ironic Choice in Not Calculating Grades." In Blum 2020b, 161–170.

Csikszentmihalyi, Mihaly. 2013. *Creativity: Flow and The Psychology of Discovery and Invention.* New York: Harper Perennial.

Domonoske, Camille. "Students Have Dismaying Inability to Tell Fake News from Real, Study Finds." *National Public Radio.* November 23, 2016. https://www.npr.org/sections/thetwo-way/2016/11/23/503129818/study-finds-students-have-dismaying-inability-to-tell-fake-news-from-real

Ericsson, Anders, and Robert Pool. 2016. *Peak: Secrets from the New Science of Expertise.* Boston: Houghton Mifflin Harcourt.

Eyler, Joshua R. 2018. *How Humans Learn: The Science and Stories Behind Effective College Teaching.* Morgantown: West Virginia University Press.

Feldman, Joe. 2019. *Grading for Equity: What It Is, Why It Matters, and How It Can Transform Schools and Classroom.* Thousand Oaks, CA: Corwin.

Inoue, Asao B. 2015. *Antiracist Writing Assessment Ecologies.* Anderson, SC: Parlor Press.

Inoue, Asao B. 2019. *Labor-Based Grading Contracts: Building Equity and Inclusion in the Compassionate Writing Classroom.* Boulder: University Press of Colorado. doi: 10.37514/PER-B.2019.0216.0

Muhammad, Anthony. 2015. *Overcoming the Achievement Gap Trap: Liberating Mindsets to Effect Change.* Bloomington, IN: Solution Tree.

Reeves, Douglas. 2016. *Elements of Grading: A Guide to Effective Practice.* 2nd ed. Bloomington, IN: Solution Tree.

Sawyer, Keith. 2013. *Zig Zag: The Surprising Path to Greater Creativity.* San Franciso: Jossey-Bass.

Sorensen-Unruh, Clarissa. 2020. "A STEM Ungrading Case Study: A Reflection on First-Time Implementation in Organic Chemistry II." In Blum 2020, 140–160.

Strommel, Jesse. 2020. "How to Ungrade." In Blum 2020b, 25–41.

Warner, John. 2020. "Wile E. Coyote, The Hero of Ungrading." In Blum 2020b, 204–217.

Wineburg, Sam, and Sarah McGrew. 2019. "Lateral Reading and the Nature of Expertise: Reading Less and Learning More When Evaluating Digital Information." Teachers College Record 121(11): 1–20.

Appendix 1

Power Draft Reflection Form

Instructions: Turn in your Power Draft to D2L Dropbox. Then, complete the Reflection and turn it in to the same D2L Dropbox. Put an X in the blank box that applies.

How do you feel about this draft?

	Proud/Happy 😎
	Meh/Okay 😕
	Bad/Worried ☹
	Other (list):

What do you need guidance on? What would you like me to pay close attention to as a I read? (Select all that apply. Some categories may not apply to certain assignments.)

	Following/understanding the assignment		Transitions
	Content: Am I writing about the right thing?		Punctuation (such as commas, semicolons)
	Content/Depth: What else should I include?		Grammar (such as subject-verb agreement)
	Content/Depth: Did I include too much?		Tone—coming across the "right way"
	Organization (the order of ideas) for the project as a whole		Voice—sounding like *I* wrote this
	Organization for paragraphs—where to break them apart, combine, etc.		Design—the way it looks including visual elements, font, etc.
	Sentence variety		Choppiness/Sentence Combining
	Topic sentences		Finding Research/Sources
	Meeting genre expectations		Source Integration—making sources "talk" to each other
	Creativity/Originality		Internal/Parenthetical Citations
	Writing to/Appealing to my audience		References Page Citations
	Rhetorical appeals		Wordiness
	Word choice		Quoting/Paraphrasing/Summarizing
	Thesis statement		Other:

Explain more about the selections above as needed. What specifically are your concerns? What questions do you have for me?

What are you feeling most confident about concerning this project and your writing?

Which would you prefer?

	Extensive feedback—give me all the suggestions!
	Limited feedback—an end comment will suffice.

I need... (select all that apply)

	Encouragement!
	You to give it to me straight!

Appendix 2

FINAL GRADE RUBRIC
Carter S21 ENGL 1020

Criteria 1: Writing-to-Learn Assignments/Opportunities to Learn
Did you complete all **opportunities to learn (OTL)** each week (readings, videos, etc.) and complete all **Writing-to-Learn (WTL) assignments** (listed below) thoroughly and on time? Rate each category on a scale of 1-4

- 1= Weak/Incomplete—did not do the work/over a week late
- 2= Progressing—average work and/or completed a week late
- 3= Much Improved—average work completed on time
- 4= Strong to Excellent—strong to excellent work completed on time

Rating	**Week**	**WTL Due** (consider OTL completion as well)
	Week 1	Discussion: Introductions
		Dropbox: Interest Inventory
	Week 2	Discussion: Topics and Titles
	Week 3	Discussion: Practicing Losing the War
	Week 4	Dropbox: Opposing Viewpoints Power Draft Reflection Document
	Week 5	Discussion: Fake News
	Week 6	Dropbox: Proposal Planning Document
	Week 7	Midterm Survey (Google form)
	Week 8	Dropbox: Research-Based Argument Outline
	Week 9	Discussion: Thesis Statements
	Week 10	Dropbox: Notes about Example Papers
		Discussion: Example Papers
	Week 11	Dropbox: Research-Based Argument Power Draft Reflection Document
NA	Week 12	No WTL assignment
	Week 13	Add Remix to the D2L Discussion Board
	Week 14	Discussion: Remix Discussion Board (Responses)
Notes/Reflections:		

Criteria 2: Power Drafts
Rate each category on a scale of 1-4

- 1= Weak/Incomplete—Power Draft/Reflection NOT full/complete or 2+ weeks late.
- 2= Progressing—Power Draft/Reflection FULL/COMPLETE but was 1-2 weeks late.
- 3= Much Improved—Power Draft/Reflection FULL/COMPLETE but late (less than a week).
- 4= Strong to Excellent—Power Draft/Reflection COMPLETE and ON TIME.

NOTE: You MUST receive feedback on drafts to complete the final portfolio.

	Project 1 Opposing Viewpoints Assignment
	Project 2 Research-Based Argument Assignment
	Project 3 Remix Assignment
Notes/Reflections:	

Criteria 3: Final Portfolio Rubric

Rate each category on a scale of 1-4

- 1= Weak/needs a lot more development
- 2= Progressing/but needs more development
- 3= Much Improved/but could use some development
- 4= Strong/little work needed to Excellent/could serve as a model for future courses

	Include Power Draft and Revised Draft of Project 1, then examine: My ability to thoroughly revise Opposing Viewpoints Assignment as needed
	Include Power Draft and Revised Draft of Project 2, then examine: My ability to thoroughly revise Research-Based Argument Assignment as needed
	Include Remix, then examine: My ability to transform my ideas and research into a new genre
	Overall: My ability to read and examine texts in depth to elicit important information
	Overall: My ability to examine and analyze the rhetorical choices an author makes
	Overall: My ability to conduct secondary research and determine the best sources for a research project
	Overall: My ability to summarize, paraphrase, and quote from sources and cite them accurately and responsibly
	Overall: My ability to synthesize information from sources and integrate the information into my own writing and ideas
	Overall: My ability to argue a position with clarity and support
	Overall: My ability to generate in-depth, relevant content for writing projects
	Overall: My ability to organize an overall draft and create cohesive paragraphs
	Overall: My command of style in my projects: Word choice, sentence structure/variety, tone, eliminating wordiness
	Overall: My command of editing in my projects: Eliminating typos, command of commas/semicolons/other punctuation, use of grammar/mechanics

Notes on Final Grades (Read carefully):

To propose an **A** (100-90):

- **Criteria 1:** WTLs: At least 12 WTLs must be listed as 4's.
- **Criteria 2:** Power Drafts: At least two 4's. No 1's.
- **Criteria 3:** MOST portfolio ratings are 4's.

To propose a **B+** (89-87), **B** (86-83), or **B-** (82-80):

- **Criteria 1:** WTLs: At least 10 WTLs must be listed as 4's.
- **Criteria 2:** Power Drafts: At least one 4. No 1's.
- **Criteria 3:** MOST portfolio ratings are 3's and above.

To propose a **C+** (79-77), **C** (76-73), **C-** (72-70):

- **Criteria 1:** WTLs: At least 8 WTLs must be listed as 4's.
- **Criteria 2:** Power Drafts: No more than one 1.
- **Criteria 3:** MOST portfolio ratings are 2's and above.

Use +/- designations as needed to show variations in criteria above.
If you do not meet A, B, or C criteria, the instructor will designate your final grade as F/FA or N.
There is no D final grade for this course (university/departmental policy).

I have carefully reviewed and completed the above rubrics and criteria. I propose my final grade for the course to be the following letter grade:	**FINAL GRADE:**
Required: Use the space below to reflect on your course progress and to further explain your proposed grade.	

CHAPTER 8

No Such Thing as a *Bad* Question: Using Rubrics to Help Students Learn from and Strengthen Failed Research Questions

Kathleen Baril, Justine Post, and Bethany Spieth

Abstract. This chapter uses findings from a mixed-methods study of undergraduates' research experiences in a developmental writing course at a small, private university to suggest that writing bad research questions is a necessary part of the research process and that students can learn valuable lessons from the struggle to pose effective questions if given the necessary support. It offers a set of rubrics that can be used to evaluate the debatability, researchability, and feasibility of students' research questions to help students turn failed research questions into successful ones.

doi: 10.18833/cf/18

The research process is often full of failure for undergraduate students. They experience challenges choosing a topic, finding sources, and using those sources in a written work. Many researchers have written about the fraught process of research for students, although mentors do not always teach students that failure is part of the research process.

Developing research questions can be difficult even for the most accomplished of researchers. Many books and articles are directed toward question formation in graduate and professional research (e.g., Capili 2020; Mattick et al. 2018; White 2017; Williamon et al. 2021). When faced with learning how to both write and research, first-year college students are confronted with obstacles. For instance, in the information search process model of Carol Kuhlthau (1991, 366–67), she writes about the challenging feelings experienced by students in the early stages of research, beginning with uncertainty and apprehension as they realize they have a lack of knowledge or understanding and followed by feelings of confusion, frustration, and doubt that emerge in the "exploration stage." Other researchers have noted that students struggle with narrowing their topics as part of the research process (Buell and Kvinnesland 2018), and Fister (1992) writes that students in her study found that "getting a focus for research was the most challenging and the most time-consuming part of the entire project."

Without an understanding of the role that failure plays in the research process, students can experience intensified negative feelings during the early stages of their research when they inevitably encounter roadblocks in the process (Henry et al. 2019). If these roadblocks lead students to conclude that they are unable to achieve the specific demands of the research task (Henry et al. 2019), the feelings noted by scholars like Kuhlthau (1991), Buell and Kvinnesland (2018), and Fister (1992) can become debilitating. This chapter proposes a method for helping students refocus and reframe their research topics so they can learn to see "failed" research questions as an important part of the research process. Rubrics that offer concrete guidelines to students for evaluating the quality of their research questions enable them to refine their research questions and ultimately embrace moments of failure as necessary steps toward creating more effective questions.

Consequently, there is no such thing as a bad research question, as students must write their way through failed questions to develop research questions worthy of scholarly inquiry. For students to learn from the struggle to pose effective research questions, their failures must be recognized and supported. By creating space for failed research questions and actively inviting failure into the research process, research mentors can help students start to see the obstacles they encounter not as failures but as opportunities to refine and strengthen their research.

Posing Effective Research Questions: A Review of the Literature

Students' ability to pose effective research questions is essential to their success as researchers. According to Scharf and Dera (2021, 1), "Having a good question provides focus and clarity to research and provides organization that helps synthesize the evidence." Despite the significance of research questions, however, little attention has been paid to the formulation of research questions in the many writing and research handbooks produced by the rhetoric and composition community (Scharf and Dera 2021).

Question formulation has been addressed in information literacy scholarship but usually in reference to topic formation (Bodi 2002; Eckel 2019; Lundstrom and Shrode 2013; Rinto, Bowles-Terry, and Santos 2016) rather than the formation of research questions. For instance, Bodi (2002) wrote about ways to assist students in narrowing their topics through asking a series of questions, and Eckel (2019) examined how students choose topics and analyzed their thesis statements in their papers. In both of these studies, question formation was explored as an additional or alternative way to approach the topic narrowing process, not as an essential preliminary research skill.

The few studies that have examined question formation as an essential research skill have proposed instructional methods for improving this skill that range from short units to individual class activities or worksheets. Strangman and Knowles (2012) created lessons for an introductory business research methods class that included a three-day research question unit that substantially improved students' questions. Badia (2016) conducted a class in which students created research questions from general topics and then discussed each question to determine its quality. Unlike Strangman and Knowles (2012), Badia did not provide any formal assessment data, noting only that the students gave positive feedback on the activity. Similarly, in two separate studies, Kanter and Byrd (2020) as well as Pecher, Chu, and Byrd (2020) developed worksheets that assisted students in refining their topics into appropriate research questions but did not formally assess the effectiveness of these approaches. Kanter and Byrd (2020, 5) reported that "the students found the worksheet to be helpful in articulating what students want to find out (what they don't know) about a topic and figure out what they want their readers to understand about the topic (why is the research important)." Pecher et al. (2020) likewise reported that students found their worksheet helpful, as it moved them from a topic to what the researchers referred to as a problem statement.

Although studies like these offer promising pedagogical strategies that students clearly perceived as useful, the lack of attention to the quality of the research questions that students produced—with the notable exception of Strangman and Knowles (2012)—means it remains unclear whether the majority of these interventions are actually effective in improving students' research skills. To assess the quality of students' research questions, a reliable and valid tool is needed.

Rubrics offer great promise for effectively assessing students' research questions, as Oakleaf (2009, 970) notes that rubrics create "agreed-upon values of student learning" between university librarians and faculty as well as provide detailed assessment data that can increase consistency across assessments. In fact, rubrics have been used to evaluate students' information literacy skills, including their ability to find quality sources, find varied sources, annotate sources, effectively use sources in writing, and accurately cite sources (Carbery and Leahy 2015; Chisholm and Spencer 2019; Daniels 2010; Gola et al. 2014; Jastram, Leebaw, and Tompkins 2014; Lantz, Inusa, and Armstrong 2016; Rinto 2013; Rinto and Cogbill-Seiders 2014; Rosenblatt 2010). Rubrics in these studies enabled researchers to draw conclusions about the quality of a wide range of students' information literacy skills.

Few studies, however, have used rubrics to assess the quality of students' research questions. In the studies that have been conducted, researchers were able to identify key issues encountered by students as they struggle to pose effective questions. Using a rubric that assessed researchability, breadth, topic-related vocabulary/language context, and arguability, Rinto, Bowles-Terry, and Santos (2016) found that first-year students struggled with choosing topics that were researchable and offered an appropriate breadth. Furthermore, they found most students were at the developing stage for arguability, an outcome they found satisfactory, noting that "students need a great deal of time to fully engage with a topic before they have the necessary knowledge to fully enter into a scholarly conversation and make a persuasive claim" (Rinto et al. 2016, 760). In a similar study, Eckel (2019) refined the rubric used by Rinto et al. (2016) and used it to evaluate the topics of first-year engineering students. Eckel's students also struggled with topic breadth and, like the previous study, scored in the beginning or developing stages for arguability.

Although these studies generated valuable insights for the researchers, one limitation is that rubrics like these are usually designed for assessment by instructors rather than supporting the development of students' information literacy skills. Consequently, the pedagogical benefits that rubrics can provide have not been fully realized. Furthermore, despite the great promise that rubrics hold, they also pose clear challenges for those who use them. As Erlinger (2018, 453) explains, rubrics "can provide very reliable assessment results, but they can be difficult and time-consuming to develop and use effectively." Although rubrics can provide reliable assessment results, reliability is not inherent within all rubrics but instead results from careful development of rubric criteria and intensive user training. Both Rinto et al. (2016) and Eckel (2019), for instance, reported that they were unable to achieve sufficient interrater reliability using the rubrics they developed in their studies. Although alternative methods can be used to resolve scoring discrepancies such as the "tertium quid" method used by Rinto et al. (2016) in which every response is scored by two raters and then discrepancies are resolved by a third rater, studies like these highlight the need for intensive work in both the development of rubric criteria and user norming before a rubric can be effectively utilized. This is particularly important for consideration if rubrics are used as a pedagogical tool to support the development of students' information literacy skills.

Consequently, what follows below are new rubrics that—with proper norming—can be used to reliably evaluate the quality of students' research questions. These rubrics not only can help researchers better assess the quality of students' research questions but also can be utilized by students to help them learn to recognize successes and failures in the research questions crafted by themselves and/or their peers. This pedagogical use can help students identify and overcome the obstacles they encounter in their research process, ultimately creating opportunities for them to strengthen and refine their research as they work their way through moments of failure.

Supporting Students: Curricular Interventions and Rubric Development

The rubrics presented in this chapter emerged from a mixed-methods case study of undergraduates' research experiences in a developmental writing course at a small, private university. This study was designed to examine the effects of coordinating and embedding library and writing center support for the first-year students enrolled in the course. In part, this involved intensive collaboration between the writing center director, who was also the course instructor, and the instructional librarian to significantly improve the course curriculum and expand the research instruction and support received by students.

Curricular Interventions Supporting the Development of Students' Research Questions

Over the course of a six-week unit, students were required to pose four research questions so that they could have repeated practice developing this essential research skill. During the first week of the unit, students read a short selection about academic research from the second edition of *An Insider's Guide to Academic Writing* (Miller-Cochran, Stamper, and Cochran 2019). In addition, they completed a brainstorming activity to generate a list of potential research questions and refined that list using five criteria from this book: personal investment, debatable subject, researchable issue, feasibility, and contribution.

These criteria, which are outlined in Table 1, became the framework for the research instruction that students received in this course and directly shaped the rubrics that emerged from this study, with two exceptions. Contribution was not emphasized in the research instruction that students received or in the rubrics that were developed, because students' status as beginning academic writers limited their ability to contribute to a scholarly conversation as scholars such as Rinto et al. (2016) have found. Eliminating this criterion removed one barrier that might have posed difficulties for first-year students, therefore increasing their chances to succeed at this early stage in the development of their research skills. Personal investment, in contrast, was emphasized in research instruction but omitted from the rubrics that were developed to ensure that questions could be assessed by any individual, not just the person who asked the research question.

TABLE 1. Research question criteria

Criteria	Guiding questions
Personal investment	Is this an issue you care about? If the issue is too broad, is there a way you can narrow down the topic to an aspect of the issue that is of the most importance to you?
Debatable subject	Could two reasonable people looking at evidence about this issue come to different conclusions?
Researchable issue	Can you find adequate published evidence to support a position on this issue?
Feasibility	Is the scope of the research question manageable, given the amount of time you have to research the issue and the amount of space in which you will make your argument?
Contribution	Will your response to your question contribute to the ongoing conversation about the issue?

Source: Miller-Cochran et al. 2019, 82

The next week, students attended a library instruction session, selected the research question they wanted to develop, and completed a worksheet that used the questions provided by Miller-Cochran et al. (2019) to guide their self-assessment of the debatability, researchability, and feasibility of their research question and to reflect on their personal investment in their question (see Table 1). In addition, the worksheet required them to obtain feedback from a librarian on the debatability, researchability, and feasibility of their question. Using their self-assessments and librarian feedback, students were then required to revise their initial research questions by the end of week 2.

Once their research questions were revised, students spent the third week of the unit finding three scholarly journal articles that answered their question. In addition to further developing students' research skills, this experience offered an additional opportunity for students to assess and refine the quality of their research questions as they struggled or succeeded in finding scholarly sources. Students were then provided a simple rubric that they could use to evaluate their research questions. The rubric asked students to score their personal investment in their research question and to score the debatability, researchability, and feasibility of their question. This rubric offered a simple five-point Likert scale ranging from *not at all* to *extremely* (e.g., not at all debatable to extremely debatable) without descriptions of specific criteria for each score.

Finally, as students learned about writing conventions in three academic disciplines, they continued to practice posing effective research questions, writing a new research question at the end of each week-long unit that would be asked by a scholar in the humanities during week 4, the social sciences in week 5, and the natural sciences in week 6. Students continued to complete self-assessments of the debatability, researchability, and feasibility of their research questions and additionally engaged in a peer workshop for each discipline where they used these criteria to assess their classmates' research questions and provide one another with additional feedback.

Data Collection: A Corpus of Student Research Questions

Research questions were collected from 19 study participants (70.4 percent of enrolled students) across two sections of the developmental writing course. The questions collected included students' initial research questions that they posed early in the semester; their revised questions that they submitted three weeks later; and their humanities, social sciences, and natural sciences questions that were each submitted a week apart at the end of mini-units on each discipline. A total of 93 research questions was collected across these five assignments. Complete data sets were collected from 17 participants, with two participants each failing to complete one assignment.

Developing Rubrics to Evaluate the Quality of Students' Research Questions

After the conclusion of the semester, the analysis of students' research questions began. Initial attempts to apply the rubrics used by students for their self-assessments immediately revealed that more robust rubrics were needed, as the researchers' scores were extremely inconsistent. In the initial coding efforts, there were very few agreements across researchers, which required a fair amount of discussion to resolve discrepancies in the scoring. It became clear that debatability, researchability, and feasibility were not straightforward concepts as the researchers had originally assumed but instead were subject to wildly differing interpretations. These discussions led to the development of specific criteria that could be used to evaluate the debatability, researchability, and feasibility of students' research questions, and two separate norming sessions were conducted for each rubric. However, like Rinto et al. (2016) and Eckel (2019), the authors were unable to achieve sufficient interrater reliability with the initial rubrics.

Because the goal was to not only evaluate the quality of students' research questions but also to develop a tool that could be reliably used to support the development of students' research skills, the initial scoring discrepancies were not resolved; instead, the rubrics were substantially revised for debatability, researchability, and feasibility. For each rubric, the authors made preliminary revisions; scored a set of research questions; and met to discuss discrepancies, resolve discrepancies, and refine the rubric criteria. After three to four rounds of scoring, discussion, and revision of each rubric, substantial agreement was achieved for debatability and moderate agreement for researchability and feasibility according to the guidelines suggested by Landis and Koch (1977), with weighted Cohen's kappas of 0.636, 0.556, and 0.469 respectively.[1] Furthermore, because the authors discussed and resolved all the discrepancies, they ultimately achieved 100 percent agreement for the rubric scores presented here.

The final rubric for debatability is presented in Table 2, researchability in Table 3, and feasibility in Table 4 (see also Ohio Northern University n.d. for the full set of rubrics). Each rubric provides evaluations of the quality of students' research questions accompanied by definitions, examples from the dataset, explanations of examples, and numeric scores. Example questions were pulled directly from the dataset and are authentic, unrevised student work. Although the scores are useful for identifying patterns across students, a higher score on each rubric does not always mean a more effective research question. For debatability, for instance, extremely debatable questions are certainly the most debatable questions that students can ask; however, they may not be the most effective research questions as they rely on the evaluation of values and belief systems that make persuading those who disagree particularly challenging. The highest scores on the feasibility rubric, in contrast, indicate that a question is too broad; the lowest scores indicate that a question is too narrow; and the strongest questions actually receive a score of three for being appropriate in scope.

Although these rubrics were not utilized by the students who participated in the study, the fact that they can be used with moderate to substantial agreement among instructors suggests that they would make stronger pedagogical tools than existing models. However, for students to be able to effectively use these tools, they must be integrated into class activities in ways that help students develop shared understandings of the rubric criteria. The results of the analysis of students' research questions are presented below, demonstrating how these rubrics can be used outside of the classroom to assess students' learning and suggesting ways that rubrics can be used as pedagogical tools to support the development of students' information literacy skills by enabling students to identify and effectively revise failed research questions.

Using Rubrics to Assess the Quality of Students' Research Questions

The students who participated in the study showed improvement in the debatability, feasibility, and researchability of their research questions over the course of their six-week research unit. It should be noted, however, that due to the small sample size, these results are based only on descriptive statistics and have not been tested with inferential statistics. As Figure 1 demonstrates, students showed steady improvement in the debatability of the questions they posed during the first half of the unit, moving from an average score of 2.42 to 2.70.[2] Students' average researchability score showed a similar increase from 4.32 to 4.61 by the end of the unit. Additionally, students' feasibility scores showed an even more dramatic improvement, shifting from an average of 4.16, indicating that most students were asking broad questions at the start of the unit, to 3.33, indicating that students were asking increasingly appropriate questions by the unit's end.

TABLE 2. Rubric for evaluating the debatability of research questions

Evaluation	Definition	Example	Explanation	Score
Not at all debatable: *Identification*	The question or statement is an *identification* of a topic in broad terms that do not indicate a debate.	Abortion	Although abortion is a highly controversial topic, research questions can range from description to evaluation.	0
Not at all debatable: *Description*	Answering the question requires a simple, factual *description* that reports information that is well established.	Do all psychopaths become criminals or killers?	The answer to this question is simple and well documented: no.	1
Not debatable: *Explanation*	Answering the question requires a more in-depth or detailed *explanation* that outlines a process, concept, or mechanism that is well understood and documented.	How does playing video games affect kids' sleep?	Because this question asks *how* playing video games affects sleep, the answer must explain this well-understood process.	2
Neither debatable nor undebatable: *Interpretation*	Answering the question requires a more in-depth or detailed *interpretation* that outlines a process, concept, or mechanism that is not well understood due to insufficient or inconclusive evidence.	Do violent video games cause depression in adolescents?	Although this question calls for a simple yes or no answer, the relationship between violent video games and depression is not well understood.	3
Debatable: *Decision*	Answering the question requires a *decision* about which of a number of conflicting evidence-based stances can be most persuasively supported.	Should schools have a later start time based on the amount of sleep that students get?	This question requires making a decision between two evidence-based stances: yes due to the benefits of increasing sleep or no because of the drawbacks of delaying school start times.	4
Extremely debatable: *Evaluation*	Answering the question requires an *evaluation* of values or belief systems that provoke passionate and conflicting evidence-based stances.	Should teachers carry guns in a high school classroom?	The evaluation this question calls for includes numerous values and beliefs such as the right to bear arms and the right to a safe learning environment.	5

TABLE 3. Rubric for evaluating the researchability of research questions

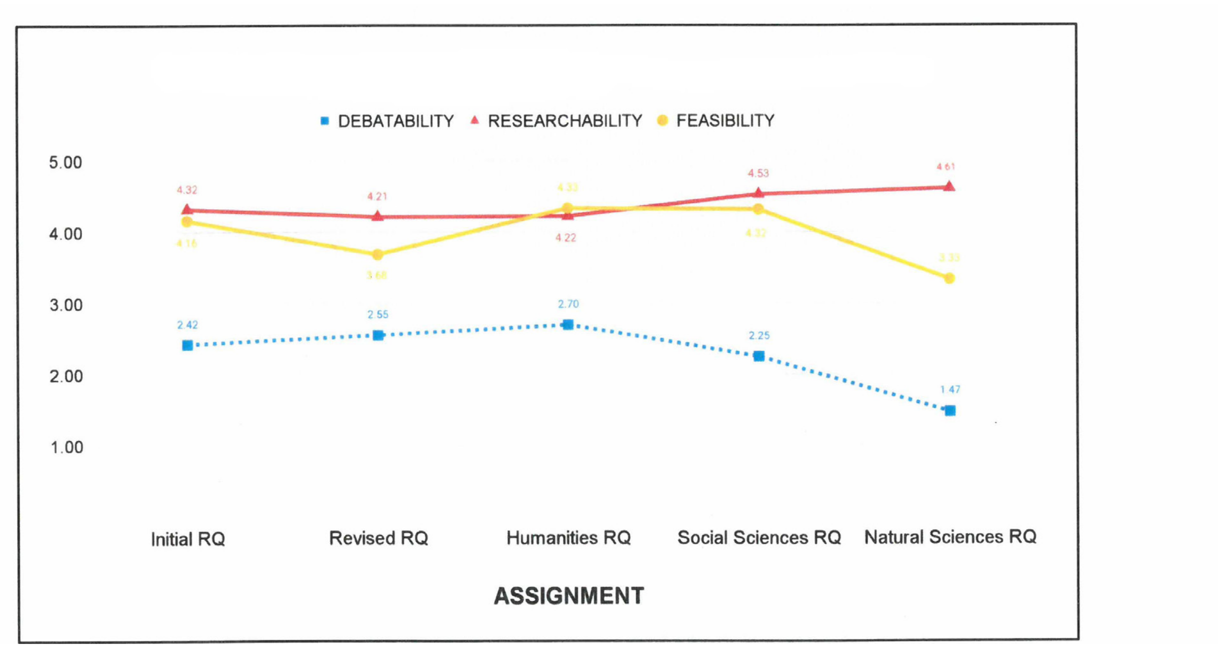
Evaluation	Definition	Example	Explanation	Score
Not at all researchable	Searching does not reveal any relevant sources of any type.	What are the effects of blue light on sleep from different smartphone operating systems?	Although the effects of blue light from electronic screens on sleep are well documented, the issue of different effects from different smartphone operating systems is not one that has been written about, as there is likely to be little to no difference in effects among operating systems.	1
Not researchable	Searching does not reveal any relevant sources of an appropriate type. Some relevant sources of other types may be found.	Is having a Mac or a PC better for sound design and operation?	This question is mostly a matter of personal preference and therefore not something that scholars investigate. However, numerous popular consumer electronics publications and personal blogs have articles on the topic.	2
Neither researchable nor unresearchable	Searching reveals some relevant sources of an appropriate type, defined as between 1 and 5 sources in the first 50 results.	Is it ethical to change the geography of Mars?	The ethics of colonizing Mars appears to be an emerging topic that selected scholars are just beginning to examine. The researchers found only a few relevant scholarly publications on the topic.	3
Researchable	Searching reveals many relevant sources of an appropriate type, defined as between 6 and 10 sources in the first 50 results.	How do you run hurdles faster?	The science of running hurdles faster is a topic that has received some scholarly study, meaning the researchers were able to find a handful of sources on the topic.	4
Extremely researchable	Searching immediately reveals many relevant sources of an appropriate type, defined as 11 or more sources in the first 50 results.	Do video games cause violence?	Possible links between video games and violence have been researched extensively in a variety of fields (public health, economics, criminal justice), meaning there is a large amount of published scholarly literature on the topic.	5

TABLE 4. Rubric for evaluating the feasibility of research questions

Evaluation	Definition	Example	Explanation	Score
Not at all feasible: *Extremely narrow in scope*	The question is too focused in ***two*** or more areas, addressing a topic, population, time period, and/or location that is too specific to draw meaningful conclusions that can be generalized or applied to other contexts.	How does the iPhone operating system make interaction personalized for teens?	Because observations about the iPhone operating system cannot be generalized to other platforms and operating systems are not tailored to age groups, the topic and population are too focused.	1
Not feasible: *Narrow in scope*	The question is too focused in ***one*** area, addressing a topic, population, time period, or location that is too specific to draw meaningful conclusions that can be generalized or applied to other contexts.	What are the effects of blue light on sleep from different operating systems?	There are no differences in the effects of blue light across different operating systems; therefore, the topic is too focused.	2
Feasible: *Appropriate in scope*	The question uses a specific approach to a single topic that cannot be meaningfully broken down into smaller topics, populations, time periods, or locations in a way that impacts the conclusions that can be drawn.	Would reducing the use of motor vehicles help reduce air pollution?	This question takes a specific approach (cause and effect) to a single topic. Although the topic could be broken down by type of vehicle or location, it is unlikely that doing so would impact the conclusions that can be drawn.	3
Not feasible: *Broad in scope*	The question is unfocused in ***one*** area, addressing (a) multiple topics, populations, time periods, or locations, or (b) a topic, population, time period, or location across which one conclusion would not hold.	Should schools have a later start time based on the amount of sleep students get?	Since biological needs and rhythms differ across age groups, one conclusion cannot hold across the entire population of students from K–12 to higher education.	4
Not at all feasible: *Extremely broad in scope*	The question requires a specific approach that is not defined, or it is unfocused in ***two*** or more areas, addressing (a) multiple topics, populations, time periods, and/or locations, or (b) topics, populations, time periods, and/or locations across which one conclusion would not hold.	How does mental health affect a prisoner?	Mental health is a complex topic that encompasses a wide range of issues and conditions. Prisoner populations also have significant differences (e.g., age, race, gender) across which one conclusion would not hold.	5

These increases in the quality of students' research questions, however, were accompanied by comparable declines in quality. For each assigned research question, students' average scores improved or remained relatively stable in two categories and declined in one. When students revised their initial research questions, for example, they improved their debatability and feasibility scores, whereas their researchability scores declined. As debatability peaked in students' humanities research questions, feasibility became correspondingly worse, with students posing the broadest questions they asked all semester. In the students' social sciences research questions, they made positive gains in researchability and feasibility, whereas debatability declined. This pattern held through students' natural sciences research questions, where they simultaneously achieved their strongest scores for researchability and feasibility and their weakest score for debatability. Like Rinto et al. (2016), as well as Eckel (2019), the students struggled most with posing debatable research questions.

FIGURE 1. Quality of Research Questions Over Time



Quality of research questions (RQ) by category and assignment.

These patterns could suggest that the task of developing an effective research question is taxing; as resources and attention are devoted to improving some aspects of a research question, other aspects—even those with which students have had prior success—break down (see Gere 2019 for a consideration of the role that regression plays in writing development). There are, of course, limitations to what be concluded from this data, as the sample size is too small to establish statistical significance, and other variables likely played a role in the effectiveness of students' research questions (such as the challenge clearly encountered by students when trying to pose debatable questions in the sciences or the relative ease they may have experienced when writing feasible natural sciences questions). Future research could avoid these limitations by generating larger sample sizes and more carefully controlling variables across assignments. Even so, these patterns still offer meaningful insights into the research experiences of the students enrolled in this course. Failure, it seems, was integral to the development of their research questions.

For each success experienced by the students in the study, they encountered a corresponding failure. This held true as students revised their initial research questions, which were not disciplinary-specific, and as they attempted to pose discipline-specific questions later in the semester. Certainly, asking students to explore disciplinary conventions presented unique challenges and depleted some of the resources and attention that students were able to devote to improving the researchability, debatability, and feasibility of their research questions. Had students been given the time and space to focus exclusively on writing research questions without competing pedagogical goals like learning disciplinary conventions, they may have had more opportunities to learn from their failures and strengthen their research questions. In any case, it is clear from their failures that these students would have benefited from more concrete evaluative criteria to guide their revisions, like the definitions and examples outlined in the rubrics that emerged from this study.

These limitations aside, students did demonstrate gains from repeated opportunities to pose research questions. Alongside their moments of failure, every student who participated in the study also showed improvement in at least one category of the analysis on at least one research question, with 89.5 percent of participants improving the overall quality of at least one of the research questions they posed. As Table 5 demonstrates, students showed the greatest gains as they revised their initial research questions, with 42.1 percent of participants improving the overall quality of their revised questions. This result is not surprising, as the first three weeks of the curriculum included targeted interventions to support students' revision of their initial questions—interventions that were not provided for later research questions. This suggests that the initial interventions not only helped a higher proportion of students improve the quality of their research questions but also that these kinds of targeted interventions are necessary to sustain and support students' continued development. This point is reinforced by the inconsistent quality of students' revisions, which are exemplified by the data in this table. Clearly, more robust support for students' question development is needed.

TABLE 5. Developments in students' overall question quality by assignment

Overall quality[a]	Improved quality	No change	Worsened quality
Revised research question	42.1%	26.3%	31.6%
Humanities research question	16.7%	44.4%	38.9%
Social sciences research question	21.1%	42.1%	36.8%
Natural sciences research question	33.3%	61.1%	5.6%

[a] Overall quality was determined by comparing a research question to the previous question posed by the student and identifying whether the score in each category of analysis improved, stayed the same, or worsened. When gains outweighed losses (i.e., improvement in two out of three categories or improvement in one category with no change in two categories), the question was designated as improved in overall quality. When losses outweighed gains (i.e., losses in two out of three categories or losses in one category with no change in two categories), the question was designated as worsened in overall quality. When there was no net difference across questions (i.e., no change in any category or an improvement in one category, a loss in one category, and no change in one category), the question was designated as unchanged in overall quality.

Although the support offered at the start of this unit certainly benefited some students, Table 5 also shows that a significant portion of students, 31.6 percent, actually worsened the overall quality of their revised research questions. None of these six students showed improvement in any category, with one declining in both debatability and feasibility, three declining in debatability, and two declining in researchability. All but one of these students' revisions targeted categories that did not need improvement and overlooked categories that did, leaving students with revised research questions that were ultimately less successful. This issue was not limited to the six students who made ineffective revisions to their initial research questions. Every student who participated in this study declined in effectiveness in at least one category on at least one research question, with 84.2 percent of participants worsening the overall quality of at least one of their research questions. For these students in particular, more support was clearly needed to help them recognize the strengths and limitations of their research questions and effectively focus their revisions.

Students' lack of self-assessment skills likely played a key role in the failures they encountered while revising their research questions. Each of the six students who worsened the overall quality of their revised research questions significantly overestimated their success in at least one category of evaluation when their self-assessment scores were compared to the researchers' resolved rubric scores. Five of the six students identified questions that the researchers coded not debatable as debatable or extremely debatable. Students also struggled to accurately assess the feasibility of their research questions, with four students overestimating the feasibility of their questions and one student identifying a question that the researchers coded as appropriate in scope as not at all feasible. Similarly, half of these students overestimated the researchability of their questions, whereas the other half underestimated researchability, in contrast to the researchers' scores. The inconsistencies between the researchers' evaluations and the students' self-assessments reinforce the need for increased support such as reliable rubrics and targeted instructional interventions that can help students learn to effectively evaluate the quality of their research questions.

Without more robust guidelines like the rubrics presented in this chapter, students were left to rely on their own often limited knowledge of the topics addressed in the questions they posed. In contrast to writing handbooks like *An Insider's Guide to Academic Writing* (Miller-Cochran et al. 2019), which tend to position posing effective research questions as a simple and straightforward process, concepts like *debatability, researchability,* and *feasibility* in actuality are abstract and open to a wide range of interpretations even among experts such as librarians and writing instructors. If students do not have concrete methods for crafting and evaluating their research questions, the complexity and importance of this process is overlooked, and a substantial opportunity to further students' development and research skills is missed. To learn from their failed research questions, students need the opportunity to turn them into successful ones.

More than anything else, then, these results demonstrate the need for a reliable pedagogical tool that can be used by writing instructors, librarians, students, and others to evaluate the quality of research questions. To better support students' development, the rubrics offered here should be integrated into library and classroom instruction, with careful attention devoted to training students to accurately and reliably use them to evaluate the effectiveness of research questions.

Using Rubrics to Improve Students' Research Skills

The rubrics provided in this chapter offer promising tools to help students better recognize where their research questions succeed and where they fail, ultimately helping them overcome obstacles they may encounter in the early stages of the research process. Many studies have indicated the usefulness of rubrics in improving student performance in the classroom (Andrade 2005; Forrest and Moquett 2016; Rublee 2014). For these rubrics to contribute to the development of students' research skills, however, they must be effectively integrated into classroom instruction.

The time spent calibrating these rubrics—scoring small sets of questions, resolving discrepancies, and refining the criteria—helped the authors to reach a better understanding of the criteria established and think more critically about what really makes a question debatable, researchable, and feasible. For students to benefit from the use of rubrics in the classroom, they need to experience this same kind of norming process, scoring small sets of questions as a class and individually, discussing and resolving discrepancies across scores, and refining the criteria on each rubric as needed so that they align with the evolving understandings of a particular classroom community. This work could take place in any combination of full class discussions or workshops, in peer workshops, and even in individual worksheets. What is key, however, is that students can practice using these rubrics with guidance from mentors. The fact that students and mentors do not understand rubric criteria in the same way is well documented (Li and Lindsey 2015; Rust, Price, and O'Donovan 2003; Sadler 2010). Because most students have little to no experience using rubrics, proper training and support are essential for even a reliable rubric to benefit students.

Initial rubric training should involve instructional sessions discussing examples of pre-scored questions with students. The initial and revised research questions provided in Tables 6, 7, and 8 may prove particularly useful for these discussions, as students can compare each question set to the relevant rubric and discuss why the quality of the question improved, worsened, or remained unchanged as a result of the revisions made. This approach not only helps familiarize students with the rubric and scoring criteria but also provides them with models of effective and ineffective research questions. Research has demonstrated that looking at expert or model examples can improve student writing (Bunn 2013; Charney and Carlson 1995). Consequently, these rubrics hold potential to improve students' abilities to both write and assess research questions. Students can also practice revising the ineffective questions in these tables and in the rubric examples, so they meet the criteria established for effective questions. By introducing the rubrics in this way, mentors can practice a gradual release of responsibility (Duke and Pearson 2008–2009), beginning with explicit instruction and demonstration before asking students to use the rubrics collaboratively, individually with guidance, and finally on their own. Using this approach, students and mentors can develop shared understandings of the rubric criteria and begin to concretize abstract concepts that might otherwise remain obscured.

