

Nipped in the Bud: COVID-19 Reveals the Malleability of STEM Student Self-Efficacy

Eileen Kogl Camfield,^{1*} NaTasha R. Schiller,² and Kirkwood M. Land³

¹Center for Engaged Teaching and Learning, University of California at Merced, Merced, CA 95343;

²Department of Biology, Wingate University, Wingate, NC 28174; ³Department of Biological Sciences, University of the Pacific, Stockton, CA 95211

ABSTRACT

When a global pandemic hits during a longitudinal study of biology student success, researchers can unearth rich information about student resilience. By sharing case studies from two demographically different mid-sized 4-year institutions, this article illustrates the aspects of student self-efficacy beliefs that were undercut by the shift to emergency remote instruction (ERI) in introductory biology courses in Spring 2020: agency and belonging. By assessing student predictions of exam performance and analyzing themes from 276 student narrative surveys, we highlight the power of a careful balance between cognitive and social interventions to help students recover. Students in this study showed a 50% loss of efficacy beliefs after ERI (midsemester) but were able to improve to at least 75% above starting efficacy beliefs after instructor interventions. Thus, we also show how academic efficacy is highly malleable and is mediated in relationships. In turn, we demonstrate a new assessment model that uses student narrative writing to reveal “invisible” threats to students’ perceptions of their capacity to succeed. Finally, we generalize from their findings to provide recommendations for effective strategies for supporting those students for whom every semester feels like a pandemic.

Science, technology, engineering, and math (STEM) fields have the potential to find solutions to some of society’s most pressing problems, and identifying these solutions “requires attracting and retaining new generations of creative and versatile scientists who are well prepared to participate in fast-paced, information-rich, collaborative forms of science” (Hanauer and Bauerle, 2012, para. 2). That said, few of our students may actually be pursuing careers as scientific researchers. Perhaps more likely, they will pursue work as healthcare professionals. There, too, diversity matters. As the recent COVID-19 pandemic has demonstrated, significant health outcome disparities exist in low-income communities of color (Centers for Disease Control and Prevention, 2020). Diversifying the pipeline for potential healthcare providers, who may return to serve their home communities, might assuage this disparity. In fact, the Health Professionals for Diversity Coalition describes several ways provider diversity may improve disparities in health status between White populations and communities of color in the United States (2012). Thus, this new generation of scientists and healthcare workers must be drawn from a “broad and diverse talent pool of students who are interested in science” (Hanauer and Bauerle, 2012, para. 2); the challenge becomes how to generate such a pool.

Access is one issue facing STEM programs. However, as Gannon (2020) points out, “Increasing access is a laudable goal, but *only if* we mean students should be able to access the types of resources that allow them to fashion their own academic success” (p. 74). Hanauer and Bauerle (2012) report students’ failure to persist in college science classes at a national rate above 50%, but this number masks the differential outcomes for certain populations of students. For example, the degree completion rates of Black and Hispanic students in the United States are significantly lower, at 41.9%, compared with White and Asian students, at 62.2% (Shapiro *et al.*, 2017).

Tessa C. Andrews, *Monitoring Editor*

Submitted Sep 8, 2020; Revised Mar 5, 2021;

Accepted Mar 15, 2021

CBE Life Sci Educ June 1, 2021 20:ar25

DOI:10.1187/cbe.20-09-0206

All collection of material from human subjects has been IRB approved.

*Address correspondence to: Eileen Kogl Camfield (ecamfield@ucmerced.edu).

© 2021 E. K. Camfield *et al.* CBE—Life Sciences Education © 2021 The American Society for Cell Biology. This article is distributed by The American Society for Cell Biology under license from the author(s). It is available to the public under an Attribution–Noncommercial–Share Alike 3.0 Unported Creative Commons License (<http://creativecommons.org/licenses/by-nc-sa/3.0>).

“ASCB®” and “The American Society for Cell Biology®” are registered trademarks of The American Society for Cell Biology.

Further, for a slew of reasons, students who experience failure in at least one academic area fail to persist in either their course or university at a rate 4.2 times higher than those who were successful in their academic pursuits (Ajjawi *et al.*, 2020).

This means we need to increase *both* access and success in STEM majors for students from previously underrepresented groups. Unfortunately, some in the academy have validated the lack of student persistence from a defensive position, justifying student failure as a consequence of faculty having so-called rigorous standards. Their deficit-oriented arguments blame the students for a lack of preparation and lack of engagement. Tinto (2017) challenges this mindset and suggests that we investigate persistence from a student standpoint. He posits that students' motivation to persist in degree completion is more related to sociocognitive domains: sense of belonging, mindset, perceived value, and self-efficacy. These are malleable constructs that individual instructors can influence. Therefore, he suggests that we in the institution start to ask "what [we] can do to influence student motivation to stay, persist, and complete degrees" (p. 2). The researchers in this study approached student success in introductory biology courses from this perspective.