TABLE 6. Developments in debatability from initial to revised research question

Debatability	Initial question and its score		Revised question and its score	
Improved quality	Gun violence	0	Should teachers carry guns in a high school classroom?	5
No change	Is it possible for humans to live on Mars?	1	What resources are needed to colonize Mars?	1
Worsened quality	Why should assisted suicide be legal?	5	What is the impact of assisted suicide on the community?	3

TABLE 7. Developments in researchability from initial to revised research question

Researchability	Initial question and its score		Revised question and its score	
Improved quality	How has depression and anxiety become more prevalent?	4	How does public stigma affect the way depression and anxiety are treated in today's society?	5
No change	Is having a Mac or a PC better for sound design and operation?	2	Is iPhone or Android more popular?	2
Worsened quality	Do video games cause violence?	5	Do violent video games cause depression in preadolescents?	3

TABLE 8. Developments in feasibility from initial to revised research question

Feasibility	Initial question and its score		Revised question and its score	
Improved quality	What is the best diesel motor?	5	What additives can increase the longevity and performance of diesel motors?	3
No change	How has depression and anxiety become more prevalent?	5	How does public stigma affect the way depression and anxiety are treated in today's society?	5
Worsened quality	Are all serial killers psychotic?	3	Do all psychopaths become criminals or killers?	4

Ultimately, the goal of these rubrics is to support students' development of effective research questions. To do this, students must learn to effectively evaluate where their own research questions succeed and where they fail; identify concrete targets for revision; and balance the competing demands of making a question debatable, researchable, and feasible. Using these rubrics, students can transform *bad* research questions from moments of failure into necessary stepping stones that support the development of their research skills. The benefits of this approach are twofold: students learn that there is no such thing as a *bad* research question—as *bad* questions lead the way to good ones—and also that failure is not an ending but rather an opportunity to begin again from a stronger position. Consequently, giving students the time and space to write their way into effective research questions creates necessary opportunities to learn from their failures and strengthen their research questions before they embark on writing a research paper.

Acknowledgments

This study was funded by an Association of College and Research Libraries Academic Library Impact Grant. The authors thank Carah Porter and Matthew Morgan for their participation in the study and their substantial contributions to data collection and early analysis.

Endnotes

1. Cohen's kappa is a statistical tool for measuring interrater reliability that accounts for both the frequency of agreements between coders and the likelihood of agreements based on chance. A weighted kappa score also accounts for the degree of disagreement between coders and can only be used when the variables being coded are ranked in relation to one another, as was the case in this study. Although Cohen's kappa is one of the most commonly used methods for assessing interrater reliability, it also has shortcomings. One key point of contention is Cohen's categorization of agreement (slight agreement: 0.01–0.20, fair agreement: 0.21–0.40, moderate agreement: 0.41–0.60, substantial agreement: 0.61–0.80, almost perfect agreement: 0.81–1.00), which identifies moderate agreement or higher as acceptable for establishing interrater reliability. In some fields, such as health-care studies, this standard has been critiqued as too lenient. See McHugh (2012) for more on this issue.
2. While the improvement in debatability is certainly positive, it is worth noting that neither score is actually debatable, as scores of two and three respectively indicate that a question can be answered by offering an *explanation* of a process, concept, or mechanism that is well understood or an *interpretation* of a process, concept, or mechanism that is not well understood due to insufficient or inconclusive evidence.

References

Andrade, Heidi. 2005. "Teaching with Rubrics: The Good, the Bad and the Ugly." *College Teaching* 53(1): 27–30.

Badia, Giovanna. 2016. "Question Formation: A Teachable Art." *College and Undergraduate Libraries* 23: 210–216. doi: 10.1080/10691316.2016.1167501

Bodi, Sonia. 2002. "How Do We Bridge the Gap between What We Teach and What They Do? Some Thoughts on the Place of Questions in the Process of Research." *Journal of Academic Librarianship* 28(3): 109–114. doi: 10.1016/S0099-1333(01)00302-0

Buell, Jesi, and Lynne Kvinnesland. 2018. "Exploring Information Literacy Assessment: Content Analysis of Student Prefocus Essays." *College and Research Libraries News* 79: 598–600. doi: 10.5860/crln.79.11.598

Bunn, Michael. 2013. "Motivation and Connection: Teaching Reading (and Writing) in the Composition Classroom." *College Composition and Communication* 64: 496–516.

Capili, Bernadette. 2021. "How Does Research Start? Identifying a Strong Topic of Interest and Developing a Well-Defined Research Question." *American Journal of Nursing* 120(10): 41–44. doi: 10.1097/01.naj.0000718644.96765.b3

Carbery, Alan, and Sean Leahy. 2015. "Evidence-Based Instruction: Assessing Student Work Using Rubrics and Citation Analysis to Inform Instructional Design." *Journal of Information Literacy* 9(1): 74–90. doi: 10.11645/9.1.1980

Charney, Davida H., and Richard A. Carlson. 1995. "Learning to Write in a Genre: What Student Writers Take from Model Texts." *Research in the Teaching of English* 29(1): 88–125.

Chisholm, Alexandria, and Brett Spencer. 2019. "Through the Looking Glass: Viewing First-Year Composition through the Lens of Information Literacy." *Communications in Information Literacy* 13(1): 43–60.

Daniels, Erin. 2010. "Using a Targeted Rubric to Deepen Direct Assessment of College Students' Abilities to Evaluate the Credibility of Sources." *College and Undergraduate Libraries* 17(1): 31–43. doi: 10.1080/10691310903584767

Duke, Nell K., and P. David Pearson. 2008/2009. "Effective Practices for Developing Reading Comprehension." *Journal of Education* 189(1–2): 107–122.

Eckel, Edward J. 2019. "Topic Development in the Freshman Engineering Paper: Finding a Focus." *Science and Technology Libraries* 38: 137–160. doi: 10.1080/0194262X.2019.1566042

Erlinger, Allison. 2018. "Outcomes Assessment in Undergraduate Information Literacy Instruction: A Systematic Review." *College and Research Libraries* 79: 442–479. doi:10.5860/crl.79.4.442

Fister, Barbara. 1992. "The Research Processes of Undergraduate Students." *Journal of Academic Librarianship* 18: 163–169.

Forrest, Scott N., and Kerry D. Moquett. 2016. "Improving Writing of College-Bound Students with Rubrics: An English Department's Collaborative Journey through Teacher Leadership." *Clearing House: A Journal of Educational Strategies, Issues and Ideas* 89(6): 179–184. doi: 10.1080/00098655.2016.1196103

Gere, Anne Ruggles. 2019. Introduction to *Developing Writers in Higher Education: A Longitudinal Study,* ed. Anne Ruggles Gere, 1–20. Ann Arbor: University of Michigan Press.

Gola, Christina H., Irene Ke, Kerry M. Creelman, and Shawn P. Vaillancourt. 2014. "Developing an Information Literacy Assessment Rubric: A Case Study of Collaboration, Process and Outcomes." *Communications in Information Literacy* 8(1): 131–144.

Henry, Meredith A., Shayla Shorter, Louise Charkoudian, Jennifer M. Heemstra, and Lisa A. Corwin. 2019. "*FAIL* Is Not a Four-Letter Word: A Theoretical Framework for Exploring Undergraduate Students' Approaches to Academic Challenge and Responses to Failure in STEM Learning Environments." *CBE–Life Sciences Education.* 18(1): 1–17. doi: 10.1187/cbe.18-06-0108

Jastram, Iris, Danya Leebaw, and Heather Tompkins. 2014. "Situating Information Literacy within the Curriculum: Using a Rubric to Shape a Program." *portal: Libraries and the Academy* 14: 165–186.

Kanter, Nathan R., and Vetria L. Byrd. 2020. "A Method for Transforming a Broad Topic to a Focused Topic for Developing Research Questions." Paper presented at the 2020 IEEE Frontiers in Education Conference, Uppsala, Sweden, October 2020. doi: 10.1109/FIE44824.2020.9273817

Kuhlthau, Carol. 1991. "Inside the Search Process: Information Seeking from the User's Perspective." *Journal of the American Society for Information Science* 42: 361–371.

Landis, J. R., and G. G. Koch. 1977. "The Measurement of Observer Agreement for Categorical Data." *Biometrics* 33(1): 159–174.

Lantz, Catherine, Glenda Marie Insua, and Annie R. Armstrong. 2016. "Student Bibliographies: Charting Research Skills over Time." *Reference Service Review* 44: 253–265. doi: 10.1108/RSR-12-2015-0053

Li, Jinrong, and Peggy Lindsey. 2015. "Understanding Variations between Student and Teacher Applications of Rubrics." *Assessing Writing* 26: 67–79.

Lundstrom, Kacy, and Flora Shrode. 2013. "Undergraduates and Topic Selection: A Librarian's Role." *Journal of Library Innovation* 4(2): 23–41.

Mattick, Karen, Jenny Johnston, and Anne de la Croix. 2018. "How to . . . Write a Good Research Question." *The Clinical Teacher* 15: 104–108. doi: 10.1111/tct.12776

McHugh, Mary L. 2012. "Interrater Reliability: The Kappa Statistic." *Bichemia Medica* 22:276–282.

Miller-Cochran, Susan, Roy Stamper, and Stacey Cochran. 2019. *An Insider's Guide to Academic Writing: A Brief Rhetoric.* 2nd ed. Boston: Bedford/St. Martin's.

Oakleaf, Megan. 2009. "Using Rubrics to Assess Information Literacy: An Examination of Methodology and Interrater Reliability." *Journal of the American Society for Information Science and Technology* 60: 969–983.

Ohio Northern University. n.d. "No Such Thing as a Bad Question—Supplementary Material." Accessed April 30, 2022. https://library.onu.edu/question-rubrics

Pecher, Devun, Zongchen Chu, and Vetria L. Byrd. 2020. "Developing Research Questions: A Method for Transforming a Question into a Problem Statement." Paper presented at the 2020 IEEE Frontiers in Education Conference, Uppsala, Sweden, October 2020. doi: 10.1109/FIE44824.2020.9274275.

Rinto, Erin E. 2013. "Developing and Applying an Information Literacy Rubric to Student Annotated Bibliographies." *Evidence Based Library and Information Practice* 8(3): 5–18.

Rinto, Erin, Melissa Bowles-Terry, and Ariel J. Santos. 2016. "Assessing the Scope and Feasibility of First-Year Students' Research Paper Topics." *College & Research Libraries* 77: 749–764. doi: 10.5860/crl.77.6.749

Rinto, Erin E., and Elisa I. Cogbill-Seiders. 2014. "Library Instruction and Themed Composition Courses: An Investigation of Factors That Impact Student Learning." *Journal of Academic Librarianship* 41: 14–20. doi: 10.1016/j.acalib.2014.11.010

Rosenblatt, Stephanie. 2010. "They Can Find It, but They Don't Know What to Do with It: Describing the Use of Scholarly Literature by Undergraduate Students." *Journal of Information Literacy* 4(2): 50–61.

Rublee, Maria Rost. 2014. "Rubrics in the Political Science Classroom: Packing a Serious Analytical Punch." *PS: Political Science and Politics* 47(1): 199–203.

Rust, Chris, Margaret Price, and Berry O'Donovan. 2003. "Improving Students' Learning by Developing Their Understanding of Assessment Criteria and Processes." *Assessment & Evaluation in Higher Education* 28: 147–164.

Sadler, D. Royce. 2010. "Interpretations of Criteria-Based Assessment and Grading in Higher Education." *Assessment & Evaluation in Higher Education* 30: 175–194. doi: 10.1080/0260293042000264262

Scharf, Davida, and Joanne Dera. 2021. "Question Formulation for Information Literacy: Theory and Practice." *Journal of Academic Librarianship* 47(4): 1–5. doi: 10.1016/j.acalib.2021.102365

Strangman, Laurie, and Elizabeth Knowles. 2012. "Improving the Development of Students' Research Questions and Hypotheses in an Introductory Business Research Methods Course." *International Journal for the Scholarship of Teaching and Learning* 6(2): 1–13.

White, Patrick. 2017. *Developing Research Questions.* London: Palgrave.

Williamon, Aaron, Jane Ginsborg, Rosie Perkins, and George Waddell. 2021. "Research Questions." In *Performing Music Research: Methods in Music Education, Psychology, and Performance Science,* 3–30. Oxford: Oxford University Press.

CHAPTER 9

Resilience in Research: Confronting Failure in Information Literacy Instruction

Catherine Meals

Abstract. This chapter describes an academic librarian's adoption of a research resilience philosophy toward teaching information literacy. It describes how such an approach, which focuses on the values and attitudes that are foundational to students' development as researchers, addresses the emotional elements of information seeking, challenges in instruction formats, and guidance from academic librarians' professional organization.

doi: 10.18833/cf/6

Discovering Research Resilience

As an academic librarian, one of my many roles is as a teacher, working with students to develop research skills and information literacy. In spring 2020, as I was planning an upcoming information literacy instruction session, a professor asked me to incorporate resiliency in research into my lesson plan—that is, what to do when things do not go well. I thought it was a great idea, and for the class, I included a module acknowledging that research almost inevitably involves struggles and offered specific tips on how to handle the most common research challenges that I had seen in working with students.

As I reflected on the class session later, I realized how much sense a resiliency approach made for information literacy and research skills instruction, particularly for students who are new to academic research and within the teaching constraints faced by many librarians. The Association of College & Research Libraries Framework for Information Literacy in Higher Education (2016), an influential guiding document for academic librarians who support the development of student information literacy, offers theoretical frames that had already encouraged me to think of, teach, and feel comfortable with the idea of searching and research as an iterative, exploratory process. So had my pre-librarianship career as a labor union researcher, where iteration and exploration were part of my daily work. But the conceptualization of research resiliency helped me understand that students often experience iteration and exploration—a perfectly normal and even useful aspect of the research process—as a form of failure and that I needed to address those feelings of failure head-on. The professor's request inspired me to adopt a research resilience approach to my information literacy instruction, one which names research as a complex process and focuses on the values and attitudes that students will need to successfully complete research projects rather than on specific research skills. With that approach, I can better address the role of affect in information seeking, respond to some of the challenges faced by librarians in typical information literacy instruction formats, and integrate the aspirations of the highly theoretical ACRL Framework into my classes in a more meaningful way.

The Role of Affect in Information Seeking

Carol Kuhlthau's influential research on information-seeking behaviors (1991, 2004, 2013) describes the role of emotion and feeling in student research, a concept that has been echoed in the library and information science literature since her first work was published (Cahoy and Schroeder 2012; Insua, Lantz, and Armstrong 2018). Students often anticipate that the research process will be a linear, relatively neat process of searching for and gathering information, and when it isn't, they experience anxiety and feel stymied (Kuhlthau 2013). These feelings are particularly acute for students who are encountering academic research for the first time, have never had formal education on research skills, or are returning students years removed from their last research assignment. These negative feelings in the research process not only cause emotional distress but can also derail students' cognitive processes and actions (Kuhlthau 2013).

Revisiting Kuhlthau's work through the lens of research resilience has deepened my appreciation of the connection between affect and cognitive outcomes and the gap between what students anticipate of research and the reality. My focus, then, has become preparing students for the emotional elements of research and possible negative feelings that may arise—what Kuhlthau refers to as the "tolerance of uncertainty [that] leads to patience and persistence that allows for building interest in emerging ideas" (2013, 93). If students are to achieve cognitive outcomes associated with research, we must first attend to the affective outcomes that serve as a foundation for them. That means supporting students in learning the values and attitudes necessary for successful research by initially focusing on affective dispositions such as persistence and resilience.

Addressing the Limitations of One-Shot Instruction

Focusing on affective outcomes is also a means of facing the limitations inherent in one-shot library instruction, a model in which a librarian teaches only a single class session on information literacy and research skills during the semester. The one-shot is the primary information literacy format at myriad institutions, including mine. Librarians are deeply aware of the limitations of the one-shot approach (Julien, Gross, and Latham 2018; Pagowsky 2021): one class session is insufficient to achieve measurable, lasting learning; it assumes a banking model of education; and it positions librarians as service providers when they are also teachers (Pagowsky 2021). As a result, academic librarians hope to replace the one-shot model with a more effective approach that integrates and scaffolds information literacy throughout the curriculum. But one-shots remain ubiquitous and, for now, are a reality that constrains teaching.

A research resilience approach to one-shot information literacy instruction, as well as a stronger recognition of the role of affect in the research process, has helped me focus on what I can do more successfully within the one-shot context—i.e., emphasize those affective outcomes that form the foundation for further learning—and reluctantly let go of the idea that my one-shot sessions must always achieve meaningful higher-level cognitive outcomes. Rather, I want students to understand that research is a complex process, that it requires exploration and experimentation, and that they may experience exploration and experimentation as failure. I want them to be prepared to feel these feelings, understand that they are normal, and know that exploration and experimentation are actually an integral component of the research process regardless of a researcher's level of expertise. I want them to know that my colleagues and I are there to help them as they learn, because knowing how to do research requires learning over time; it isn't innate. Where there is value in one-shots, then, it is in addressing these affective outcomes that better support students' research journey.

Integration with the ACRL Framework for Information Literacy in Higher Education

The affective outcomes I seek align with those described in the ACRL Framework. ACRL's adoption of the Framework in 2016 marked a major philosophical shift: the previous Information Literacy Competency Standards (2000) replaced by the Framework were skill- and performance-oriented, whereas the Framework is grounded in information literacy theory. The Framework focuses on core concepts and values of information literacy that acknowledge the complexity and ever-evolving nature of the information landscape and encourage the metaliteracy and metacognition that foster academic growth and lifelong learning. Further, it acknowledges the affective side of information literacy and encourages attitudes and values that reflect a resiliency approach to information literacy instruction.

The ACRL Framework contains six conceptual frames, each of which identifies a core information literacy concept and associated knowledge practices and affective dispositions. Two of the frames—Research as Inquiry ("Research is iterative and depends upon asking increasingly complex or new questions whose answers in turn develop additional questions or lines of inquiry in any field") and Searching as Strategic Exploration ("Searching for information is often nonlinear and iterative, requiring the evaluation of a range of information sources and the mental flexibility to pursue alternate avenues as new understanding develops")—include several dispositions tied to persistence that are especially relevant to research resilience. They call for students to "exhibit mental flexibility and creativity," "understand that first attempts at searching do not always produce adequate results," "seek guidance from experts, such as librarians, researchers, and professionals," and "persist in the face of search challenges"—that is, precisely the affective outcomes aligned with research resilience that I try to focus on the most. Given its theoretical nature, librarians have grappled with, and extensively debated, how to apply the ACRL Framework in information literacy instruction. Perhaps the best application, especially for novice researchers and in one-shots, seizes upon of what the Framework does well: emphasizing the role of the affective dimension in research and information literacy.

Research Resilience in the Classroom

To be clear, I still very much care about cognitive outcomes and want students to become skillful researchers. I do hope that students gain some skills from their time with me. I struggle with the feeling that, by focusing on affective outcomes, that I am not doing enough, so I do use my sessions to introduce specific research skills and tools. But I also clarify that my goal is to share concepts and introduce skills, and that my sessions are a launching pad for a longer research journey. Specific skills and knowledge are sharpened by practice and experience over time, by scaffolding of information literacy and research skills throughout the university curriculum, and by one-on-one time with me or my colleagues.

The following are a few of the specific approaches that I have begun using in one-shot classes to address research resilience. First, to reinforce the concept of research as a process, I typically organize the sessions around the arc of a common research process, from conducting background research and developing research questions to brainstorming and preparing search strategies, exploring and evaluating sources, and synthesizing and citing sources.

One activity, meant to illustrate the attitudes and values of research resilience, is a warm-up activity where students draw their research process. Students have drawn anything from elaborate winding paths and question marks to stick figures muttering expletives, but nearly all of them express anxiety, confusion, or uncertainty. This simple activity serves as a formative assessment, giving me a quick glimpse into students' confidence levels and stumbling blocks so that I can address them, but it also allows students to see their classmates' perspectives and appreciate that their fears and struggles are common and shared. In the hopes of normalizing failure, demonstrating that it is possible and part of the research process to face it and overcome it (Brown and Ramsey 2015; Ward 2020), and conveying that researchers at all levels of expertise face challenges, I also share a representation of my own process and all its peaks and valleys.

When I do introduce specific research skills to students, I avoid pre-prepared sample topics and searches to the greatest extent possible and specifically name stumbling blocks that students should anticipate and be prepared for. For instance, in modules on developing search terms, I include a class brainstorming activity in which students choose a research topic and generate potential keywords together. I encourage students to identify synonyms and related concepts or phrases as well, signaling that they will need to be ready to adjust their searches when they almost certainly will not find what they are looking for on their first, second, or maybe even tenth search. The brainstorm is intended to encourage the "mental flexibility and creativity" described in the ACRL Framework, as well as forecast the need to "understand that first attempts at searching do not always produce adequate results" and to "persist in the face of challenges." When we move to searching for sources, the next phase of the research process, we use the keywords, synonyms, and related phrases generated in the class brainstorm and do a live search, offering a real-time, real-life example of searching as strategic exploration. Any difficulties that arise in the process of searching for sources serve, for librarians, as an object lesson in the iterative, exploratory nature of the research process, and as a specific example of how to respond to research roadblocks (Brown and Ramsey 2015) and "persist in the face of search challenges."

I have also continued to use the module I included in the class for the professor who first asked about research resilience, with specific tips on the most common search-related challenges I see among students—finding too many or too few resources, or not finding relevant materials. I begin by explicitly acknowledging how challenging research can be and say to students that I want to offer tips for when, not if, things become hard and overwhelming. I start here by simply saying, "Breathe! This is normal! Research is a process! You got this (and can get help)!" Recognizing that students, especially low-income or first-generation students, may have a complicated relationship with the concept of failure (Hallmark 2018), I reiterate that my colleagues and I are here to help students develop research skills and information literacy and share the multiple ways they can contact us for support. Again, I hope to encourage the development of the resilience-oriented Research as Inquiry and Searching as Strategic exploration dispositions. Feedback on post-session assessment forms has suggested this approach is helpful. As one student wrote: "I will stop worrying about trying to be perfect, but I will actually let the process take its course and do more breathing." I am not trying to teach students to be resilient people or students—frankly, the vast majority of students at my institution are more resilient than I will ever be. What I hope to do, rather, is encourage this growth-oriented mindset: Research is a specific process that will require students to draw on the resilience already within them, and in which they can learn to overcome research struggles and grow into skillful researchers through the information resources and research techniques I am sharing and the support from my colleagues and me (Bowman and Levtov 2020; Yeager and Dweck 2012). Although it appears that there is not yet literature on the impact of such a growth mindset framework specifically in information literacy instruction, work in other disciplines suggests that teaching from this perspective, where challenges and overcoming failures are considered part of the learning process and academic growth, may accrue benefits to students (Darabi, Arrington, and Sayilir 2018; Fink et al. 2022). Tawfik, Rong, and Choi (2015) suggest, too, that an approach seeking to help students respond to mistakes or challenges may help students, specifically through strengthening their self-efficacy.

The Application and Evolution of Research Resilience

I want to acknowledge that some of what I have been able to do with a research resilience perspective could be unique to my setting: a small library with a close-knit team of librarians who have significant autonomy. Some librarians elsewhere may work with pre-prepared class plans and standardized content that do not allow the flexibility to prioritize affective outcomes or, in an increasingly neoliberal higher education environment, face extreme pressure to demonstrate "effectiveness" or "value" in metrics that do not reflect affective outcomes. I hope at least that my experience can contribute some perspectives or ideas that others can integrate into their teaching in whatever way feels appropriate.

What I have written here is a snapshot in time of my thinking on research resilience, and I expect it to evolve. I have only been an academic librarian since 2018, and with time, experience, and reflective practice, I will refine and improve upon my approach. As an assessment librarian, I want to explore approaches to assessing research resiliency and will therefore need to grapple with the challenges to meaningful assessment that the myriad variations in depth, content, and context of information literacy instruction present. As a teacher, I hope to reflect on and incorporate the idea of Cahoy and Schroder (2012) of honoring the positive emotions related to research, and the work of Mabee and Fancher (2020) suggesting that students may face additional challenges in achieving affective outcomes for research when they are experiencing poverty or trying to balance academic work with paid work and caregiving responsibilities. I hope, too, that my thinking will evolve as information literacy instruction is better integrated and scaffolded throughout the curriculum and we collaborate more deeply with course instructors. In essence, to help students succeed in research and increase their information literacy, I will need to explore and persist.

References

Association of College & Research Libraries (ACRL). 2000. "Information Literacy Competency Standards for Higher Education." Chicago: American Library Association. Last modified January 18, 2000. https://alair.ala.org/handle/11213/7668.

Association of College & Research Libraries (ACRL). 2016. "Framework for Information Literacy for Higher Education." Chicago: American Library Association. Last modified January 11, 2016. https://www.ala.org/acrl/standards/ilframework.

Bowman, Nicholas A., and Anat H. Levtov. 2020. "Understanding and Using Growth Mindset to Foster College Student Learning and Achievement." In "Effective Instruction in College Classrooms: Research-Based Approaches to College and University Teaching," ed. K. C. Culver and Teniell L. Trolian, spec. issue, *New Directions for Teaching and Learning* 164: 75–83. doi: 10.1002/tl.20426

Brown, Deana, and Elizabeth Ramsey. 2015. "Translating Failure into Success." *PNLA Quarterly* 80: 16–19.

Cahoy, Ellyssa Stern, and Robert Schroeder. 2012. "Embedding Affective Outcomes in Library Instruction." *Communications in Information Literacy* 6: 74–90. doi: 10.15760/comminfolit.2012.6.1.119

Darabi, Aubteen, Thomas Logan Arrington, and Erkan Sayilir. "Learning from Failure: A Meta-Analysis of the Empirical Studies." *Education Technology Research and Development* 66: 1101–1118. doi: 10.1007/s11423-018-9579-9

Fink, Angela, Paul S. Mattson, Michael J. Cahill, Regina F. Frey, and Mark A. McDaniel. 2022, February. "Growth Mindset Intervention Improves Performance of Highly Nontraditional Introductory Psychology Students at a Community College." *Teaching of Psychology* 49. doi: 10.1177/00986283211053806

Hallmark, Tyler. 2018, February 11. "When 'Failure Is OK' Is Not OK." *Chronicle of Higher Education.* https://www.chronicle.com/article/when-failure-is-ok-is-not-ok/

Insua, Glenda M., Catherine Lantz, and Annie Armstrong. 2018. "Navigating Roadblocks: First-Year Writing Challenges through the Lens of the ACRL Framework." *Communications in Information Literacy* 12: 86–106. doi: 10.15760/comminfolit.2018.12.2.3

Julien, Heidi, Melissa Gross, and Don Latham. 2018. "Survey of Information Literacy Instructional Practices in U.S. Academic Libraries." *College & Research Libraries* 79: 179–199. doi: 10.5860/crl.79.2.179

Kuhlthau, Carol. 1991. "Inside the Search Process: Information Seeking from the User's Perspective." *Journal of the American Society for Information Science* 45: 361–371.

Kuhlthau, Carol. 2004. *Seeking Meaning: A Process Approach to Library and Information Services.* Westport, CT: Libraries Unlimited.

Kuhlthau, Carol. 2013. "Rethinking the 2000 ACRL Standards: Some Things to Consider." *Communications in Information Literacy* 7: 92–97. doi: 10.15760/comminfolit.2013.7.2.139

Mabee, Sarah H., and Sarah E. Fancher. 2020. "Curiosity Is a Luxury of the Financially Secure: The Affective Thresholds of Information Literacy." *Library Trends* 68: 482–505. doi: 10.1353/lib.2020.0002

Pagowsky, Nicole. 2021. "The Contested One-Shot: Deconstructing Power Structures to Imagine New Futures." *College & Research Libraries* 82: 300–301. doi: 10.5860/crl.82.3.300

Tawfik, Andrew A., Hui Rong, and Ikseon Choi. 2015. "Failing to Learn: Towards a Unified Design Approach for Failure-Based Learning." *Education Technology Research and Development* 63: 975–994. doi: 10.1007/s11423-015-9399-0

Ward, Lindsay M. 2020. "On Becoming a Better Failure: How Failure Stories Can Shape Our Identities." *Character and . . . Identity* 6: 11–29. https://digitalud.dbq.edu/ojs/index.php/character/article/view/35

Yeager, David Scott, and Carol S. Dweck. 2012. "Mindsets That Promote Resilience: When Students Believe That Personal Characteristics Can Be Developed." *Educational Psychologist* 47: 302–314. doi: 10.1080/00461520.2012.722805

CHAPTER 10

A First-Year Community Intervention

Rory Waterman

Abstract. This chapter describes the efforts of a collaborative team at the University of Vermont that has developed a first-year seminar led by near-peer leaders emphasizing the tools of success in science as the foundation for community building in the university's largest science majors. The program has yielded greater persistence in these majors and greater retention at the university regardless of major, which indirectly supports positive coping with the pressures of the early science curriculum—retention markers that can only support future researchers.

doi: 10.18833/cf/5

Higher education demands individual achievement from students, yet many marginalized students come from collective home life or cultures (Estrada et al. 2016). Large, introductory courses have traditionally not been a venue to develop community around being a student in science. Additionally, introductory coursework continues to rely on lecture-based conceptualization rather than more effective "failure-based" models (Tawfik, Rong, and Choi 2015; Deslauriers et al. 2019; Freeman et al. 2014) that deemphasize the focus on "correctness" that leads to superficial learning (Chi and Wylie 2014) and is inconsistent with student development as scientists (Henry et al. 2019). Over several years, a collaborative team at the University of Vermont (UVM) has developed a first-year seminar that groups students with a near-peer leaders that emphasize the tools for success in science as the foundation for community building in the largest science majors.

Exams and grades, among many factors, are cause for student anxiety (AlKandari 2020), and that anxiety is a basis for a fear of failure in these courses. Although grades and processes by which they are determined is in question, they remain and are a major driver for a particular set of postgraduation outcomes (Schinske and Tanner 2014), making these courses "high stakes," which can increase the fear of failure (Henry et al. 2019). For example, students seeking admission to medical school represent a large portion of first-time, first-year students (i.e., new, non-transfer students entering in fall) with a declared a major in biology and seeking a bachelor of arts degree at UVM. Medical school admission is notoriously competitive, which heightens anxiety among students, and has stronger negative impacts on students historically minoritized from STEM majors (Yusoff et al. 2013). The university has a reputation for providing good pre-medical preparation (Martin n.d., citing 2010 data), and many out-of-state students come to this state flagship university to advance their medical ambitions. Despite UVM's high retention rate as compared to other state universities (approximately 85 percent), student attrition from the entry-level science curriculum is a uniform problem. Although university personnel work with students to help them find their genuine academic passion, it is key that introductory science coursework is not a barrier in that process. However, it has been well articulated that the reducing the stigma of failure is absent from the life science curriculum, and an early intervention is necessary to support students (Nunes et al. 2022).

In 2017, a first-year seminar course was designed and launched for life science majors within the College of Arts and Sciences at UVM. This collaborative effort between the dean's office and the Department of Biology also partnered with the Center for Academic Success on campus. The plan was to organize the cohort of majors into small discussion groups with a near-peer leader (second-year or later in the major). A mapped curriculum of student support as provided by the Center from Academic Success and department input, academic advising (see curriculum maps for new students at CAS n.d.), and major-specific information (e.g., information on research and professional development) was planned and provided. The entire operation was overseen by the biology first-year professional adviser, and near-peer leader training was provided by the Center for Academic Success. These sections included students seeking a bachelor of arts degree with majors in biology and zoology, and a bachelor of science degree with majors in biological sciences, neuroscience, and plant biology. The course had three critical goals: (1) Orient students within the major, (2) provide academic supports to promote success in introductory STEM classes, and (3) develop community among the large cohort of first-time, first-year biology majors. The near-peer leaders are in a relevant major in their second year or later; they completed the subject area and study skills tutor training through the Center for Academic Success (n.d.); and they are compensated on an hourly basis for training, planning, weekly meetings, and office hours (one per section) for their individual section(s) of the seminar that were capped at 24 students. UVM has moved to a responsibility center management (RCM) model, which made the tuition for the one-credit course available to funnel directly to student leader training and pay for hours worked. The Center for Academic Success paid for the transitional period.

The first goal of orienting the students to the majors was entirely pragmatic. The pool of life science majors is large, and effectively communicating opportunities in these majors for research, internship, and other enrichment opportunities was a challenge. These majors are also highly programmed such that communal advising during the sections prior to course registration is an effective practice. This was especially important in the time prior to uniform professional advising (i.e., dedicated full-time advising staff for first-year students) for all first-year students in the College of Arts and Sciences at UVM that was initiated in fall 2021. Students are required to declare a major by the close of their second year in the college, but many STEM-focused students arrive with a declared major. In recent years, the UVM Office of Institutional Research has provided "flow" data about trends of entering and leaving majors.

The second goal had evolved from prior attempts at academic interventions for students who had low first-semester GPAs but were above the cut-off for academic probation or other interventions. It had been found that such interventions proceeded with mixed efficacy. Some students had significant academic gains as a result of the interventions, but for others, the second-semester intervention seemed too late. The interventions for second-semester students followed a model of what would become this course, focusing on study skills, academic support, and community. Any intervention attached to first-semester performance appears punitive, despite the clear intent for student benefit. Therefore, providing equal introduction to UVM's student support network of academic coaching (time management, study skills, and so forth) as well as tutoring and other academic interventions was equitable and meant to promote access (Capstick et al. 2019). The introduction of these to all majors was deliberate in reducing potential stigma associate with their use. These are, of course, best practices to promote success, thereby minimizing anxiety, failure, and fear thereof. Indeed, student facilitators of the individual 24-seat sections are all trained as subject tutors in the key first-year courses as well as tutors in study skills.

Developing community was, in frank retrospect, the least well-formed or measurable goal. However, this objective was also most related to the notion of confronting failure. The initial thinking was that these groups would provide some sense of identity within a large major, and the emphasis on study skills and lessons in developing effective study groups would help nucleate cohorts of students that would develop into peer support groups. Students are assigned to provide evidence of working in peer study groups outside of the class, and anecdotal reports indicate that these groups persist. The tracking here is limited and relies primarily on self-report. One indication that these groups are steadfast through the students' first year is that students report choosing spring semester sections based on the schedules of study peers, at least according to limited anecdotal reports. The literature indicates that students in groups with peers regarded as safe can share their concerns over failure and be supported in developing failure tolerance (Nunes et al. 2022), which often is manifested as performance below personal expectation rather than literal failure.

True evidence for efficacy of these efforts comes from retention data. For each of the first three years of the program, retention at UVM of first-time, first-year students who had declared a biology major improved annually—around 0.75 percentage points on average per year. Retention across the College of Arts and Sciences was otherwise statistically unchanged in the same period—around 85 percent. It is important to note that the goal of this program was not to retain students in the majors. As described, many entering students with pre-medical ambitions may pursue the biology major under various assumptions, when any major pursuing a bachelor of arts degree would allow students to complete the requisite pre-medical coursework. Educating these students that they are not beholden to a major because of their medical ambitions complements UVM's Career Center advising that encourages students to study a range of disciplines rather than a prescribed major (UVM n.d.). An interesting aside has been the data from UVM's Office of Institutional Research that shows students leaving the biology major are increasingly staying in life science majors. This suggests that the program is helping students make more informed decisions about their life science majors, and it also indicates that persistence in science overall is being promoted. More work is needed to understand what factors are actually supporting greater retention in science, but there is a greater awareness of failure tolerance as a critical factor in this complex equation.

Failure tolerance, however, has been absent from this description of this activity because it was not an explicit objective. However, observation of these groups has shown that they have become a venue for *productive* coping (Skinner et al. 2003). After exams in the various introductory courses (biology, chemistry, and mathematics), near-peer mentors would ask students to engage in reflection on those exams to promote metacognition (Tanner 2012) based on their training. Participating students are open—and candid—about their expectations and whether or not those were met. Those conversations dovetail into problem solving, and those behaviors are reinforced by productive support from peers both emotionally and academically. This is an observation made by visiting some sections, but near-peer leaders report these as routine interactions as well.

Although not deliberate, there are reasons that may contribute to positive coping as a result of the course. First, the near-peer section leaders are subject area tutors and involved in other aspects of student success training. Part of UVM's approach to student success is to promote metacognition, and that translates easily into this environment. The near-peer mentors are easily trusted and provide a safe space for sharing met and missed expectations. Faculty members work hard to create those kinds of environments, but indeed, they only arise through deliberate effort. The extent to which these near-peer student leaders demystify support systems is an underexplored idea. If the challenge of the science = scientist paradigm (Archer et al. 2010) is accepted, then it can be recognized why many students would feel the need to “go it alone” if such assumptions were not being challenged by the near-peer mentors championing collective study and leveraging available supports. Beyond the positive effects of peer-led learning for minoritized identities in science (Snyder et al. 2016), there is good support for peer leaders being seen as more reliable and as potential role models that supports the notion of destigmatizing supports and positive learning practice (Winterton, Dunk, and Wiles 2020).

The end result is a need for further development on these initial, albeit unintentional, successes with respect to resilience. The UVM life science sections are sufficiently large so that the academic-year 2022 entering cohort has been able to select sections by identity, providing a yet more comfortable space and the chance to develop more supportive peer networks. The management of expectations and outcomes is crucial. The deliberate connection of the sections and the growth mindset language and lessons that are far more prevalent in the K–12 educational domain is another area for improvement in the program because it can help solidify the lifelong use of these techniques by students.

Acknowledgment

The first-year life science seminar at UVM was the product of a collaborative effort by biology faculty members, student services professionals, professional advisers, and academic support professionals with tremendous feedback from student section leaders. The author is pleased to share the rich fruit of their labors.

References

AlKandari, Nabila Y. 2020. "Students' Anxiety Experiences in Higher Education Institutions." In *Anxiety Disorders: The New Achievements,* ed. Vladimir V. Kalinin, Cicek Hocaoglu, and Shafizan Mohamed, 67–77. London: IntechOpen Ltd.

Archer, Louise, Jennifer DeWitt, Jonathan Osborne, Justin Dillon, Beatrice Willis, and Billy Wong. 2010. "'Doing' Science versus 'Being' a Scientist: Examining 10/11-Year-Old Schoolchildren's Constructions of Science through the Lens of Identity." *Science Education* 94: 617–639. doi: 10.1002/sce.20399

Capstick, M. Kyle, Leigh M. Harrell-Williams, Colton D. Cockrum, and Steven L. West. 2019. "Exploring the Effectiveness of Academic Coaching for Academically At-Risk College Students." *Innovative Higher Education* 44: 219–231. doi: 10.1007/s10755-019-9459-1

Center for Academic Success, University of Vermont. n.d. "Become a Tutor." Accessed April 17, 2022. https://www.uvm.edu/academicsuccess/become_tutor

Chi, Michelene T. H., and Ruth Wylie. 2014. "The ICAP Framework: Linking Cognitive Engagement to Active Learning Outcomes." *Educational Psychologist* 49: 219–243. doi: 10.1080/00461520.2014.965823

College of Arts and Sciences (CAS), University of Vermont. n.d. "Four Year Academic Roadmaps." Accessed April 17, 2022. https://www.uvm.edu/cas/four_year_academic_road_maps

Deslauriers, Louis, S. McCarty Logan, Kelly Miller, Kristina Callaghan, and Greg Kestin. 2019. "Measuring Actual Learning versus Feeling of Learning in Response to Being Actively Engaged in the Classroom." *PNAS* 116: 19251–19257. doi: 10.1073/pnas.1821936116

Estrada, Mica, Myra Burnett, Andrew G. Campbell, Patricia B. Campbell, Wilfred F. Denetclaw, Carlos G. Gutiérrez, Sylvia Hurtado, et al. 2016. "Improving Underrepresented Minority Student Persistence in STEM." *CBE–Life Sciences Education* 15: es5. doi: 10.1187/cbe.16-01-0038

Freeman, Scott, Sarah L. Eddy, Miles McDonough, Michelle K. Smith, Nnadozie Okoroafor, Hannah Jordt, and Mary Pat Wenderoth. 2014. "Active Learning Increases Student Performance in Science, Engineering, and Mathematics." *PNAS* 111: 8410–8415. doi: 10.1073/pnas.1319030111

Henry, Meredith A., Shayla Shorter, Louise Charkoudian, Jennifer M. Heemstra, and Lisa A. Corwin. 2019. "*FAIL* Is Not a Four-Letter Word: A Theoretical Framework for Exploring Undergraduate Students' Approaches to Academic Challenge and Responses to Failure in STEM Learning Environments." *CBE–Life Sciences Education* 18: ar11. doi: 10.1187/cbe.18-06-0108

Martin, Liza. n.d. "Top 10 Pre-Med Schools." Accessed October 10, 2021. https://www.theclassroom.com/top-10-premed-schools-2566.html

Nunes, Krystal, Sherry Du, Riya Philip, Mohammed Majd Mourad, Zainab Mansoor, Nicole Laliberté, and Fiona Rawle. 2022. "Science Students' Perspectives on How to Decrease the Stigma of Failure." *FEBS Open Bio* 12(1): 24–37. doi: 10.1002/2211-5463.13345

Schinske, Jeffrey, and Kimberly Tanner. 2014. "Teaching More by Grading Less (or Differently)." *CBE–Life Sciences Education* 13(2): 159–166. doi: 10.1187/cbe.cbe-14-03-0054.

Skinner, Ellen A., Kathleen Edge, Jeffrey Altman, and Hayley Sherwood. 2003. "Searching for the Structure of Coping: A Review and Critique of Category Systems for Classifying Ways of Coping." *Psychological Bulletin* 129: 216–269. doi: 10.1037/0033-2909.129.2.216

Snyder, Julia J., Jeremy D. Sloane, Ryan D. P. Dunk, and Jason R. Wiles. 2016. "Peer-Led Team Learning Helps Minority Students Succeed." *PLOS Biology* 14: e1002398. doi: 10.1371/journal.pbio.1002398

Tanner, Kimberly D. 2012. "Promoting Student Metacognition." *CBE–Life Sciences Education* 11(2): 113–120. doi: 10.1187/cbe.12-03-0033

Tawfik, Andrew A., Hui Rong, and Ikseon Choi. 2015. "Failing to Learn: Towards a Unified Design Approach for Failure-Based Learning." *Educational Technology Research and Development* 63: 975–994. doi: 10.1007/s11423-015-9399-0

University of Vermont (UVM). n.d. "Pre-Med at UVM." Accessed April 17, 2022. https://www.uvm.edu/premed/major-choice

Winterton, Christina I., Ryan D. P. Dunk, and Jason R. Wiles. 2020. "Peer-Led Team Learning for Introductory Biology: Relationships between Peer-Leader Relatability, Perceived Role Model Status, and the Potential Influences of These Variables on Student Learning Gains." *Disciplinary and Interdisciplinary Science Education Research* 2(1): ar3. doi: 10.1186/s43031-020-00020-9

Yusoff, Muhamad Saiful Bahri, Ahmad Fuad Abdul Rahim, Abdul Aziz Baba, Shaiful Bahari Ismail, Mohamad Najib Mat Pa, and Ab Rahman Esa. 2013. "Prevalence and Associated Factors of Stress, Anxiety and Depression among Prospective Medical Students." *Asian Journal of Psychiatry* 6: 128–133. doi: 10.1016/j.ajp.2012.09.012

CHAPTER 11

Picture This: Normalizing Struggle and Failure among Summer Undergraduate Researchers in the Arts and Humanities

Lisa Jasinski

Abstract. This chapter summarizes how a research project became a just-in-time intervention strategy to enable undergraduate researchers to address what it means to fall short—either of their own goals or the goals they perceived that others held for them—and to set the stage for appropriate coping mechanisms they could exercise to address the disconnect. The project extends research about how undergraduate STEM majors conceive of failure to a broader array of disciplines, including the arts and humanities.

doi: 10.18833/cf/14

Overcoming unfamiliar problems and mastering complex tasks is integral to learning. Psychologists Elizabeth and Robert Bjork (2015) touted the importance of "desirable difficulties" to the overall learning process, wherein a learner encounters ideally calibrated conditions (the task is neither too easy nor too hard). The Bjorks argued that when a learner lacks sufficient experience or background knowledge, a task may prove inscrutable, resulting in "undesirable" difficulties. Their work draws on the research of psychologist Lev Vygotsky (1978) that, when faced with an unfamiliar or difficult task, learners enter a "zone of proximal development" (ZPD), whereby they require the support of a more knowledgeable other (such as a tutor, teacher, or peers) and scaffolded opportunities to practice skills to master the unfamiliar task. Vygotsky argued that teachers ought to place learners in experiential situations wherein they can inhabit the ZPD and advance in their learning through interactions with peers and teacher guidance.

Undergraduate research, long recognized as a high-impact educational practice, has the potential to provide college students with this optimal degree of challenge—stretching them to extend their skills and knowledge beyond coursework—toward the pursuit of original contributions (Kuh 2008). At the same time, during an extended research project, an undergraduate researcher is all but guaranteed to encounter some undesirable difficulties such as skill gaps, setbacks, feelings of being overwhelmed, or even a failure that may require scrapping the project entirely (Latta 2019; Yu and Kuo 2017). Recognizing this likelihood, the research team framed a series of reflective prompts and discussion opportunities to learn about the ways in which more than 20 summer undergraduate research fellows (SURFs) engaged in arts and humanities projects navigated these arduous passages and to offer support when these moments inevitably arose.

This chapter summarizes how a research project to investigate students' cognitive and affective experiences as undergraduate researchers became a just-in-time intervention strategy to enable study participants to address what it means to fall short—either of their own goals or the goals they perceived that others held for them—and to identify the coping mechanisms they exercised to address the disconnect. The project extends research about how undergraduate STEM majors conceive of failure to a broader array of disciplines, including the arts and humanities. The chapter ends with practical tips for incorporating these reflective practices to guide undergraduate researchers in developing awareness, confidence, and skill to overcome potential derailments.

Translating Failure Research to Arts and Humanities Undergraduate Research

Failing—or the possibility of failing—has long been a routine and yet under discussed aspect of undergraduate education (Peelo and Wareham 2002). Seeking to shine additional light on this topic, the research of Meredith Henry et al. (2019) about STEM undergraduates provides a useful working definition for "challenge" or academic "failure," as "the inability to meet the demands of an achievement context, with the result of not achieving a specific goal." Their failure framework explains that STEM undergraduates often evaluate their own success according to both objective and subjective measures. For example, an objective measure might include successfully completing a technical task according to a provided protocol, while a subjective measure refers to a student's internal judgment of success (e.g., earning an "A" on said assignment). Henry et al.'s Failure Mindset Coping Model (2019) also makes an important temporal distinction between pre-failure and post-failure—namely how students think, act, and cope when failure is a looming prospect and after a setback has occurred. Attitudinal constructs such as mindset, goal orientation, and fear of failure often influence how a student responds to a challenge (pre-failure), while students' perceptions and responses to an actual failure are determined by factors such as attribution (what caused the failure) and coping strategies. A STEM student's ability to encounter and overcome a challenge (or a failure), reasoned Henry et al., is determined in large part by their attitudinal constructs and post-failure behavioral responses. This case study seeks to apply the Failure Mindset Coping Model to a different population, namely undergraduate researchers engaged in arts and humanities projects.

Background

In summer 2019, the research team received a small grant from Trinity University to investigate how 24 students experienced a 10-week Summer Undergraduate Research Fellowship (SURF) in the arts and humanities at a residential liberal arts college. Undergraduate research has been a mainstay of STEM disciplines for decades, and its benefits are well documented (Russell, Hancock, and McCullough 2007). Yet only in recent years have a critical mass of faculty-student teams partnered to advance research projects involving literature, film, culture, history, performing arts, and similar fields. In the last decade, Trinity has seen exponential growth in humanistic SURFs through a multiyear external grant that has involved hundreds of students (Mellon Initiative n.d.).

The team had two broad goals. First, it sought to better understand the experiences of SURFs to contribute to a broader understanding of how students develop the knowledge, skills, and confidence to engage in arts and humanities undergraduate research. Second, it aspired to translate this understanding into improved practice for faculty mentors and program administrators to bridge any gaps between unmet needs and support. While pursuing these goals, the team inadvertently came to understand a great deal about undergraduate humanities researchers' thoughts, attitudes, and responses to failure. This chapter will summarize what the team learned about the thoughts of SURFs about failure, hoping to inspire additional research on this topic and offering suggestions to improve the support to this student population in the future.

Sample Demographics and Characteristics

Although participation in the research study was voluntary, all 24 students enrolled in the 2019 summer undergraduate research program in the arts and humanities elected to participate. Via a participant questionnaire (Humanities SURF n.d.a), the majority (n = 17) self-identified as female (73.9 percent), six students identified as male, and one student identified as nonbinary. Eighteen students identified as White (75 percent), and six identified as students of color; this was roughly proportional to the overall racial demographics of the university. Eight students (33 percent) identified as having a disability, ranging from a mental health disorder to a long-term medical condition. Half of the students (n = 12) identified as heterosexual, whereas the other half identified as bisexual, queer, lesbian, or other. All students self-identified as U.S. citizens; no international students participated in the program that summer. All participants had matriculated as first-year students—none had transferred. More than half of participants (52 percent) reported that at least one of their parents had earned a master's degree or higher; two students identified the first person in their family to attend college. Seventeen percent of students received a Pell Grant, roughly proportionate to the overall student body at the university. Participating students were high academic performers—the group had an average cumulative GPA of 3.58 (the range was 2.5–3.97). At the start of the program, 70 percent (n = 16) expressed an interest in earning an advanced degree in the arts or humanities. Twenty participants lived on or near campus throughout the 10-week summer program (a few traveled to visit archives or collect data). Four of the study participants were away from campus for most or all of the summer, completing projects in other states or abroad; these students participated in the data collection to the extent they were able.

Methodology

Trinity's Institutional Review Board sanctioned the three social scientific research strategies of the project: online surveys, focus group discussions, and Photovoice prompts. Although the first two strategies may be more familiar, Photovoice emerged in the late 1990s from the field of health research; researchers empowered study participants by providing them with cameras to document their lived experiences, inviting them to reflect on those images through critical dialogue, and for the researchers to use their findings to lobby policymakers to align policy with community-identified needs (Wang and Burris 1997). Aided by the ubiquity of digital cameras and smartphones, the methodology has since been adapted for use in higher education settings (Latz 2017). These overlapping techniques yielded candid insights about students' thoughts and behaviors about undergraduate research, and empowered SURFs to verbalize their own challenges and to support peers in overcoming theirs. The data collected through focus groups and Photovoice prompts provided the most nuanced insights about how undergraduate researchers in the arts and humanities conceptualize and address their struggles and serves as the primary focus of this chapter.

Strategy 1: Weekly Online Surveys

Across the 10 weeks of the research program, the team administered a weekly electronic survey (Humanities SURF Research Study n.d.b). Students were diligent about completing the 10- to 15-minute "pulse" questionnaire as the response rates were consistently high (often greater than 90 percent). The instrument included fixed-answer prompts such as "I felt I made a valuable contribution to the research project in the last seven days," to be answered on a 4-point Likert scale *(often, sometimes, rarely, never)* and open-ended prompts, including "Please describe a setback, challenge, or obstacle you faced this week." Common responses included a student reporting that they felt ill, struggled to stay on task, or experienced conflict with a research team member. When prompted to share successes and highlights, students cited having earned praise from their mentor, completing a writing milestone, finding a "breakthrough document" in an archive, or having an energizing conversation about graduate school.

The benefit of the weekly survey was multi-fold. Not only did responses yield data about students' experiences over time, they also enabled the research team to calibrate the questions and to elevate topics in biweekly focus groups. Although the research team had mapped out a rough outline of the questions to be posed to each focus group (Humanities SURF Research Study n.d.c), an uptick in survey comments about communication challenges might lead to seeding the discussion accordingly. Completing the survey prompted students to do regular stocktaking—an effort that helped them become more attentive to shifts in mood or behavior and to identify matters to share in the focus group. Inviting students to mention successes, setbacks, and mental states signaled to them that these were worthy items to notice, think about, and address as needed. When combined with the other research strategies (described below), the surveys contributed toward the summer program's overarching goal to support students' development as researchers. Had the team not administered the survey or provided follow-up during focus groups, students would be left to navigate this process more or less on their own. These research methods had the positive effect of making students' reflection more regular, consistent, and rigorous.

Strategy 2: Focus Group Discussions

Focus groups are adept at surfacing varying perspectives among diverse individuals (Morgan 1996; OMNI n.d.). Whereas focus groups can produce rich data for researchers, Grudens-Schuck, Allen, and Larson (2004, n.p.) argued that participation can be mutually beneficial and provide subjects with a sense of community and practical resources:

> Focus group method strives to produce good conversation on a given topic. Good conversation ebbs and flows. Individuals laugh, tell personal stories, revisit an earlier question, disagree, contract themselves, and interrupt. … A well-designed guide assists group members to relax, open up, think deeply, and consider alternatives.

Indeed, the biweekly discussions did more than yield data—they became a space where students spoke candidly, shared challenges, sought and received feedback, griped, listened, and explored insights about the research process and themselves as learners. Students frequently likened these sessions to "group therapy" because the affective dimensions of the research experience were the focus amid a judgment-free climate.

For practical purposes, the team divided the 24 SURFs into three smaller groups; two groups of 10 students who were "in residence" on or near campus, and another group of four students who were mostly away from campus. Students were assigned to groups randomly—each group included a variety of academic majors. A few students were part of research teams; some were assigned to groups with teammates, others were separated due to the random draw. On-campus groups met four times for approximately 75 to 90 minutes, alternating across the 10 weeks of the summer. The students who completed off-campus projects met for a single discussion in late August. The research team chose to hold the focus groups immediately following a weekly catered lunch to boost participation and to give faculty-student teams the ability to plan around a standing commitment. After getting students to the table, well-placed and probing questions, consistency, free snacks, good conversations, and abundant good humor kept them there.

The research team opened each focus group by reviewing the ground rules, including a pledge to uphold confidentiality (it was jokingly called the "Vegas Rule" because "what happens in the focus group stays in the focus group"). Each session was designed around four to six substantive questions, beginning with a warm-up question such as "What's something that went well this week?" The research team balanced advanced planning with improvisation—most of the questions were designed in advance, drawing on themes that emerged from the weekly survey or felt timely such as "What have you learned about the research process that you didn't know a few weeks ago?" These topics were broad enough so that students could speak about whatever was on their minds. The team routinely left time at the end for students to raise a question or topic for the group to consider. Up to 30 minutes of a focus group was allotted to address Photovoice prompts.

Although some SURFs described concerns that were unique to their project or the personalities on their research team, the topic of failure most arose in accordance with three emerging themes. First, SURFs harbored great anxiety about falling short of their mentors' expectations. Consistent with the Failure Mindset Coping Model of Henry and colleagues (2019), the students in this study also exhibited a fear of failure. Across the 10 weeks of the program, students regularly talked about their fear of disappointing their mentors—specifically, failing to meet the *perceived* expectations of the accuracy, quality, and quantity of contributions to the research project. When pressed to describe their mentors' expectations, one student said, "my mentor expects me to write a paper that could be published in a peer-reviewed journal"; another said, "my mentor expects me to get a Ph.D. in this field." When a student made such a statement, the focus group facilitator gently prodded the student to explain how this conclusion was reached. Asking some clarifying questions would typically lead students to realize that they might have manifested these expectations—absent follow-up probing, students might continue to carry these unrealistic expectations around with them.

Since students did not want their mentors to think less of them, they often kept these thoughts to themselves or only shared them in the focus group under the assurance of confidentiality. One student described how she tentatively broached her changing postgraduation plans with her mentor:

> My advisor really thinks I'm going to grad school, but I am trying to figure out what I want. [My mentor] is super encouraging but also, when I brought up the idea that I may not go to grad school for a few years, she was like "I don't see you doing that." And I see myself maybe doing that now. Maybe. I don't know.

Although the student called her mentor "encouraging," the student was careful to qualify that her own thinking might be moving in a different direction. Given what this student had shared throughout the summer—coping with anxieties stemming from impostor syndrome, struggling to stay on task, and experiencing waning interest in her research topic—the student's plans to delay graduate school seemed warranted (to me at least). Given her mentor's direct feedback, the student felt less comfortable sharing plans with her mentor.

Mindset is a second theme that emerged during the focus-group conversations concerning SURFs' attitudes regarding the possibility of failure. Consistent with the model of Henry et al. (2019), students demonstrated both fixed and growth mindsets regarding the prospect of success or failure. Some students often held what researcher Carol Dweck (2006) has called a fixed mindset about research, citing aspects of their personalities or workstyle that made them ill-suited to research, such as an inability to adapt to changing situations. Rather than see themselves on a developmental continuum, SURFs with a fixed mindset were quick to characterize themselves as inept or "not smart" when things did not go as planned. Students who lacked the awareness that "good researchers are made, not born" articulated greater anxiety about the prospect of failing to achieve success. Other SURFs exhibited a growth mindset, wherein setbacks and failures were readily accepted as integral to the learning process. A comment from an undergraduate researcher majoring in communication demonstrates how she came to see the ebbs and flows of the research process:

> When I think about my summer research experience, I think there is also a lot of highs and lows, in the sense that some weeks are really great and we are making good progress on research, and other weeks, you know, something happens and there was a slip-up and I have to go and re-do something time-consuming.

The student recognized that over time, researchers develop the dispositions and strategies to navigate the ambiguity, difficulty, and demands of research such as using databases, managing time, regrouping after a setback, and overcoming writers' block (Hemmings 2012). By seeing herself as a learner—as a researcher-in-the-making—the model of Henry et al. (2019) would predict that this student was better positioned to navigate setbacks and challenges without becoming totally derailed.

The final failure-related theme that emerged in focus groups was students' concerns about productivity and output. Students often flagged their effort and achievement as a potential failure; for example, one said, "I am worried that I am not working enough," or "I'm not making enough progress." These statements were often followed by descriptions of behaviors consistent with the patterned stress responses *overfunctioning* and *underfunctioning,* first described by family psychologist Murray Bowen (1976). These tendencies often manifest when an individual experiencing stress responds by doing more or less than what might be regarded as a fair share. For SURFs, this ranged from attempting to read 20 scholarly articles in a single day or spending 8 hours binging Netflix to avoid engaging with research. The high frequency of these comments indicated that many students lacked a clear understanding of what constituted an appropriate level of accomplishment or workload, a yardstick by which to measure success or failure; these coping strategies are consistent with research about how undergraduates respond to actual or impending failure in STEM disciplines (Henry et al. 2019).

The potential to fail often triggered maladaptive behaviors that only exacerbated underlying problems. For instance, one student who demonstrated overfunctioning tendencies was so worried that she had not made sufficient progress on her literature review that she spent the holiday weekend working in the library, ignoring her visiting boyfriend, only to emerge exhausted and heavy with guilt about what she perceived to be insufficient progress. Other students expressed concern not only about the amount of effort they expended but also the quality of their work. Said one student, "I feel like I'm working hard and I feel like I'm trying to make a good product but sometimes I'm not really satisfied with my work and I'm nervous about the deadline and I really want to get things up to my standard." Much like their STEM peers, the prospect of failing led many SURFs in the arts and humanities to engage in maladaptive coping strategies (Henry et al. 2019).

Strategy 3: Photovoice Prompts

During the focus groups, the research team engaged in a third data collection technique called "Photovoice" in which study participants created an image in response to a specific prompt and explained its significance (Wang and Burris 1997). Photovoice can produce vivid, engaging, and often beautiful artifacts that call attention to insights or experiences that might not otherwise surface in ordinary conversation; as such, its use is growing in higher education, as it is especially effective to encourage undergraduates to share life experiences (Latz 2017). Across the summer, the research team presented students with three prompts (Humanities SURF Research Study n.d.c), giving them a week to create (or select) an image:

1. Bring a photo of you doing research on a typical day. (Week 4/5)
2. Bring a photo that conveys how research makes you feel. (Week 6/7)
3. Bring a photo that represents your overall experience in summer research. (Week 8/9)

The research team intentionally gave students few parameters or guidelines: some took photos of things they saw, others "posed" for a photo taken by someone else, whereas others chose popular memes or images found online. The images ranged from a documentary approach to those that were more abstract/artistic.

Prior to each week's focus group, students uploaded their images to a shared online folder. During the session, each image was projected on a screen, and the creator was asked to describe it. Sometimes clarifying questions were posed to the creator (e.g., "I hear you using X term, what it does mean to you?" or "Is this a new feeling you are describing or one you've felt before?"). After all individuals shared their images, the group engaged in some collective sensemaking by asking, "What do these images have in common?" or "What did you learn from someone else's photo?" In addition to surfacing some nuanced insights about students' experiences, Photovoice proved to be an effective trust-building and trust-deepening exercise; for a creator, sharing an image that was self-created and describing its meaning involved a degree of vulnerability (Latz 2017). Once one individual in the group was brave enough to take an initial risk—to talk about something that was not going well or to reveal a nascent sense of self-doubt—it engendered a sense of trust and invited greater and deeper self-disclosure from others. As the summer progressed, the facilitator had to do progressively less heavy lifting; students' comfort and ability to describe their own experiences and to respond to others improved exponentially.

Here is how a Photovoice presentation played out in a typical session. In response to the prompt "Bring a photo that conveys how research makes you feel," one student shared this photo of being inside an automated car wash (see Figure 1).

FIGURE 1. Automated Car Wash

Photographer name withheld to preserve anonymity. Reproduced by permission of the photographer.

She offered this description:

> I feel like I'm going through a car wash with [the research] process. You're kind of put on the rack—the car is. You're kind of pushed through and you don't really feel time pass when you're inside. And you kind of just get hit with different stuff; so whether it's like my advisor telling me like "Okay, we're going to have to push this archive trip two weeks" or just feeling like glazed over when writing or doing research.

The student's comments reflected several maladaptive behaviors—helplessness and escape—of how students respond to the potential for failure identified by Henry et al. (2019). Her response incited a lively group discussion about stress and motivation. For example, other SURFs shared their own discomfort with adapting their schedules to a last-minute change or deviating from an established plan. Many students expressed a sense of frustration of having little agency over external obstacles (leading some to feel like they were "just going through the motions" rather than positioned to solve problems). Several students related to the "glazed over" feeling for one reason or another, whether it was due to being physically tired or working hard to finish time-consuming tasks that amounted to little "progress." After seeing this image, one student remarked, "everyone seems to be in this period where like, they know the end is near but, it seems like there's a lot more work that still needs to be done." Another added, "I'm just overwhelmed and stressed." After naming these challenges, the group brainstormed responses, such as stepping away from the work to gain perspective and/or focusing on completing a manageable task to get back on track.

Recommendations for Practice

When recast as a support intervention rather than research methods, focus groups and Photovoice prompts encourage students to engage in metacognitive reflection that help them thrive and adapt as researchers, especially in the face of failure. The low-cost, "just in time" model used at Trinity University—providing structured opportunities for individual and group reflection—could be easily replicated for use in various higher education contexts to better equip undergraduate researchers to reduce the stigma of struggling, manage their self-doubt, engage in adaptive coping strategies, and persist through impending or actual failure. One student in the study described how these structures might benefit others in the future:

> I don't want to say force—but I am going to use it for lack of a better word right now—to force all of the [research] students to interact with each other. … I think, just building that sense of community, because people get overwhelmed, they get stressed out. I think having that sense of security or sense of community and knowing, like people are going through the same thing that I am going through and kind of having the same feelings I am having. I think that will help a lot of people and relieve a lot of stress and tension too.

Although the students who participated in the focus groups did so voluntarily, many other students concurred with this student that such conversations were so valuable that they should be compulsory.

Three recommendations based on the responses to an end-of-study questionnaire (Humanities SURF Research Study n.d d) may be helpful for those who plan to use or adapt these techniques on their campuses:

1. ***Distance promotes radical candor.*** Students explained that they felt more comfortable speaking with a focus group facilitator who was independent, neutral, and not responsible for the operation of the research program. They liked having someone to filter their feedback anonymously. One student said:

> because I'd feel bad about saying *"Yeah, I didn't really get a lot out of your presentation on posters . . ."* to [the program director's] face. I'm glad he was there and I'm glad he did everything for us. I would feel really bad about saying that. Make sure [groups are] organized by somebody that's not at the head.

This is consistent with methodological research findings that participants often find it easier to disclose feelings to a neutral researcher who is not intimately connected to their daily lives (Dexter 1970).

2. ***Summer is different.*** The team learned that the shift to the summer can be jarring for students who are accustomed to balancing several courses, extracurricular commitments, jobs, and full social lives during the academic year. Undergraduate researchers found themselves living apart from their friends and support networks; the sense of isolation might be even greater for students participating in summer projects away from their home campuses. At Trinity, many campus operations slow or stop completely during the summer, making it more challenging for students to access routine services (including counselors), prepared meals, and technical/computing support. When combined, these small differences seemed to have a compounding impact on students' mental health, overall well-being, ability to perform assigned tasks, and coping skills. More social support and community building is needed during the summer to counteract students' feelings of self-doubt and isolation.
3. ***Enlist the help of a student.*** The support of a full-time undergraduate researcher was crucial in conducting this project. Not only did she help with the hefty (and sometimes tedious) work of qualitative data collection and analysis, but she proved to be a true partner in using language that would resonate best with students. In some ways, her proximity to the study participants—she often saw students in the residence hall or interacted with them socially—made her an embedded ethnographer, living among participants (Creswell and Poth 2018). For example, this mentee was especially attuned to noticing shifts in morale that the mentor had missed such as a subtle rise in anxiety about deadlines or declining motivation as the summer progressed. She used those insights to craft timely questions. Engaging and empowering student partners in the collection and analysis of qualitative data has proven useful in other collegiate contexts as well (Werder et al. 2016; Wabash 2019). Indeed, an advanced student could take responsibility for organizing and facilitating focus groups with a little external support.

Conclusion

In the early 2010s, student success practitioner Adina Glickman coined the term the "Stanford [University] Duck Syndrome" (n.d., n.p.) to describe a common mindset and set of behaviors she observed among high-achieving college students, wherein "everyone on campus appears to be gliding effortlessly . . . but below the surface, our little duck feet are paddling furiously, working our feathered little tails off." By naming the disconnect and providing practical resources in the blog *The Duck Stops Here,* she sought to normalize common learning struggles and to erode the stigma of seeking help in postsecondary settings, especially in elite Ivy League institutions. The metaphor resonates with how summer undergraduate researchers in the arts and humanities conceptualized failure—which often manifested as worries about disappointing respected faculty mentors, diminished confidence, self-doubt, reversion to a fixed mindset, or engagement in maladaptive patterns of over- and under-work.

The summer undergraduate researchers at Trinity University are reminiscent of the high-achieving students described in Glickman's blog. All had been admitted to this competitive program on the basis of impeccable GPAs and strong faculty recommendations. Facing the steep learning curve of becoming a proficient researcher left many of these high-flyers "paddling furiously" while carrying the added burden of attempting to make their exertion seem effortless. Some of these highly-accomplished students had yet to meet an academic challenge they could not handle—struggle and failure were often unfamiliar and very unwelcome.

Faculty mentors and research program administrators can do undergraduate researchers a great service by creating spaces and places that empower these high flyers to drop the façade. This is not accomplished by lowering expectations or shielding students from hard tasks. Rather, it is achieved by encouraging them to take justifiable pride in persisting, to name challenges and identify healthy strategies to overcome them, and to recognize that all learning carries some "desirable difficulty" that can be eased with peer and instructor support. Positioning students to acquire these dispositions will prepare them for whatever lies ahead, be it advanced study or another pursuit.

Acknowledgments

The author thanks the research partners involved in this 2019 project—Katherine A. Troyer and undergraduates Simone Washington and Toni Tresca—and acknowledges the generous support from the Mellon Initiative at Trinity University.

References

Bjork, Elizabeth Ligon, and Robert A. Bjork. 2015. "Making Things Hard on Yourself in a Good Way: Creating Desirable Difficulties to Enhance Learning." *Psychology and the Real World,* 2nd ed., ed. Morton Ann Gernsbachler and James R. Pomerantz, 60–68. New York: Worth.

Bowen, Murray. 1976. "Theory in the Practice of Psychotherapy." *Family Therapy: Theory and Practice* 4(1): 2–90.

Creswell, John W., and Cheryl N. Poth. 2018. *Qualitative Inquiry and Research Design: Choosing among Five Approaches.* Los Angeles: Sage.

Dexter, Lewis Anthony. 1970. *Elite and Specialized Interviewing.* Evanston, IL: Northwestern University Press.

Dweck, Carol S. 2006. *Mindset: The New Psychology of Success.* New York: Random House.

Glickman, Adina. n.d. "Why Does the Duck Stop Here?" *The Duck Stops Here.* https://duckstop.stanford.edu/why-does-duck-stop-here

Grudens-Schuck, Nancy, Beverlyn Lundy Allen, and Kathlene Larson. 2004, May. "Focus Group Fundamentals: Methodology Brief." Extension and Outreach, Iowa State University. https://store.extension.iastate.edu/product/6457

Hemmings, Brian. 2012. "Sources of Research Confidence for Early Career Academics: A Qualitative Study," *Higher Education Research & Development* 31: 171–184. doi: 10.1080/07294360.2011.559198

Henry, Meredith A., Shayla Shorter, Louise Charkoudian, Jennifer M. Heemstra, and Lisa A. Corwin. 2019. "*FAIL* Is Not a Four-Letter Word: A Theoretical Framework for Exploring Undergraduate Students' Approaches to Academic Challenge and Responses to Failure in STEM Learning Environments." *CBE–Life Sciences Education* 18(1): ar11. doi: 10.1187/cbe.18-06-0108

Humanities SURF Research Study, Trinity University. n.d.a "Participant Questionnaire and Demographics." https://drive.google.com/file/d/1LslDPqtyA8hsNAGn-hKHTqBR5Rror89T/view?usp=sharing

Humanities SURF Research Study, Trinity University. n.d.b "Weekly Check-In Survey." https://drive.google.com/file/d/1rxzemwqrmEDHTQ5mKbIF9f59Qgw12w0K/view?usp=sharing

Humanities SURF Research Study, Trinity University. n.d.c "Focus Group Protocols and Photovoice Prompts." https://drive.google.com/file/d/1pSlwOqx_gpO-nBpYxaq1_phzegHs-uQD/view

Humanities SURF Research Study, Trinity University. n.d.d "End of Summer Survey." https://drive.google.com/file/d/1hwtJTZXGaGO1nVNtxwh4zJM2CHYUIdyF/view?usp=sharing

Kuh, George D. 2008. *High-Impact Educational Practices: What They Are, Who Has Access to Them, and Why They Matter.* Washington, DC: Association of American Colleges and Universities.

Latta, Maria. 2019, Nov. 14. "Setbacks in Your Project? We've All Been There." Office of Undergraduate Research Blog, University of Connecticut. https://ugradresearch.uconn.edu/2019/11/14/setbacks-in-your-project-weve-all-been-there/

Latz, Amanda O. 2017. *Photovoice Research in Education and beyond: A Practical Guide from Theory to Exhibition.* New York: Routledge.

"Mellon Initiative." n.d. Trinity University. Accessed January 24, 2022. https://www.trinity.edu/sites/mellon-initiative

Morgan, David L. 1996. "Focus Groups." *Annual Review of Sociology* 22: 129–152. doi: 10.1146/annurev.soc.22.1.129

OMNI Institute. n.d. "Information Gathering Toolkit: Basic Tools for Quantitative and Qualitative Data Collection." Accessed January 24, 2022. https://omni.org/information-gathering-toolkit

Peelo, Moira, and Terry Wareham. 2002. *Failing Students in Higher Education.* Society for Research into Higher Education.

Russell, Susan H., Mary P. Hancock, and James McCullough. 2007, Apr. 27. "Benefits of Undergraduate Research Experiences." *Science* 316: 548–549. doi: 10.1126/science.1140384

"Using Student-Led Focus Groups to Support Assessments: Our Workshop." Center of Inquiry, Wabash College, May 22, 2019. https://centerofinquiry.org/workshop-on-using-student-led-focus-groups-to-support-assessment/#1557178277602-34ea12b2-a5ed

Vygotsky, Lev S. 1978. *Mind in Society: The Development of Higher Psychological Processes.* Cambridge, MA: Harvard University Press.

Wang, Caroline, and Mary Ann Burris. 1997. "Photovoice: Concept, Methodology, and Use for Participatory Needs Assessment." *Health Education & Behavior* 24: 369–387. doi: 10.1177/109019819702400309

Werder, Carmen, Shevell Thibou, Scott Simkins, Karen Hornsby, Kali Legg, and Tawanna Franklin. 2016. "Co-Inquiry with Students: When Shared Questions Lead the Way." *Teaching & Learning Inquiry: The ISSOTL Journal* 4(2): 21–35. doi: 10.20343/teachlearninqu.4.2.4

Yu, Megan, and Yu-Min Kuo. 2017. "Ten Simple Rules to Make the Most Out of Your Undergraduate Research Career." *PLoS Comput Biol* 13: e1005484. doi: 10.1371/journal.pcbi

CHAPTER 12

"You're Invited to the Rejection Party" and Other Strategies for Normalizing Rejection and Failure as Part of the Research Process

Heather Haeger and Natasha Oehlman

Abstract. Undergraduate research can facilitate remarkable achievements and successes, but experiences of failure in research can be just as transformative. Experiencing failure can communicate to students that they do not belong in their field or in research, but reframing those experiences can help students persist and catalyze their learning and development. This case study presents interventions developed at California State University, Monterey Bay aimed at normalizing failure in the research process, recognizing failure and rejection as part of academic success, and utilizing failure as a catalyst for growth. The authors use interviews and written reflections from a diverse group of undergraduate researchers to understand how students make meaning out of experiences of failure and rejection, as well as the factors that shape how students respond to these challenges.

doi: 10.18833/cf/16

Undergraduate research (UR) is a popular means of engaging students in authentic learning (National Academies of Sciences, Engineering and Medicine 2017), building connections to faculty (Houser, Lemmons, and Cahill 2013, 297–305), and socializing into the academic or professional community (Crowe and Brakke 2019). Higher education websites and news stories are full of examples of shining success and the remarkable achievements of undergraduate researchers and their faculty mentors (e.g., Beall 2021; Becker 2021). What these stories and the general discourse around UR does not show is the struggle, failure, and rejection faced by those students and faculty in the research process and in academia on their way to that success. Hiding the reality of failure and rejection in academia provides unrealistic expectations, exacerbates imposter syndrome and stereotype threat (Chang 2018), increases the likelihood of burnout, and decreases research productivity in students and faculty (Sherry et al. 2010).

Engagement in UR can be transformative, particularly for students of color, first-generation students, and low-income students (Parker 2018); however, experiences of failure can steer these students out of research and out of their field of study, particularly in STEM (Haeger and Deil-Amen 2016). The way challenge and failure are framed can impact whether students can adapt and persist through challenges or whether they leave the challenging situation such as quit their research experience or transfer out of STEM fields (Ajjawi et al. 2020, 185–189; Haeger and Deil-Amen 2016). The Undergraduate Research Opportunities Center (UROC) of California State University, Monterey Bay (CSUMB) has developed several interventions aimed at:

- Normalizing failure in the research process.
- Recognizing failure and rejection as part of academic success.
- Utilizing failure as a catalyst for growth by focusing on process.

This chapter explores strategies to normalize, recognize, and utilize failure and rejection on the path to academic success. Interviews, focus groups, and written reflection data are used from a diverse group of students engaged in mentored research at CSUMB (a public, Hispanic-serving institution) to understand how students process these experiences, how students make meaning out of experiences of failure and rejection, and the factors (including the developed interventions) that shape how students respond to these challenges.

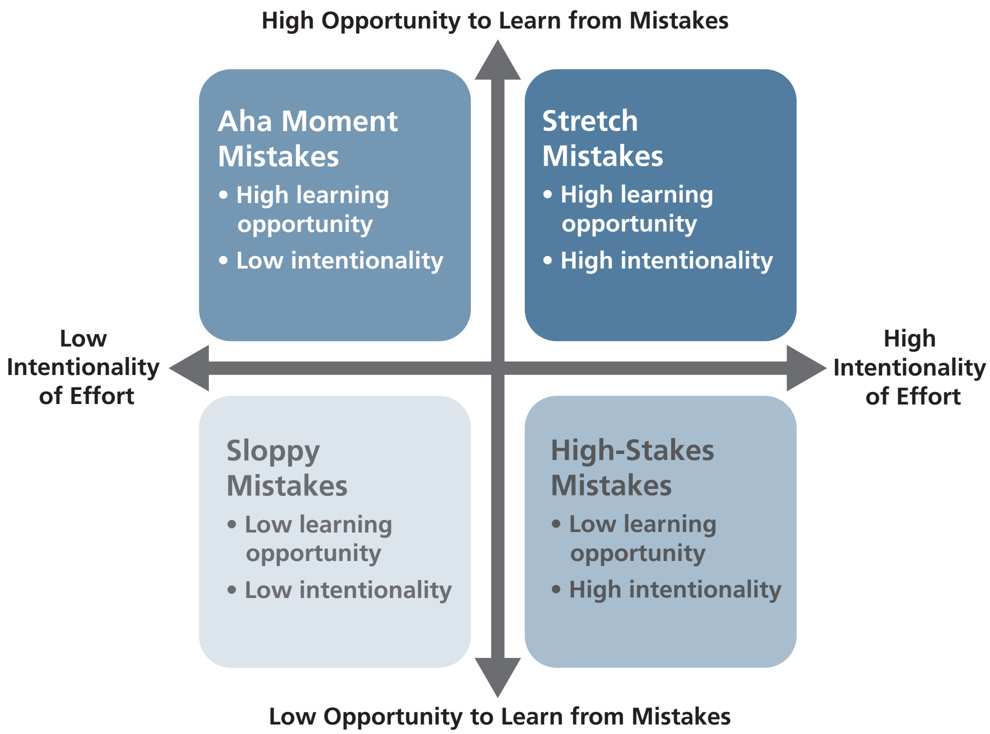
Conceptual Framework

A growth mindset approach (Dweck and Leggett 1988; Dweck 2006) was used in developing interventions that support students in learning and growing through failure, focusing on the types of mistakes, failures, or rejections they were facing (Briceño 2015) (see Figure 1).

Specifically, when students begin their research experience, they are introduced to this framework and given the expectation that they will fail; they will make an error, the experiment will fail, the sample will be contaminated, the paper will be rejected, the scholarship will not be awarded, and so on. Experiencing failure, setback, and rejection in academia is not a sign that they are unfit for research; rather, it is an inevitability. Students are asked to think about why and how they fail, maximizing their learning and growth rather than grappling with the impediment of the fear of failure. The growth mindset framework of Dweck (2006) focuses on the intentionality behind the students' efforts and the opportunity for learning when they make a mistake or encounter a failure (see Figure 1). *Intentionality* is conceptualized along the continuum of low intentionality (lower effort, accidental failure, or success that leads to "ah-ha moments" of accidental success or "sloppy mistakes") and high intentionality (higher amounts of effort and intentional planning/preparation that leads to mistakes that can happen when the effort is beyond the current level of ability in low-stakes environments ("stretch mistakes" or high-stakes environments). Dweck (2006) regards the combination of intentional effort and lower-stakes environments as providing the greatest opportunity to learn ("stretch mistakes").

Most individuals might regard most mistakes or failures as *sloppy mistakes* where they have not put in enough effort or have not tried hard enough (low intentionality and low learning potential). In mentors' work with students, particularly students underrepresented in research such as female students, students of color, and first-generation students, this is the default way they often frame their failures and draw the conclusion that they may not belong in research or their academic discipline. Culturally, the individual can interpret failures and mistakes as the result of not doing enough or being enough, although ah-ha mistakes can be acknowledged like Spencer Silver's accidental creation of sticky notes from spilled adhesives. This growth mindset framework and view of mistakes can be opportunities to learn (see Figure 1) to help students increase their intentionality and understand how to learn from failures.

FIGURE 1. Types of mistakes by opportunity to learn and level of intentionality



It should be particularly celebrated when students make stretch mistakes (high in intentionality and high in learning opportunity; see Figure 1), where students attempt to do something beyond their current ability in low-stakes environments. For example, encouraging students to apply for smaller scholarships and research competitions as undergraduates allows them to stretch and make mistakes from which they can learn in preparation for applying to high-stakes endeavors like graduate fellowships or graduate programs. To encourage undergraduate researchers to make optimal stretch mistakes from which they can learn, structured virtual and face-to-face writing spaces (i.e., peer writing feedback groups, sessions called Just Write) are facilitated during the academic terms for students to explore writing as a process that involves feedback and drafting central to writing production. Normalizing the writing process and production celebrates writing while stressing the intentional labor involved (Chavez 2021, 51–59; Inoue 2015). Making stretch mistakes and learning from them can prevent *high-stakes mistakes* in the future.

This chapter presents interventions aimed at normalizing failure, recognizing failure and rejection as part of academia, and utilizing failure as a tool for learning and development.

Methods

To explore the experiences of undergraduate researchers with rejection and failure, several sources of data were collected and qualitatively analyzed on experiences of failure. All the students in the sample participated in research with a faculty mentor between 2016 and 2019 and were affiliated with the UROC Scholars program that provides support for research, writing, and other professional development.

Data

Qualitative data collection happened through multiple modalities (written reflections, interviews and focus groups) and at a variety of points of time. Ninety-three students participated in research and data collection and many students submitted multiple pieces of writing or both submitted reflections and participated in interviews/focus groups for a total of 195 pieces of data between reflections, blog posts, interviews, and focus groups. The sample of students was racially diverse, and the majority of students were the first in their family to attend college (see Table 1). The sample demographics are consistent with the demographics of the larger university, although female students and students with upper-division standing were overrepresented.

TABLE 1. Sample description (N = 93)

		Undergraduate researchers	CSUMB overall
Gender	Male	17%	36%
	Female	69%	64%
	Prefer not to respond or other gender identity	3%	
Class standing	Second year	12%	13%
	Third year	22%	32%
	Fourth year	66%	42%
Parental education	Parent or primary guardian has a bachelor's or advanced degree	43%	46%
	First-generation in college	50%	54%
Race/ethnicity	African American/Black	5%	4%
	Asian American and Pacific Islander	5%	10%
	Latino/a	48%	45%
	White	29%	29%
	Multiracial	2%	9%
	Prefer not to respond	10%	
Data sources	87 Post-panel reflections		
	26 Blogs (8–10 posts in each blog)		
	58 Reflective essays		
	8 Focus groups		
	16 Interviews		

Note: Six students declined to answer some or all of the demographic questions.
CSUMB = California State University, Monterey Bay

Students in the UROC Scholars program engage in at least two summers of research along with participating in a professional development program structured as a two-year cohort model. Data were collected during the orientation program at the start of their experience (post-panel reflections), during each summer of research (blog posts and reflective essays), and during the last semester of the program (focus groups and interviews).

The first piece of data was collected anonymously through PollEverywhere immediately after students started their first research experience and attended a faculty mentor panel about failure. After the panel, students were asked to write a short reflection on one thing they would take away from the panel. Eighty-seven students submitted a short reflection after the panel. In addition to these short reflections, 58 undergraduate researchers wrote mid-summer and end-of-summer research reflections, and half of the students also wrote weekly blog reflections.

Students were invited to participate in focus-group discussions and interviews in their fourth year and asked to reflect on their experiences in research and in applying to graduate school (the majority—greater than 80 percent—of students in the UROC Scholars program apply to and are accepted to graduate school after completing their bachelor's degree). UROC program staff conducted the interviews and focus groups, which increased the rapport with students but could have influenced student responses. Participants were informed of the steps that would be taken to de-identify their response after the interview or focus group. The interviews were loosely structured and focused more holistically on their experiences as an undergraduate researcher. Focus groups were conducted with students who applied for research or graduate school fellowships and focused more specifically on that process.

A priori coding was used to analyze reflections, blog posts, and interviews/focus group transcripts for linguistic structure and issues of challenge and response to challenge, examining how students responded to difficult situations and failures. To ensure consistency in coding, three researchers coded on the same set of cases. After norming on a consistent set of criteria for coding, the lead researcher reviewed final coding done by all researchers. Findings were also checked against participant experiences by presenting findings to undergraduate researchers to check for validity from their perspective.