BACKGROUND/LITERATURE REVIEW

Self-Efficacy and Resilience

In doing so, we build off our previous work that began with an interest in student self-efficacy development. Pioneering researcher Albert Bandura (2008) defines self-efficacy as individuals' belief in their capacity to accomplish something. He demonstrated that it is highly correlated with agency and motivation, because when people see themselves as competent, they are more likely to engage and persist through setbacks. Thus, self-efficacy is also associated with learning and can be a harbinger for future positive performance (Pajares, 1996). Conversely, such self-beliefs matter, because when a student's self-efficacy drops, that student is more likely to be disengaged from learning and school (Anderson *et al.*, 2019).

Bandura (2008) described self-efficacy as a social-cognitive theory of motivation, meaning it is forged in a dialectic between the self and one's social environment. He noted four dimensions of that self-efficacy dialectic: mastery experiences, social modeling, social persuasion, and positive emotions. While each dimension matters, as educators committed to fostering positive learning relationships with our students, we were particularly intrigued by the power of social modeling and mastery experiences, noting the potential impact of pedagogical design. Bandura's (2008) work shows us how modeling can help individuals develop the kind of self-regulation necessary to control debilitating emotions brought on by failure. Thus, he ties self-efficacy with resilience. He explains: "Resilient efficacy requires experience in overcoming obstacles through perseverant effort. Success is achieved by learning from failed efforts. Hence, resilience is also built by training how to manage failure so it is instructive rather than demoralizing" (p. 168).

Instructors are well positioned to coach students in reframing failure. For example, they can teach students to accurately evaluate their knowledge and/or to reflect on exam performance with an eye to improved study techniques. Instructors can create low-stakes assignments that make failure feel less catastrophic and can also scaffold assignments to optimize student success/mastery. Further, resilience-focused instructional feedback can

help students develop agency and growth mindsets (Dweck, 2007), important components of students' beliefs in their capacities to master the material in a course. Given that students from marginalized and lower socioeconomic backgrounds tend to be dependent learners (Hammond, 2014) and to hold a fixed mindset (Claro *et al.*, 2016; Aelenei *et al.*, 2017; Destin *et al.*, 2019), the intentional design of an instructor's feedback to foster students' positive self-perceptions of their capabilities is essential.

Active Learning: Student Engagement, Sense of Belonging, and Agency

Along with optimizing student efficacy and resilience, instructors can also employ active-learning techniques to improve student engagement (Hodges, 2020). Active learning challenges students to develop higher-order thinking skills, such as analysis, synthesis, and evaluation. These skills typically involve some form of reading, writing, discussion, or problem-solving within the classroom environment, where the instructor is present to provide constructive feedback.

The benefits to students of this pedagogical approach have been well established since at least the late 1960s. A 2014 meta-analysis of more than 200 studies revealed substantially enhanced learning and significantly less failure in courses in which active-learning techniques are employed (Wieman, 2014). However, the instructor must also create a "climate conducive to students' deep constructive and integrative engagement" (Hodges, 2020, p. 35) where active learning can be effective. Such a climate both depends upon and promotes student trust in the instructor (Cavanagh *et al.*, 2018). This trust is also a determining component of the student's subsequent willingness to be taught. Here we see a beneficent cycle that depends upon relationship building to foster a simultaneous sense of belonging and agency. To underscore the value of cultivating a student sense of belonging, Strayhorn's (2012) research indicates that if we were to do just one thing to improve persistence, sense of belonging is where we should invest our efforts.

Student engagement and motivation is also activated through perceptions of their learning as valuable (Tinto, 2017; Gannon, 2020). However, students can perceive value through various dimensions of the course, and various learners will respond differently. Therefore, developing student agency through metacognition can help increase the likelihood students will discover those things they value. This can come from the students' personal reflection on how their past experiences connect to their current learning or on how their future goals align with content in the course. Students can also perceive personal value from the instructor. When the instructor creates space within the course for students to actively participate in explanation and analysis of material, the students can gain even more agency. For students of color, this agency can serve as "an important safeguard against some of the processes, such as stereotype threat, that work against [their] motivation and performance" (Gannon, 2020, p. 62). Therefore, a savvy instructor will teach "transparently" (Winkelmess *et al.*, 2019) and strive to inject multiple opportunities for students to see the applicability and worth of what they are being asked to learn.