This research is intended to provide a case study of how undergraduate researchers negotiated experiences of failure at a single institution. The study was designed to capture evidence of how students process these experiences and move forward from them within the context of specific interventions aimed to help them navigate academic challenges. The project was submitted to the CSUMB Institutional Review Board and was determined to be non–human subjects research (Part 46 of the 45 Code of Federal Regulations), because all of the data was collected through established educational practices, and the primary purpose was to facilitate programmatic improvement. Although not designated as human subjects research, the research team followed ethical practices in use of student data and FERPA regulations, including de-identifying data to be used for evaluation purposes.

Interventions and Findings

To shift from a culture of fearing failure to a culture of learning from failure, CSUMB has implemented multiple interventions to normalize, recognize, and utilize failure in undergraduate research. Qualitative data were collected on students' experiences of failure and ways that these interventions shaped their perception of failure. This section will describe each intervention along with findings from the analysis of that data.

Normalize: Faculty Mentor Failures

The first introduction to seeing failure as part of the academic process is the Mentor Path Presentation built off of national movements to acknowledge and normalize failure in academic careers, including the Failure C.V. (Edwards and Ashkanasy 2018; Hrala 2017; Herrera 2019). When students are first paired with a faculty mentor, they are asked to interview their mentor to find out how the mentor reached their current position, the unexpected twists and turns that the mentor may have encountered along the way, and the biggest challenges and obstacles that the mentor may have faced, and use other prompts to facilitate a dialog about the messiness of research and career paths in research. Students then create a short presentation on their mentor's path that they share with their cohort of undergraduate researchers.

In addition to the mentor path presentations, faculty are invited to participate each spring in the panel Finding Success in Failure, focused on failure for undergraduates new to the world of undergraduate research. This panel is similar to the ideas of Growing Up in Science (Ma 2017) which promotes opportunities for faculty to talk about struggles, failures, and uncertainties in their academic career so as to normalize these experiences for beginning scholars. During the first installment of the Finding Success in Failure panel, there were a few faculty volunteers. As the reputation of this particular panel spread, more faculty volunteered than could be accommodated. Faculty were excited to share not only their positive academic journeys but also the messy, meaningful, and transformative points in their career that shaped them. The panel begins with faculty introductions and participants giving one piece of advice: "What is one thing you wish you knew about research when you were an undergraduate?". The panel facilitator then asks humanizing questions:

- "What is the most painful rejection you've experienced as a researcher?"
- "How have you experienced failure in your career?"
- "What is the biggest mistake you have made…?"

After the responses, undergraduate researchers dialog with faculty. Honest, vulnerable, and engaging conversations with faculty allow student researchers an opportunity to learn about the varied journeys as well as how some of those journeys and experiences happened because of a rejection or failure.

At the culmination of the panel and the mentor interviews, undergraduate researchers are often shocked when they learn about the failures, rejections, and challenges faced by faculty. More than 65 percent of students' written reflections expressed surprise that their mentors experienced failure and discussed the impact that revelation had on them. As one student noted:

> Prior to the panel, I had many preconceived notions regarding research and was fairly nervous; however, I came in open-minded and came out with much more than I thought I would. I now understand how collaborative the science world truly is on a social and intellectual level. Although I realize the work will be hard, I also understand that *failures are never truly failures, they only make one closer to finding a solution. With this I now have reinforced perseverance and confidence* to grasp what I truly crave. Thank you so much!

When the undergraduate researchers share information about their mentors or when the mentors share it themselves, the other students audibly gasp when they hear about failures (e.g., a mentor who was academically disqualified as an undergraduate or another mentor who accidentally started a fire in the lab in graduate school) and enjoy hearing about the human side of faculty mentors (e.g., faculty who toured the country with a punk band before attending graduate school, faculty who struggled to balance their family and research responsibilities, or faculty who talked about their love of superhero movies). The mentor path presentation and mentor panel serve to humanize faculty mentors; demonstrate and normalize their struggles; and illustrate that failures and rejections happen to everyone, even successful faculty.

Recognize: Rejection Parties and Application Celebrations

Rejection Parties. Undergraduate researchers are encouraged to make stretch mistakes (e.g., try to apply for competitive summer research experiences or scholarships, etc.), activities that feel beyond the bounds of what they know and feel comfortable with. Both acceptances and rejections on those applications are celebrated, as they are equally important in the process of learning and becoming a scholar. Rejection parties are hosted where students, faculty and staff bring rejections (e.g., Research Experiences for Undergraduates or graduate school rejection letters, papers rejected for publication, harsh feedback from a reviewer). These parties include both the new cohort of UROC Scholars, who have applied for their first summer research experiences, and the fourth-year cohort who are applying for graduate school (the vast majority of the students in the UROC Scholars program apply for graduate school in their final year of undergraduate study). Taking the physical representation of rejections (usually a printed copy of the rejection letter or feedback), the students then create something out of it like an origami animal, a paper flower, or other creations (see Figure 2).

FIGURE 2.

Flowers, origami, and paper airplanes made from rejection letters from students and faculty

The physical act of deconstructing this painful experience of failure, sharing those experiences and using them to create something new, is not only cathartic but also helps students reframe these rejections as a step along their path instead of an end to their research career. Many students reflected on this relationship between failure and persistence, as this student noted:

> What stuck with me the most was putting into words that being a research scientist, or a UROC scholar, or just researcher in general isn't about knowing more than the next person. It isn't about having the best answer or being sensational. It's about not knowing what you're doing all of the time, but *still* having the intellectual ability to find AN answer. At the very least, what you find will benefit other research in the future and benefit the greater community.

Art has long been used to process difficult emotions and experiences (Beans 2019). Having students and faculty both share in the pain of rejection and turn those rejections into art or origami helps students see that other people are experiencing the same feelings of failure and process how to move forward from it (see Figure 3). Notably, experiencing failure when framed in a growth mindset leads to brain growth in the form of neural pathway developing (Moser et al. 2011).

FIGURE 3.

Students at a "Rejection Party" sharing food and making art out of letters of rejection from summer research experiences and graduate school applications

FIGURE 4.

Instagram post of three undergraduate researchers celebrating application submission

Application Celebrations. Undergraduate researchers who have applied for national scholarships or fellowships are invited to share an "I Hit Submit" statement on the center's social media platforms (see Figure 4) to celebrate the application process. Whether or not the undergraduate researcher receives such support, highlighting and acknowledging the initiative and labor it required to apply are paramount. Navigating the application process in some cases is a win.

Utilize: Failure as a Catalyst for Growth by Focusing on the Process

There are common tropes when it comes to failure: "there is value in failure" and "no risk, no reward." But, in the academic world, taking risks, although applauded, can also feel scary and raise common questions of insecurity such as "am I good enough?" or "what if I fail?". Part of professional growth and development is to engage in new risks—submitting proposals to present research at national conferences, publishing manuscripts, and applying for funding opportunities are all meant to open a new door to opportunities within academe.

In focus groups, applicants often share that the start of taking on a new writing task, like a Research Experiences for Undergraduates application or national scholarship, although exciting, can also feel risky. Once on the other side of the application process, undergraduate researchers reflect that they feel proud about the submitted application and that the writing and thinking processes allowed them to consider their futures in ways never done before. Many undergraduate researchers have expressed a similar sentiment: "I learned a great deal about myself and I feel confident about my application even if I don't win."

Many students echoed the same sentiment that even in failure, reflection on that perceived failure had significant benefits, as this student focus group noted:

> You don't have to be the winner, like you don't have to get the scholarships; your success can come in different ways and your success is having tried in the first place and putting yourself out there and if you gained all these essential skills in the writing process then that's where your success is, … it's not the award, and so I never felt like I wasn't successful or I didn't succeed because I didn't get these things. UROC didn't put that burden on it. *I think some students outside think like "ooh they get everything" or it's all about the success; it's not, it's about improving these weaknesses* [laughs] that have never been worked on before and building on those, being really successful, continuing.

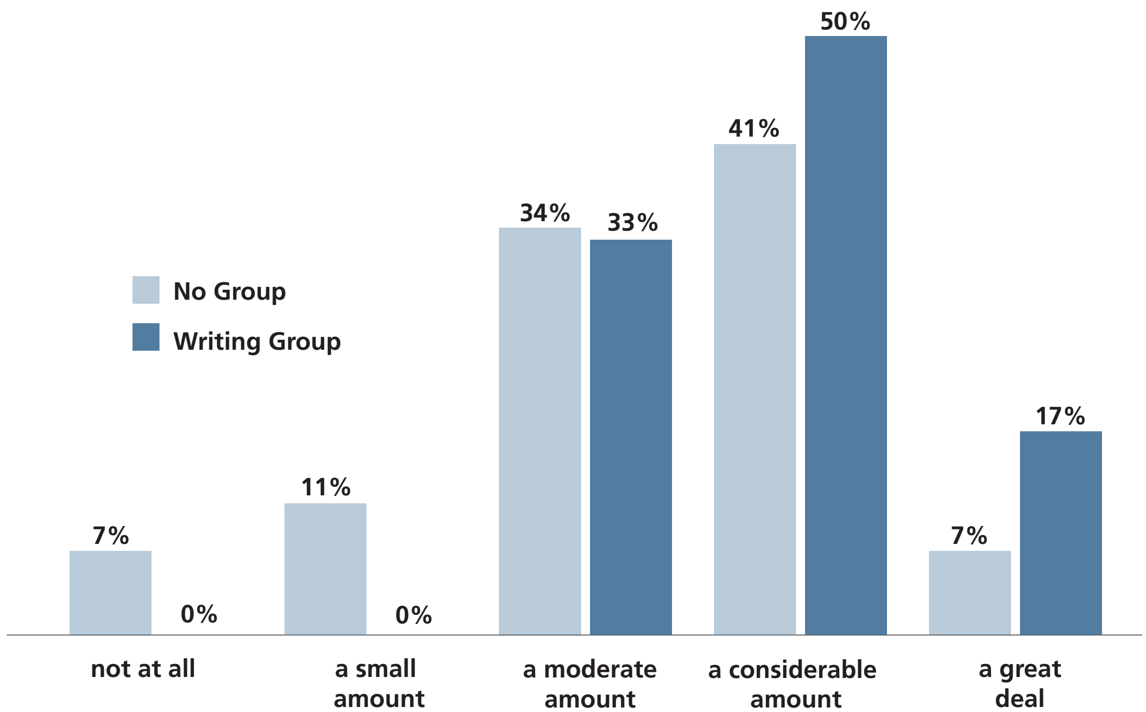
In explicitly talking about the process of applying as well as reframing rejection and failure as part of the process that enables, students can learn and move forward in their research and academic pursuits.

Writing Together

For high-stakes writing products such as research fellowships, nationally competitive awards, or research manuscripts, the aim is to set up a culture of writing together to further build on the growth model as well as challenge notions of failure in writing (Anderson 2017). For the nationally competitive STEM Goldwater Scholarship, for example, applicants are convened to support and learn from one another as they brainstorm ideas and share writing with each other for feedback as they develop their applications. Although this might seem antithetical to the competitive environment often part of the national scholarship culture, applicants utilize one another as strategic partners when they get together, building on their assets to create synergistic approaches and thinking as they take on high-stakes, academic writing (Chavez 2021).

Students who participated in writing groups (see Figure 5) were more likely to say that they gained a great deal in terms of their ability to communicate about research in writing, and none of the students in writing groups rated their gains in the lowest two categories. Students also noted the positive experience of working together in high-stakes writing as seen in the following statements from a focus group: "I became a better writer working with others," "I learned how to be my own reviewer and how to refine at a higher threshold," and "I am not as fearful about my own writing."

FIGURE 5. Ability to Communicate Research Results in a Written Format



Students' perceptions of their growth in written communication ability by solitary writing or small-group writing
Note: Student post-research survey $N = 68$.

Participating in writing groups also supported students in thinking about the value of high-stakes writing even if they fail or receive a rejection. As a student stated in an interview, writing groups supported their thinking about their future and goal development:

> I don't think that people are just chilling on the weekend like, "hm, one day when I'm a professor, I really want to do this" . . . llike I wasn't. So it gave me like a reason [sic] to think more deeply about it, which is what I told all the students in my writing group . . . *Even if you don't get it, . . . thinking about it is really worthwhile.*

In addition to structured writing groups, weekly Just Write sessions of uninterrupted writing time focus on realistic goal setting and scheduled time to write. At the end of the timed sessions, even the small writing wins are celebrated, as participants share what they were able to accomplish during the structured group writing time. Writers express their struggles and challenges, but aha moments and writing wins are also mentioned. As undergraduate researchers reflect on their experiences of failure in the structured writing time, the writing group feedback, and the writing process, they come to realize that mistakes are part of the learning process (Burleson 2005).

Conclusion

When undergraduate researchers are given the tools and appropriate interventions to normalize failure within high-stakes, risky situations, they begin to examine their understanding of "failure." Focusing on the concept of failure as an opportunity for growth and learning negates common tropes of failure equating to being "less than" or "not equal to" something or someone—feelings that could perpetuate imposter syndrome. It also is important that undergraduate researchers, predominantly from historically underrepresented groups, discard a dualistic judgment—“She’s good; I am bad” (Chavez 2021)—and replace it with a growth mindset model focused on flourishing. Using guided metacognitive reflection and supportive interventions (such as creating art to talk through feelings of failure, writing, and supporting one another), they learn that mistakes are part of the process that can help curtail negative outcomes (Anderson 2017; Edwards and Ashkanasy 2018). Reframing challenge and failure is a win in a competitive world.

Acknowledgments

The authors would like to acknowledge the undergraduate research students mentioned in this article. The research study was funded by Department of Education Hispanic Serving Institution (HSI) STEM and Articulation Programs Grant no. P031C160221 and Department of Education, Ronald E. McNair Grant # P217A170213.

References

Ajjawi, Rola, Mary Dracup, Nadine Zacharias, Sue Bennett, and David Boud. 2020. "Persisting Students' Explanations of and Emotional Responses to Academic Failure." *Higher Education Research & Development* 39: 185–199. doi: 10.1080/07294360.2019.1664999

Anderson, Jeff. 2017. "Sharing Our Vulnerabilities as Writers: Writing and Revising Even If You Don't Want To." *Voices from the Middle* 25(2): 14–17.

Beall, Alex. 2021. "Great Minds, Big Ideas." The California State University. Accessed March 1, 2022. https://www.calstate.edu/csu-system/news/Pages/student-research-competition.aspx?fbclid=IwAR1vmP8Nv4Wd4GWj2-zmc5fRpZB1DEpjR-Te09cCcPZoG8iKmMlWClwpxvU

Beans, Carolyn. 2019. "Searching for the Science Behind Art Therapy." *Proceedings of the National Academy of Sciences* 116: 707–710. doi: 10.1073/pnas.1821297116

Becker, Sam. 2021. "How Networking Helped a 23-Year-Old Student Make a 'Career-Starting' Discovery." *CNBC.* September 29, 2021. https://www.cnbc.com/2021/09/29/how-networking-helped-a-23-year-old-student-make-a-career-starting-discovery.html

Briceño, Eduardo. 2015. "Mistakes Are Not All Created Equal." *Mindworks.* Retrieved April 30, 2021. http://community.mindsetworks.com/entry/mistakes-are-not-all-created-equal

Burleson, Winslow. 2005. "Developing Creativity, Motivation and Self-Actualization with Learning Systems." *International Journal of Human-Computer Studies* 63: 436–451.

Chang, Aurora. 2018. "Academic Agency and the Burden of Perfectionism." In *The Struggles of Identity, Education, and Agency in the Lives of Undocumented Students,* 121–130. Cham, Switzerland: Palgrave Macmillan. doi: 10.1007/978-3-319-64614-5_7

Chavez, Felicia Rose. 2021. *The Anti-Racist Writing Workshop: How to Decolonize the Creative Writing Classroom.* Chicago: Haymarket Books.

Crowe, Mary, and David Brakke. 2019. "Assessing Undergraduate Research Experiences: An Annotative Bibliography." *Scholarship and Practice of Undergraduate Research* 3(2): 21–30.

Dweck, Carol. S. 2006. *Mindset: The New Psychology of Success.* New York: Random House.

Dweck, Carol, S. and Ellen, L. Leggett. 1988. "A Social-Cognitive Approach to Motivation and Personality." *Psychological Review* 95: 256–273.

Edwards, Marissa, and Neal M. Ashkanasy. 2018. "Emotions and Failure in Academic Life: Normalising the Experience and Building Resilience." *Journal of Management & Organization* 24: 167–188. doi: 10.1017/jmo.2018.20

Haeger, Heather, and Regina Deil-Amen. 2016. "Cooling Out and Leveled Aspirations among Low-Income University STEM Students." In *Paradoxes of the Democratization of Higher Education,* ed. Ted I. K. Youn, 69–96. Vol. 22 of Research in Social Problems and Public Policy. Bingley, UK: Emerald Group Publishing.

Herrera, Tim. 2019, February 4. "Do You Keep a Failure Résumé? Here's Why You Should Start." *New York Times,* sec. Smarter Living. https://www.nytimes.com/2019/02/03/smarter-living/failure-resume.html.

Houser, Chris, Kelly Lemmons, and Anthony Cahill. 2013. "Role of the Faculty Mentor in an Undergraduate Research Experience." *Journal of Geoscience Education* 61: 297–305.

Hrala, Josh. 2017. "This Princeton Professor's CV of Failures Is Something We Should All Learn From." *ScienceAlert.* Accessed March 4, 2022. https://www.sciencealert.com/why-creating-a-cv-of-failures-is-good-Princeton-professor-viral.

Inoue, Asao B. 2015. *Antiracist Writing Assessment Ecologies: Teaching and Assessing Writing for a Socially Just Future.* Fort Collins, CO: The WAC Clearinghouse.

Ma, Wei Ji, 2017. "The Stories Behind a CV." *Science* 357: 942.

Moser, Jason, Hans Schroder, Carrie Heeter, Tim Moran, and Yu-Hao Lee. 2011. "Mind Your Errors." *Psychological Science* 22: 1484–1489. doi: 10.1177/0956797611419520

National Academies of Sciences, Engineering and Medicine. 2017. *Undergraduate Research Experiences for STEM Students: Successes, Challenges, and Opportunities.* Washington, DC: National Academies Press. doi: 10.17226/24622.

Parker, Jonathan. 2018. "Undergraduate Research, Learning Gain and Equity: The Impact of Final Year Research Projects." *Higher Education Pedagogies* 3(1): 145–157.

Sherry, Simon B., Paul L. Hewitt, Dayna L. Sherry, Gordon L. Flett, and Aislin R. Graham. 2010. "Perfectionism Dimensions and Research Productivity in Psychology Professors: Implications for Understanding the (mal)Adaptiveness of Perfectionism." *Canadian Journal of Behavioural Science / Revue canadienne des sciences du comportement* 42: 273–283. doi: 10.1037/a0020466

CHAPTER 13

Case Study: Helping Faculty Mentors Help Undergraduates Confront and Cope with Research Failures

Alison N. Olcott, Nicole Perry, Dawn Tallchief, and Ayah H. Wakkad

Abstract. This case study describes various ways that the Center for Undergraduate Research at the University of Kansas normalizes research failures to create an understanding that research is an iterative process from exposure through expertise and that failing is just one of the steps in the process. It highlights the work done with faculty members to help them share and model their own research failures, which has proven to be a very effective way for students to learn to accept and embrace this crucial step in the research process.

doi: 10.18833/cf/7

Failure, defined here as "the inability to meet the demands of an achievement context, with the result of not achieving a specific goal" (Henry et al. 2019), is a natural and expected part of the research process (Firestein 2015; Lin-Siegler et al. 2016). Study after study has revealed that innovation in research comes about because of—not despite—challenges, setbacks, and mistakes (Timmermans 2011; Nuth et al. 2016; Zhang, Li, and Mei 2015; Kristal and Whillans 2020; Chalmers 1999; Kuhn 1970). However, this is not something that is innately understood by most students. Research has revealed that many students tend to view research success as the result of innate talent or intellect, and thus that their research failures reveal that they are not competent or skilled enough to do research (Dweck 2013; Limeri et al. 2020). At the University of Kansas, the Center for Undergraduate Research works with instructors and mentors to develop and promote curricula and models for mentoring, engages and advises students in their development as researchers, and provides campus-wide opportunities to celebrate undergraduate research at KU. Part of this training and support involves normalizing research failures across KU's programs to create an understanding that research is an iterative process from exposure through expertise, and that failing is just one of the steps in the process. Some of this work is done through student-facing programming, but the center also works with faculty to help them share and model their own research failures, which has proven to be a very effective way for students to learn to accept and embrace this crucial step in the research process (Hu et al. 2020; Lin-Siegler et al. 2016).

Studies have revealed that one way to help students understand the role failure plays in research is to share the struggles of scientists (Hu et al. 2020; Lin-Siegler et al. 2016). Traditional curricula tend to teach students the end-result of a research process without illustrating the failures and struggles along the way, which in turn reinforces the idea that research is something that is only suited for people with innate abilities (Firestein 2015). The natural consequence of this, then, is that when a student hits a natural bump or challenge, they often lack the motivation to persevere, as they feel they do not have the natural skills needed (Lin-Siegler et al. 2016). However, when students are introduced to the stories behind great discoveries, they begin to understand that everyone experiences these failures (Lin-Siegler et al. 2016). This humanizing of failure has been shown to be crucial if failure is going to act as a growth agent and catalyst for change (Young 2019). Originally, these failure narratives were done for famous researchers, like Marie Curie and Albert Einstein (Lin-Siegler et al. 2016). However, subsequent research revealed that these tales resonated more if the role models were relatively unknown researchers, as the students were better able to relate to these researchers rather than the near mythological figures of science (Hu et al. 2020).

These findings indicate that faculty can be tremendously effective as role models in normalizing failure as part of the research process. Research into role models have shown that the most effective role models are those whose success seems attainable, who has demonstrated competence in a particular domain, and someone who is viewed as similar to one's self (Hu et al. 2020). With undergraduate research experiences in particular, studies have shown that students viewed faculty as the most important and impactful mentors (Palmer et al. 2018), and that faculty are vital to student success (Stevenson, Buchanan, and Sharpe 2006).

The Center for Undergraduate Research aligns its work with a triangular framework that addresses the three stages in a student's development as a researcher: (1) Exposure to research, (2) experience with research, and (3) expertise on a research topic. The goal is that almost all students reach stage 1, many reach stage 2, and some reach stage 3. Although the concept of failure is an integrated part of each stage, much of the work with faculty around this issue is concentrated at the lower levels of the triangle, as it is best if students encounter this idea from the beginning of their time in college. Studies have shown that that when novice students are exposed to the nature and process of research, they benefit even without formal instruction in said ideas (Schmid, Dunk, and Wiles 2021) and that early exposure to the ideas of research failures produces students that are more self-motivated to succeed (Lin-Siegler et al. 2016; Herrmann et al. 2016; Simpson and Maltese 2017; Rong and Choi 2019).

For instance, at the Exposure level, there are monthly research spotlights focusing on students, mentors, and alumni. Each month, people are asked a standard set of research-related questions, and the answers are posted on the center's website (Center n.d.) and shared on social media (Twitter, Facebook, Instagram; see Appendix 1). One standard question asked of mentors, most of whom are faculty, is "For many students, doing research or a larger creative project is the first time they have done work that routinely involves setbacks and the need to troubleshoot problems. Can you tell us about a time that your research didn't go as expected? Or about any tricks or habits that you've developed to help you stay resilient in the face of obstacles?" This question has produced a slew of thoughtful responses about the role of failure across all academic disciplines (see Table 1). Two-thirds of the respondents explicitly described research failures they have experienced, whereas 58 percent of the answers described how failure is an integral part of the research process, with 54 percent describing how this failure leads to learning or discovery. Also of note is the fact that 32 percent of the respondents specifically instructed students not to take this failure personally, whereas 28 percentage described the need to redirect effort to help move past a research failure. The answers provided by faculty can serve to reassure students that failure is a normal, even integral, part of the research process, as it allows for further innovation and discovery. Although this view of failure has long been accepted in the research community (Timmermans 2011; Nuth et al. 2016; Zhang, Li, and Mei 2015; Kristal and Whillans 2020; Chalmers 1999; Kuhn 1970), it is not something easily understood by novice researchers, who tend to view failure as an indicator that

TABLE 1. Example Responses from Profiled Faculty Research Mentors

Types of responses by faculty mentors	Sample responses
Personal research failures they have experienced	"I think the harder question would be to name a time when things DID go as expected, as that pretty much never happens. Research is at least 95% troubleshooting, trying to figure out why things aren't working. When it finally works, you run the experiment, collect all your data, write up the paper, and move on to the next problem." "I feel that my research almost never goes the way I think it will at the beginning of the project, and that is the glory of it. This is how science works—you have a hypothesis about what will happen, but proving that hypothesis wrong is just as important as proving it right."
Failure is an integral part of the research process	"The ability to withstand disappointments, persist in the face of challenges and troubleshoot through difficult experiments are all skills that make us better scientists." "Research never goes as expected! In fact, that is one of the interesting things about research. Even though I start a project by developing a very detailed, thoughtful, and rigorous research plan, this plan tends to evolve along the way. This is a part of the process of doing research."
Failure leads to learning or discovery	"In chemistry, unexpected problems can actually indicate you've found something new." "The most important thing is that with each setback, we are able to learn what worked and what didn't to help refine our research and devices into something that works all the time."
Do not take failure personally	"One of the things I've learned from research is that people have different definitions of success. Some people feel successful when they give their maximum personal effort and see their improvement over time. This definition of success is key for helping them maintain high motivation over time, because they're trying to become the best they can be. They don't have the same distractions that people have who only feel successful when they win or outperform others. I have found this to be a key quality of people who do interesting and meaningful research. They try to put themselves in situations where they are challenged and excited to keep learning more." "Sometimes, we also find effects that we did not expect. When this happens, we can revise our initial hypothesis and run additional experiments to see if we can provide additional evidence for the new hypothesis. The key to being resilient is not letting yourself be disappointed when finding something different from what you expected. In my experience, often times, unexpected findings are the most interesting ones!"
Redirect effort to help move past a research failure	"Sometimes you may also just need to take a step back and take a little break to make the project the best it can be." "No matter how hard you try, it may never work. With my students now, if something isn't working after a few attempts, we stop and work on something else. It's important not to waste time on things that don't work really well!"

they are not well-suited to do research (Dweck 2013; Limeri et al. 2020). Having faculty explicitly list failures they have experienced and describe the ways that failure has helped them succeed is a potent message for undergraduate students, as studies have shown that faculty serve as powerful role models for their students (Rask and Bailey 2002; Bettinger and Long 2005; Stevenson, Buchanan, and Sharpe 2006; Palmer et al. 2018).

A similar questionnaire is used in Emerging Scholars, a college retention program aimed at students with financial need. This program has two components: a paid faculty-mentored research position as well as required college-readiness workshops and support coordinated through the Center for Undergraduate Research. This program allows federal work study students to have a paid research job beginning in their first semester in college while providing the crucial and yet often untaught soft skills that are paramount for undergraduate success (Nagda et al. 1998). Early in the first semester, Emerging Scholars are required to interview their mentors about the mentor's own path through research, and one question they must ask is "This Research/Creative Cycle picture looks like things follow this simple path, but I have been told that research is a lot messier and you frequently have to go back and forth between steps. Can you tell me about any examples from your research where you had to go back and forth between different steps in this process, or where things didn't go as planned?" This then prompts faculty to have a dialog with these students about the failures and redirects that are a crucial part of the research process, assisting students in understanding that their path will not be a linear one. The answers shared with students are wide-ranging, with some faculty sharing issues such as concerns about troubleshooting equipment in the lab ("This is something we are currently facing as the pH meter and electrode has not been working well and requiring us to often back step and problem solve within this process"), and others sharing large, philosophical tenets such as the importance of negative results in advancing the research project ("Also, in research, finding nothing is something! You can still have a conversation about the research that has meaningful conclusions." and "Things didn't go as planned on particular experiments. [The faculty member] had to make a shift to the question she was going for."). In both cases, however, the faculty experiences with failure are presented in a context relevant to the student's research. End-of-year reflection pieces written by the Emerging Scholars reveal that these lessons are important to the students, echoing findings in the literature that faculty serve as important role models for students (Rask and Bailey 2002; Bettinger and Long 2005; Stevenson, Buchanan, and Sharpe 2006; Palmer et al. 2018). Emerging Scholars are asked to write letters to next year's incoming class, providing the class with tips for how to succeed in research, and many of these letters include encouraging remarks about failure. These include statements such as "[m]y general advice for you as you open a new page in your life is to come into research open-minded and understand that you are going to fail. Research isn't full of success, but it gives you room to grow and learn from your mistakes so you can be successful the next time around" and "Through the opportunities provided by the Emerging Scholars Program, I have also been subject to the trials and tribulations that are ever-present in conducting research. It was very eye opening to see that it is perfectly okay, if not expected, to get many things wrong and make many mistakes while on the road to forming presentable research results." Sharing these letters with the next year's Emerging Scholars allows the previous students to help humanize and normalize research failures for the new students, creating a community in which all are comfortable discussing failure (Young 2019).

By encouraging faculty to share their experiences with failure through website spotlights and student conversations, the iterative nature of research can be normalized. One element of research that makes it such an impactful learning experience is the fact that students must use their knowledge in flexible ways to solve problems that do not have clear-cut answers. Unlike the list of readings on their syllabi and canned labs that work on the first try, research necessarily involves iteration and setbacks (Rong and Choi 2019). This is fundamentally different from the types of learning experiences that students bring to college and requires explicit mentoring and guidance. Otherwise, students may view the setbacks as a reflection of their own abilities and lose confidence in themselves as researchers. Having faculty mentors share their own struggles helps to humanize the process of failure (Herrmann et al. 2016; Young 2019), allowing students to see that failing is just one necessary step in the research process.

Acknowledgment

Students quoted in this chapter gave explicit permission for their words to be published.

References

Bettinger, Eric P., and Bridget Terry Long. 2005. "Do Faculty Serve as Role Models? The Impact of Instructor Gender on Female Students." *American Economic Review* 95: 152–157.

Center for Undergraduate Research, University of Kansas. n.d. "Home." https://ugresearch.ku.edu

Chalmers, A. 1999. *What Is This Thing Called Science?* Queensland, Australia: University of Queensland Press.

Dweck, Carol S. 2013. *Self-Theories: Their Role in Motivation, Personality, and Development.* London: Psychology Press.

Firestein, Stuart. 2015. *Failure: Why Science Is So Successful.* Oxford: Oxford University Press.

Henry, Meredith A., Shayla Shorter, Louise Charkoudian, Jennifer M. Heemstra, and Lisa A. Corwin. 2019. "*FAIL* Is Not a Four-Letter Word: A Theoretical Framework for Exploring Undergraduate Students' Approaches to Academic Challenge and Responses to Failure in STEM Learning Environments." *CBE–Life Sciences Education* 18: art.11. doi: 10.1187/cbe.18-06-0108

Herrmann, Sarah D., Robert Mark Adelman, Jessica E. Bodford, Oliver Graudejus, Morris A. Okun, and Virginia S. Y. Kwan. 2016. "The Effects of a Female Role Model on Academic Performance and Persistence of Women in STEM Courses." *Basic and Applied Social Psychology* 38: 258–268.

Hu, Danfei, Janet N. Ahn, Melissa Vega, and Xiaodong Lin-Siegler. 2020. "Not All Scientists Are Equal: Role Aspirants Influence Role Modeling Outcomes in STEM." *Basic and Applied Social Psychology* 42: 192–208.

Kristal, Ariella S., and Ashley V. Whillans. 2020. "What We Can Learn from Five Naturalistic Field Experiments That Failed to Shift Commuter Behaviour." *Nature Human Behaviour* 4(2): 169–176.

Kuhn, Thomas S. 1970. *The Structure of Scientific Revolutions.* Edited by Otto Neurath. Chicago: University of Chicago Press.

Limeri, Lisa B., Nathan T. Carter, Jun Choe, Hannah G. Harper, Hannah R. Martin, Annaleigh Benton, and Erin L. Dolan. 2020. "Growing a Growth Mindset: Characterizing How and Why Undergraduate Students' Mindsets Change." *International Journal of STEM Education* 7(1): 1–19.

Lin-Siegler, Xiaodong, Janet N. Ahn, Jondou Chen, Fu-Fen Anny Fang, and Myra Luna-Lucero. 2016. "Even Einstein Struggled: Effects of Learning about Great Scientists' Struggles on High School Students' Motivation to Learn Science." *Journal of Educational Psychology* 108: 314–328.

Nagda, Biren A., Sandra R. Gregerman, John Jonides, William von Hippel, and Jennifer S. Lerner. 1998. "Undergraduate Student-Faculty Research Partnerships Affect Student Retention." *Review of Higher Education* 22(1): 55–72.

Nuth, Joseph A., Natasha M. Johnson, Frank T. Ferguson, Frans J. M. Rietmeijer, and Hugh G. M. Hill. 2016. "Great New Insights from Failed Experiments, Unanticipated Results and Embracing Controversial Observations." *Geochemistry: Exploration, Environment, Analysis* 76(1): 1–12.

Palmer, Ruth J., Andrea N. Hunt, Michael R. Neal, and Brad Wuetherick. 2018. "The Influence of Mentored Undergraduate Research on Students' Identity Development." *Scholarship and Practice of Undergraduate Research* 2(2): 4–14.

Rask, Kevin N., and Elizabeth M. Bailey. 2002. "Are Faculty Role Models? Evidence from Major Choice in an Undergraduate Institution." *Journal of Economic Education* 33(2): 99–124.

Rong, Hui, and Ikseon Choi. 2019. "Integrating Failure in Case-Based Learning: A Conceptual Framework for Failure Classification and Its Instructional Implications." *Educational Technology Research and Development* 67: 617–637.

Schmid, Kelly M., Ryan D. P. Dunk, and Jason R. Wiles. 2021. "Early Exposure to Primary Literature and Interactions with Scientists Influences Novice Students' Views on the Nature of Science." *Journal of College Science Teaching* 50(6): 40–47. https://www.nsta.org/journal-college-science-teaching/journal-college-science-teaching-julyaugust-2021/early-exposure.

Simpson, Amber, and Adam Maltese. 2017. "'Failure Is a Major Component of Learning Anything': The Role of Failure in the Development of STEM Professionals." *Journal of Science Education and Technology* 26: 223–237.

Stevenson, Joseph M., Debra A. Buchanan, and Abby Sharpe. 2006. "Commentary: The Pivotal Role of the Faculty in Propelling Student Persistence and Progress toward Degree Completion." *Journal of College Student Retention: Research, Theory & Practice* 8: 141–148.

Timmermans, Stefan. 2011. "The Joy of Science: Finding Success in a 'Failed' Randomized Clinical Trial." *Science, Technology & Human Values* 36: 549–572.

Young, Meredith. 2019. "The Utility of Failure: A Taxonomy for Research and Scholarship." *Perspectives on Medical Education* 8: 365–371.

Zhang, Qi, Meiqi Li, and Xuefeng Mei. 2015. "A New Polymorph of 1-Hydroxy-2-Naphthoic Acid Obtained during Failed Co-Crystallization Experiments." *Acta Crystallographica Section B, Structural Science, Crystal Engineering and Materials* 71 (Pt. 1): 119–121.

Appendix 1

Mentor Questions Asked

Directions: Please answer the following questions and email this document back to cur@ku.edu. If you would prefer not to answer one of the questions, feel free to leave it blank. We will also need a photo of yourself that we can use on our website and social media; you can either email one over, or we can get one off of your departmental website.

Bio:
Name:
Department:
Describe your research/creative scholarship in a few sentences that we can all understand:

Questions:
Q: What does your research look like on a day-to-day basis? What do you spend most of your time doing?

A:

Q: How did you first get interested in doing research or creative work?

A:

Q: What do students in your discipline learn by doing research that they wouldn't learn by just taking classes?

A:

Q: What do you find to be the most exciting part of doing research or creative work? What makes this line of work meaningful and interesting to you?

A:

Q: For many students, doing research or a larger creative project is the first time they have done work that routinely involves setbacks and the need to troubleshoot problems. Can you tell us about a time that your research didn't go as expected? Or about any tricks or habits that you've developed to help you stay resilient in the face of obstacles?

A:

Q: How do you spend your time outside of work?

A:

Optional info to help us with social media posts (this will not be posted on your spotlight webpage):

- Preferred pronouns (he/him, they/theirs, etc.):
- List the social media handles you use for Instagram, Twitter, and/or Facebook if you would like us to tag you:

CHAPTER 14

How Mentors Help Us Learn to Fail: Reflections from the Academic Family Tree

Amy Dunbar-Wallis and Meredith A. Henry

Abstract. In this chapter, the authors reflect on their mentoring experiences and use semi-structured interviews with their past mentors to explore and categorize specific mentoring approaches that may help build resilience and confidence in undergraduate researchers confronting failure. They provide three hypotheses about how mentoring might help students cope with failure, challenge, and fear of failure, seeking to provide future researchers with potential practices to test and explore further.

doi: 10.18833/cf/4

Scientists expect that most ideas or experiments will require some iteration and that some will lead to apparent dead ends. Scientists develop the skill to view failure experiences as data points that help to shape and strengthen future work or experimental design (Simpson and Maltese 2017). Individuals who identify as scientists are likely to be able to name key instructors or lab mentors who helped them overcome failed experiments, clarify misunderstood concepts, or reframe failure as a learning opportunity (Robnett et al. 2018). Conversely, some scientists are also likely to have had negative relationship experiences within the lab or classroom environment that increased fear of failure or contributed to a fixed mindset (Henry et al. 2019; Cooper, Downing, and Browning 2018). Either way, interactions between scientific instructors and their students/mentees during failure experiences may ultimately shape how these future scientists respond to failure in their professional life—and whether their responses are ultimately productive or unproductive.

College instructors can engage in many types of mentoring experiences throughout their careers: teaching, advising, supervising research, and more. Early work by Levinson (1978) and Kram (1985) defines mentoring as a relationship between a more experienced person and novice protégé with the goal of furthering the career of the protégé. Mentoring in educational settings can be unique in that it has a "broad scope of potential influence" across contexts and varies in formality (Eby, Rhodes, and Allen 2007, 7). Different facets of mentoring within the educational context have been explored over the past two decades: undergraduate outcomes in persistence and performance (Griffin et al. 2010), relationship structure (Joshi, Aikens, and Dolan 2019; Aikens et al. 2016), negative mentoring experiences (Limeri et al. 2019), and even outcomes for mentors (Eby et al. 2006). Effective mentors assist students in developing new study habits, improving metacognition, becoming actively engaged learners, and finding resources to support learning, as well as by providing research opportunities to explore new ideas (Cook, Kennedy, and McGuire 2013; Stanton, Sebesta, and Dunlosky 2021; Kranzfelder et al. 2019).

Mentorship, whether positive or negative, can leave a lasting impression on a novice researcher. When mentoring goes well, a novice researcher will feel empowered, resourced, and supported (McKinsey 2016; Aikens et al. 2016). Undergraduate students can experience mentoring through a variety of channels: undergraduate research experiences, peer-to-peer mentoring, coaching, and more recently through course-based undergraduate research experiences (CUREs). Importantly, mentoring of undergraduates through both CUREs and one-on-one experiences has been seen to help students develop the ability to navigate scientific challenges and cope with failure (Gin et al. 2018; Harsh, Maltese, and Tai 2011; Laursen et al. 2010). Learning to face challenges and navigate failure are critical skills in scientific development (Henry et al. 2019). Adaptive approaches to failure are associated with several positive outcomes for students in higher education, such as higher rates of future challenge-engaging behavior (including with future research), greater resilience in the face of future challenges, and overall higher rates of academic success and lowered chances of attrition (reviewed in Henry et al. 2019). In addition, learning to successfully navigate failure and challenge may play a key role in helping students to develop science identity. For example, students may value CUREs over traditional labs because the failure and iteration involved make them feel like “real scientists” (Corwin et al. 2018; Goodwin et al. 2021). Thus, it is important to understand how to use the mentor-mentee relationship to help students develop their abilities to leverage failure.

Previous work has set out to identify specific mentoring practices that help students succeed (Eby et al. 2013; Pfund et al. 2016). However, although some of this work describes practices that may improve students’ approaches toward failure, there is an absence of literature that studies how mentors help students navigate scientific failure specifically. Similarly, several recent studies, not necessarily focused on mentoring, have made concrete recommendations for mentor actions when students fail. Limeri and colleagues (2019) as well as Cooper and colleagues (2020) recommend that mentors take action to normalize failure, share personal failure experiences, encourage students, and reiterate the value of failure when things go wrong. Furthermore, specific support frameworks have been suggested to promote the success of the mentor-mentee relationship more broadly: instrumental support (mentor actions that facilitate goal attainment by the protégé), psychosocial support (mentor actions that facilitate personal and emotional development), and relationship quality all have a part to play in the success of a mentoring relationship (Eby et al. 2013). Eby et al. (2006) and Pfund et al. (2016) have also identified specific mentoring behaviors that might be more closely linked with positive student outcomes. For example, providing career support, conducting research together, and performing informal socialization provide psychosocial support that aids the student as an emergent scientist and enhances their personal development (Eby and Dolan 2014). Further, Pfund and colleagues (2016) discuss the importance of mentors in helping a student develop a science identity through providing recognition, validation, teaching, and opportunities to support student/mentee development of competency. Thus, although it is clear that mentoring supports students’ development of the ability to navigate failure and that there are specific mentoring best practices, what is less clear is which best practices contribute to a lasting ability to navigate science failures and view them as learning opportunities.

In this chapter, the authors reflect on their experiences as mentees, using semi-structured interviews with past mentors to explore and categorize specific mentoring approaches that may help build resilience and confidence confronting failure in undergraduate researchers. In the reflections and interviews, they aim to build from previous work and begin to address existing gaps by characterizing aspects of the mentor-mentee relationship, specifically mentor beliefs and behaviors, that encourage students to develop a more favorable, growth-minded view of failure. They reflect on their experiences as undergraduate students and researchers to identify qualities of "effective" mentors; interview such "effective" mentors; describe these mentors' thoughts on failure and specific mentoring practices used in their mentoring relationships; and suggest specific actions that instructors may use to improve mentoring of undergraduate students and to promote an adaptive, growth-minded view of failure. Anecdotes and prior experience from previous work with former mentors along with responses to interview questions were utilized to create a set of hypotheses that can support undergraduate resilience and confidence when confronting failure. Possible applications of these hypotheses and future directions for both aspiring mentors and researchers are also discussed.

Mentees' Reflections on Mentoring

To begin exploring which aspects of mentoring may be useful in helping students grow from failures and challenges, the authors reflected on their experiences as undergraduate researchers and students. They used written free expression to contemplate the following questions:

1. What experiences with mentors made the authors feel like it was okay/good to fail or like they could grow from failure?
2. What did these mentors do?
3. How did it make the authors feel?

Using the mentoring practices identified by Eby et al. (2013) and Pfund et al. (2016) as codes, the authors read through these reflections to highlight the practices that were present in these scenarios. *Coding* is a method for analyzing qualitative data and, in this case, predetermined codes from the literature and emergent themes arising from the reflections were used (Saldaña 2016). The predetermined *(a priori)* codes are listed in Table 1 as a "mentoring variable."

For example, MAH recalled a time when an unexpected news event occurred during the middle of data collection for a research project, which could have been argued to affect participants' perceptions and skew results. Instead of suggesting this be viewed as a daunting issue to overcome or simply acknowledging it as a limitation of the design, MAH's mentor encouraged envisioning it as a unique opportunity to explore a new variable in the data. As a result, MAH reflected that "this really encouraged me to start trying to see unexpected things that come up in research as opportunities and potential areas for growth, rather than hindrances and other setbacks." This would be an example of *facilitating coping efficacy.*

ADW recalled a time when it was discovered that she had been measuring a floral characteristic incorrectly for several months, which led to hundreds of measurements that were unusable for data analysis. ADW was not fired or shamed; instead, her mentors patiently retaught the measurement protocol and ensured that the entire team was making measurements in the same way. This is an example of *developing research skills* and *facilitating coping efficacy* (Pfund et al. 2016, Table 1). ADW reflected that "the investment in re-training and the kindness in doing so made me feel like I was worth the effort and that I could grow in my learning, try new skills, and teach those to others." ADW also recalled a time when a mentor had a very frank conversation regarding admission to graduate school. At the time, GRE exam scores were required, and ADW had noncompetitive scores. ADW's mentor "encouraged me to re-test, and focus on building a strong base as a research technician to be able to demonstrate that I have persistence and success in science research." This is an example of *perceived psychosocial support* (Eby et al. 2013, Table 2).

Both authors were able to recall several moments like this in past mentoring relationships. Within these moments, most of the "good" mentoring practices proposed by past research (i.e., Eby et al. 2013;

Pfund et al. 2016, Table 1) could be identified. However, although moments were identified where mentors' behavior helped the authors to hold a more positive view of failure, it was not entirely clear which specific mentoring practices contributed to the ability to view failure and challenge favorably. Therefore, interviews were conducted with "effective" mentors (see Figure 1) that queried them specifically about their attitudes toward failure and challenges in research, as well as their specific mentoring practices that can encourage mentees to grow through failure and challenge. The authors' reflections on their experiences with "effective" mentors were used to design a set of interview questions for this purpose.

FIGURE 1. Profiles of Mentors Interviewed

Emeritus Professor (EP)
(Postbac mentor to ADW)

- PhD-granting institution on the west coast of the United States
- Institution is majority minority student population (13% white)
- Active research lab that includes undergraduate and graduate students, technicians, and postdoctoral researchers
- Secured funding from national granting agency to develop a scaffolded mentoring program as part of a national professional society

Professor at Research University (R1)
(re-entry mentor to ADW)

- Tenured professor at a large PhD-granting institution in the Rocky Mountain region of the United States
- Institution has a majority white (67%) population
- Teaches undergraduate and graduate classes
- Undergraduate students work with graduate students or postdoctoral researchers with similar interests
- Lab partners with organizations on campus to provide research opportunities in the summer months to students who might not otherwise have access to authentic research experiences

Professor at Primarily Undergraduate Institution (PUI)
(near-peer mentor to ADW)

- Tenured professor at a private, primarily undergraduate institution on the east coast of the United States with research laboratory
- Institution has a predominantly white (59%) student population
- Teaches research-based classes
- Mentors undergraduate researchers
- Provides opportunities for students to gain experience at a field research station over the summer months

ADW conducted three semi-structured interviews with mentors whom she perceived as instrumental in her development as a scientist. For ADW, these included a mentor from a postbaccalaureate research experience that lasted several years (EP), a near-peer mentor who became a tenured professor at an undergraduate-serving institution (PUI), and a mentor who helped ADW re-enter academia after nearly a decade away (R1). Each semi-structured interview consisted of 13 open-ended questions (see Table 2) that included descriptions of the mentor's general mentoring philosophies and practices, positive and negative mentoring experiences, mentoring training received, types of support provided to students, perceptions of failure, and approaches to guiding students through failure experiences. These interviews were coded using *a priori,* simultaneous, and inductive coding methods in the same method as the author's personal reflections (Saldaña 2016).

TABLE 1. Mentoring Practices Identified by Literature Review and Used in Coding Authors' Self-Reflections

Mentoring Variable	Definition/Examples	Source
Perceived instrumental support	Providing challenges, assistance, exposure and visibility, sponsorship, protection, or coaching	Eby et al. 2013, Table 2
Developing disciplinary research skills	Teach mentees to design and carry out a research project; provide opportunities to observe techniques	Pfund et al. 2016, Table 1
Teaching disciplinary knowledge	Identify the knowledge mentees need to be successful in the discipline and guide them in learning that knowledge	Pfund et al. 2016, Table 1
Perceived psychosocial support	Mentor support behaviors that consist of providing encouragement, acceptance, confirmation, counseling, role modeling, or engaging in social activities with protege	Eby et al. 2013, Table 2
Aligning mentor and mentee expectations	Establish and communicate mutual expectations for the mentoring relationship	Pfund et al. 2016,Table 1
Developing science identity	Recognize mentees as scientists	Pfund et al. 2016, Table 1
Developing sense of belonging	Create a welcoming and inclusive research environment, especially at transition points	Pfund et al. 2016, Table 1
Perceived relationship quality	Satisfaction with the mentoring relationship, mentor, liking, or overall perceptions of relationship quality	Eby et al. 2013, Table 2
Facilitating coping efficacy	Scaffold research work in ways that yield periodic success; celebrate successes and offer support after failures	Pfund et al. 2016, Table 1
Similarity to mentor	Similarity in attitudes, beliefs, values, personality, gender, race, education, academic discipline, functional area, departmental affiliation, or organizational setting	Eby et al. 2013, Table 2
Relationship formality	Assigned mentoring relationship or informal mentoring relationships	Eby et al. 2013, Table 2
Advancing equity and inclusion	Employ strategies for recognizing and addressing issues of equity and inclusion	Pfund et al. 2016, Table 1
Foster independence	Continuously assess mentees' development and design increasingly challenging tasks and projects to advance mentees' independence	Pfund et al. 2016, Table 1
Developing mentee self-efficacy	Foster and affirm mentees' aspirations	Eby et al. 2013, Table 2 Pfund et al. 2016, Table 1

TABLE 2. Interview Questions for Mentors of Undergraduate Researchers

Describe the mentoring approach/philosophy that you have utilized throughout your career.
How do you judge whether or not a mentoring relationship is "successful"?
Could you describe a positive mentoring experience? A negative mentoring experience?
How has your mentoring improved across your career?
Can you describe one experience that significantly changed your mentoring approach and why this shift happened?
Did you have formal mentoring training as part of your career development?
In general, many like to provide support in one of two areas. These are psychosocial (where the mentor enhances protege sense of competence, identity, and effectiveness in professional role) and instrumental (where the mentor provides career-related support that facilitates protege learning the ropes and preparing for advancement) From these, do you have a preference between psychosocial, instrumental, or both? (Eby and Dolan 2014) • Is one of these more appropriate than the other in some situations? • Can you provide examples?
Do your students seem to prefer one or the other? In which situations?
What is your definition of failure? • In your opinion, is experiencing failures generally productive or unproductive for students?
Describe how you respond when a student encounters a research failure or obstacle.
We consider that one possible positive outcome of mentoring is helping students learn to "embrace failure". By that, we mean, viewing failure not as a negative end point, but an opportunity for iteration, further learning, and growth. How can mentors help students "embrace failure"? What types of failures should mentors get involved with? 1. Student failing class? 2. Student not getting expected results in research? 3. Student not getting into grad school/difficulty navigating grad experience 4. Student paper not accepted/rejected 5. Student with difficulties navigating professional relationships Can you think of others?
Describe what science identity means to you as a researcher? • Does "failing" have a role to play in students developing a science identity? • In what ways do you perceive failure as impacting science identity development in students? • What roles should a mentor take in this process, if any?

Mentor Reflections

The interviewees discussed failures experienced by students in both the classroom and laboratory. The EP "perceive[d] failure as having [a student] not think that anybody cared about them or that [instructors] were actively working against [them]." Notably, this definition of failure focuses on a failure in mentoring and not on student research failures.

The other professors' views of failure were focused on research failures specifically. For the R1 professor, failure involved a lack of foresight toward potential difficulties: "The times when I feel like I failed are when I didn't expect something when in hindsight [it] was pretty obviously gonna happen, like if I had spent a bit of time thinking about how this was gonna go it would have occurred to me that this was not how this was gonna work."

However, the PUI professor described failure in terms of whether or not a person perseveres in the face of a challenge:

> If we can learn something from that and then change as we move on, that is not a failure in the grand scheme of things, like it's a stumbling block. A failure might be like, if you completely give up and you're just "like I just I can't go on, I'm not going to do anything, and I just have to completely stop." But we can usually get something out of any situation where it doesn't work out like you'd expect it [to] work out.

This demonstrates an important nuance between thinking of failure as experiencing an undesirable challenge, where the person may or may not succeed, and an extreme of giving up completely or abandoning all hope of success on a task.

With this understanding of how these mentors view failure, the authors next sought to understand their views of how they helped students navigate failure. In line with the definition of mentorship having "failed" if a student perceived a lack of care, EP described the approach to supporting a student through an important professional challenge with a high risk of failure—preparing for a medical school interview:

> He was going to be flying to the east coast to do a job interview, had to fly to get to the medical school that was not near the airport, had to rent a car, was less than 25 years old, drive to the that town, rent a hotel room, do the interview, and then reverse the process. So, we said, okay, we want you to come and we want you to dress as you would dress for the interview, and then we explained to him how you get to [the airport] and get through security, and all that sort of thing, and then practice[d] some questions with them.

When EP asked this formally mentored student what the most impactful moment of preparation was, he responded that it was how to navigate the airport. EP reflected: "[I]t's hard to know what information people need and what will help them, whether things like [navigating the airport], or whether it's academic things." EP had believed that role-playing the interview would be the best preparation for decreasing the mentee's fear of failure and anxiety in performing the interview, whereas the mentee thought the logistical preparation was the most important aspect in avoiding failure.

The above support, which was categorized as *perceived psychosocial support* and *developing the mentee's self-efficacy,* was highly important in helping the mentee avoid anxiety about failing at the logistical tasks necessary to complete the more substantive career tasks (i.e., the interview). This illustrates the importance of providing psychosocial support for research/career tasks and the associated tasks that mentors may take for granted but that could lead to minor failures or increased anxiety overall.

In response to the question regarding how the individual's mentoring has improved across a career, the PUI instructor explained how struggle and failure is normalized by sharing personal "vulnerabilities" so that students would feel more comfortable in sharing their own vulnerabilities when confronting challenge and failure:

> what I'm sometimes trying to show is that I have vulnerabilities so that they feel comfortable with their own and they can share it with whoever they feel the most comfortable and just say like here's some place where I've felt vulnerable and we all have our own ways that we do, and you just need to find that group of people that you can share that with.

The PUI professor later explained that such an approach led to trust, so that when the overall mentorship relationship or lab did not work out, mentees could more easily exit:

> there is mutual understanding that things aren't just working out. I tell students in that situation if it's a research based [issue] to try for a semester, [they] usually volunteer for a semester before they take [course] credit and sometimes the scheduling doesn't work out, personalities don't match, and I'm thinking of two examples in particular. I think it was kind of a mutual understanding and what made me feel good is that the students are comfortable saying like "hey, I think, maybe this other lab might work better" or "you know I think I'm interested in this and I probably should find somebody who's in that discipline" and I was like that's really good and you still kind of talk to me, but I don't want [students] to feel like they can't.

Although this was not related to research failures explicitly, it is clear that this trust (and alignment of expectations) led to clear communication during challenges. Helping students to understand when a different situation would better serve their goals and encouraging self-advocacy can help students to develop resiliency. Creating a culture of trust can also be helpful in encouraging students to identify and confront areas of confusion (Leighton and Bustos Gómez 2018).

In response to the question regarding the role of failure in developing a student's science identity, the R1 professor spoke most directly about research failures and the professor's perspectives on helping students to navigate unexpected results and "failed" experiments. The R1 professor first explained the impact on students in calling something a failure:

> I think [that if] people think they failed at something they'll write themselves off as being able to do that, like "I failed this molecular biology experiment, I could never be a molecular biologist" and that's really why I tried to not talk to students about successes or failures as much as I talk to them about interest. When I'm in the office with students I talk to them about what they thought was interesting, what they thought was the explanation, how cool it seems to relate to this, and if they seem interested maybe they can talk about it.

This quote was coded as developing *science identity, perceived psychosocial support,* and *developing mentee self-efficacy,* because the R1 professor counsels, fosters the mentee's interests, and recognizes the mentee as a scientist through fostering discussion and taking interest in the mentee's ideas. Notably, the mentor recognizes that some students may have a fixed mindset (Dweck 2006) that would regard an external failure as confirmation that the student was "unable" to do something. The R1 professor tries to counter this view by reframing the experiment as an opportunity to be curious, to be a scientist, and to think about what was interesting or notable within the failure, driving the student's focus away from what went wrong to what the student noticed and what could be done about it.

Later in the interview, the R1 professor made an important point regarding unexpected or null results in research. When asked about working with students who are not getting expected results in research, R1 responded:

> Oh that's constant! That's all research is! Of the interactions I have with a student, most of it is around that and you know, honestly, all results are celebrated if you completed an experiment and something happened at the end. Congratulations! The interpretation is the fun part. I would never call getting something different than you expected failure. Completing the experiment is, was, the work, you know, you got there, and now we have the joy of trying to figure out what [happened] and it's just the setup for the next experiment because it's an ongoing process. Science never, never ends, right, but you can't fail at it, because it never ends! It's constant.

This quote was coded as *developing science identity* and *facilitating coping efficacy,* demonstrating how they normalize failure while helping draw back the veil of the scientific process and the "important" and "fun" parts of the process. They uncover for students that science is an iterative practice that requires failure experiences to progress. When an experiment does not yield expected results, it gives the researcher important information for reshaping a hypothesis and can help lead to better understanding of the question being asked.

Further elaborating on this idea, the PUI professor explained a personal philosophy in mentoring students:

> What I can train [a mentee] to be as a diligent scientist is to pay attention to details, to know that iterative process, that you're going to try something and it's not going to work, but it doesn't mean it failed, because to learn something from that and how we go on from that is going to be applicable, whether you go on to academia, industry, whatever you go on to. These are really just life skills, we're just learning it in this context.

This quote further illustrates this professor's philosophy that failures are opportunities to learn, which she wishes to impart during her mentoring. This quote was coded as *developing mentee self-efficacy* and *developing science identity.*

Lessons and Limitations

The interviewees expressed the desire for students to learn from their challenges, advocate for themselves, and apply the lessons learned from their mentoring experiences to future goals and challenges. These professors have created research environments that led undergraduates to seek out further formal mentoring from them. Based on their quotes, three hypotheses can be proposed related to mentoring's role in helping students cope with failure, challenge, and fear of failure. These may act as a starting guide of "good practices" for instructors wishing to create effective mentoring environments that encourage all students to leverage failure and challenge experiences for growth, as well as provide future researchers with potential practices to test and explore further.

- ***Hypothesis 1:*** Mentoring that addresses *all* facets of a scientific or professional endeavor, including what experts consider to be intuitive or commonly known in addition to what experts consider to require specific skills, helps decrease anxiety and reduce fear of failure when students engage in new research or professional tasks. This type of mentoring may be especially effective at communicating aspects of the "hidden curriculum" that disproportionately affects underrepresented students (Gardeshi, Amini, and Nabeiei 2018).

  Recommendation: Consider all aspects of a new research or professional experience when advising mentees. Err on the side of assuming that mentees may not know common practices and ask mentees if they need more information on certain steps/parts of a process.

- ***Hypothesis 2:*** Sharing failure experiences and vulnerabilities creates space for students to share vulnerabilities and fears, as well as opens lines of communication. It also creates the perception of instructor immediacy, which has been shown to decrease undergraduate anxiety and improve students' failure experiences (Tonsing 2018).

  Recommendation: Sharing experiences such as failed experiments, paper rejections, and past challenges in classes, along with ways in which those experiences were resolved and ultimately provided growth, help students navigate failure in their careers. Allowing students to observe and participate in responding to reviewer comments, providing feedback in lab notebooks regarding experiments, and encouraging students to seek feedback from peers and others in the lab when an experiment fails helps to provide scaffolding that could lead to persistence in STEM.

- ***Hypothesis 3:*** When unexpected results or failures occur, focusing on the process of doing science, the curiosities and questions that the process elicits, and the opportunities for learning, rather than just the results, can reframe failure as a positive experience and allow for learning to occur. This can be seen through the fact that students who perceive instructors to have a growth mindset tend to have better outcomes, especially if the students are from underrepresented groups (Canning et al. 2019).

Recommendation: When a student fails, actively focus on the potential opportunities to evaluate, troubleshoot, and iterate instead of focusing on costs, time lost, or other resource issues when appropriate. Focusing on growth over achievement can facilitate coping efficacy, foster student independence, and develop mentee self-efficacy.

This chapter, based on personal experiences of the authors and their past mentors, is intended as a brief perspective rather than an in-depth analysis of undergraduate perceptions of mentoring or failure. A survey of students from both formal and informal mentoring situations in which respondents are asked specifically about interactions that supported them through failure experiences would be a next step for this topic. It has been shown here, through personal reflections and interviews with mentors, that there are specific mentoring practices that are likely tied to the development of students' ability to grow through failure experiences. Future research and practical implementation are encouraged to further elucidate the discussion here about the importance of mentoring for fostering undergraduate resilience.

References

Aikens, Melissa L., Sona Sadselia, Keiana Watkins, Mara Evans, Lillian T. Eby, and Erin L. Dolan. 2016. "A Social Capital Perspective on the Mentoring of Undergraduate Life Science Researchers: An Empirical Study of Undergraduate–Postgraduate–Faculty Triads." *CBE–Life Sciences Education* 15(2): 1–15. doi: 10.1187/cbe.15-10-0208

Canning, Elizabeth A., Katherine Muenks, Dorainne J. Green, and Mary C. Murphy. 2019. "STEM Faculty who Believe Ability Is Fixed Have Larger Racial Achievement Gaps and Inspire Less Student Motivation in Their Classes." *Science Advances* 5(2): eaau473. doi: 10.1126/sciadv.aau4734

Cook, Elzbieta, Eugene Kennedy, and Saundra Y. McGuire. 2013. "Effect of Teaching Metacognitive Learning Strategies on Performance in General Chemistry Courses." *Journal of Chemical Education* 90: 961–967. doi: 10.1021/ed300686h

Cooper, Katelyn M., Virginia R. Downing, and Sara E. Brownell. 2018. "The Influence of Active Learning Practices on Student Anxiety in Large-Enrollment College Science Classrooms." *International Journal of STEM Education* 5(1): ar23. doi: 10.1186/s40594-018-0123-6

Cooper, Katelyn M., Logan E. Gin, M. Elizabeth Barnes, and Sara E. Brownell. 2020. "An Exploratory Study of Students with Depression in Undergraduate Research Experiences." *CBE–Life Sciences Education* 19: ar19. doi: 10.1187/cbe.19-11-0217

Corwin, Lisa A., Christopher R. Runyon, Eman Ghanem, Moriah Sandy, Greg Clark, Gregory C. Palmer, Stuart Reichler, Stacia E. Rodenbusch, and Erin L. Dolan. 2018. "Effects of Discovery, Iteration, and Collaboration in Laboratory Courses on Undergraduates' Research Career Intentions Fully Mediated by Student Ownership." *CBE–Life Sciences Education* 17(2): 1–11. doi: 10.1187/cbe.17-07-0141

Dweck, Carol S. 2006. *Mindset: The New Psychology of Success*. New York: Ballantine.

Eby, Lillian T., Jaime R. Durley, Sarah C. Evans, and Belle Rose Ragins. 2006. "The Relationship between Short-Term Mentoring Benefits and Long-Term Mentor Outcomes." *Journal of Vocational Behavior* 69: 424–44. doi: 10.1016/j.jvb.2006.05.003

Eby, Lillian T., Jean E. Rhodes, and Tammy D. Allen. 2007. "Definition and Evolution of Mentoring." In *The Blackwell Handbook of Mentoring: A Multiple Perspectives Approach,* ed. Tammy D. Allen and Lillian T. Eby, 7–20. Oxford: Blackwell.

Eby, Lillian Turner de Tormes, Tammy D. Allen, Brian J. Hoffman, Lisa E. Baranik, Julia B. Sauer, Sean Baldwin, M. Ashley Morrison, et al. 2013. "An Interdisciplinary Meta-Analysis of the Potential Antecedents, Correlates, and Consequences of Protégé Perceptions of Mentoring." *Psychological Bulletin* 139: 441–76. doi: 10.1037/a0029279

Eby, Lillian T., and Erin L. Dolan. 2014. "Mentoring in Postsecondary Education and Organizational Settings." In *APA Handbook of Career Intervention,* Vol. 2: Applications, ed. Paul J. Hartung, Mark L. Savickas, and W. Bruce Walsh, 383–395. doi: 10.1037/14439-028

Gardeshi, Zahra, Mitra Amini, and Parisa Nabeiei. 2018. "The Perception of Hidden Curriculum among Undergraduate Medical Students: A Qualitative Study." *BMC Research Notes* 11(1): 1–4. doi: 10.1186/s13104-018-3385-7

Gin, Logan E., Ashley A. Rowland, Blaire Steinwand, John Bruno, and Lisa A. Corwin. 2018. "Students Who Fail to Achieve Predefined Research Goals May Still Experience Many Positive Outcomes as a Result of CURE Participation." *CBE–Life Sciences Education* 17: ar57. doi: 10.1187/cbe.18-03-0036

Goodwin, Emma C., Vladimir Anokhin, Mackenzie J. Gray, Daniel E. Zajic, Jason E. Podrabsky, and Erin E. Shortlidge. 2021. "Is This Science? Students' Experiences of Failure Make a Research-Based Course Feel Authentic." *CBE–Life Sciences Education* 20(1): 1–15. doi: 10.1187/cbe.20-07-0149

Griffin, Kimberly A., David Pérez, Annie P. E. Holmes, and Claude E. P. Mayo. 2010. "Investing in the Future: The Importance of Faculty Mentoring in the Development of Students of Color in STEM." In "Students of Color in STEM," ed. Shaun R. Harper and Christopher B. Newman, spec. issue, *New Directions for Institutional Research* 148: 95–103. doi: 10.1002/ir.365

Harsh, Joseph A., Adam V. Maltese, and Robert H. Tai. 2011. "Undergraduate Research Experiences from a Longitudinal Perspective." *Journal of College Science Teaching* 41: 84–91.

Henry, Meredith A., Shayla Shorter, Louise Charkoudian, Jennifer M. Heemstra, and Lisa A. Corwin. 2019. "*FAIL* Is Not a Four-Letter Word: A Theoretical Framework for Exploring Undergraduate Students' Approaches to Academic Challenge and Responses to Failure in STEM Learning Environments." *CBE–Life Sciences Education* 18: ar11. doi: 10.1187/cbe.18-06-0108

Joshi, Megha, Melissa L. Aikens, and Erin L. Dolan. 2019. "Direct Ties to a Faculty Mentor Related to Positive Outcomes for Undergraduate Researchers." *BioScience* 69(5): 1–9. Doi: 10.1093/biosci/biz039

Kram, Kathy E. 1985. *Mentoring at Work: Developmental Relationships in Organizational Life.* Glenview, IL: Scott, Foresman.

Kranzfelder, Petra, Alexander T. Lo, Marin P. Melloy, Lindsey E. Walker, and Abdi Rizak M. Warfa. 2019. "Instructional Practices in Reformed Undergraduate STEM Learning Environments: A Study of Instructor and Student Behaviors in Biology Courses." *International Journal of Science Education* 41: 1944–1961. doi: 10.1080/09500693.2019.1649503

Laursen, Sandra, Anne-Barrie Hunter, Elaine Seymour, Heather Thiry, and Ginger Melton. 2010. *Undergraduate Research in the Sciences: Engaging Students in Real Science.* Hoboken, NJ: Wiley.

Leighton, Jacqueline P., and María Clara Bustos Gómez. 2018. "A Pedagogical Alliance for Trust, Wellbeing and the Identification of Errors for Learning and Formative Assessment." *Educational Psychology* 38: 381–406. doi: 10.1080/01443410.2017.1390073

Levinson, Daniel J. 1978. *The Seasons of a Man's Life.* New York: Knopf.

Limeri, Lisa B., Muhammad Zaka Asif, Benjamin H. T. Bridges, David Esparza, Trevor T. Tuma, Daquan Sanders, Alexander J. Morrison, et al. 2019. "'Where's My Mentor?!' Characterizing Negative Mentoring Experiences in Undergraduate Life Science Research." *CBE–Life Sciences Education* 18(4): 1–13. doi: 10.1187/cbe.19-02-0036

McKinsey, Elizabeth. 2016. "Faculty Mentoring Undergraduates: The Nature, Development, and Benefits of Mentoring Relationships." *Teaching and Learning Inquiry* 4(1): 25–39. doi: 10.20343/teachlearninqu.4.1.5

Pfund, Christine, Angela Byars-Winston, Janet Branchaw, Sylvia Hurtado, and Kevin Eagan. 2016. "Defining Attributes and Metrics of Effective Research Mentoring Relationships." *AIDS and Behavior* 20: 238–248. doi: 10.1007/s10461-016-1384-z

Robnett, Rachael D., Paul A. Nelson, Eileen L. Zurbriggen, Faye J. Crosby, and Martin M. Chemers. 2018. "Research Mentoring and Scientist Identity: Insights from Undergraduates and Their Mentors." *International Journal of STEM Education* 5(1): ar41. doi: 10.1186/s40594-018-0139-y

Saldaña, Johnny. 2016. *The Coding Manual for Qualitative Researchers.* London: Sage.

Simpson, Amber, and Adam Maltese. 2017. "'Failure Is a Major Component of Learning Anything': The Role of Failure in the Development of STEM Professionals." *Journal of Science Education and Technology* 26: 223–237. doi: 10.1007/s10956-016-9674-9

Stanton, Julie Dangremond, Amanda J. Sebesta, and John Dunlosky. 2021. "Fostering Metacognition to Support Student Learning and Performance." *CBE–Life Sciences Educatio*n 20(2): 1–7. doi: 10.1187/cbe.20-12-0289

Tonsing, Kareen N. 2018. "Instructor Immediacy and Statistics Anxiety in Social Work Undergraduate Students." *Social Work Education* 37: 223–233. doi: 10.1080/02615479.2017.1395009

CHAPTER 15

Coping with the Researcher's School of Hard Knocks: How Undergraduate Research Students and Their Mentors Respond to Failure and Rejection

Andrea J. Sell, Jodie Kocur, and Kayley J. Hall

Abstract. This chapter presents a survey of undergraduate research students and faculty mentors about (1) the coping strategies faculty are currently teaching and find effective in helping students deal with their research failures and rejections and (2) the strategies students are currently using and find effective in dealing with research failures and rejections. It describes the strategies reported by students and faculty to be highly used and most effective, as well as includes analyses that compare what students and faculty report using to what they believe are effective. Recommendations based on survey results and previous literature on how to integrate coping strategies into undergraduate research experiences are included.

doi: 10.18833/cf/17

Seasoned faculty know that academic research is fraught with rejection and challenges. Some researchers even go so far as to define the academic culture as one of rejection (e.g., Allen et al. 2020, 1). This "culture of rejection" is driven by low acceptance rates in academic journals and grant applications, some less than 10 percent (e.g., Chan, Mazzucchelli, and Rees 2020, 448). Day (2011) estimates that more than half of academics will experience manuscript rejections at least two or three times in publishing just one article (706). High rejection rates of papers and grants affect academics at all levels (Day 2011, 706). Most need to publish research and obtain grant funding to stay employed in academe (e.g., Carson, Bartneck, and Voges 2013, 184).

However, academics who have persisted in this culture understand that most rejection experiences are surmountable. To succeed in research careers, these faculty have developed skills to persevere through their many instances of rejection. For example, Chan, Mazzucchelli, and Rees (2020) found that successful faculty know to lean on their belief systems, engage with collegial support, keep their expectations realistic, and manage their emotional response to stay positive and productive in academia (456). Additionally, Gomes, Faria, and Gonçalves (2013) found that faculty who used a challenge-framed cognitive appraisal of their work (e.g., seeing a stressful situation as a challenge versus as harmful or threatening) were better able to handle stress and avoid burnout than faculty who appraised their work in terms of threat (363).

Now, the next generation of scientists needs mentoring, and these novice researchers are bound to experience failure and rejection along their educational journey (e.g., Day 2011, 705-706). How and when they are taught to manage these challenges will shape their choices and career satisfaction for years to come (e.g., DeCastro et al. 2013, 497; Lopatto 2003, 141). This may be particularly true for the growing number of beginning researchers who are from communities that are historically underrepresented in academic ranks (e.g., Davis and Fry 2019; National Center for Education Statistics 2021). For example, Guillaume, Cisneros, and Martinez (2020) report case studies of early-career women of color who faced significant professional and personal challenges because they did not feel prepared to deal with the level of rejection and failure in their first few years on the tenure track. Additionally, Simpson and Maltese (2017) found that at least 17 percent of their sample of professionals in STEM had at some point changed their plans because of experiences with failure along their journey (230). Undergraduate students find real intrinsic and extrinsic value in their research experiences (Seymour, Hunter, and Laursen 2004, 507–529). However, if unprepared for the emotional consequences of failure, research students may feel too much opportunity cost associated with research experiences and may look elsewhere for professional skill development (Ceyhan and Tillotsen 2020).

In addition to learning to anticipate these challenges and learning ways to cope with research setbacks, students may also need mentoring regarding what these research rejections or failures mean about who they are and their possible future success as a researcher. A person's beliefs about, or cognitive appraisal of, negative or undesirable events is a significant predictor of feelings and behaviors (e.g., Beck 1976; Rubenstein et al. 2016). For example, pessimistic attributional styles, which include one's beliefs that adverse events in one's life are due to stable, general parts of themselves (known as stable, global internal attributions), are related to a sense of helplessness and hopelessness, which decrease the likelihood of persisting after the experience of a challenging event (e.g., Maier and Seligman 2016; McCauley, Pavlidis, and Kendall 2001; Rubenstein 2016). Therapy that targets and challenges these beliefs effectively prevents the onset of and reduces symptoms of anxiety and depression (e.g., Merry et al. 2012; Kishita and Laidlaw 2017). Research on students' beliefs about negative feedback is consistent with this model. For example, Hill and colleagues (2021) found that how students perceive and handle negative feedback can affect their beliefs about their potential success in their future careers (309). Thus, without structured training, resources, and support, novice researchers facing this intense "culture of rejection" may risk negative thoughts, avoidance, and disengagement in their fields (Allen et al. 2020, 2; Day 2011, 709).

However, numerous studies show that well-structured and supportive undergraduate research experiences can help students gain the skills and confidence they need to overcome the challenges of research and set the student up for a fulfilling research career (e.g., Harsh, Maltese, and Tai 2011, 86–87; Thiry et al. 2012, 267–268; Russell, Hancock, and McCullough 2007; Lopatto 2003, 141). Indeed, Simpson and Maltese (2017) reported that many professionals in STEM attributed their success in their careers to successfully working through their early experiences of failure in research (233). Well-structured, supportive undergraduate research experiences can also increase persistence and retention rates for students from historically underserved communities (Nagda et al. 1998). Henry et al. (2019) predicted that students who can employ adaptive coping strategies and a challenge (versus threat) framing of obstacles in research would ultimately have positive long-term outcomes in STEM careers (11).

What strategies do undergraduate students employ in working through experiences of failure and rejection in academia, and what can faculty do to assist them? In one study, Hill et al. (2021) found that how a student chooses to handle receiving negative feedback on a paper or an assignment varies substantially from student to student and has wide-ranging, downstream effects. Some students reported intense, lingering, and sometimes debilitating emotions related to negative feedback. These emotions impacted their motivation about doing future work in the discipline (310). However, Hill et al. (2021) noted that more experienced students tended to report more effective approaches to receive feedback, potentially showing that students can avoid the detrimental disengagement effects after experiencing failure with training and mentorship (309).

Additionally, there is some research on what classroom instructors can do to help students deal with anxiety and academic stress (Hsu and Goldsmith 2021). For example, Hsu and Goldsmith (2021) advocate that faculty help students build social relationships with their peers, cultivate an empowering classroom environment, and teach practical academic skills (3). Other work on course-based undergraduate research shows specific and deliberate actions in which instructors can engage, such as modeling how to respond to challenges, that can effectively support student success (Gin et al. 2018, 9–10). However, it is not easy to generalize these classroom strategies to the educational context of working with undergraduate students in a research context outside of the classroom.

Thus, although there is some previous work on what is effective in helping students face failure in educational settings, there is less research specific to the unique instructional environment of training undergraduate research students (e.g., what helps them feel positive about their research experience, what allows them to continue working on and finishing their project). It is currently unclear what strategies and approaches faculty are teaching research students and what students find helpful. Therefore, the goals of this study are threefold: to ascertain (1) the coping strategies that faculty are currently teaching to their research students and how effective they feel those strategies are, (2) the strategies that research students are currently using and how effective they believe them to be, and (3) the faculty and student perceptions of what failure experiences indicate about students and their research. To answer these questions, the authors surveyed faculty and students who had been involved in undergraduate research within the past nine months. Students and faculty responded to questions about their strategies for dealing with failure and rejection in their research as well as questions about their attributions for these failures and rejections.

Participants, Measures, and Procedures

Participants

Forty-two participants completed the survey, including 30 undergraduate researchers and 12 faculty mentors of undergraduate research. Participants were recruited from a single mid-sized, private, regional university with a Hispanic-Serving Institution designation. Among the student participants (M_{age} = 20.9, SD_{age} = 1.352), 26 (86.7 percent) were women; 19 (63.3 percent) were White; 14 (46.7 percent) were Hispanic; 3 (10 percent) were Black; 2 (6.7 percent) were Asian; and 3 (10 percent) were American Indian, Alaskan Native, Native Hawaiian, or Other Pacific Islander. Additionally, 16 (53.3 percent) reported being first-generation college students. Over half the student sample were STEM students (n = 19, 63.3 percent), two students were from humanities (6.7 percent), eight were from social science (26.7 percent), and one chose not to disclose an academic field (3.3 percent). Among the faculty participants (n = 12, M_{age} = 46.6, SD_{age} = 6.85), 7 (58.3 percent) were women, 7 (58.3 percent) were White, 2 (16.7 percent) were Asian, 3 (25 percent) were Hispanic, and 1 (8.3 percent) were Black, and 1 (8.3 percent) were American Indian or Alaskan Native. Additionally, 4 (33.3 percent) reported being first-generation college students. Therefore, overall, 78.57 percent of the sample reported belonging to at least one historically underrepresented demographic in academia. Faculty mentors had a wide range of experience, with an average of 12.9 years of mentoring (*Range:* 1-22, SD = 6.9). Over half the faculty sample were from STEM disciplines (*n* = 7, 58.3 percent), one faculty respondent was from social science (8.3 percent), two were from humanities (16.7 percent), and two chose not to disclose their academic field (16.7 percent).

Participants were recruited with an email from the university's Office of Educational Effectiveness and Institutional Research sent to all students who had registered for research credits in the past nine months and all faculty who had taught a section of directed research in the same period. These research opportunities included students from multiple programs on campus, including federally funded initiatives that promote undergraduate research for traditionally underrepresented groups, donor and university-sponsored summer research fellowships, honors student research projects, and faculty research teams. Participants were given the option of receiving a $10 gift card to their choice of either Amazon or Starbucks after completing the survey.

Measures

The survey was hosted by Qualtrics and included both quantitative and qualitative questions. Faculty and students were given the following instructions:

> In this survey, we are exploring attribution styles and coping strategies for research failures, such as rejections. We want to know what strategies you're currently using in your daily research life or have used in the recent past *to deal with failure and rejection regarding your research.* We realize everyone is at a different place in their research journey, so we define research failures and rejections in a broad, general sense. This can include things like applying to a conference and not getting accepted, not getting an expected result in your data, making a mistake in your methodology, etc.

After these instructions, participants were asked about 17 coping strategies. Participants were asked to utilize Likert scales to respond to two questions about each strategy:

1. the extent to which they use the strategy after the experience of rejection or failure (1 = "not at all" to 7 = "to a great extent") and
2. how effective they believe that strategy is for helping them feel optimistic about the research and continue making progress (1 = "not at all" to 7 = "to a great extent").

The coping strategies were adapted from Chan, Mazzucchelli, and Rees (2020, 450), Horn (2016, 18), and DeCastro et al. (2013, 500). Students and faculty received the same items, slightly modified for each group. For example, whereas a student saw, "I tell myself failure and rejection are part of the research process," faculty participants saw, "I tell the student that failure and rejection are part of the research process" (for a complete list of items, see Table 1).

The second questionnaire included three questions about the research failure/rejection attributions. The researchers created these questions based on three types of attributions for negative events called internal, stable, and global attributions (Seligman et al. 1979, 242). The three questions were created to exemplify the three types of attributions of the negative event of experiencing a research rejection or failure. Participants were prompted to think of a time when they experienced a research rejection or failure and were then asked to use Likert scales to rate how strongly they believed the three attributions (see Table 2 for items).

The following section included a few open-ended questions regarding undergraduate researchers' opinions and beliefs regarding rejection and failure or how faculty mentors approach the topic of rejection and failure with their students. For example, one student question asked, "In your experience, what does a research setback mean about your ability as a researcher?" Preliminary analyses of the open-ended questions did not yield additional information over-and-above the quantitative analyses and are thus not included in the results. Lastly, participants answered standard demographic questions about their major/field, gender, race, ethnicity, etc. After the demographic questions and the debriefing, participants were directed to follow a link to request a $10 digital gift card from either Starbucks or Amazon.

TABLE 1. Strategy labels and corresponding survey items

Coping strategy	Survey item
Reinterpretation	I tell myself it's the narrowmindedness of the person issuing the rejection/negativity, so it's their problem, not mine.
Pragmatism	I tell myself the person who issued the rejection (reviewer, commenter) did not understand what I was talking about.
Broad Focus	I make sure to have multiple projects so that if one doesn't work out, I still have the others.
Avoidance	I avoid working on the project, even during the time I should be working on it.
Denial	I downplay the rejection/failure or pretend it didn't happen.
Narrow Focus	I double-down on the project and focus only on that study.
Beliefs and Values	I re-center myself by thinking about my beliefs and value system; for example, I lean on my religious beliefs, go to religious service, etc.
Comparison	I look at what my peers are doing and compare my work with theirs.
Social Withdraw	I retreat to my lab/desk/workspace and work on my research alone for a while.
Physical Activity	I use physical activity to cope. For example, I go to the gym or go for a run.
Work Life Balance	I work to strengthen my work life balance; for example, I make sure to spend time on hobbies outside of work, in addition to my work.
Emotion Regulation	I take a step back from the project and calm down my emotions before going back to work.
Support Network	I engage my support network; for example, I try to get together with people that care about me.
Celebrate Successes	I celebrate my successes so far and focus on what is going well with my research.
Reflection	I reflect on my rejection/failure and think about what I could have done differently.
Rationalizing	I tell myself failure and rejection are part of the research process.
Behavior Change	I try to make changes to my work; I talk to my adviser about what to do differently next time.

Note: Adapted from Chan, Mazzucchelli, and Rees 2021, 450; Horn 2016, 18; and DeCastro et al. 2013, 500.