Mediated-Efficacy and Introductory Biology

As the previous sections have illustrated, the instructor plays a powerful role in engaging students in the learning task, in

helping develop student agency, and in activating students' positive self-beliefs. Indeed, Camfield's (2016) grounded theory analysis of student self-efficacy development posited that the construct of *self-efficacy* may be a misnomer and that, for first-year students especially, learning is mediated in relationships with instructors and peers. Thus, she developed the construct and coined the term "mediated-efficacy," which we use in this article. That work was expanded and developed for application in STEM classrooms. The ensuing study (Camfield *et al.*, 2020) revealed ways writing could be used in science class to activate students' engagement and build efficacy. There we also showed efficacy to be highly malleable, that it is associated with STEM student persistence, and that student narrative writing can reveal "invisible" threats to students' perceptions of their capacity to succeed. The work presented in this article is a continuation of our longitudinal study and 1) investigates the particular mechanisms through which mediated-efficacy is forged and 2) describes how those mechanisms were disrupted in the Spring of 2020 during the shift to emergency remote instruction (ERI) due to the COVID-19 pandemic.

We will demonstrate how mediated-efficacy is strengthened by student agency forged through a trifecta of resilience coaching, student engagement, and sense of belonging. In turn, we infer that, by activating student efficacy, we will improve subsequent student persistence and sense of community. Therefore, we suggest that efficacy is more than a motivational tool and has a wider-ranging impact on student success and well-being. We also will show how writing serves as both an effective metacognitive and assessment tool for activating student efficacy and for gathering actionable information about student experiences in our courses.

As mentioned earlier, before the COVID-19 pandemic, the authors of this study were already experimenting with a variety of pedagogical interventions aimed at improving student success and persistence through both cognitive and affective channels. Our interventions are summarized in Table 1.

RESEARCH QUESTIONS

However, ERI due to the COVID-19 pandemic disrupted many of these interventions. Therefore, the questions that guided our research in the study described here are: What was the specific impact of that disruption in terms of student efficacy develop-

ment? And, what does that disruption suggest to us in terms of more generalized student support needs?

Because we were working under the assumption that efficacy is coconstructed by and with other motivational and affective components of learning, we initially posited that ERI would rob students of a sense of belonging. We further hypothesized that this loss of a sense of belonging would likely contribute to increased anxiety and to a loss in sense of resilience, engagement, and agency. This anxiety and these losses may have added to student cognitive loads (Verschelden, 2017) in ways that allowed for less bandwidth to devote to learning (including metacognition). We also posited that first-year students' efficacy is initially more dependent on instructors and is fostered by an intentionally constructed learning environment. Therefore, when students lost contact with their instructors, they lost mediated-efficacy. In this study we aimed to contribute to the discussion about culturally responsive teaching and first-year students as dependent learners requiring instructor support to transition into being independent learners (Hammond, 2014).

OUR CASE STUDIES: CONTEXTS, METHODS, AND RESULTS

We present two case studies with instructors equally committed to improving student outcomes in their introductory courses. (See Table 2 for how the two campuses compare). In illustrating their students' experiences, the instructors describe the settings, existing curricular and pedagogical interventions pre-COVID-19, the new challenges ERI presented, and ways they responded to these challenges. Because both instructors were already working on a student efficacy-development project, they were able to compare past semesters (as a kind of control) to Spring 2020. These data reveal both the impact of ERI on students and how successful the instructors' pedagogical responses were in mitigating negative impacts.

Case Study 1: Wingate University, Dr. NaTasha Schiller

Schiller Context. At Wingate University, 17% of entering increasingly diverse students are pursuing a biology-related major. The freshman to sophomore persistence rate of these students within the major is 22%, which is below the university average of 52%. A likely contributing factor to this decrease in

TABLE 1. Pedagogical practices to improve student success

(Meta)cognitive elements used in this study	Benefits
Written exam wrappers and learning reflections	Resilience; perceived value; sense of belonging/mattering; real-time feedback to instructors
Training on how to study	Mastery; agency
Transparent teaching activities	Perceived value; engagement
Sociocognitive elements used in this study	
Active-learning strategies	Engagement; positive modeling; perceived value
Narrative assessment efficacy surveys (pre, mid, and post)	Sense of belonging; positive modeling; perceived value
Social elements used in this study	
Embedded peer educators/supplemental instructors	Sense of belonging, resilience
Team-based learning	Real-time peer feedback; sense of belonging
Constructive instructor feedback	Sense of belonging; mastery; resilience