TABLE 2. Attribution questions

Participant group	Type	Survey item	Scale
Student	Attribution to Self or Others	Do you believe the cause of your research rejection, failure, or challenge was due to something about you (e.g., lacking skills or knowledge) or about something or someone else?	1 = Entirely due to me *to* 7 = Entirely due to others
	Generalization	Was the cause of this research rejection, failure, or challenge specific only to research (e.g., I only struggled with this research), or does it impact other areas of your life (e.g., I struggled because I struggle in all areas of my life)?	1 = Specific only to research *to* 7 = Impacts all other areas of life
	Stability	In the future, do you believe the cause will be present in your research work again?	1 = Will never again be present *to* 7 = Will always be present
Faculty	Attribution to Self or Others	Did you teach your student to believe the cause of the student's research rejection, failure, or challenge was due to something about the student (e.g., lacking skills or knowledge) versus about something or someone else?	1 = Entirely due to student *to* 7 = Entirely due to others
	Generalization	Did you teach your student to believe that the cause of this research rejection, failure, or challenge was specific only to this research or that it was something that is likely causing struggles in other areas of the student's life?	1 = Specific only to research *to* 7 = Impacts all other areas of life
	Stability	Did you teach your student to believe that the cause will be present in the research work again in the future or will never again be present?	1 = Will never again be present *to* 7 = Will always be present

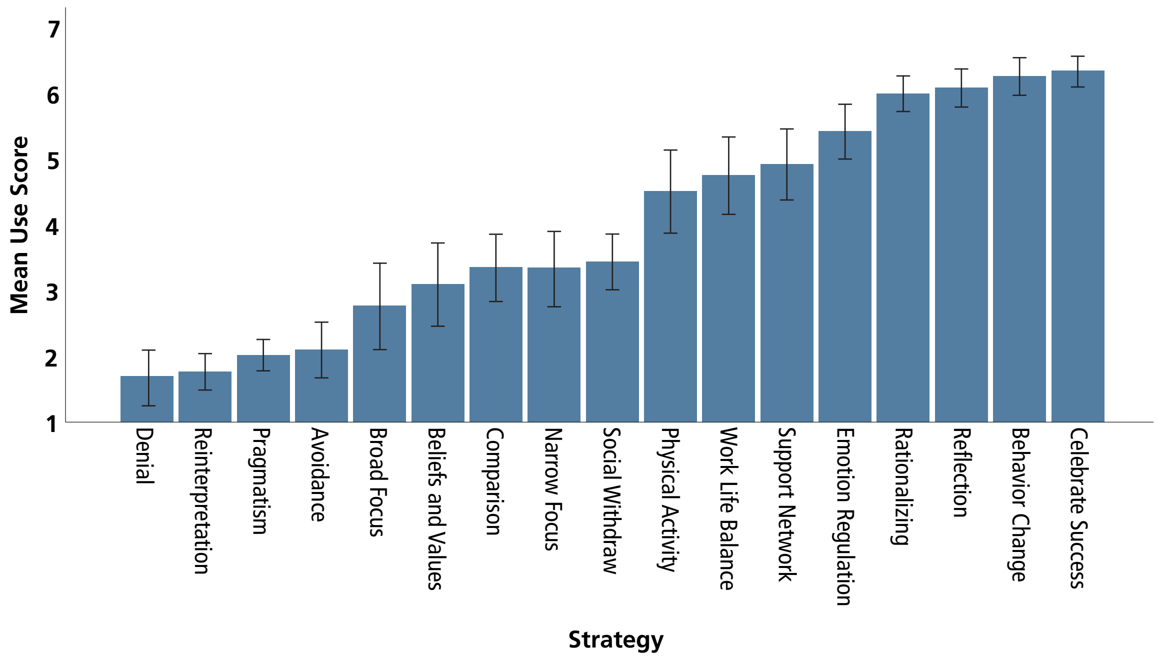
Analytical Methods and Results

Strategy Use

What strategies do faculty teach to support students in coping with rejection and failure in research? What strategies do students report using? To answer these questions, the authors first calculated the means and standard deviations for each strategy's "use" scores for faculty and students. These means and standard deviations were used to define sample-specific thresholds for high and low use of each strategy. *High use* was defined as strategies with average use scores one standard deviation above the overall average use score by role (faculty and student). *Low use* was defined as strategies one standard deviation below the overall mean use score by role. Therefore, "High use" for faculty included items with ratings above 5.64 (M = 3.98, SD = 2.32). Students' high use ratings included items with average ratings above 5.75 (M = 4.30, SD = 1.45). "Low use" for faculty included items with average ratings below 2.32, and "low use" for students included items with ratings below 2.85.

Faculty reported average "high use" scores for teaching their students the following strategies: Celebrate Success (M = 6.33, SD = 0.778), Behavior Change (M = 6.25, SD = 0.965), Reflection (M = 6.08, SD = 0.996), and Rationalization (M = 6.0, SD = 0.953). Faculty reported average "low use" scores for teaching their students the following: Avoidance (M = 2.08, SD = 1.443), Pragmatism (M = 2, SD = 0.853), Reinterpretation (M = 1.75, SD = 0.97), and Denial (M = 1.67, SD = 1.50). (See Figure 1)

FIGURE 1. Faculty research mentors' average use scores for each strategy



Note: Error bars: +/- 1 SE

Students reported average "high use" ratings for the following strategies: Behavior Change (M = 5.8, SD = 1.289) and Rationalizing (M = 5.8, SD = 1.297). Students reported average "low use" ratings of the following strategies: Avoidance (M = 2.7, SD = 1.8), Denial (M = 2.7, SD = 1.8), Broad Focus (M = 2.67, SD = 1.86), Pragmatism (M = 2.37, SD = 1.38), and Reinterpretation (M = 1.93, SD = 1.29). (See Figure 2)

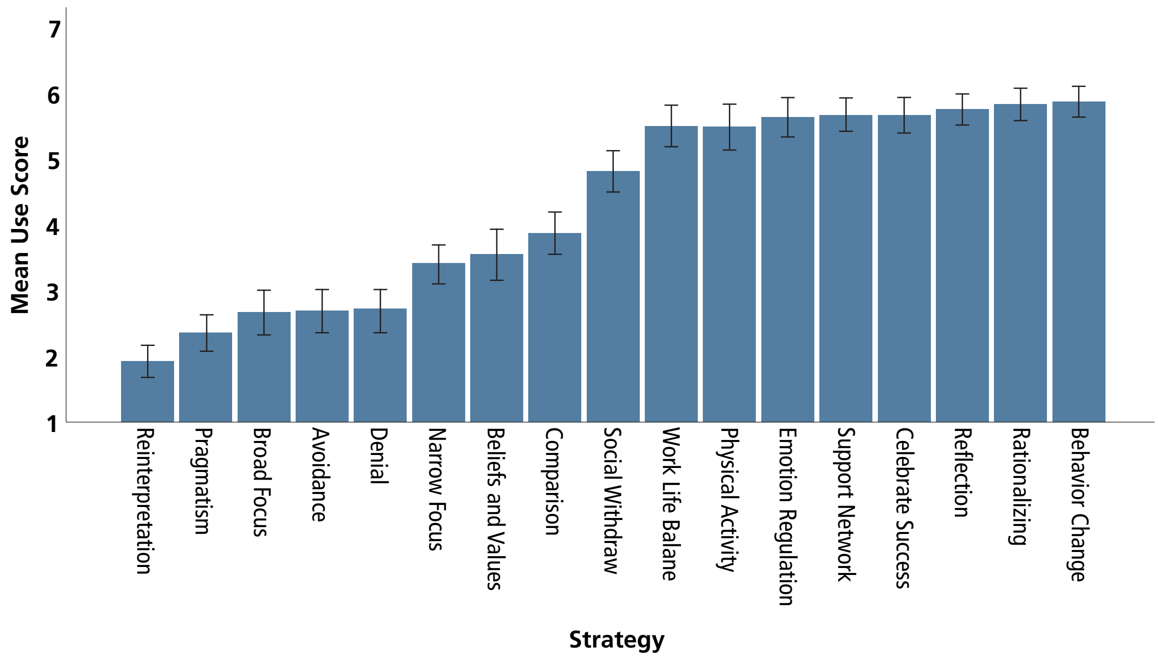
Additionally, to investigate if there was a misalignment between what faculty report teaching students and what students report using, a series of independent samples t-tests were used to compare use scores between students and faculty for each item. Students reported using Social Withdraw more (M = 4.8, SD = 1.73) than faculty reported using it (M = 3.42, SD = 1.44), $t(40) = 2.445$, $p = 0.019$, 95 percent CI [0.240, -2.527], $d = 0.835$. Although both rated Celebrating Success highly, faculty reported encouraging it more (M = 6.33, SD = 0.778) than students reported using it (M = 5.63, SD = 1.497), $t(36.94) = -1.531$, $p = 0.055$, 95 percent CI [-1.417, -0.017], $d = 0.5232$ (Levene's violated, $F = 7.652$, $p = 0.009$). There was also a marginally significant difference between faculty ratings of Denial, where students reported higher ratings for its use (M = 2.7, SD = 1.803) than faculty reported teaching it (M = 1.67, SD = 1.45), $t(40) = 1.754$, $p = 0.087$, 95 percent CI [-0.157, 2.224], $d = 0.599$. (See Figure 3)

Strategy Effectiveness Beliefs

What strategies do students and faculty find most effective in dealing with failure and rejection in research? The authors calculated means and standard deviations of faculty and student ratings for each item to investigate this question. Perceived high and low effectiveness ratings were calculated similarly as "use" ratings. Therefore, perceived "high effectiveness" for faculty included items with ratings above 6.04 (M = 4.27, SD = 1.76). Students' perceived "high effectiveness" ratings included items with average ratings above 6.21 (M = 4.43, SD = 1.78). Perceived "low effectiveness" for faculty had items with average ratings below 2.52, and perceived "low effectiveness" for students included items with ratings below 6.21.

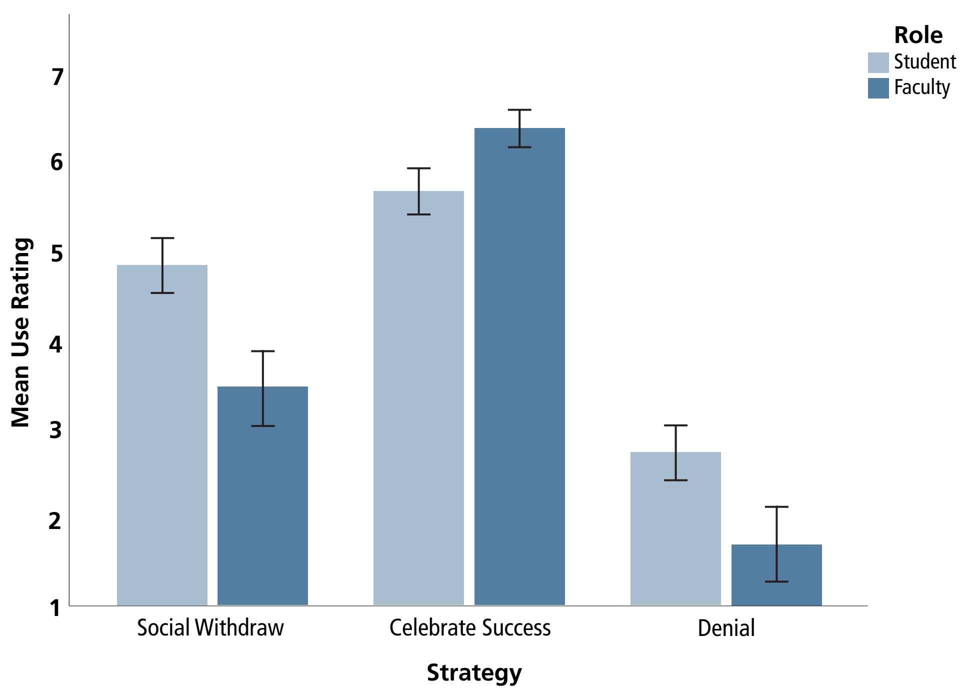
Faculty reported believing the following strategies to be highly effective: Reflection (M = 6.5, SD = 1.17), Behavior Change (M = 6.42, SD = 0.9), Celebrate Success (M = 6.42, SD = 0.67), and Rationalizing (M = 6.25, SD = 0.75). Faculty reported believing the following strategies had low effectiveness: Pragmatism (M = 2, SD = 1.94), Avoidance

FIGURE 2. Student researchers' average use scores for each strategy



Note: Error bars: +/- 1 SE

FIGURE 3. Strategies with statistically significant different use ratings by role



Note: Error bars: +/- 1 SE

(*M* = 2.0, *SD* = 1.45), Denial (*M* = 1.83, *SD* = 1.75), and Reinterpretation (*M* = 1.67, *SD* = 0.99). (See Figure 4)

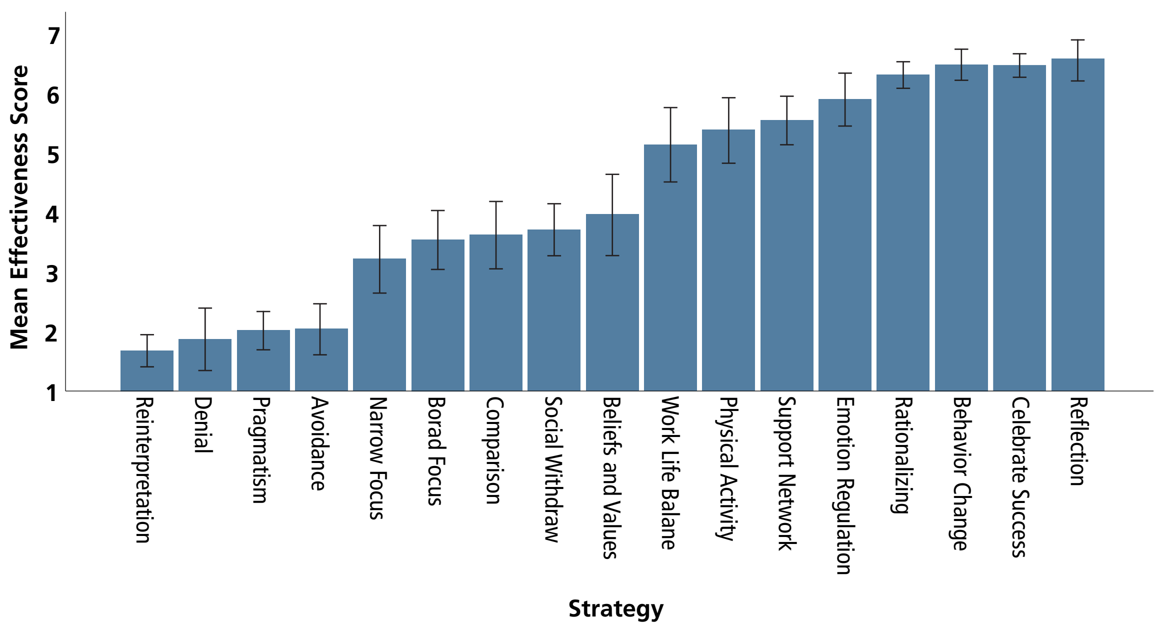
Students reported believing the following strategies are highly effective: Emotion Regulation (*M* = 6.43, *SD* = 0.817), Behavior Change (*M* = 6.3, *SD* = 1.34), and Work Life Balance (*M* = 6.3, *SD* = 1.02). Students reported believing the following strategies had low effectiveness: Pragmatism (*M* = 2.3, *SD* = 1.58), Reinterpretation (*M* = 2.03, *SD* = 1.79), Denial (*M* = 1.8, *SD* = 1.215), and Avoidance (*M* = 1.73, *SD* = 1.60). (See Figure 5)

Independent samples *t*-tests comparing faculty and student effectiveness ratings showed that faculty and students generally agreed on the effectiveness of strategies. Only two strategies showed marginal statistical differences; all other comparisons were not significant. Students marginally rated the efficacy of Work Life Balance higher (*M* = 6.3, *SD* = 1.02) than faculty (*M* = 5.08, *SD* = 2.11) $t(13.121) = 1.911$, $p = 0.078$, 95 percent CI [-0.158, 2.59], $d = 0.265$ (Levene's violated, $F = 26.521$, $p < 0.001$). Faculty rated Rationalizing marginally more effective (*M* = 6.25, *SD* = 0.754) than students rated it (*M* = 5.6, *SD* = 1.61), $t(38.79) = -1.78$, $p = 0.083$, 95 percent CI [-1.390, 0.090], $d = 0.456$ (Levene's violated; $F = 5.327$, $p = 0.026$). (See Figure 6)

Relationship between Strategy Use and Effectiveness Beliefs

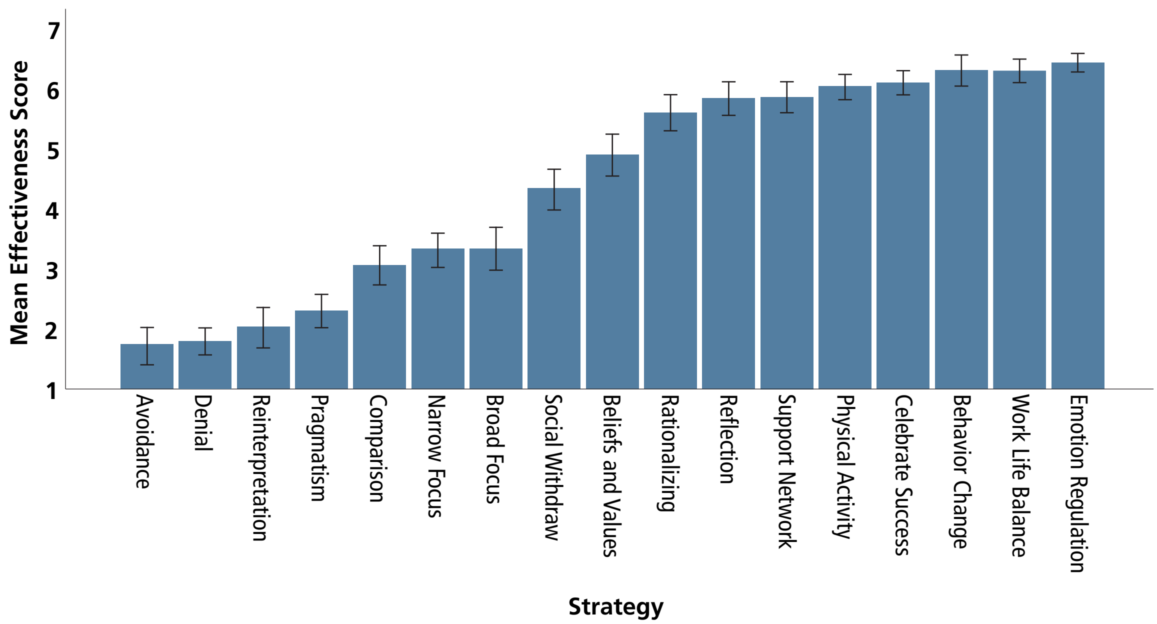
Additionally, several analyses were conducted to investigate a possible relationship between use and perceived effectiveness ratings for faculty and students. Results showed that, in general, faculty and students reported high use of strategies that they also rated as effective. Strategy use ratings strongly and positively correlated with effectiveness ratings for all strategies except one—Comparison. For students, there was no relationship between ratings of the effectiveness of the Comparison strategy and the extent

FIGURE 4. Faculty research mentors' average effectiveness rating scores for each strategy



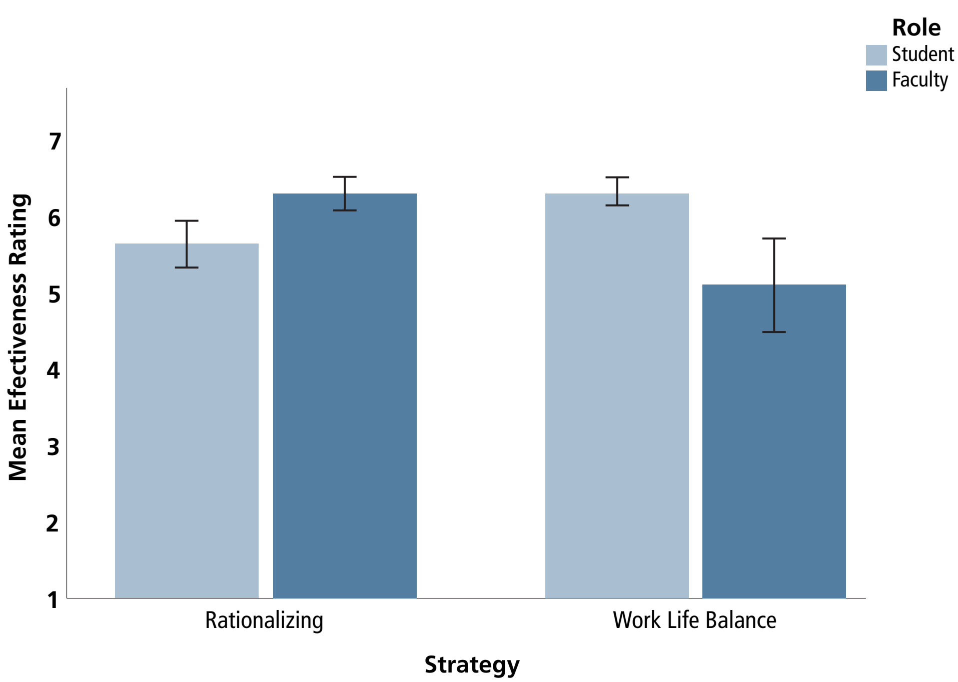
Note: Error bars: +/- 1 SE

FIGURE 5. Student researchers' average effectiveness rating scores for each strategy



Note: Error bars: +/- 1 SE

FIGURE 6. Strategies with statistically significant different effectiveness ratings by role

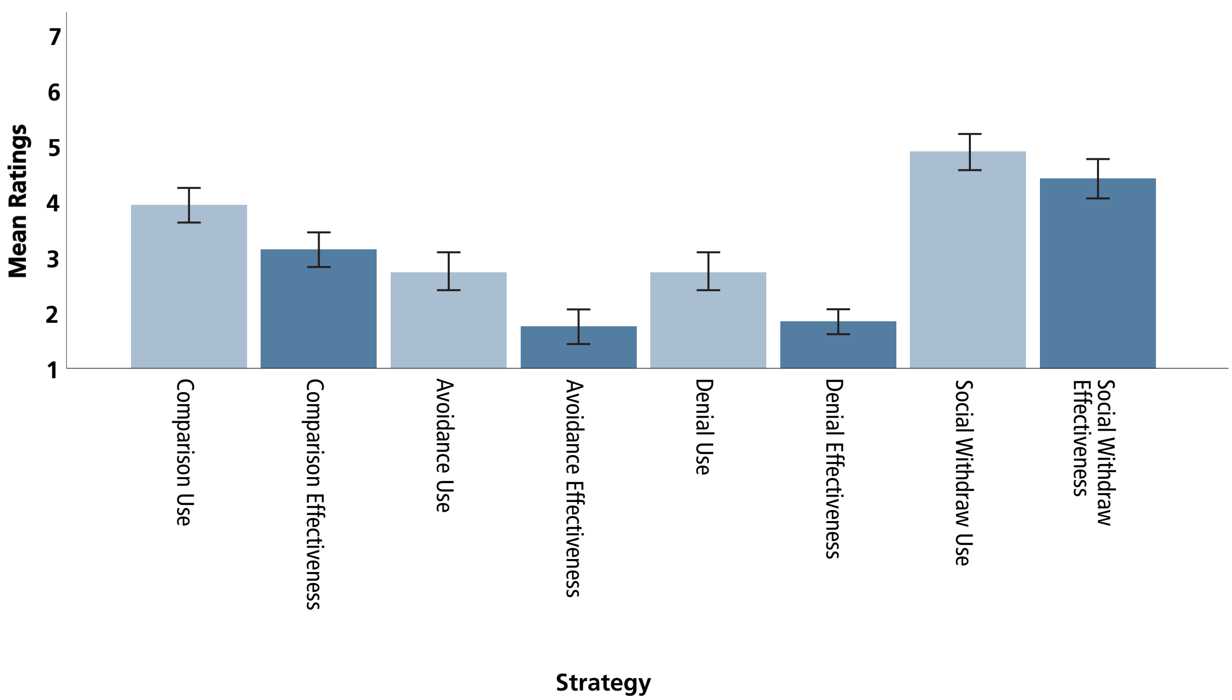


Note: Error bars: +/- 1 SE

that students use it, *r*(28) = 0.249, *p* = 0.186. For all other strategies, as both faculty and students believed a strategy to be more effective, they reported higher levels of using it or teaching it (Faculty *r*'s > 0.5822, *p*'s < 0.05; Student *r*'s > 0.408, *p*'s < 0.025).

Additionally, to further investigate the possibility of a mismatch between what students believe is effective and what they report using in their day-to-day practice, the authors conducted a series of exploratory paired samples *t*-tests comparing students' strategy use and effectiveness ratings. There were several strategies that students rated as lower effectiveness but higher use: Comparison, *t*(29) = 2.25, *p* = 0.032, 95 percent CI [-0.005, 1.605], *d* = 0.371; Avoidance, *t*(29) = 3.385, @ = 0.002, 95 percent CI [0.383, 1.551], *d* = 0.618; Denial, *t*(29) = 4.062, *p* < 0.001, 95 percent CI [0.447, 1.353], *d* = 0.742; and Social Withdraw, *t*(29) = 2.25, *p* = 0.032, 95 percent CI [0.042, 0.891], *d* = 0.411. However, none of these were strategies that students reported as "high use" strategies. (See Figure 7)

FIGURE 7. Strategies with statistically significantly higher use than effectiveness ratings for students

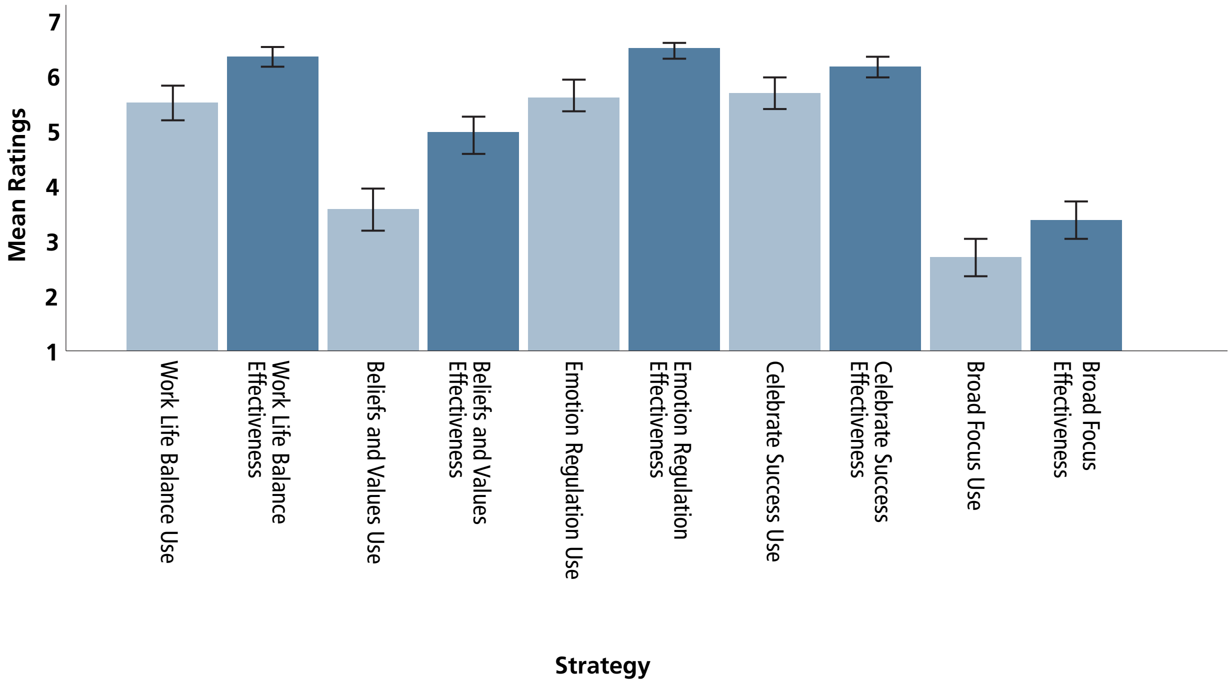


Note: Error bars: +/- 1 SE

Additionally, there were several strategies that students rated as more effective but reported lower use: Work Life Balance, *t*(29) = -3.542, *p* = 0.001, 95 percent CI [-1.315, -0.352], *d* = 0.65; Beliefs and Values, *t*(29) = -4.052, *p* < 0.001, 95 percent CI [-2.056, -0.677], *d* = 0.74; Emotion Regulation, *t*(29) = -3.62, *p* = 0.001, 95 percent CI[-1.304, -0.362], *d* = 0.66; Celebrate Success, *t*(29) = -2.249, *p* = 0.032, 95 percent CI[-0.891, -0.042], *d* = 0.411; and Broad Focus, *t*(29) = -2.22, *p* = 0.035, 95 percent CI [-1.282, -0.052], *d* = 0.41. Students reported that two strategies were highly effective: Emotion Regulation and Work Life Balance. (See Figure 8)

Do faculty teach the strategies they believe to be effective? To investigate if faculty are teaching the strategies that they perceive to be effective, the authors conducted a series of exploratory paired samples *t*-tests comparing faculty use and perceived effectiveness ratings. Faculty only reported lower

FIGURE 8. Strategies with statistically significantly higher effectiveness than use ratings for students



Note: Error bars: +/- 1 SE

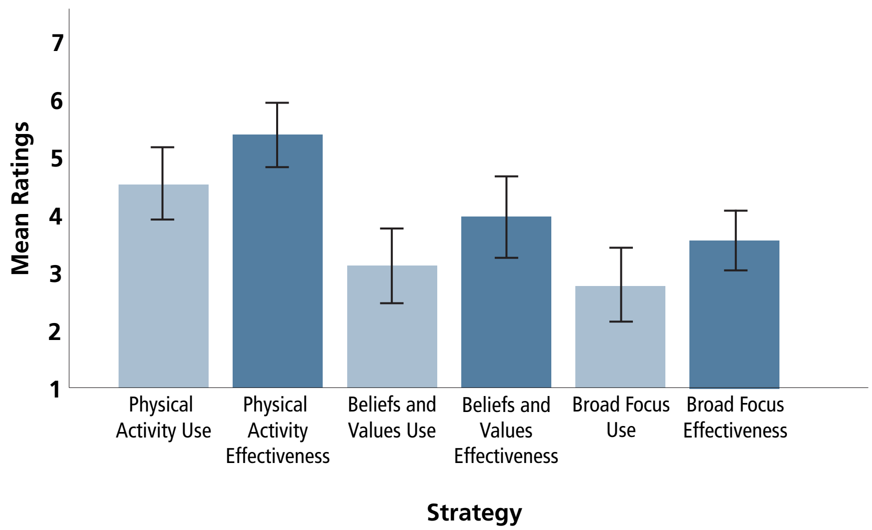
use ratings than effectiveness ratings for a few strategies: Physical Activity, $t(11) = -2.59$, $p = 0.025$, 95 percent CI [-1.542, -0.125], $d = 0.748$; Beliefs and Values, $t(11) = -2.803$, $p = 0.017$, 95 percent CI [-1.488, -0.179], $d = 0.81$; and Broad Focus, $t(11) = -2.462$, $p = 0.032$, 95 percent CI [-1.420, -0.080], $d = 0.711$. Importantly, none of the strategies with a use-efficacy misalignment were in the handful that faculty rated as either "High use" or "High efficacy." Hence, these use-effectiveness rating mismatches are not of practical significance. Overall, faculty reported that they teach and encourage strategies that they believe to be effective in dealing with failure and avoid teaching strategies they believe do not work. (See Figure 9)

Attributions

To investigate what students believe was the cause of their research failures or rejections, the authors calculated means and standard deviations for the three questions about attributions. Students and faculty answered the questions using a 7-point Likert scale. Scores closer to 7 indicated that the student and faculty member believed (or taught) that the cause of the failure (1) was more due to the something or someone else as opposed to the student (external attribution), (2) would always be present as opposed to would only be present for this project (stable attribution), and (3) was related to all aspects of the student's life as opposed to only connected to this aspect of the student's life (global attribution).

In general, both students and faculty reported only moderate agreement with the internal, stable, and global attributions for each question. A series of one-sample t-tests comparing the student's scores to the mid-point on each scale (4) showed no differences. Students did not believe their research failure was due to themselves more than other people or other things ($M = 3.70$, $SD = 1.47$), $t(29) = -1.121$, $p =$

FIGURE 9. Strategies with significantly higher effectiveness and use ratings for faculty



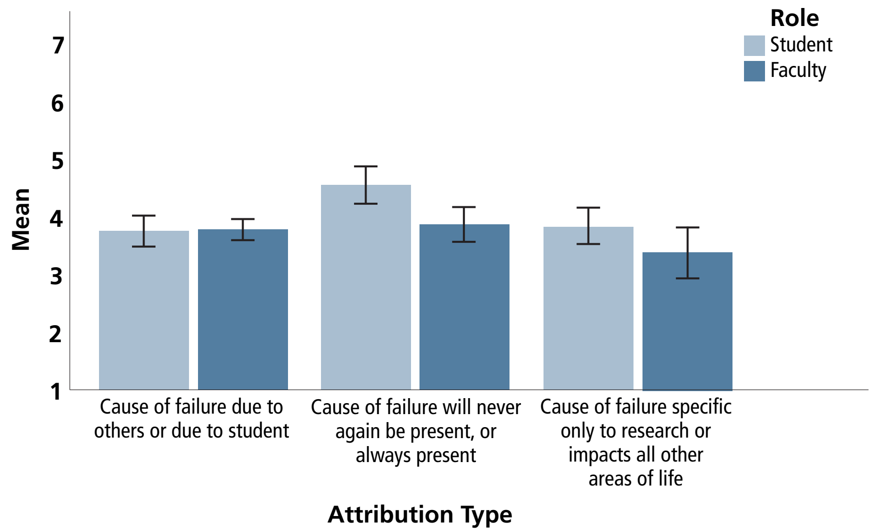
Note: Error bars: +/- 1 SE

0.271, $d = 0.21$. Nor did they think the cause of their failure would be present in their work again more so than never again ($M = 4.5$, $SD = 1.834$), $t(29) = 1.50$, $p = 0.146$, $d = 0.273$. They also felt the cause of the failure was just as much specific only to their research as much as it would be likely to impact other areas of their lives ($M = 3.8$, $SD = 1.669$), $t(29) = -0.656$, $p = 0.517$, $d = 0.12$. The faculty reported similarly. They reported teaching their students that the research failure was just as much due to others as it was due to the student ($M = 3.75$, $SD = .622$), $t(11) = -1.393$, $p = 0.191$, $d = 0.40$, and that the cause of the failure would be always present just as much as never again present ($M = 3.83$, $SD = 1.03$), $t(11) = 0.561$, $p = 0.586$, $d = 0.162$. They also reported teaching the students that the cause of the failure was just as specific only to the research project as it was reflective of the student's struggles in other areas as well ($M = 3.80$, $SD = 3.33$), $t(11) = -1.61$, $p = 0.136$, $d = 0.464$. (See Figure 10)

Also explored was the possibility of a difference between the beliefs held by students and the teaching of those beliefs by faculty. Independent samples *t*-tests comparing the faculty responses on the attribution questions to the student responses showed no statistically significant differences—all p's > 0.15. However, the effect sizes for two of the three questions were medium (d's > 0.30), indicating that this set of analyses may be underpowered.

Although not one of the initial research questions, given that research suggests that attributions regarding negative events in life can have a significant impact on an individual's behavioral response (e.g., Beck 1976; Rubenstein et al. 2016), the authors next sought to explore whether students' beliefs about why failure and rejection occurs could set the stage for the types of strategies they use to cope with the failure. In other words, do student and faculty beliefs about why the rejection or failure occurred correlate with the types of strategies they report using to cope with the failure? Given that internal, stable, and global beliefs about negative events in life are linked to feelings of hopelessness and helplessness (e.g., Seligman et al. 1979), the authors explored whether these beliefs about failures in research (the belief that the failure was a reflection of something about the student, that will always be present, and that reflects their struggles in many areas versus only related to their specific research project) could be

FIGURE 10. Mean attribution scores by role



Note: Error bars: +/- 1 SE

related to the use or avoidance of specific coping strategies. To examine this hypothesis, a series of exploratory Pearson Correlations were run to investigate relationships between the attribution questions and the strategy use and effectiveness ratings.

Results show that students who reported higher levels of global attributions (the belief that the failure was a reflection of their struggles in many areas versus tied to their specific research project) reported more use of the following strategies when coping with research failures: Avoidance, $r(28) = 0.552$, $p = 0.002$; Pragmatism, $r(28) = 0.408$, $p = 0.025$; Denial, $r(28) = 0.392$, $p = 0.032$; and Broad Focus, $r(28) = 0.410$, $p = 0.024$. Significantly, these strategies were all rated by students and faculty overall as lower in effectiveness.

Additionally, there were marginally significant relationships with the students' external versus internal attributions. Students that reported higher levels of the belief that the failure was caused by something or someone else reported less use of Avoidance, $r(30) = -0.309$, $p = 0.096$, and more use of Celebrating Success, $r(30) = 0.310$, $p = 0.096$. In other words, students who were more likely to believe the failure was due to something negative about themselves (e.g., a negative trait) were more likely to cope by avoiding the project and less likely to celebrate successes. As noted above, Avoidance was a strategy rated as less effective by students and faculty, and Celebrating Success was rated as highly effective by faculty.

Additionally, there were some marginally significant relationships in the faculty responses; faculty who reported higher levels of teaching students that their rejection or failure was likely causing struggles in other areas of their lives were also more likely to report teaching avoidance strategies, $r(10) = 0.512$, $p = 0.089$. They were also less likely to say that the rationalizing strategy, $r(10) = -504$, $p = 0.095$; Pragmatism, $r(10) = -0.546$, $p = 0.066$; and Narrow Focus, $r(10) = -0.510$, $p = 0.09$, were effective for students dealing with research failures.

Last, faculty who reported higher levels of teaching students that the cause of their failure was due to something or someone else were more likely to report teaching students to use Narrow Focus, $r(10) = 0.609$, $p = 0.036$, and less likely to report teaching students to use Work Life Balance, $r(10) = -0.695$,

$p = 0.012$; Physical Activity $r(10) = -0.700$, $p = 0.011$; and Social Withdraw, $r(10) = -0.583$, $p = 0.047$. They were also more likely to say that Narrow Focus was an effective strategy, $r(10) = 0.639$, $p = 0.025$, and less likely to say Physical Activity, $r(10) = -0.624$, p = 0.030, and Work Life Balance, r(10) = -0.676, p = 0.016, were effective strategies.

Discussion

Experiencing research failures such as methodology difficulties and rejection of papers and grants affects academics at all levels (Day 2011, 706). Therefore, undergraduate research students engaging in the research process for the first time are also likely to experience various research difficulties or rejections. Previous research has found that individuals' experiences of research failure and rejection are essential in shaping their perseverance in the field (Thiry et al. 2012, 268; DeCastro et al. 2013, 498; Simpson and Maltese 2017, 230). The study sought to understand better the strategies used by undergraduate student researchers to cope with these difficulties and the causes, in their view, of their research failures or rejections. The students surveyed were from diverse backgrounds, with a majority identifying as belonging to a traditionally underrepresented group. Therefore, this data responds to the need for more robust research on helping historically underrepresented students succeed in academia, especially given the national data indicating that a growing number of beginning researchers are from communities that are underrepresented in academic ranks (e.g., Davis and Fry 2019; National Center for Education Statistics 2021).

Coping Strategies Used and Taught

The results from the study found that in the face of failure and rejection in research, undergraduate students reported high use of the following strategies: Behavior Change (e.g., "I try to make changes to my work; I talk to my advisor about what to do differently next time") and Rationalizing (e.g., "I tell myself failure and rejection are part of the research process"). Faculty also reported high levels of teaching students to use those strategies plus two others: Celebrate Success (e.g., "I celebrate my successes so far and focus on what is going well with my research") and Reflection (e.g., "I reflect on my rejection/failure and think about what I could have done differently"). In general, there was only a slight misalignment between the strategies that faculty reported teaching to their research students and what students reported using. For example, students reported using Social Withdraw (e.g., "I retreat to my lab/desk/workspace and work on my research alone for a while") more than faculty reported teaching it, and faculty reported encouraging Celebrating Success more than students reported using it.

Effectiveness of Strategies Used and Taught

Faculty mentors and students generally agreed on the effectiveness of the strategies they used, and both reported that the strategies they used most often were also strategies that they rated as highly effective. The strategies reported in this study are generally consistent with previous literature on helpful coping strategies, including those predicted by Henry et al. (2019, 10) to be generally adaptive for undergraduate research students dealing with failure and rejection in their work. The strategies also align well with research on what professional academics use to manage their challenges and rejections (Salimzadeh, Hall, and Saroyan 2021, 71; Chan, Mazzucchelli and Rees 2021, 450–455). Additionally, many of the reported strategies are consistent with work on resiliency in youth (Prince-Embury 2006, 279).

For example, the three-factor model of personal resiliency based on risk and resiliency factors research includes a sense of mastery, relatedness, and emotional reactivity (Prince-Embury 2006). The Behavior Change strategy rated as high use by faculty and highly effective by both faculty and students is consistent with the "sense of mastery" factor, described by Prince-Embury as a positive view of oneself, a belief in one's abilities (self-efficacy), and confidence in one's ability to adapt and change one's behavior when needed (Prince-Embury 2006). Behavior Change has also been shown to be an effective strategy in the literature on how faculty manage stress. For example, in a review paper, Salimzadeh, Hall, and Saroyan (2021) noted multiple studies showing that, by modifying situations or behavior—for example, by reorganizing a project's focus or by planning out action steps for a revision—faculty have found success by changing their behaviors (6).

The Emotion Regulation strategy was rated as highly effective by students and is consistent with the three-factor personal resiliency model's "emotional reactivity" factor. Given that research shows that difficulty regulating emotional intensity is related to mental health difficulties after adversity, Prince-Embury et al. (2017) explains that "emotional reactivity" is included as a "vulnerability factor" in the resiliency model (279). Additionally, successful emotion regulation, especially the type that involves reappraisal to change the emotion and increase positive emotional responses to events (as opposed to the suppression of the initial emotion), has been found to strongly improve work performance, social relationships, and general levels of well-being (e.g., Lawrence et al. 2011, 208–215; Lopes et al. 2005, 116; Gross 2002, 287; Catalino and Fredrickson 2011, 10; Salimzadeh, Hall, and Saroyan 2021, 4).