TABLE 2. Two campuses compared

	University of the Pacific ^a	Wingate University ^b
Location	Stockton, CA	Wingate, NC
Size	4639 students; (3559 undergraduates)	3600 students; (2726 undergraduates)
Selectivity	65% admissions rate	85% admissions rate
Degrees granted	16% of the total number of bachelor's degrees conferred in 2018–2019 were in biochemistry or general biological sciences.	15% of the total number of bachelor's degrees conferred in 2018–2019 were in general biological sciences or environmental biology. 20% of undergraduates are preparing to be a pharmacist, physician assistant, physical therapist, or nurse.
Number of first-generation students	~ 30%	~28%
Pell Grant Aid Received (The national average is 31%, anything significantly above that is considered low income; http://edreformnow.org/wp-content/uploads/2020/01/A-Fair-Share-for-Ohio_final_embargoed1.22.pdf)	37%	48%
Diversity	77.6% non-White Asian-Pacific Islander (largest student demographic) at 38.2% generating federal AANAPISI ^c designation	42% non-White with 18% identifying as Black or African American (largest non-White demographic)
Overall first-year persistence rates	85.6% (with Hispanic students at 79.7% and Black and African-American students trailing at 50%)	68.6% (with Hispanic students at 86.7% and Black and African-American students trailing at 61.0%)

^aData from National Center for Education Statistics (n.d.) and University of the Pacific (2019).

^bData from National Center for Education Statistics (n.d.) and Wingate University (n.d.).

^cCampuses with at least 10% Asian American and Native American Pacific Islander student populations, along with demonstrated campuswide students with financial need, receive the AANAPISI-serving status.

retention in the major is the high D/W/F rate of 53% for the Introductory Cell and Molecular Biology course, which is taken by all first-year biology majors. This introductory course is taught by multiple faculty each semester, often as an overload. The course has a common syllabus, textbook, homework, and lab. The differences between offerings of this course are the style of exams and instructional delivery.

Preliminary Concerns about Students' Capacity to Succeed in Introductory Biology. Based on Fall 2018 teaching, Schiller observed that students had a high dependence on undeveloped surface-level learning strategies coupled with a lack of faith in their abilities, often referring to themselves or their questions categorically as “stupid” or “dumb.” These deficiencies made them ill-prepared for navigating higher-level Bloom's assessments including application and synthesis questions. Metacognitively, students were also unable to predict their performance on exams, likely due to a mix of their inappropriate learning strategies, lack of community for contextual comparison, and perceived low self-efficacy. Therefore, Schiller felt an imperative to initiate interventions, enumerated in the next section.

Schiller Performance and Persistence Interventions (Pre-ERI). In Fall 2018, before engaging in our collaborative study, Schiller used university student success services, including an embedded peer educator, activation of early-alert mechanisms, and reporting of first work and midterm grades to student care teams. Additional interventions were undertaken, as outlined in the following sections.

High-Impact Teaching Practices. To help decrease the student failure, Schiller also implemented several evidence-based strate-

gies to support the students' development of appropriate higher-level learning strategies. These evidence-based strategies included a microflipped classroom, in which short minilectures were followed by a team-based application/evaluation inquiry assessment, typically with a series of three microlectures/assessments per 75-minute class period (Michaelsen *et al.*, 2014; Pedaste *et al.*, 2015; Borchardt and Bozer, 2017). The microflipped model also provided time for positive coaching from the instructor and peer educator to model and encourage critical thinking. The intentional identity and *team* dimension (paired with team-generated bylaws) of this strategy proved powerful in creating student-driven microcommunities within the classroom. Further, all in-class team assessments were handed in by the students, graded by Schiller with extensive detailed feedback, and handed back to the students in the next lecture period. However, only seven (out of 32) random team assessment scores counted toward student final grades. This random grading reduced the instructor's workload while still serving as an effective incentive for student assignment completion. Grades for assignments and exams were updated in the course on-line learning management system (LMS) and visible to students within 24 hours of the due date.

In addition to facilitating learning in the lecture (e.g., checking in with student teams as they were working on the assigned task), the peer educator held study sessions outside class. Students were also connected early and often to tutoring and other academic services. Schiller also held all office hours in the tutoring center to regularly expose students to student academic support and normalize help-seeking.

Study Strategies Instruction. Students who scored less than 70% on the first exam were provided the opportunity for dedicated

“resilience coaching.” Schiller sent them personal emailed invitations, intentionally crafted to convey support without judgment (Supplemental Material 1), to participate in one-on-one strategy meetings to discuss their personal experiences with the course material and to learn how to tailor their studying techniques to best fit their preferred learning methods and lifestyles. During these meetings, students were introduced to things like the SQ5R reading strategy, how to predict exam questions, and growth versus fixed mindset strategies (McGuire, 2015) and were also directly connected, in person, to campus resources, including supplemental instruction, tutoring, disability services, counseling services, Title IX staff, residential life services, and/or financial planning services, depending on the student’s needs.

Exam Wrappers for Metacognition. Exam wrappers, adapted from Ambrose *et al.* (2010), were used before and after exams as tools specifically to predict student grades as a proxy for self-efficacy. In other words, the assumption was that accurate grade prediction was linked to accurate perceptions of learning capabilities. This accuracy might also be connected to the kind of intellectual independence from teachers that lifelong learners need to develop (Hammond, 2014). Additionally, the students were asked to reflect on their exam performance (Supplemental Material 2). Excepting the first exam, students were asked for a written reflection about their previous exam’s wrapper 1 week before each new exam. Students received all personal reflections back before the final exam.

Schiller Methods. Seemingly in direct response to these interventions, the D/F/W rate dropped from 53% to 23%. Such results were encouraging but may also have had an unintended downside of inflating the instructor’s sense of personal responsibility for “saving” students. In addition to improved course performance, Schiller’s sub-hypothesis was that these interventions would also have a positive impact on student self-beliefs about their ability, their capacity to “name what they know,” and on motivation. To determine whether this desired impact was an actual result, Schiller analyzed two kinds of data.

Exam Prediction Statistics. Due to the fact that biology courses scaffold upon one another and get increasingly more difficult, students need to develop study strategies for determining what they do and do not know. In other words, student performances/grades alone in introductory courses, even if strong, are not necessarily sufficient to carry them forward to success in the major (Creech and Sweeder, 2012). As was previously discussed, Schiller coached grade prediction in the learning strategy meetings where exam wrappers were discussed. IBM (2017) SPSS statistical software was used to perform two-tailed paired *t* tests on exam 1 and final exam data sets using absolute values comparing the difference in the students’ predicted exam scores and their actual exam scores (see Figure 1, 2, and 3 legends). This was intended to serve both as a quantitative measure of metacognitive ability and an indirect measure of self-efficacy (i.e., accurate belief in capability), each of which might also be an indicator of a student’s level of independence from the instructor (Hammond, 2014).

Narrative Assessment Efficacy Surveys. After Schiller joined Camfield’s and Land’s project in 2019, precourse narrative

surveys were also administered to assess student baseline self-efficacy, to capture the student’s mindset, and to determine sense of belonging before beginning course activities (Supplemental Material 3). Similarly, mid- and postcourse surveys were administered to capture the progression of the change in the student’s self-efficacy, mindset, and sense of belonging. Surveys were scored using a pre and post self-efficacy rubric developed by Camfield (2016) and described in Camfield *et al.* (2020; Supplemental Material 4). Surveys were instructor scored, with blind scoring done by Camfield for instructor calibration and validity verification. A second round of thematic coding was also employed.

Schiller Results: Exam Prediction Numeric Scores

Fall 2018 (Baseline Control). Despite the improvements in D/F/W rates, before the 2019 implementation of the mediated-efficacy narrative assignments outlined previously, paired *t* tests revealed that students in the Fall of 2018, when asked to forecast a grade percentage, were unable to predict their final exam scores any better than they had predicted their first exam (Figure 1). The mean difference between student’s predicted and actual scores was 11.2 percentage points (SD = 10.2) on exam 1 and 10.5 percentage points (SD = 8.3) on the final exam; $t(19) = 0.26, p = 0.79$.

Fall 2019 (Post Intervention in Pedagogy). After implementation of intentional efforts to build mediated-efficacy through written reflections, in addition to an improved D/W/F rate, students in the Fall of 2019 were able to more accurately predict their final exam score compared with their first exam score (Figure 2). For the Fall 2019 cohort, the mean difference between student’s predicted and actual scores was 15.2 percentage points (SD = 14.5) on exam 1 and just 8.8 percentage points (SD = 7.3) on the final exam; $t(29) = 2.93, p = 0.006$.

Spring 2020 (Post-ERI). These students did not improve their ability to predict their final exam scores by the end of the semester (Figure 3). For the Spring 2020 cohort, the mean difference between student’s predicted and actual scores was 8.8 percentage points (SD = 6.2) for exam 1 and 8.3 percentage points (SD = 7.9) on the final exam; $t(18) = 0.22, p = 0.83$. This lack of improvement may have been caused by COVID-19 ERI reducing their belief in their ability, increasing anxiety, adding to cognitive burden, and decreasing feelings of social agency.

Schiller Results: Narrative Assessment Efficacy Surveys. In Fall 2019, all self-efficacy surveys (pre, mid, and post) were taken by students in person and in class. In Spring 2020, students took their first (precourse) survey face-to-face and in class and were also administered their first midsemester survey in class on March 11, 2020, 1 day before Wingate’s announcement of ERI and the evacuation of all students from campus by March 14, 2020. One week later, on March 18, 2020, students took a second midcourse survey. This was emailed to students and intended to capture any changes in student self-efficacy that may have occurred in the emergency environment. The postcourse survey was similarly administered via email. All 21 students completed all surveys. Students were incentivized with 1.5% on their second and final exam grades to complete the remote surveys.