Rationalizing (e.g., "I tell myself that failure and rejection are a normal part of the research process"), which was rated as "high use" by faculty and students in the study, has also been highlighted by faculty members in previous research. In a survey of faculty research mentors and their students, Hunter, Laursen, and Seymour (2006) found that, although many faculty research mentors noted that failure was a critically important part of becoming a scientist, only a small percentage of their student researcher respondents regarded it as necessary. Therefore, Hunter, Laursen, and Seymour underscore that supportive relationships, where faculty can ensure that students understand that failures are an integral part of the research process, are essential for student success (56–57). Furthermore, in a review paper, Salimzadeh and colleagues note multiple studies where academics' use of "cognitive reappraisal," similar to the Rationalizing strategy in the current study, led to reduced stress and fewer negative emotions (2021, 6). Chan, Mazzucchelli, and Rees (2021) also noted that faculty's use of reframing was a key component of down-regulating a negative emotional response to rejection (454).

Lastly, the Support Network strategy rated as moderately high use and effectiveness by both students and faculty in the study is well supported by multiple branches of literature. This strategy is consistent with the "sense of relatedness" factor in the three-factor personal resiliency model, which draws from Luthar's review of research on resilience in children. Luthar notes, "Resilience rests, fundamentally, on relationships" (2006, 780). Utilizing social support has also been found to be an effective coping strategy in the literature on faculty persistence, productivity, and job satisfaction (e.g., Campbell and O'Meara 2014; Greene et al. 2008, 437; Stupnisky et al. 2017, 393; Chan, Mazzucchelli, and Rees 2021, 455). For example, Lechuga (2012) found that for Latino faculty in STEM fields, developing social networks and finding an academic community aligned with their values was a key component of their success as academics (119). Relying on the opposite of social support—namely, social withdrawal and isolation—may be particularly problematic for undergraduate researchers with depression (Cooper et al. 2020, 7). Cooper et al. note that these students seemed to struggle most when "the lab was empty" (2020, 8–9). This finding underscores the idea that faculty mentors can make a positive impact by ensuring undergraduate researchers have peers or colleagues with whom they can build a network and prevent possible social withdrawal.

Closely related to Social Support is Celebrating Success. Celebrating Success was rated as highly effective by the study's faculty and has also been found in previous work to be an adaptive method for faculty facing the challenges of academia. Celebrating Success can help individuals feel that their work is valued and can be an avenue to help them "up-regulate" positive emotions related to a complex project (Bozeman and Gaughan 2011, 177; Rawn and Fox 2018, 617; Catalino and Fredrickson 2011, 10). Interestingly, although this strategy was noted as high use and high effectiveness by the faculty mentors in the study, it was not reported as either high use or high effectiveness by the student researchers. This suggests that undergraduate student researchers may need faculty to take the lead in helping them celebrate the small steps within the process of the research project (e.g., receiving IRB approval or the creation of a new measure), rather than only the final outcome (e.g., a publication or conference presentation).

Use versus Effectiveness

Although the study generally found that faculty mentors and student researchers reported high use of the strategies that they also reported to be most effective, there were a few strategies that students admitted to using more frequently, despite also rating them as less effective. For example, students reported moderate use of Social Withdraw and Comparison despite rating them as less effective strategies. Similarly, students rated several strategies as more effective but admitted to relatively lower use such as Work Life Balance and Emotion Regulation. Given that the students' ratings of the effectiveness of these strategies are consistent with previous research (e.g., Henry et al. 2019; Skinner et al. 2003; Prince-Embury 2006; Salimzadeh, Hall, and Saroyan 2021, 7), these results indicate that students may need more support from their faculty mentors to apply strategies such as Work Life Balance, Emotion Regulation, and Social Engagement (versus Withdraw and Comparison) to their daily lives.

Faculty also rated a few strategies as higher in effectiveness than they rated their use: Physical Activity, Beliefs and Values, and Broad Focus. This misalignment may be because faculty rated many of the strategies as effective but may not have time to work all of them into their work with their research students. Indeed, faculty often note that a lack of time is a leading factor in increasing stress, burnout, and lower satisfaction in academia (e.g., Gmelch, Wilke, and Lovrich 1986, 272; Sabagh, Hall, and Saroyan 2018, 144). Given the inherent time conflict between publishing pressures and the significant time and effort mentoring undergraduate research students requires (e.g., Malachowski 2012,12), it is understandable that faculty may see the value in teaching students multiple coping strategies but cannot really put them all into practice.

Attitudes and Beliefs About Research Failures

Some cognitive beliefs such as a pessimistic or depressive attributional style are less helpful for resilience and perseverance after the experience of undesirable events (e.g., Abramson, Seligman, and Teasdale 1978; Maier and Seligman 2016, 363; McCauley, Pavlidis, and Kendall 2001, 57; Rubenstein 2016, 106–107; Luten, Ralph, and Mineka 1997, 703–719). The pessimistic, attributional style includes beliefs that adverse events in life are due to stable, general parts of themselves (known as stable, global internal attributions). In other words, negative experiences are believed to reflect something permanent, pervasive, and personal (Luten, Ralph, and Mineka 1997). Neither students nor faculty reported intense levels of thinking (or teaching) these pessimistic beliefs.

Regarding the possible connection between attributions and coping behaviors, the current analyses indicated that students who reported higher levels of a global attribution of their failure reported higher levels of use of avoidance, denial, and pragmatism. In addition, students who reported higher internal attributions (e.g., a negative personal trait) were more likely to report coping by avoiding the project and less likely to Celebrate Successes. Given that these strategies were rated as less effective by students and faculty, these findings are consistent with research suggesting that these attributions of negative or undesirable events are related to lower levels of resiliency. However, given the exploratory nature of these analyses, more research is needed to determine whether a pessimistic thinking style predicts more significant use of less effective strategies and lower use of more effective strategies.

The Importance of Faculty Mentorship

In summary, although the study found that students report using many effective coping strategies, the results also highlight areas where faculty mentors can be more supportive such as taking the lead in the celebration of small successes, setting up workspaces to promote social connection over social withdrawal, modeling work-life balance and emotion regulation, and counseling students to see failure as an essential part of the learning process. Indeed, previous work on course-based undergraduate research experiences demonstrates that faculty who deliberately model strategies such as Behavior Change, Reframing, and Emotion Regulation can help students overcome their research challenges (Gin et al. 2018, 9–10).

Additionally, these results highlight the idea that it may not be enough for faculty to simply encourage students to use coping strategies they believe to be effective. It is essential that research mentors deliberately create research environments that put these strategies into practice for the research student. For example, faculty can scaffold reflection by requiring a "learning logbook" where research students regularly submit written responses to open-ended prompts such as "what might you have done differently if you had known two weeks ago what you know now?" (Howitt and Wilson 2016, 35). Faculty mentors can also help research students celebrate success and foster community within their lab group and department. For example, Pita et al. (2013) recommends faculty research mentors build a research community by attending research presentations or local sporting events as a group or organizing a potluck where students can network with others in the department (13). These community-building activities can also be used to celebrate successes; for example, a mentor could take the research team out to lunch after submitting a conference abstract.

Limitations and Future Directions

One limitation of the current work was the relatively small sample size of faculty who participated in the survey. This created some statistical limitations such as lower statistical power and significant Levene's tests for a few of the analyses. Additionally, this chapter included many analyses, which, without statistical correction, can increase Type 1 error (e.g., Maxwell and Delaney 2004, 202–203). Therefore, confidence intervals and effect sizes are included where appropriate and used in addition to p-values to interpret these results (e.g., Harris 1997, 145). Furthermore, the researchers created the survey instruments by adapting relevant research and previously used survey items and theories. As such, they were not tested for reliability or validity. Future research in this area could test the reliability and validity of these survey instruments. Lastly, given the self-report nature of the survey, it is possible that participants reported thoughts and behaviors that align with what they think is socially desirable rather than what they actually do in the face of failure and rejection. Additionally, the self-report nature makes it difficult to assess student success outcomes directly. Therefore, more work is needed to investigate the relationships between coping strategies used (rather than reported) and student success outcomes.

Conclusion

Overall, the study results reinforce the idea that faculty have an essential role in shaping their undergraduate research mentees' experiences with research, including the everyday experience of research failures and rejections. With solid support, student researchers will be more likely to use their research experiences to cope effectively with these adverse events. These learning opportunities can significantly impact students' experience of research failures that they will undoubtedly encounter throughout their careers.

References

Abramson, Lyn Y., Martin E. Seligman, and John D. Teasdale. 1978. "Learned Helplessness in Humans: Critique and Reformulation." *Journal of Abnormal Psychology* 87(1): 49–74. doi: 10.1037/0021-843X.87.1.49

Allen, Kelly-Ann, Gregory M. Donoghue, Saeed Pahlevansharif, Shane R. Jimerson, and John A. C. Hattie. 2020. "Addressing Academic Rejection: Recommendations for Reform." *Journal of University Teaching & Learning Practice* 17(5): ar19.

Beck, Aaron T. 1967. *Depression: Clinical, Experimental, and Theoretical Aspects.* New York: Hoeber Medical Division, Harper & Row.

Bozeman, Barry, and Monica Gaughan. 2011. "Job Satisfaction among University Faculty: Individual, Work and Institutional Determinants." *Journal of Higher Education* 82: 154–186. doi: 10.1080/00221546.2011.11779090

Campbell, Corbin M., and KerryAnn O'Meara. 2014. "Faculty Agency: Departmental Contexts that Matter in Faculty Centers." *Research in Higher Education* 55: 49–74. doi: 10.1007/s11162-013-9303-x

Carson, Lydia, Christoph Bartneck, and Kevin Voges. 2013. "Over-Competitiveness in Academia: A Literature Review." *Disruptive Science and Technology* 1(4): 183–190. doi: 10.1089/dst.2013.0013

Catalino, Lahna I., and Barbara L. Fredrickson. 2011. "A Tuesday in the Life of a Flourisher: The Role of Positive Emotional Reactivity in Optimal Mental Health." *Emotion* 11(1): 938–950. doi: 10.1037/a0024889

Ceyhan, Gaye D., and John W. Tillotson. 2020. "Early Year Undergraduate Researchers' Reflections on the Values and Perceived Costs of Their Research Experience." *International Journal of STEM Education* 7: ar54. doi: 10.1186/s40594-020-00248-x

Chan, Hannah, Trevor G. Mazzucchelli, and Clare S. Rees. 2021. "The Battle-Hardened Academic: An Exploration of the Resilience of University Academics in the Race of Ongoing Criticism and Rejection of Their Research." *Higher Education Research & Development* 40: 446–460. doi: 10.1080/07294360.2020.1765743

Cooper, Katelyn M., Logan E. Gin, M. Elizabeth Barnes, and Sara E. Brownell. 2020. "An Exploratory Study of Students with Depression in Undergraduate Research Experiences." *CBE–Life Sciences Education* 19: ar19. doi: 10.1187/cbe.19-11-0217

Davis, Leslie, and Richard Fry. 2019. "College Faculty Have Become More Racially and Ethnically Diverse, but Remain Far Less So than Students." Last modified July 31, 2019. https://www.pewresearch.org/fact-tank/2019/07/31/us-college-faculty-student-diversity/

Day, Nancy Evelyn. 2011. "The Silent Majority: Manuscript Rejection and Its Impact on Scholars." *Academy of Management Learning & Education* 10: 704–718. doi: 10.5465/amle.2010.0027

DeCastro, Rochelle, Dana Sambuco, Peter A. Ubel, Abigail Stewart, and Reshma Jagsi. 2013. "Battling 300 Is Good: Perspectives of Faculty Researchers and Their Mentors on Rejection, Resilience, and Persistence in Academic Medical Careers." *Academic Medicine: Journal of the Association of American Medical Colleges* 88: 497–504. doi: 10.1097/ACM.0b013e318285f3c0

Gin, Logan E., Ashley A. Rowland, Balire Steinwand, John Bruno, and Lisa A. Corwin. 2018. "Students Who Fail to Achieve Predefined Research Goals May Still Experience Many Positive Outcomes as a Result of CURE Participation." *CBE–Life Sciences Education* 17: ar57. doi: 10.1187/cbe.18-03-0036

Gmelch, Walter H., Phillis Kay Wilke, and Nicholas P. Lovrich. 1986. "Dimensions of Stress among University Faculty: Factor-Analytic Results from a National Study." *Research in Higher Education* 24: 266–286. doi: 10.1007/BF00992075

Gomes, A. Rui, Susanna Faria, and A. Manuela Gonçalves. 2013. "Cognitive Appraisal as a Mediator in the Relationship between Stress and Burnout." *Work & Stress* 27: 351–367. doi: 10.1080/02678373.2013.840341

Greene, H. Carol, Katherine A. O'Connor, Amy J. Good, Carolyn C. Legford, Betty B. Peel, and Guili Zhang. 2008. "Building a Support System, towards Tenure: Challenges and Needs of Tenure-Track Faculty in Colleges of Education." *Mentoring & Tutoring: Partnership in Learning* 16: 429–447. doi: 10.1080/13611260802433791

Gross, James J. 2002. "Emotion Regulation: Affective, Cognitive, and Social Consequences." *Psychophysiology* 39: 281–291. doi: 10.1017/S0048577201393198

Guillame, Rene, Jesus Cisneros, and Edna Martinez. 2020. "Manuscript Rejection and Shame Resilience in Early Career Faculty of Color: Vignettes on Coping and Overcoming." *Taboo: The Journal of Culture and Education* 19(5): ar3.

Harris, Richard J. 2016. "Reforming Significance Testing via Three-Valued Logic." In *What If There Were No Significance Tests?*, ed. Lisa L. Harlow, Stanley A. Mulaik, and James H. Streiger, 131–158. New York: Routledge.

Harsh, Joseph A., Adam V. Maltese, and Robert H. Tai. 2011. "Undergraduate Research Experiences from a Longitudinal Perspective." *Journal of College Science Teaching* 41(1): 84–91.

Henry, Meredith A., Shayla Shorter, Louise Charkoudian, Jennifer M. Heemstra, and Lisa A. Corwin. 2019. "*FAIL* Is Not a Four-Letter Word: A Theoretical Framework for Exploring Undergraduate Students' Approaches to Academic Challenge and Responses to Failure in STEM Learning Environments." *CBE–Life Sciences Education* 18(1): ar11. doi: 10.1187/cbe.18-06-0108

Hill, Jennifer, Kathy Berlin, Julia Choate, Lisa Cravens-Brown, Lisa McKendrick-Calder, and Susan Smith. 2021. "Exploring the Emotional Responses of Undergraduate Students to Assessment Feedback: Implications for Instructors." *Teaching & Learning Inquiry* 9(1): 294–316. doi: 10.20343/teachlearninqu.9.1.20

Howitt, Susan, and Anna Wilson. 2016. "Scaffolded Reflection as a Tool for Surfacing Complex Learning in Undergraduate Research Projects." *CUR Quarterly* 36(4): 33–38. doi: 10.18833/curq/36/4/8

Hsu, Jeremy L., and Gregory R. Goldsmith. 2021. "Instructor Strategies to Alleviate Stress and Anxiety among College and University STEM Students." *CBE–Life Sciences Education* 20(1): es1. doi: 10.1187/cbe.20-08-0198

Hunter, Anne-Barrie, Sandra L. Laursen, and Elaine Seymour. 2007. "Becoming a Scientist: The Role of Undergraduate Research in Students' Cognitive, Personal, and Professional Development." *Science Education* 91(1): 36–74. doi: 10.1002/SCE.20173

Kishita, Naoko, and Ken Laidlaw. 2017. "Cognitive-Behavioral Therapy for a Generalized Anxiety Disorder: Is CBT Equally Efficacious in Adults of Working Age and Older Adults?" *Clinical Psychology Review* 52: 124–136. doi: 10.1016/j.cpr.2017.01.003

Lawrence, Sandra A., Ashlea C. Troth, Peter J. Jordan, and Amy L. Collins. 2011. "A Review of Emotion Regulation and Development of a Framework for Emotion Regulation in the Workplace." In *The Role of Individual Differences in Occupational Stress and Well-Being,* ed. Pamela L. Perrewé and Daniel C. Ganster, vol. 9, 197–263. Bingley, UK: Emerald Publishing. doi: 10.1108/S1479-3555(2011)0000009010

Lechuga, Vicente M. 2012. "Latino Faculty in STEM Disciplines: Motivation to Engage in Research Activities." *Journal of Latinos and Education* 11(2): 107–123. doi: 10.1080/15348431.2012.659564

Lopatto, David. 2003. "The Essential Features of Undergraduate Research." *CUR Quarterly* 23(3): 139–142.

Lopes, Paulo N., Peter Salovey, Stéphane Côté, and Michael Beers. 2005. "Emotion Regulation Abilities and the Quality of Social Interaction." *Emotion* 5(1): 113–118. doi: 10.1037/1528-3542.5.1.113

Luten, Alice G., John A. Ralph, and Susan Mineka. 1997. "Pessimistic Attributional Style: Is It Specific to Depression versus Anxiety versus Negative Affect?" *Behavior Research and Therapy,* 35: 703–719. https://doi.org/10.1016/S0005-7967(97)00027-2

Luthar, Suniya S. 2006. "Resilience in Development: A Synthesis of Research across Five Decades." In *Developmental Psychopathology: Risk, Disorder, and Adaptation,* ed. Dante Cicchetti and Donald J. Cohen, 739–795. Hoboken, NJ: Wiley.

Maier, Steven F., and Martin E. P. Seligman. 2016. "Learned Helplessness at Fifty: Insights from Neuroscience." *Psychological Review* 123: 349–367. doi: 10.1037/rev0000033

Malachowski, Mitchell R. 2012. "Living in Parallel Universes: The Great Faculty Divide between Product-Oriented and Process-Oriented Scholarship." In *Faculty Support and Undergraduate Research: Innovations in Faculty Role Definition, Workload, and Reward,* ed. Nancy H. Hensel and Elizabeth L. Paul, 7–18. Washington, DC: Council on Undergraduate Research.

Maxwell, Scott E., Harold D. Delaney, and Ken Kelley. *Designing Experiments and Analyzing Data: A Model Comparison Perspective.* New York: Taylor & Francis.

McCauley, Elizabeth, Karen Pavlidis, and Kim Kendall. 2001. "Developmental Precursors of Depression: The Child and the Social Environment." In *The Depressed Child and Adolescent,* ed. Ian M. Goodyer, 46–78. Cambridge, UK: Cambridge University Press.

Merry, Sally N., Sarah E. Hetrick, Georgina R. Cox, Tessa Brudevold-Iversen, Juliet J. Bir, and Heather McDowell. 2012. "Psychological and Educational Interventions for Preventing Depression in Children and Adolescents." *Evidence-Based Child Health* 7: 1409–1685. doi: 10.1002/ebch.1867

Nagda, Biren A., Sandra R. Gregerman, John Jonides, William von Hippel, and Jennifer S. Lerner. 1998. "Undergraduate Student-Faculty Research Partnerships Affect Student Retention." *Review of Higher Education* 22(1): 55–72. doi: 10.1353/rhe.1998.0016

National Center for Education Statistics. 2021. "Full-Time Faculty in Degree-Granting Postsecondary Institutions, by Race/Ethnicity, Sex, and Academic Rank: Fall 2017, Fall 2018, and Fall 2019." Last modified March 2021. https://nces.ed.gov/programs/digest/d20/tables/dt20_315.20.asp

Pita, Mario, Christopher Ramirez, Nathanaelle Joacin, Sarah Prentice, and Christy Clarke. 2013. "Five Strategies for Mentoring Undergraduates: Students' Perspectives." *CUR Quarterly* 33(3): 11–16.

Prince-Embury, Sandra. 2006. "Resiliency Scales for Adolescents: Profiles of Personal Strengths." San Antonio: Harcourt Assessment.

Prince-Embury, Sandra, Donald H. Saklofske, and David W. Nordstokke. 2017. "The Resiliency Scale for Young Adults." *Journal of Psychoeducational Assessment* 35: 276–290. doi: 10.1177/0734282916641866

Rawn, Catherine D., and Joanne A. Fox. 2018. "Understanding the Work and Perceptions of Teaching-Focused Faculty in a Changing Academic Landscape." *Research in Higher Education* 59: 591–622. doi: 10.1007/s11162-017-9479-6

Rubenstein, Liza M., Rachel D. Freed, Benjamin G. Shapero, Robert L. Fauber, and Lauren B. Alloy. 2016. "Cognitive Attributions in Depression: Bridging the Gap between Research and Clinical Practice." *Journal of Psychotherapy Integration* 26: 103–115.

Russell, Susan H., Mary P. Hancock, and James McCullough. 2007. "Benefits of Undergraduate Research Experiences." *Science* 316: 548–549. doi: 10.1126/science.1140384

Sabagh, Zaynab, Nathan C. Hall, and Alenoush Saroyan. 2018. "Antecedents Correlates and Consequences of Faculty Burnout." *Educational Research,* 60: 131–156. doi: 10.1080/00131881.2018.1461573

Salimzadeh, Raheleh, Nathan C. Hall, and Alenoush Saroyan. 2021. "Examining Academics' Strategies for Coping with Stress and Emotions: A Review of Research." *Frontiers in Education* 6: ar660676. doi: 10.3389/feduc.2021.660676

Seligman, Martin E., Lyn Y. Abramson, Amy Semmel, and Carl von Baeyer. 1979. "Depressive Attributional Style." *Journal of Abnormal Psychology* 88: 242–247. doi: 10.1037/0021-843X.88.3.242

Seymour, Elaine, Anne-Barrie Hunter, Sandra L. Laursen, and Tracee Deantoni. 2003. "Establishing the Benefits of Research Experiences for Undergraduates in the Sciences: First Findings from a Three-Year Study." *Science Education* 88: 493–534.

Simpson, Amber, and Adam Maltese. 2017. "'Failure Is a Major Component of Learning Anything': The Role of Failure in the Development of STEM Professionals." *Journal of Science Education and Technology* 26: 223–237. doi: 10.1007/s10956-016-9674-9

Skinner, Ellen A., Kathleen Edge, Jeffrey Altman, and Hayley Sherwood. 2003. "Searching for the Structure of Coping: A Review and Critique of Category Systems for Classifying Ways of Coping." *Psychological Bulletin* 129: 216–269. doi: 10.1037/0033-2909.129.2.216

Stupnisky, Robert H., Nathan C. Hall, Lia M. Daniels, and Emmanuel Mensah. 2017. "Testing a Model of Pretenure Faculty Members' Teaching and Research Success: Motivation as a Mediator of Balance, Expectations, and Collegiality." *Journal of Higher Education* 88: 376–400. doi: 10.1080/00221546.2016.1272317

Thiry, Heather, Timothy J. Weston, Sandra L. Laursen, and Anne Barrie Hunter. 2012. "The Benefits of Multi-Year Research Experiences: Differences in Novice and Experienced Students' Reported Gains from Undergraduate Research." *CBE–Life Sciences Education* 11: 260–272. doi: 10.1187/cbe.11-11-0098

CHAPTER 16

A Community-of-Scholars Approach to Building Resilience and Overcoming Failures through Undergraduate Research Mentoring

Eric E. Hall and Caroline J. Ketcham

Abstract. This case study discusses the merits of a co-mentored undergraduate research model, the Elon BrainCARE Research Institute, and how this model as implemented by the two mentors promotes a culture of resiliency to help confront and overcome failure when it arises. This chapter focuses on how the Salient Practice Framework of Undergraduate Research Mentoring can be implemented to help mentors build resilience in their student researchers.

doi: 10.18833/cf/10

This chapter discusses the merits of a co-mentored undergraduate research model, the Elon BrainCARE Research Institute. Specifically, two evidence-based frameworks, Salient Practices and Act-Belong-Commit, have nurtured a culture of resiliency to help confront and overcome failure when it arises. Undergraduate research is one of the five Elon Experiences supported at Elon University, a primarily undergraduate liberal arts institution with professional schools that include graduate programs. The university has a strong focus on student success with a focus on innovative teaching and experiential education.

Mentoring undergraduate students through substantial research projects has been foundational to our careers at Elon University; we both have won the institutional mentoring award and we serve as leaders, mentors and partners to students through Elon BrainCARE. Elon BrainCare Research Institute leads research and support for concussion management and education; Act-Belong-Commit, a positive campus mental well-being campaign; and access to high-impact experiences (Kuh 2008). Students are included in all aspects of our work, and we utilize a unique model where both mentors engage all aspects of the research process (Ketcham, Hall, and Miller 2017; Ketcham et al. 2018). We have co-mentored more than 30 undergraduate researchers over the last decade, who have gone on to presentations, publications, and top graduate and professional programs in health sciences (e.g., medicine, nursing, and rehabilitation sciences).

These milestone outcomes are a result of an intentional, high-quality, mentored experience where students often encounter setbacks and failures along their scholarly and academic journey (e.g., missing data, participant no-shows, failed grant applications, rejected paper submissions, and rejected graduate school applications). To help students build skills that enhance self-efficacy, confidence, resilience, and growth, the mentors intentionally integrate two evidence-based frameworks: The Act-Belong-Commit Framework (Donovan and Anwar-McHenry 2014) and the Salient Practices Framework of Undergraduate Research Mentoring (Shanahan et al. 2015). This chapter describes the integration of these two frameworks into Elon BrainCARE and ways that others can adopt these practices to help students build resilience. Specifically, student researchers are encouraged to adopt the Act-Belong-Commit Framework to proactively learn habits and skills that will help maintain and improve their well-being, which will allow them to overcome failures and build resilience through the research process. The Salient Practices Framework is employed in our mentoring to ensure the needs of student researchers are met, to build teamwork, and to create a positive and safe environment in which the normal setbacks and failures that occur during research can be overcome.

Approaches to Proactively Prepare Students for Failure and Setbacks: Building Resilience and Improving Well-Being

Act-Belong-Commit is a positive mental health campaign based on decades of evidence-based research (Donovan et al. 2007; Hagerty et al. 1992), which uses a proactive framework to build resilience and improve well-being (Donovan and Anwar-McHenry 2014). This framework encourages individuals and communities to implement what are considered healthy habits along three distinct and related constructs: *Act*—do something; *Belong*—do something with someone; and *Commit*—do something meaningful and with purpose (Donovan and Anwar-Henry 2014).

Holistically, this framework is about building habits in which people can engage to improve their resiliency and well-being. It is about what one can do to be engaged, find community, and find challenge and purpose (Nielsen et al. 2021; Santini et al. 2022). The challenge and purpose piece is aligned with best practices in student development to support belonging and college success (Felten and Lambert 2020). As mentors of students in Elon BrainCARE, we lead discussions with students about the model and the importance of finding Acts that are meaningful for them to Belong and find Purpose (Commit) in their lives. Research has shown that resilience can be built through having a sense of belonging (Scarf et al. 2016; Koni et al. 2019) and purpose (Ostafin and Proulx 2020; Platsidou and Daniilidou 2021).

The Act-Belong-Commit framework is one way in which individuals can build resiliency to help overcome challenges (Hall and Ketcham 2021). Other individual strategies (e.g., a growth mindset and goal orientations) for resilience development can be taught and enhanced through intervention (see Henry et al. 2019); however, the newer concept of team resilience can be cultivated through a co-mentored, team approach to undergraduate research mentoring (Morgan, Fletcher, and Sarkar 2013, 2017). Team resilience can be defined "as a dynamic, psychosocial process which protects a group of individuals from the potential negative effect of stressors they collectively encounter. It comprises processes whereby team members use their individual and collective resources to positively adapt when experiencing adversity" (Morgan et al. 2013, 552). Although this research originated in sport psychology, the concept can be applied to a co-mentored, research team-based, undergraduate research mentoring model such as Elon BrainCARE. Specifically, this concept provides a facilitative environment to build resilience of students and faculty (Fletcher and Sarkar 2016).

In thinking about how to cultivate team resilience, Morgan and colleagues (2013) identified four characteristics of resilient teams:

- group structure (e.g., formal structure, group norms and values, and communication channels)
- mastery approaches, (e.g., learning orientation, effective behavioral responses, managing change)
- social capital (e.g., group identity, perceived social support, prosocial interactions)
- collective efficacy (e.g., past mastery experiences, group cohesion, and social persuasion)

In Elon BrainCARE, we have intentionally thought about the importance of the team-based approach to overcome challenges and to build resilience. Through this model, students engage in group activities with other students (e.g., journal clubs) but also one-to-one meetings with the two faculty mentors to discuss individual research projects. For practical purposes such as writing internal grants and receiving course credit for research, the student at times will list one mentor as primary, but in reality, both mentors are working with the student. The primary mentor is usually based on expertise for the research question being pursued by the student. This co-mentoring model at the individual and university levels has been discussed (Ketcham, Hall, and Miller 2017; Ketcham et al. 2018). Regarding *group structure* to build team resilience, we promote an environment that encourages and facilitates open communication by making sure both co-mentors are on e-mails and texts with students and when appropriate to communicate amongst all members. We also foster a climate of trust and vulnerability for students by modeling this in small- and large-group meetings. This is often done by supporting each other to share with the group our expertise and defer to the other when appropriate. We ask that all communication (e.g., emails) between students and faculty include all involved so that all can weigh in if needed. Trust and vulnerability are important characteristics for teaching in higher education (Abruzzo, Sklar, and McMahon 2019; Brantmeier 2013; Curzon-Hobson 2002), but research has shown that trust is important to enhancing resilience (Li, Gu, and He 2019).

Mastery approaches focus on creating a climate of team improvement. In Elon BrainCARE, learning is scaffolded in a team approach. We often teach technical skills as a team and then over time have the students practice these individually so that they can do the assessments on their own. Journal clubs also are conducted where students read relevant research and discuss it. We often model this for the group and then have students take the lead on articles. These scaffolded approaches help build self-efficacy and confidence for the student researchers (Bandura 1977). This confidence is valuable when mentees seek to persist in the face of adversity, and we as mentors ensure that the necessary emotional support is provided.

The branding of the lab, Elon BrainCARE, has been very important for students to build a group identity and hence *social capital*. This group identity builds loyalty among the team members and the perception of social support amongst peers and mentors. All of this helps build a positive and caring environment.

Finally, for *collective efficacy*, the group's shared belief in abilities, much of this can be enhanced by building group cohesion amongst student researchers. This includes having a commitment to the vision of Elon BrainCARE and having a strong group work ethic. This is enhanced through social persuasion by the mentors fostering a positive team attitude and giving appropriate feedback when there are setbacks so students can learn from their failures.

Understanding this concept of team resiliency can be helpful as mentors consider how to build this quality in their student researchers and thus nurture their chances for success as well as their ability to overcome obstacles and to confront failure. A mentoring framework to help build team resilience is discussed below.

Salient Practices Framework for Undergraduate Research Mentoring

Elon BrainCARE has also adopted the evidence-based mentoring framework (derived from the literature), hence referred to as the Salient Practices Framework as the way to provide high quality mentoring to students (Shanahan et al. 2015). These practices (also see Table 1; Center for Engaged Learning n.d.) have been demonstrated to be useful in a wide variety of disciplines (Moore et al. 2020; Shawyer et al. 2019; Walkington and Rushton 2019), as well as contexts such as global education (Hall et al. 2018) and virtual environments (Hall et al. 2021). These practices have also been found to be of great value in co-mentored experiences like Elon BrainCARE (Ketcham, Hall, and Miller 2017; Ketcham et al. 2018) and that the implementation of these practices maps well into enhancing overall student well-being and building resilience (Hall and Ketcham 2021). This chapter provides examples of how these practices can be used to build resilience and overcome setbacks faced in the research context (see Table 1). Explained below are the applications of the Salient Practices Framework that can help build team resilience for overcoming failures as they arise.

TABLE 1. Salient Practices of Undergraduate Research Mentoring Framework to Build Resilience in Student Researchers

Salient Practice	How practices are implemented as part of Elon BrainCARE mentoring to build resilience and overcome setbacks
1. Strategic pre-planning	The planning with a holistic view of priorities, feasibility, and goals. Additionally, that strategic planning is a dynamic process that happens individually and as Elon BrainCARE.
2. Set clear and well-scaffolded expectations	Revisiting expectations and goals each semester supports students in the planning and skills needed to support feasible expectations and project progress. It also reinforces that setbacks can be overcome if identified and built into next steps.
3. Teach technical skills necessary to do research in the discipline	Students build technical skills, leadership, and autonomy in their project. They grow in the ability to trouble-shoot and problem solve. They know how and when to reach out if they need help from mentors and peers as the data collected impacts all individual and collective projects.
4. Balance rigorous expectations with emotional support	Holistic mentoring matters in our spaces. Challenges and setbacks arise, and we collectively work to adjust, adapt, or reset as needed. It reinforces that prioritizing what takes time and attention is challenging and okay to incorporate into our discussions. Support an environment so collectively we can take more responsibility when someone else needs to step back.
5. Build community among scholars	Offering opportunities to meet as a group for journal club, to share research questions, and to practice presentations builds support from a community with shared interests. Collective curiosity and engagement often allow students to see holes in projects or interests that cross over as well as build community beyond the research setting.
6. Dedicate time to one-to-one mentoring	Having dedicated time to support personal and project growth from a mentor and expert supports strengths. Additionally this time allows space for individual questions, concerns, and accountability discussions.

continued

Table 1, continued

Salient Practice	How practices are implemented as part of Elon BrainCARE mentoring to build resilience and overcome setbacks
7. Increase student ownership over time	Support students in applying for grants, preparing abstracts, leading manuscript writing; building over time from technician to co-researcher with their own research project. The research process includes setbacks (e.g., grant rejections, missing data, manuscript revisions) and student finding success after being persistent in the process builds resilient habits.
8. Support students' professional development	Take students to relevant conferences, help with graduate school planning, and introduce them to colleagues in the field. Providing experiences for students to present ideas and interact with experts in the field allows them to network.
9. Create opportunities to learn mentoring skills	More experienced students mentor less experienced students on data collection and refining questions. Mentoring and teaching provide opportunities to see where others encounter challenges, questions, and setbacks. Helping or problem-solving together expands skills and perspective to predict where challenges might arise.
10. Encourage students to find opportunities to disseminate research	Presenting and writing manuscripts for publication often push students outside of comfort zones, but with guidance and facilitation, they often see their hard work pay off and matter.

Successful implementation of the Salient Practice Framework can also help teams (and individuals) build resilience to help overcome obstacles encountered in the research process. For example, we cultivate a *group structure* that enhances team resilience through Salient Practice 6 (one-to-one mentoring). While we co-mentor and use group activities (e.g., journal clubs) to develop team identity, we have one-to-one time with each student. The structures put in place help inform the student researchers about the expectations and norms of the group. This helps build trust between students and mentors. Building trust in these relationships is important so that mentees know that they are valued and that their development is important (Eller, Lev, and Feurer 2014; Johnson 2015). One important skill that can be cultivated to build this is for the mentors to have an empathetic mindset and active listening skills (Johnson 2015) to help better understand the needs of the student. Over time, we have a built-in apprenticeship model (Vandermaas-Peeler et al. 2011) where students begin as part of the whole project, but over time, they take on ownership of different aspects of the research (Salient Practice 7). This increase in autonomy is valuable for increasing confidence and the ability to be successful in research and is important for mentors to enact (Walkington et al. 2020).

The Salient Practices Framework can be used to help build confidence and self-efficacy amongst the mentees that are foundational to *mastery approaches* used to build team resilience. Salient Practices 1 (strategic pre-planning), 2 (setting clear and scaffolded expectations), and 3 (teaching technical skills) are easy ways to help students develop mastery over the necessary skills to be a researcher and develop increased research self-efficacy and confidence (Bandura 1977). Although these practices are important throughout the research process, they are especially important in the early stages of the research project and can help build student autonomy.

In efforts to build *social capital* and ultimately team resilience, it is critical that support be provided for all members of the team. Within the Salient Practices Framework, it has been identified that providing emotional support is critical (Salient Practice 4). This is provided collectively as a team as well as to individual members. Previous research has shown that providing compassion, one type of emotional support, can help build resilience (DeSteno 2018). This also includes recognizing students' identity and differences from that of the mentors that may impact their experience (Harrison, Comeaux, and Plecha 2006; Longmire-Avital and Miller-Dyce 2015). Having two mentors focusing on the needs of the students helps ensure that even small setbacks—in research, academic, or personal areas—are not missed, and proper amounts of support can be given to the students.

Finally, in an effort to support team resiliency through *collective efficacy,* Salient Practices 5 and 9 deal with building a community that can foster resilience amongst its team members. For Salient Practice 5, we are trying to build a community of scholars in almost everything we do. This is through establishing the name of the group and holding group journal clubs and testing sessions. These initiatives may assist students in realizing that they are not alone and are supported by others when obstacles come along. The students come from a variety of majors and thus have different experiences, expertise, and disciplinary skills. These qualities can be leveraged when various group members mentor each other in matters such as content or testing procedures (Salient Practice 9). It is always easier for people to overcome obstacles when they know they are supported by others.

The Elon BrainCARE model serves as a case study where a co-mentored community of scholars supports individual and team resilience. To build resilience and help overcome failure, the Salient Practices Framework supports scaffolded individual and team experiences, and support of positive mental health habits for undergraduate research students is central via the Act-Belong-Commit framework. This model of co-mentors supporting opportunities for students to explore a topic of interest within a lab's mission, learn and sharpen technical and research skills, disseminate research in public presentations and publications, and contribute to an ongoing research agenda is one that can be extrapolated to many mentoring contexts. As many research mentors know, the nature of the research process often includes some level of failure and setbacks to overcome. Creating a structure that incorporates a team approach of support, as well as normalizes overcoming failures and setbacks, provides built-in resources to support students and projects. Students often ask for or provide a helping hand, problem solve and strategize new approaches, commiserate across experiences, and celebrate accomplishments and triumphs over setbacks and failures. This has led to significant personal, professional, and team outcomes over the years and a professional network for alumni. Alumni often reach out to support current students and articulate the value of the Elon BrainCARE experience in preparing them for graduate programs and career paths. Ultimately, such successes in high-quality mentored research experiences can nurture personal and professional growth in students from a range of backgrounds who are pursuing a variety of career paths.

References

Abruzzo, Dane, David P. Sklar, and Graham T. McMahon. 2019. "Improving Trust between Learners and Teachers in Medicine." *Academic Medicine* 94: 147–150. doi: 10.1097/ACM.0000000000002514

Bandura, Albert. 1977. "Self-Efficacy: Toward a Unifying Theory of Behavioral Change." *Psychological Review* 84: 191–215. doi: 10.1037/0033-295X.84.2.191

Brantmeier, Edward J. 2013. "Pedagogy of Vulnerability: Definitions, Assumptions, and Applications." In *Re-Envisioning Higher Education: Embodied Pathways to Wisdom and Transformation,* edited by Jing Lin, Rebecca L. Oxford, and Edward J. Brantmeier, 95–106. Charlotte, NC: Information Age Publishing.

Center for Engaged Learning, Elon University. n.d. "Salient Practices." Accessed April 22, 2022. https://www.centerforengagedlearning.org/salientpractices

Curzon-Hobson, Aidan. 2002. "A Pedagogy of Trust in Higher Learning." *Teaching in Higher Education* 7: 265–276. doi: 10.1080/13562510220144770

DeSteno, David. 2018. *Emotional Success: The Power of Gratitude, Compassion, and Pride.* Boston: Houghton Mifflin Harcourt.

Donovan, Robert J., and Julia Anwar-McHenry. 2014. "Act-Belong-Commit." *American Journal of Lifestyle Medicine* 10: 193–199. doi: 10.1177/1559827614536846

Donovan, Robert J., Nadine Henley, Geoffrey Jalleh, Sven R. Silburn, Steve R. Zubrick, and Anwen Williams. 2007. "People's Beliefs About Factors Contributing to Mental Health: Implications for Mental Health Promotion." *Health Promotion Journal of Australia: Official Journal of Australian Association of Health Promotion Professionals* 18(1): 50–56. doi: 10.1071/he07050

Eller, Lucilee S., Elise L. Lev, and Amy Feurer. 2014. "Key Components of an Effective Mentoring Relationship: A Qualitative Study." *Nurse Education Today* 34: 815–820. doi: 10.1016/j.nedt.2013.07.020

Felten, Peter, and Leo M. Lambert. 2020. *Relationship-Rich Education: How Human Connections Drive Success in College.* Baltimore: Johns Hopkins University Press.

Fletcher, David, and Mustafa Sarkar. 2016. "Mental Fortitude Training: An Evidence-Based Approach to Developing Psychological Resilience for Sustained Success." *Journal of Sport Psychology in Action* 7: 135–157. doi: 10.1080/21520704.2016.1255496

Hagerty, Bonnie M. K., Judith Lynch-Sauer, Kathleen L. Patusky, Maria Bouwsema, and Peggy Collier. 1992. "Sense of Belonging: A Vital Mental Health Concept." *Archives of Psychiatric Nursing* 6: 172–177. doi: 10.1016/0883-9417(92)90028-h

Hall, Eric, Elizabeth Bailey, Simon Higgins, Caroline Ketcham, Svetlana Nepocatych, and Matthew Wittstein. 2021. "Application of the Salient Practices Framework for Undergraduate Research Mentoring in Virtual Environments." *Journal of Microbiology & Biology Education* 22(1): ev22i1.2287. doi: 10.1128/jmbe.v22i1.2287

Hall, Eric E., and Caroline J. Ketcham. (2021, November 2). "Mentoring with Mental Health in Mind." [Blog Post]. Retrieved from https://www.centerforengagedlearning.org/mentoring-with-mental-health-in-mind

Hall, Eric E., Helen Walkington, Maureen Vandermaas-Peeler, Jenny Olin Shanahan, Rikke Kolbech Gudiksen, and Margaret Mackenzie Zimmer. 2018. "Enhancing Short-Term Undergraduate Research Experiences in Study Abroad: Curriculum Design and Mentor Development." *Perspectives on Undergraduate Research and Mentoring* 7(1): 1–17.