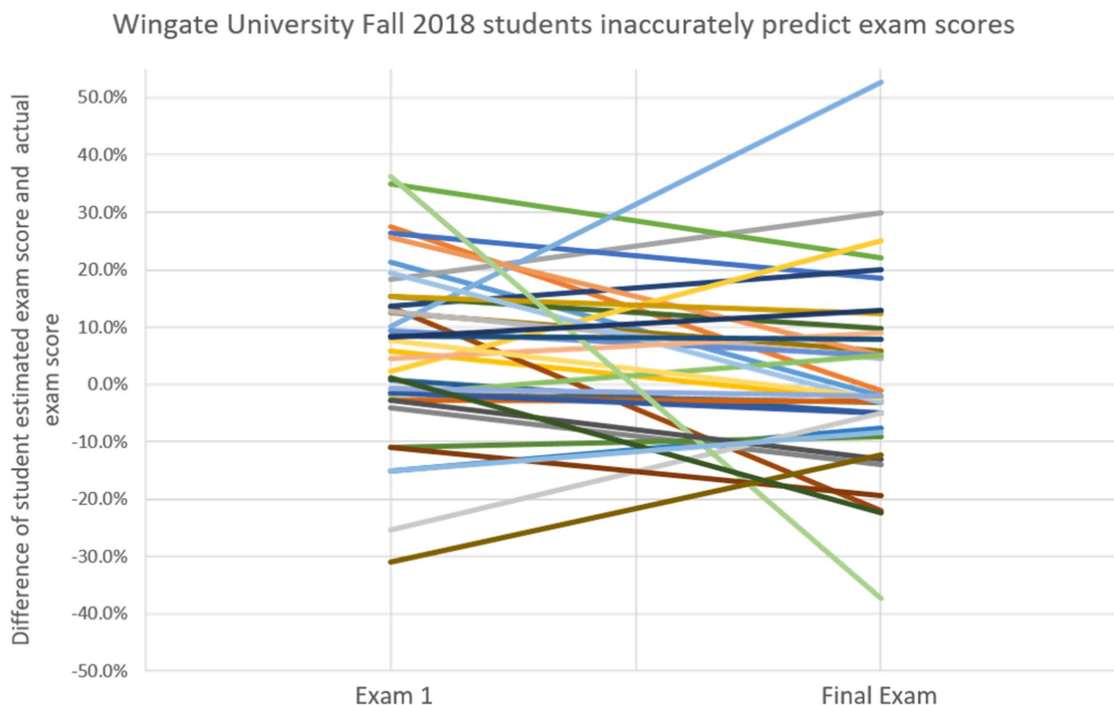


FIGURE 1. Schiller Fall 2018 students do not improve exam score predictions between exam 1 and final exam; $t(19) = 0.26, p = 0.79, d = 0.075$.

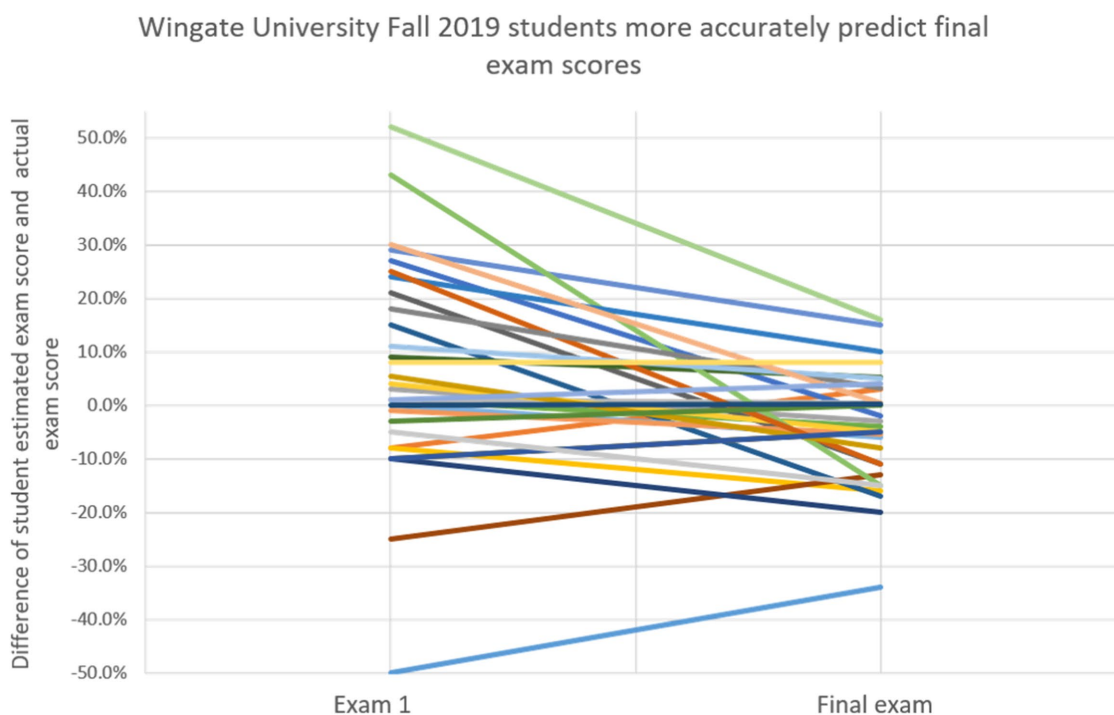


FIGURE 2. Schiller Fall 2019 students improve exam score prediction between exam 1 and final exam by an average of 6.4 percentage points; $t(29) = 2.93, p = 0.006, d = 1.05$.

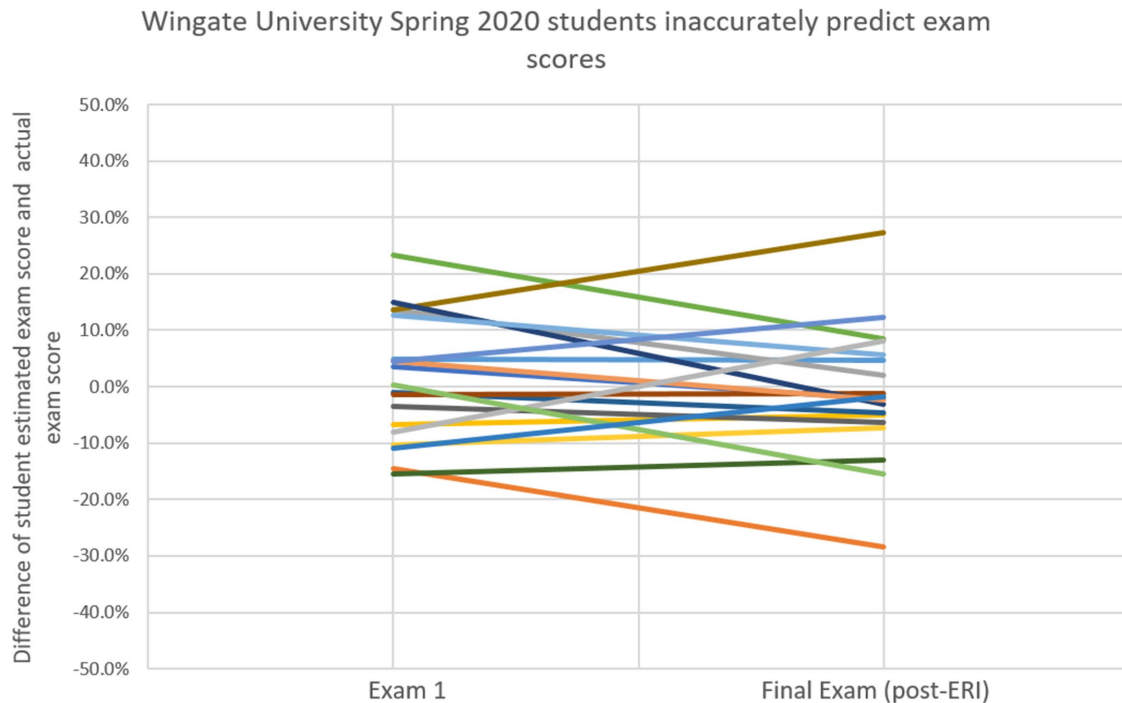


FIGURE 3. Schiller Spring 2020 students do not improve their ability to predict their exam scores; $t(18) = 0.22$, $p = 0.83$, $d = 0.07$.

Numeric Scores. Numeric scores were derived based on the aforementioned rubric, and comparative results can be seen in Figure 4.

When comparing the average narrative score change between the Fall 2019 and Spring 2020 cohorts, we see that, by the end of the course, the Spring cohort scores improved only slightly above starting levels. The Spring 2020 cohort exhibited lower midsemester (pre-ERI) scores compared with the Fall 2019 cohort (Figure 4); the authors suspect that this was due to the World Health Organization's announcement of SARS-CoV2 (COVID-19) being a global pandemic on the same date the survey was administered, indicating that the first midsemester (pre-ERI) survey may have captured the initial stages of decline in student emerging efficacy. Moreover, the postsemester increase was not nearly as large as that of their Fall 2019 counterparts, with average score increase from midcourse of 2.4 compared with 5.9 (Figure 4). While one might be concerned about the dramatic drop post-ERI, one might also take heart at the gains made by the end of semester. In doing so, one must acknowledge the efforts made by the instructor to intervene and mitigate the negative effect of ERI, as will be discussed further later.

Disaggregated Scores Compared. Perhaps a more powerful way of discussing the changes in scores emerges when we disaggregate student responses in each of the subcategories of the rubric and compare the pre and post scores. In doing so, we observed that, in 2019, along with an overall strong trend of improved efficacy, students made gains in their social agency and "belief in ability as a biology student" by the end of the semester (Figure 5A).