Harrison, Keith C., Eddie Comeaux, and Michelle Plecha. 2006. "Faculty and Male Football and Basketball Players on University Campuses: An Empirical Investigation of the 'Intellectual' as Mentor to the Student Athlete." *Research Quarterly for Exercise and Sport* 77: 277–284. doi: 10.1080/02701367.2006.10599361

Henry, Meredith A., Shayla Shorter, Louise Charkoudian, Jennifer M. Heemstra, and Lisa A. Corwin. 2019. "*FAIL* Is Not a Four-Letter Word: A Theoretical Framework for Exploring Undergraduate Students' Approaches to Academic Challenge and Responses to Failure in STEM Learning Environments." *CBE–Life Sciences Education* 18: ar11. doi: 10.1187/cbe.18-06-0108

Johnson, W. Brad. 2015. *On Being a Mentor: A Guide for Higher Education Faculty.* 2nd ed. New York: Routledge.

Ketcham, Caroline J., Eric E. Hall, Heather Fitz-Gibbons, and Helen Walkington. 2018. "Co-Mentoring in Undergraduate Research: A Faculty Development Perspective." In *Excellence in Mentoring Undergraduate Research,* edited by Maureen Vandermaas-Peeler, Paul C. Miller, and Jessie Moore, 155–79. Washington, DC: Council on Undergraduate Research.

Ketcham, Caroline J., Eric E. Hall, and Paul C. Miller. 2017. "Co-Mentoring Undergraduate Research: Student, Faculty and Institutional Perspectives." *Perspectives on Undergraduate Research and Mentoring* 6(1): 1–13.

Koni, Elizabeth, Saleh Moradi, Hitaua Arahanga-Doyle, Tia Neha, Jillian G. Hayhurst, Mike Boyes, Tegan Cruwys, John A. Hunter, and Damian Scarf. 2019. "Promoting Resilience in Adolescents: A New Social Identity Benefits Those Who Need It Most." *PLOS ONE* 14(1): e0210521. doi: 10.1371/journal.pone.0210521

Kuh, George D. 2008. *High-Impact Educational Practices: What They Are, Who Has Access to Them, and Why They Matter.* Washington, DC: Association of American Colleges and Universities.

Li, Qiong, Qing Gu, and Wenjie He. 2019. "Resilience of Chinese Teachers: Why Perceived Work Conditions and Relational Trust Matter." *Measurement: Interdisciplinary Research and Perspectives* 17: 143–159. doi: 10.1080/15366367.2019.1588593

Longmire-Avital, Buffie, and Cherrel Miller-Dyce. 2015. "Factors Related to Perceived Status in the Campus Community for First Generation Students at an HBCU." *College Student Journal* 49: 375–386.

Moore, Jessie L., Sophia Abbot, Hannah Bellwoar, and Field Watts. 2020. "Mentoring: Partnering with All Undergraduate Researchers in Writing." In *The Naylor Report on Undergraduate Research in Writing Studies,* edited by Dominic DelliCarpini, Jenn Fishman, and Jane Greer, 29–44. Anderson, SC: Parlor Press.

Morgan, Paul B. C., David Fletcher, and Mustafa Sarkar. 2013. "Defining and Characterizing Team Resilience in Elite Sport." *Psychology of Sport and Exercise* 14: 549–559. doi: 10.1016/j.psychsport.2013.01.004

Morgan, Paul B. C., David Fletcher, and Mustafa Sarkar. 2017. "Recent Developments in Team Resilience Research in Elite Sport." In "Sport Psychology," edited by Peter J. Beek, R. I. (Vana) Hutter, and Raôul R. D. Oudejans, spec. issue, *Current Opinion in Psychology* 16: 159–164. doi: 10.1016/j.copsyc.2017.05.013

Nielsen, Line, Carsten Hinrichsen, Katrine Rich Madsen, Malene Kubstrup Nelausen, Charlotte Meilstrup, Ai Koyanagi, Vibeke Koushede, and Ziggi Ivan Santini. 2021. "Participation in Social Leisure Activities May Benefit Mental Health Particularly among Individuals That Lack Social Connectedness at Work or School." *Mental Health and Social Inclusion* 25: 341–351. doi: 10.1108/MHSI-06-2021-0026

Ostafin, Brian D., and Travis Proulx. 2020. "Meaning in Life and Resilience to Stressors." *Anxiety, Stress, & Coping* 33: 603–622. doi: 10.1080/10615806.2020.1800655

Platsidou, Maria, and Athena Daniilidou. 2021. "Meaning in Life and Resilience among Teachers." *Journal of Positive School Psychology* 5: 97–109.

Santini, Ziggi Ivan, Vibeke Koushede, Carsten Hinrichsen, Malene Kubstrup Nelausen, Katrine Rich Madsen, Charlotte Meilstrup, Ai Koyanagi, and Line Nielsen. 2022. "Challenging Leisure Activities and Mental Health: Are They More Beneficial for Some People than for Others?" *Mental Health and Social Inclusion* 26: 34–46. doi: 10.1108/MHSI-06-2021-0033

Scarf, Damian, Saleh Moradi, Kate McGaw, Joshua Hewitt, Jillian G. Hayhurst, Mike Boyes, Ted Ruffman, and John A. Hunter. 2016. "Somewhere I Belong: Long-Term Increases in Adolescents' Resilience Are Predicted by Perceived Belonging to the in-Group." *British Journal of Social Psychology* 55: 588–599. doi: 10.1111/bjso.12151

Shanahan, Jenny Olin, Elizabeth Ackley-Holbrook, Eric Hall, Kearsley Stewart, and Helen Walkington. 2015. "Ten Salient Practices of Undergraduate Research Mentors: A Review of the Literature." *Mentoring & Tutoring: Partnership in Learning* 23: 359–376. https://doi.org/10.1080/13611267.2015.1126162

Shawyer, Susanne, Renay Aumiller, Eric E. Hall, and Kim Shively. 2019. "Mentoring Undergraduate Research in Theatre and Dance: Case Studies of the Salient Practices Framework in Action." *Perspectives on Undergraduate Research and Mentoring* 8(1): 1–12.

Vandermaas-Peeler, Maureen, Jackie A. Nelson, Larissa Ferretti, and Lauren Finn. 2011. "Developing Expertise: An Apprenticeship Model of Mentoring Undergraduate Research across Cohorts." *Perspectives on Undergraduate Research and Mentoring* 1(1): 1–10.

Walkington, Helen, and Elizabeth Rushton. 2019. "Ten Salient Practices for Mentoring Student Research in Schools: New Opportunities for Teacher Professional Development." *Higher Education Studies* 9(4): p133. https://doi.org/10.5539/hes.v9n4p133.

Walkington, Helen, Kearsley A. Stewart, Eric E. Hall, Elizabeth Ackley, and Jenny Olin Shanahan. 2020. "Salient Practices of Award-Winning Undergraduate Research Mentors – Balancing Freedom and Control to Achieve Excellence." *Studies in Higher Education* 45: 1519–32. https://doi.org/10.1080/03075079.2019.1637838

CHAPTER 17

Transforming Failure into Joyful Resilience: Discovering Fun in Failure through the Play of Theatrical Clowning

Jerome Yorke

Abstract. This chapter aims to establish the possibility and necessity of the high-impact practice of theatrical clowning to be used as a tool for developing failure resiliency in undergraduate researchers. The author shows how theatrical clowning directly engages with failure stimuli through an authentic engagement with fear, play, and laughter. Pulling from theory, pedagogy, and student auto-ethnographic analysis of two case studies from the author's course, the chapter demonstrates how clowning can be used to develop an awareness of a playful response to fear and confront failure with more resiliency.

doi: 10.18833/cf/13

Despite the need for failure to grow and learn, we develop a fear of it (Davis 2019; Weidner and Skolar 2021). It may even be something we are taught through our parents' predispositions about failure (Haimovitz and Dweck 2016). The fear of failure can be defined as a "persistent and irrational anxiety about failing to measure up to the standards and goals set by oneself or others" (VandenBos 2007, 369). Many undergraduates have a fear of failure regarding public speaking. In a study of students' perception of public speaking, 75 percent admitted it causes anxiety (Raja 2017). Perhaps this anxiety leads to a fear of failing because the addition of an audience heightens the stakes of an already fragile situation where anyone can be easily undermined by the most minor of mistakes (Grove and Fisk 1992). To capitalize on the learning failure provides, we must overcome our fear of failure, especially our fear of public failure.

Because theater involves being authentic in front of others, it presents an ideal forum to workshop overcoming fear of failure. Theater is an embodied investigation of the complexities of the human experience where we make "a believable reality which gives the heart and the senses that kind of concrete bite which all true sensation requires" (Artaud 1958, 85). Theater synchronizes a dynamic physical relationship where the audience and performer have the capability to move and be moved (Shoda, Adachi, and Umeda 2016). Theater is consequential to undergraduate research as an embodied high-impact practice that is rigorous, necessary, and already present for the development of the whole person (Hayford 2022). Theater is a laboratory space where students are researchers experimenting with trial and error, and student researchers should be acknowledged for their contributions (Hayford and Kattwinkle 2018). Theater is the perfect medium for practicing failure resiliency because actors intentionally put themselves in front of an audience, even though being in front of an audience creates a heightened sense of dread and other symptoms brought on by a fear of failure (Beery 1975). There is great reward in failing publicly as it has shown to increase empathy through a building of self-esteem (Brown and Gallagher 1992). Renewed self-esteem will carry undergraduate researchers through failure stimuli. Through the fundamentals of theater, specifically the principles of theatrical clowning, failure can be observed and normalized as a basic human gift.

Within the realm of theater, clowning is a valuable practice for overcoming fear of failure because we can use laughter as a disruptive response to failure, "It is this failure-success cycle that is at the heart of the dynamics of clowning" (Davison 2013, 203). Clowns are often identified by their red noses, and the red nose can be used as mask pedagogy (Lecoq, Carasso, and Lallias; Bayes and Scott 2019; Wright 2017). The red nose is considered the smallest mask as it allows the audience to see a full expression of the human face, particularly the eyes, where more of the clown's authenticity can be seen (Wright 2017). While students wear a red nose, their responsibility to perform clown lies in accepting their vulnerabilities and laughing in full witness of others. We do this by finding our clown nature. Jacques Lecoq, a seminal figure in physical theater styles and credited for catapulting clowning as a pedagogical tool in the western theater, expands on how a clown nature lives within all of us: "The clown doesn't exist aside from the actor performing him. We are all clowns, we all think we are beautiful, clever and strong, whereas we all have our weaknesses, our ridiculous side, which can make people laugh when we allow it to express itself" (Lecoq et al. 2002, 154). We all have a clown nature, and it manifests in our unique playfulness and shows in our ability to laugh when confronted with an inevitable flop (Lecoq et al. 2002). A flop is defined as the acknowledgment of failure, of a mistake, any moment that thrusts us into a realization of being fallible. In my classroom, the most effective and established way to practice failure resilience is to play.

Unfortunately, the beneficial act of play is lost as people enter adulthood, despite play's influence throughout the lifespan and its positive effects on early brain development, therapy, work, and well-being in older adults (Brown and Vaughn 2009; Kaduson and Schaefer 2021; Montessori 2013; Stenner, Buckley, and Mosewich 2020). Despite the nature to be playful, society expects us to stop "clowning around." Our actions are authentic and manifest as laughter when we fail through our playfulness. Laughing as a tool for healing is well established, and it is in our human nature (Davila-Ross and Dezecache 2021; Gonot-Schoupinsky, Garip, and Sheffield 2020; Yim 2016; Zijderveld 1983). Authentic laughter creates a unique energetic understanding and reaffirms our being; this is the primary life force for our clown nature (Amsden 2017). Anything and everything become a playground or play-thing ready to be honestly investigated. Undergraduate research in clowning is an opportunity to reconnect to the beneficial act of play and engage with failure opportunities to elicit laughter and develop resiliency when faced with failure.

It is for this reason that the author designed an Acting for Everyone class, in which the public nature of theater and the specific practice of clowning are leveraged to support students in developing a playful resilience when faced with failure. It is a course-based undergraduate research experience in which students engage in a theater laboratory through (1) an investigation of failure stimuli or interruption of expectation, (2) trial and error through play, and (3) failure acceptance via laughter as a triumphant rebound. The following learning outcomes related to failure are targeted:

1. Students will further develop self-awareness (of failure stimuli).
2. Students will develop their observation, listening, and communication skills (as they practice failure through play).
3. Students will develop and apply the fundamentals of performance to real-life situations (failure resilience).

There is anecdotal evidence that these outcomes are attractive to students, since students enroll to "make [themselves] more comfortable being able to speak in front of other people, which is something [they] have struggled with in [their lives] prior to this class" (Student A 2020). Undergraduate researchers see the potential that the Acting for Everyone class may have to improve their communication skills as they move into their respective fields. "I am thinking about doing sales as a career so I wanted to choose [a course] that would test my communication skills" (Student B 2017). However, during the first week of class, the students' fear presents itself as heightened insecurity, and they have somatic responses like sweaty palms or dry mouth. They are still unsure about their ability to navigate failure and triumph over adversity (Covington 1992). Students who are so afraid yet have chosen to enroll in an acting class should not go unnoticed. This is the first sign that they are willing to broaden their academic challenges into a strictly growth mindset, one where they can cultivate a mastery approach to their goal orientation (Henry et al. 2019).

Highlighted below are two classroom practices, supported by the auto-ethnography of student reflections, which can assist students in developing resilience. The first case study demonstrates how an interruption of expectation can increase self-awareness. The experience serves to challenge students' current mindset and goal orientation (Henry et al. 2019). The second case study demonstrates how playing in front of an audience can decrease students' fear of public failure. The experience serves to develop a resilience after experiencing failure through a failure-success cycle (Davison 2013). These two case studies demonstrate how student researchers directly engage with the vulnerability of fear to transform failure into joyful resilience.

Case Study 1: Interruption of Expectation

A perceived failure (in the theater) might result from the introduction of an unanticipated event (interruption of expectation) and the perceived inability of the student/actor to respond well to that event. It can be a fearful experience if performers are not prepared for the physical flood of emotions that their bodies and minds experience when faced with an interruption of expectation. The unexpected is used on the first day of class to empower the students to act and help them overcome the fear associated with disorientation to ultimately reach success. This low-stakes exercise positions the students as authorities and agents in their own path but also excites fear of failure in the students because they must choose a path. Ultimately, the students act, having to overcome their fear and find a path forward to success, which increases their confidence in the future. The activities that elicit this process are explained below.

A perfect opportunity to establish this experience of disruption comes on the first day of class when the students arrive, full of the expectation that the syllabus will be reviewed, but the instructor never appears. The students enter a black-box theater classroom, empty except for an envelope on a table in the middle of the room. The disruption of the instructor's absence can accomplish several positive outcomes. First, the purpose of the interruption of expectation is to introduce a relationship with the unexpected. It is where the work of discovering one's clown nature begins as a process of "undoing, un-growing up, and de-socializing (Bayes 2019, 6). Next, the action introduces the importance of the student's role in a class where an "engaged pedagogy" de-centers the instructor's role as the authority of the student's experience yet still utilizes the instructor's expertise (hooks 1994, 13). There is a shift in the dynamic of the instructor-student relationship that immediately establishes the fact that the student is expected to take action and investigate a path without the mentor's instruction. One student wrote the following about the experience of arriving on the first day: "Walking into the Black [Box] Studio, I was met with the familiar buzz of energy that only comes from a place that houses both vulnerability and profound fearlessness. When I saw the note, illuminated only by the dim light of an outdated desk lamp, I felt a shift in the atmosphere" (Student C 2019). Now the students are thrust into the immediate moment. They begin to question the situation before them and must take action. Another student continues: "As the time was passing, people were wondering if we were in the right room because the teacher was still not in the classroom. Finally, someone pointed out that there was a letter under the lamp, and we contemplated if we should open it or not because it was just addressed to 'You'" (Student D 2020).

In the envelope is a riddle that encourages students to go to a place on campus: the arboretum cemetery. They must choose between solving the riddle or going home. The student continued, "We finally opened [the envelope] and we still did not know if we should follow the directions, but the consensus was that we should go to the cemetery" (Student D 2020). Once the students overcome the fear stimulus (interruption of expectation) and take action, they re-center themselves as authorities, and the entire group is now invested in each other (Brown and Gallagher 1992). This develops failure resilience because it gives them autonomy over their choices. This experience is important to the students because it tracks a response to interruption in three steps: disorientation, fear, and triumph. As one student intuits, "I told my roommates and some friends about the adventure on Thursday. They laughed as I told them the story, narrating my confusion, anxiety, and ultimate excitement for what is to come with this class" (Student E 2019). The significance of the first assignment is how students' bond through the experience of disruption. They are forced to act from the honesty and spontaneity of their authentic selves, their own spirit of playfulness, and their own clown nature.

Case Study 2: Playing with Failure Resiliency

Trial and error are used through play midway through the course to empower students to overcome a fear of public failure to ultimately reach success. This exercise positions the students to directly experiment with failure by investigating how they can cause their fellow students to laugh. Ultimately, the students succeed because they overcome their failure by figuring out what their audience perceives as funny. This skill develops failure resiliency and once mastered can be applied to other endeavors outside of class, which increases their confidence in the future. The activities that elicit this process are explained below.

The students embody failure resiliency and laughter through the exercise Show & Share. This is a three-part experience: the disorientation of a failure, an acceptance in the flop, and a triumphant rebound through laughter. The students are asked to bring a physical object to class that is either meaningful to them or is something they randomly picked up to bring to class. The audience does not know whether the object is meaningful or devoid of attachment. The objective of the game is for students to show what their object can do and to embody how the function of the object makes them feel. A successful showing ends with the class laughing and sharing in the delight that the object brings the student. To achieve this, however, the performer must navigate a gauntlet of failure. When they arrive on the day of the showing, called a performance lab, a performance space is set up, and they begin on the back of the stage, facing the audience. As the student steps forward to take center stage, the student must gain approval from the audience. The approval comes from the audience, which actively encourages them to step forward by laughing, showing large-mouthed smiles, or applauding. The student clown on stage is not allowed to step forward until the audience laughs. The audience is also instructed to respond authentically. If there is nervous or polite laughter to avoid discomfort, the student clown showing the object cannot move forward. Authenticity is the key. If Show & Share loses the audience to boredom, the student clown must take a step back and try to regain center stage before resuming the act of showing the object. The challenge for the student clown is to embody the playful nature of how the object makes them feel for the delight of the audience. The only way to succeed is to step through the fear of failing and present an authentic character.

The first few times this exercise is performed, the students are very nervous; try to be funny; or do something interesting in an effort to convince the audience that they are being authentic, which reads to the audience as inauthentic (Davison 2013). Their fear of failure in public is now being directly investigated. At first, very few show their object at all, because they fail to gain acceptance and constantly have to retreat and reevaluate their plan: "This forces me and my fellow students to step outside our comfort zones and think differently about the objects around people we're interacting with. This makes us observe the world differently and listen more clearly" (Student F 2020). When they evaluate their reasons for failing in real time, some important realizations occur. One student revealed an insight that occurred directly in the middle of their experience: "I do not need to be insecure and afraid, rather let myself be creative and flow how I want" (Student G 2020).

The trial and error of repetitive flopping give the students an understanding of how they react to failure, developing their resiliency: "It is this failure-success cycle that is at the heart of the dynamics of clowning" (Davison 2013, 203). Regarding receiving a successful outburst of laughter, one student recalled: "It's so important to know yourself and be in touch with what's going on inside your mind and heart; in all honesty, I couldn't believe what this class was teaching me about myself" (Student H 2021). The significance of the Show & Share investigation comes from the experience of having faced an audience alone on stage and successfully overcoming fear.

Conclusion

Although many students may have initially taken the Acting for Everyone class to overcome a fear of failure in public, they have gained much more. This class is a unique place where students can investigate how they respond to fear with their own unique style of play to cultivate resilience when facing failure. Using theater as a foundation for research (Hayford and Kattwinkle 2018) and the pedagogy of clowning as a structure (Davison 2013), students develop greater resiliency to failure by playing through fear with a better sense of their clown nature (Lecoq et al. 2002). From the first day of class, expectations are stripped away, which allows the students to be more attuned to the present moment. Through clowning pedagogy, students then engage in experiential games and play so they can practice a rebound from the flop. Finally, the experience of laughing publicly at their failures strengthens the students' resilience. The broader impact of a failure practice is a tangible ability to orient around failure and accept it with the transformative power of laughter. It is possible and necessary for live performance to be used to develop failure resiliency in undergraduate researchers (Hayford 2022). Failure is unavoidable. We can allow ourselves a moment of laughter while experiencing a momentary tragedy, which is the clown's wisdom and our nature.

References

Amsden, Lucy. 2017. “Monsieur Marcel and Monsieur Flop: Failure in Clown Training at Ecole Philippe Gaulier.” *Theatre, Dance & Performance Training* 8: 129–142. doi: 10.1080/19443927.2017.1316304

Artaud, Antonin. 1958. *The Theater and Its Double.* New York: Grove Press.

Bayes, Christopher, and Virginia Scott. 2019. *Discovering the Clown, or, the Funny Book of Good Acting.* New York: Theatre Communications Group.

Beery, Richard G. 1975. “Special Feature: Fear of Failure in the Student Experience. (Cover Story).” *Personnel & Guidance Journal* 54: 190–203. doi: 10.1002/j.2164-4918.1975.tb04220.x

Brown, Jonathon D., and Frances M. Gallagher. 1992. “Coming to Terms with Failure: Private Self-Enhancement and Public Self-Effacement.” *Journal of Experimental Social Psychology* 28(1): 3–22.

Brown, Stuart L., and Christopher C. Vaughan. 2009. *Play: How It Shapes the Brain, Opens the Imagination, and Invigorates the Soul.* New York: Avery.

Covington, Martin V. 1992. *Making the Grade: A Self-Worth Perspective on Motivation and School Reform.* New York: Cambridge University Press.

Davila-Ross, Marina, and Guillaume Dezecache. 2021. “The Complexity and Phylogenetic Continuity of Laughter and Smiles in Hominids.” *Frontiers in Psychology* 12: ar648497. doi: 10.3389/fpsyg.2021.648497

Davis, Andrew. 2019. “Failure Is Always an Option: The Necessity, Promise & Peril of Radical Contextualism.” *Cultural Studies* 3(1): 46–56. doi: 10.1080/09502386.2018.1544264

Davison, Jon. 2013. *Clown: Readings in Theatre Practice.* Readings in Theatre Practice. New York: Palgrave Macmillan.

Gonot-Schoupinsky, Freda N., Gulcan Garip, and David Sheffield. 2020. “Laughter and Humour for Personal Development: A Systematic Scoping Review of the Evidence.” *European Journal of Integrative Medicine* 37: ar101144. doi: 10.1016/j.eujim.2020.101144

Grove, Stephen J., and Raymond P. Fisk. 1992. “The Service Experience as Theater.” In *NA—Advances in Consumer Research*, vol. 19, ed. John F. Sherry Jr. and Brian Sternthal, 455–461. Provo, UT: Association for Consumer Research.

Haimovitz, Kyla, and Carol S. Dweck. 2016. “What Predicts Children’s Fixed and Growth Intelligence Mind-Sets? Not Their Parents’ Views of Intelligence but Their Parents’ Views of Failure.” *Psychological Science* 27: 859–869. doi: 10.1177/0956797616639727

Hayford, Michelle. 2022. *Undergraduate Research in Theatre: A Guide for Students.* Routledge Undergraduate Research Series. Abingdon, UK: Routledge.

Hayford, Michelle, and Susan Kattwinkel. 2018. *Performing Arts as High-Impact Practice.* The Arts in Higher Education. Cham, Denmark: Palgrave Macmillan.

Henry, Meredith A., Shayla Shorter, Louise Charkoudian, Jennifer M. Heemstra, and Lisa A. Corwin. 2019. “*FAIL* Is Not a Four-Letter Word: A Theoretical Framework for Exploring Undergraduate Students’ Approaches to Academic Challenge and Responses to Failure in STEM Learning Environments.” *CBE–Life Sciences Education* 18: ar11. doi: 10.1187/cbe.18-06-0108

hooks, bell. 1994. *Teaching to Transgress: Education as the Practice of Freedom.* New York: Routledge.

Kaduson, Heidi Gerard, and Charles E. Schaefer. 2021. "Introduction: The Therapeutic Powers of Play." *In Play Therapy with Children: Modalities for Change.,* edited by Heidi Gerard Kaduson and Charles E. Schaefer, 3–8. Washington, DC: American Psychological Association. doi: 10.1037/0000217-001

Lecoq, Jacques, Jean-Gabriel Carasso, and Jean-Claude Lallias. 2002. *The Moving Body Teaching Creative Theatre.* Translated by David Bradby. London: Bloomsbury.

Montessori, Maria. 2013. *The Secret of Childhood.* Delhi: Aakar Books.

Raja, Farhan. 2017. "Anxiety Level in Students of Public Speaking: Causes and Remedies." *Journal of Education and Educational Development* 4(1): 94–110.

Shoda, Haruka, Mayumi Adachi, and Tomohiro Umeda. 2016. "How Live Performance Moves the Human Heart." *PLoS ONE* 11(4): e015432. doi: 10.1371/journal.pone.0154322

Stenner, Brad J., Jonathan D. Buckley, and Amber D. Mosewich. 2020. "Reasons Why Older Adults Play Sport: A Systematic Review." *Journal of Sport and Health Science* 9: 530–541. doi: 10.1016/j.jshs.2019.11.003

Student A. 2020, Jan. 25. "Reflection." "Starting Line" assignment, Acting for Everyone, University of Dayton.

Student B. 2017, Feb. 7. "Reflection." "Starting Line" assignment, Acting for Everyone, University of Dayton.

Student C. 2019, Aug. 25. "Reflection." "What You Know Now" assignment, Acting for Everyone, University of Dayton.

Student D. 2020, Jan. 15. "Reflection." "What You Know Now" assignment, Acting for Everyone, University of Dayton.

Student E. 2019, Aug. 25. "Reflection." "What You Know Now" assignment, Acting for Everyone, University of Dayton.

Student F. 2020, Jan. 28. "Reflection." "How Do You Play" assignment, Acting for Everyone, University of Dayton.

Student G. 2020, Jan. 30. "Reflection." "How Do You Play" assignment, Acting for Everyone, University of Dayton.

Student H. 2020, Sept. 14. "Reflection." "How Do You Play" assignment, Acting for Everyone, University of Dayton.

VandenBos, Gary R., ed. 2007. *APA College Dictionary of Psychology.* Washington, DC: American Psychological Association.

Weidner, Brian N., and Ellen Skolar. 2021. "Teaching for a FAIL (First Attempt in Learning) in the Ensemble Classroom." *Music Educators Journal* 108(2): 23–29. doi: 10.1177/00274321211060332

Wright, John. 2017. *Playing the Mask: Acting without Bullshit.* London: Nick Hern Books.

Yim, JongEun. 2016. "Therapeutic Benefits of Laughter in Mental Health: A Theoretical Review." *Tohoku Journal of Experimental Medicine* 239: 243–249. doi:10.1620/tjem.239.243.

Zijderveld, Anton C. 1983. "Trend Report: The Sociology of Humour and Laughter." *Current Sociology* 31(3): 1–59.

About the Contributors

Noveera T. Ahmed is chair and associate professor of biology at St. John Fisher College. Her published research focuses on identification of novel proteins needed for flagellar assembly and the integration of this research model into the classroom. To help shape policies to increase women and URMs in STEM, she serves as vice president of the Ahmadi Women Scientist Association, as a member of the board of trustees for an all-girls high school, and as a member of the Genetics Society of America's Education Committee. She serves as the TriBeta biological honor society chapter adviser and district director, as well as the co-PI on the institution's first S-STEM grant. She recently led a curricular overhaul to guarantee an undergraduate research experience for all biology majors.

Kathleen Baril is director of Heterick Memorial Library at Ohio Northern University. In her role in a small academic library, she works to create inclusive spaces and services to support student success.

Beth Beason-Abmayr, teaching professor of biosciences at Rice University, is a faculty fellow of the Rice Center for Teaching Excellence. She has developed and teaches multiple course-based undergraduate research experiences (CUREs) and a student-centered animal physiology course. She chairs the American Physiological Society's 2022 Institute on Teaching and Learning and serves as an associate editor for *Advances in Physiology Education.* She is a member of the Council on Undergraduate Research (CUR) and a leader of the National Institute on Scientific Teaching.

John Lando Carter is an assistant professor of education at Middle Tennessee State University and coauthor of *Teaching Signature Thinking: Strategies for Unleashing Creativity in the Classroom* (Routledge, 2022). He teaches classes in the Assessment, Learning, and Student Success EdD Program at MTSU.

Keri Lee Carter is the assistant director of the Margaret H. Ordoubadian University Writing Center and faculty member of the English Department at Middle Tennessee State University, where she teaches students, mentors tutors, and forges community partnerships.

Daniel J. Catanese Jr., assistant teaching professor of biosciences at Rice University, teaches an intermediate CURE and a flipped bioscience lecture course intended for first-year students and is the Natural Science instructor of a summer bridge program aimed at improving STEM retention and class performance for incoming first-year students who are academically at-risk, first generation, women, and underrepresented minorities. He is a CUR member and an associate of the National Institute on Scientific Teaching.

Louise (Lou) K. Charkoudian is an associate professor of chemistry at Haverford College. Her undergraduate-driven research program focuses on understanding how bacteria and fungi manufacture structurally complex molecules and developing sustainable routes to access diverse, therapeutically relevant molecule. She is passionate about integrating original research opportunities for undergraduate students into laboratory and seminar-style courses and working with undergraduate students to co-create symbiotic community engagement activities. She is also interested in exploring how interpersonal factors can be leveraged to build more inclusive, diverse, and accessible STEM courses and training opportunities.

Lisa A. Corwin is an assistant professor studying discipline-based education research (DBER) in the Department of Ecology and Evolutionary Biology at the University of Colorado, Boulder. Her research focuses on understanding how we, as educators, can support the next generation of community-engaged, creative, resilient scientists. She is particularly interested in how students cope with research challenges and failures, what types of learning experiences increase students ability to come up with multiple creative solutions to complex biological problems, and how to engage students in CUREs that serve local communities and draw on local culture and history. She is also dedicated to improving equity in biology education research and actively supports community college instructors in efforts to engage in DBER.

Amy Dunbar-Wallis is a National Science Foundation Graduate Research Fellow and graduate student researcher at University of Colorado, Boulder. She has been involved in research programs from plant physiology to plant genetics and is active in biology education research, community-engaged science civic engagement of students, and community-facing programs with the Boulder Apple Tree Project. She also is interested in expanding authentic research opportunities that involve introductory biology students and instructors at community colleges.

Elizabeth Eich is the associate director for undergraduate research and inquiry and Professor in the Practice in Biosciences at Rice University. Through these roles and as a consultant for the Council on Undergraduate Research's Transformations Project, she works with faculty partners to scaffold research and inquiry in the curriculum. She also directs the Sustaining Excellence in Research Scholars Program to increase diversity and retention of STEM undergraduates through support in mentored research.

Michelle Erklenz-Watts, after serving in several faculty roles at St. John Fisher College, is director of the college's Academic Student Services, seeking to assist students in their path to personal and career success. She has been an advocate for social justice in education for more than 30 years. Her published work focuses on pedagogy, student success, and social justice.

Sara G. Goodman is an assistant professor of psychology at St. John Fisher College, a co-PI on the college's current S-STEM grant, and a CUR Councilor. Her research focuses on growth and fixed mindset frameworks as self-regulatory strategies, which she applies to pedagogical development opportunities for faculty in a variety of disciplines. She also studies the impacts of novel technologies on cognition, student learning, and success.

Melissa M. Goodwin is the associate dean for the School of Arts and Sciences and director of the Core Curriculum at St. John Fisher College. She leads initiatives supporting diversity, equity, and inclusion in the School of Arts & Sciences, including those embedded in the new Core Curriculum. She also serves as the social science researcher for a National Science Foundation S-STEM grant. A developmental psychologist by training, her research focuses on social-emotional development and mindfulness in children, adolescents, young adults, as well as mindfulness as a tool for conversations around issues of social justice.

Amanda M. Greenwell is assistant professor of English and coordinator of the English Secondary Education Program at Central Connecticut State University, where she teaches courses in young adult literature and English education. Her current research focuses on U.S. literature for young people and young people in U.S. literature, particularly by investigating narrative techniques that confront exclusionary institutionalized norms and practices. Her work has appeared in journals such as *Children's Literature, Jeunesse, The Lion and the Unicorn, Studies in the American Short Story,* and *African American Review,* as well as in edited collections about literature and pedagogy.

Heather Haeger is the research director for the Science, Technology, Engineering, or Mathematics (STEM) Learning Center and an assistant professor in educational policy studies and practice at the University of Arizona. Focused on equity in educational practices and barriers to full participation in STEM education, her research is used to inform programmatic interventions aimed at engaging students who have been traditionally marginalized in higher education and creating more inclusive and culturally responsive STEM learning environments.

Eric E. Hall is a professor of exercise science at Elon University and co-director of the Elon BrainCARE Research Institute. His primary research interests are in physical activity and mental health, as well as the impact of concussions in student-athletes. Additionally, he researches the influence of high-impact practices on student development and the role of faculty in mentorship of high-impact practices specifically undergraduate research. At his institution, he has received awards for his mentorship of undergraduate students and scholarship. He will begin serving as the director of the Undergraduate Research Program in summer 2022.

Kayley J. Hall is an undergraduate research student at California Lutheran University, majoring in psychology and criminal justice. Her research interests include visual imagery and the effect of different leisure activities on human cognition. She is planning on pursuing a graduate degree in cognitive psychology and eventually becoming a professor of psychology while continuing to pursue research within the field.

Joseph (Joe) A. Harsh is an associate professor in the Department of Biology and the associate director of the Howard Hughes Medical Institute Inclusive Excellence project at James Madison University. His research focuses on understanding student experiences and engagement in undergraduate science, with current work investigating the impact of undergraduate research, scientific resiliency, the development of data visualization skills, and how to create more inclusive learning environments.

Jennifer (Jen) M. Heemstra is a professor of chemistry at Emory University. Her research group is focused on harnessing the molecular recognition and assembly properties of biomolecules to build functional systems that address unmet needs in biomedicine and the environment. She is also focused on creating educational and research spaces that help students to build the resilience and professional skills they need to be successful in their future careers. Through her research, education, and service activities, she is particularly passionate about transforming academic culture in order to create equitable and inclusive environments where every individual has what they need to thrive.

Meredith A. Henry is a lecturer of psychology at Georgia State University and a founding member of the NSF-supported Research Coordination Network FLAMEnet (Factors Affecting Learning, Attitudes, and Mindsets in Education Network). Her research focuses on students' and instructors' views of failure and challenges in higher education. She is particularly interested in how these perceptions of failure/challenge can be leveraged to improve noncognitive outcomes (e.g., fear of failure, mindset, coping behaviors, attribution style) within the classroom. Her teaching interests include finding ways to encourage students to apply class content to real-world situations and continuing the quest to convince undergraduates that stats/research methods are cool.

Oliver Hyman is a lecturer in the Department of Biology at James Madison University. His research focuses on biodiversity monitoring, species detection, and disease ecology. He is passionate about creating authentic biodiversity-related research experiences for large enrollment introductory biology courses and teaching students how tools from disparate fields like molecular biology and bioinformatics can contribute to species conservation.

Lisa Jasinski is senior director for strategic initiatives in the Office of the President at the University of Texas at San Antonio. As a higher education researcher working in the qualitative tradition, she seeks to learn from the lived experiences of students, faculty members, and administrators to support equitable practice, improved support, and institutional change. She was an American Council on Education Fellow and Fulbright Specialist to Finland.

Caroline J. Ketcham is professor of exercise science and co-director of Elon BrainCARE Research Institute. Her expertise is in the area of movement neuroscience, and her disciplinary research focuses on motor control in neurodiverse populations, the management and recovery of concussions, and positive mental well-being advocacy. She has been engaged in high-impact practice research, including co-mentoring undergraduate research for student and faculty development; access and engagement for student-athletes, neurodiverse, and disabled students; and capstone experiences. She has been recognized for her high-quality teaching, scholarship, and mentoring with college and university-wide awards.

Jodie Kocur is a professor of psychology specializing in counseling psychology and co-director of the First-Year Experience Program at California Lutheran University. With the assistance of her team of undergraduate researchers, she organizes and leads a summer program to help students with autism with the transition from secondary to postsecondary education, including an emphasis on social skills, communication with faculty and staff, and coping skills.

Catherine Meals is the reference & assessment librarian at the University of the District of Columbia. She leads the library's assessment program and supports student learning through reference services and information literacy instruction. Her research interests include personal librarianship and development of student research assignments. Prior to joining UDC, she worked at the DC Public Library and was a strategic researcher in the labor movement. She holds an MLIS from the University of Maryland and a BA from Swarthmore College. She is a founding member of the Board of Instigators of the Diverse City Fund.

Natasha Oehlman is the writing and professional communication associate at the Undergraduate Research Opportunities Center at California State University, Monterey Bay and a CSU predoctoral coordinator. She works primarily with undergraduate researchers supporting their development with professional papers/presentations and multimedia for national conferences, and application to national fellowships and scholarships. Her research interests in writing studies include studying writing models that facilitate student self-efficacy and agency.

Alison N. Olcott is an associate professor of geology and the director of the Center for Undergraduate Geology at the University of Kansas (KU). In addition to her scientific research into how chemical traces of life can be preserved across geological time, she researches how the geosciences can be more diverse and equitable, particularly for students from populations traditionally underrepresented in STEM fields and for LGBTQ+ geoscientists. As director of the Center for Undergraduate Research, she supports and guides students and faculty across KU who are interested in undergraduate research and creative endeavors.

Nicole Perry is a communications manager at a research center at the University of Kansas (KU) who holds undergraduate degrees in English and humanities as well as a PhD in sociology. She is the author of *Policing Sex in the Sunflower State: The Story of the Kansas State Industrial Farm for Women* (UP of Kansas, 2021) and is a former assistant director for faculty initiatives of KU's Center for Undergraduate Research.

Kristin Picardo, a former professor of biology, is the assistant provost overseeing the Office of Sponsored Programs and Foundation Relations and the founding director of the Center for Student Research and Creative Work at St. John Fisher College. She serves as the PI on a track 1 NSF S-STEM award, is a CUR Councilor, and is an associate editor for CUR's journal *SPUR: Scholarship and Practice of Undergraduate Research.*

Justine Post is a learning designer for a consulting company where she strives to center learners' experiences and use equitable and inclusive methods to support learning development. She previously served as an associate professor of rhetoric and composition as well as the writing center director at Ohio Northern University. Her research explores factors that impact students' writing development, including instructor feedback, pedagogical approaches, and affective dimensions of the learning experience.

Andrea J. Sell is an associate professor of psychology specializing in cognitive psychology and associate dean for faculty affairs, research, and creative scholarship in the College of Arts and Sciences at California Lutheran University. She previously directed the university's Office of Undergraduate Research. In addition to mentoring many undergraduates in the research process, she also has led workshops aimed at helping faculty better mentor their research students.

Bethany Spieth is the instruction and access services librarian at Heterick Memorial Library at Ohio Northern University. Her research interests focus on ways of making libraries and information literacy more accessible and engaging for undergraduate students.

Dawn Tallchief is the assistant director for student programs in the Center for Undergraduate Research at the University of Kansas (KU). An enrolled member of the Seneca Nation of Indians, she earned her PhD in educational leadership and policy studies. Her research and practice have focused on enhancing college student success, with an emphasis on recruitment and retention of American Indian students in postsecondary education. She is a founding member of KU's Native Faculty & Staff Council. At KU, she previously served as a program assistant for the Academic Learning Center and as assistant director for Graduate Military Programs.

Heather M. Townsend is a professor of biology at the Community College of Rhode Island. Her publications include articles, papers and chapters on virtual microscopy, biosafety in teaching laboratories, and incorporating course-based undergraduate research experiences (CUREs) into community college courses. Her interests lie in incorporating high-impact practices at the community college level to facilitate equity and inclusion in the classroom. Recently, she has focused her attention on adding research experiences for online courses, as well as enhancing a CURE by integrating ethical conduct of research to strengthen students' scientific literacy. She serves on various boards at CCRI, including the Center for Teaching Excellence and the Student Success Committee, and is the president of the New England Biology Association for Two-Year Colleges.

Ayah H. Wakkad is a graduate teaching assistant and a PhD candidate in the English Literature Program at KU. Her research interests focus on 20th-century prison literature; postcolonial studies; and diversity, equity, and inclusion (DEI) in teaching pedagogies. As an Andrew W. Mellon fellow, she worked to corporate the internationally recognized performing arts curriculum of Muslim American hip-hop artist Amirah Sackett into her research-based writing course to enhance DEI. Currently, she works on examining the significance of integrating prison writing in the undergraduate research curriculum.

Rory Waterman is a professor of chemistry at the University of Vermont (UVM). His research focuses on inorganic and materials synthesis as well as homogenous catalysis with an eye on sustainable use of limited elemental resources. He also is associate dean for research and graduate education in UVM's College of Arts and Sciences, where he has identified improving access, equity, and inclusion as key factors in meeting objectives in that role. He also works in professional development, most recently co-chairing the advisory board for the American Chemical Society New Faculty Workshop.

Nekesha B. Williams is an assistant professor of environmental science at Saint Mary's College of California. She teaches environmental and geoscience courses such as hydrology, coastal systems, and wetlands, as well as advises students within her program and mentors undergraduate researchers across STEM disciplines. Her published research focuses on sediment delivery and transport from tropical watersheds and heavy metal accumulation in coastal ecosystems.

Jerome Yorke (he-they) is an assistant professor of physical theatre at the University of Dayton and a core member of UpLift Physical Theatre. His performance research is rooted in somatic experience and expression through devised theatre-making, performance art, and clowning. He advocates for expressive practices as essential for the development of the whole person. He is active in pedagogical development encouraging creative, experiential, and cross-disciplinary opportunities toward vocation discernment.