Whereas, when we do a similar analysis of subcategories for Spring 2020, we see that students maintained increases in evidence of their belief in their ability, mastery experiences, and positive modeling compared with their precourse survey; however, they also showed drops in positive affect and social agency, with many students reporting negative feelings in both (Figure 5B).

Disaggregating the data from the midsemester scored narratives revealed disruptions in social domains, primarily in areas of the students' belief in their ability, high positive affect and empowerment, areas that showed increases in evidence in the Fall 2019 cohort (Figure 6 compared with Figure 5). From these data, we infer that ERI appears to have primarily impacted the emotional and social aspects of student efficacy.

Schiller Performance and Persistence Interventions to ERI Disruptions (Post-ERI). Upon announcement of ERI in Spring 2020, the established use of narrative assessment efficacy surveys enabled us to make immediate alternative modifications to capture the lost instructional immediacy, lost sense of belonging, and lost sense of agency that were reported by students in their narratives after the transition to ERI. These are included to illustrate the value of narrative assessment, Schiller's responsiveness to student needs, and to provide context for the post-ERI results.

High-Impact Teaching Practices Modification For Optimizing Resilience

- In-class learning strategy inquiry assessments were shifted online. Study strategy coaching was offered; however, students reported less availability to attend the optional online sessions: only one student participated, via chat server, post-ERI transition.

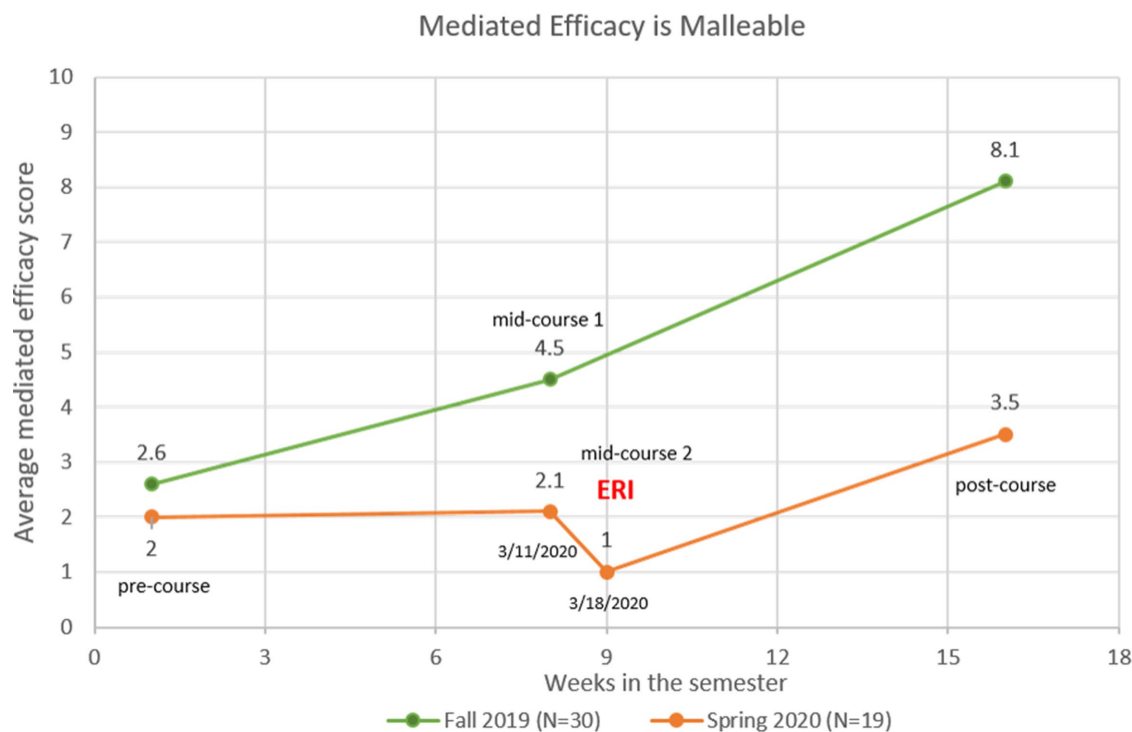


FIGURE 4. Comparison of average self-efficacy scores between Schiller Fall 2019 cohort and Spring 2020 cohort. Overall student self-efficacy scores in the Fall 2019 cohort improve at midsemester and continue with significant improvement through to the end of the semester. The two cohorts of students (Fall 2019 and Spring 2020) began the semester at about the same place. However, in Spring 2020, the results of the post-ERI midsemester survey revealed a drop in overall self-efficacy scores compared with their original pre-ERI midsemester 1 survey scores taken 1 week prior.

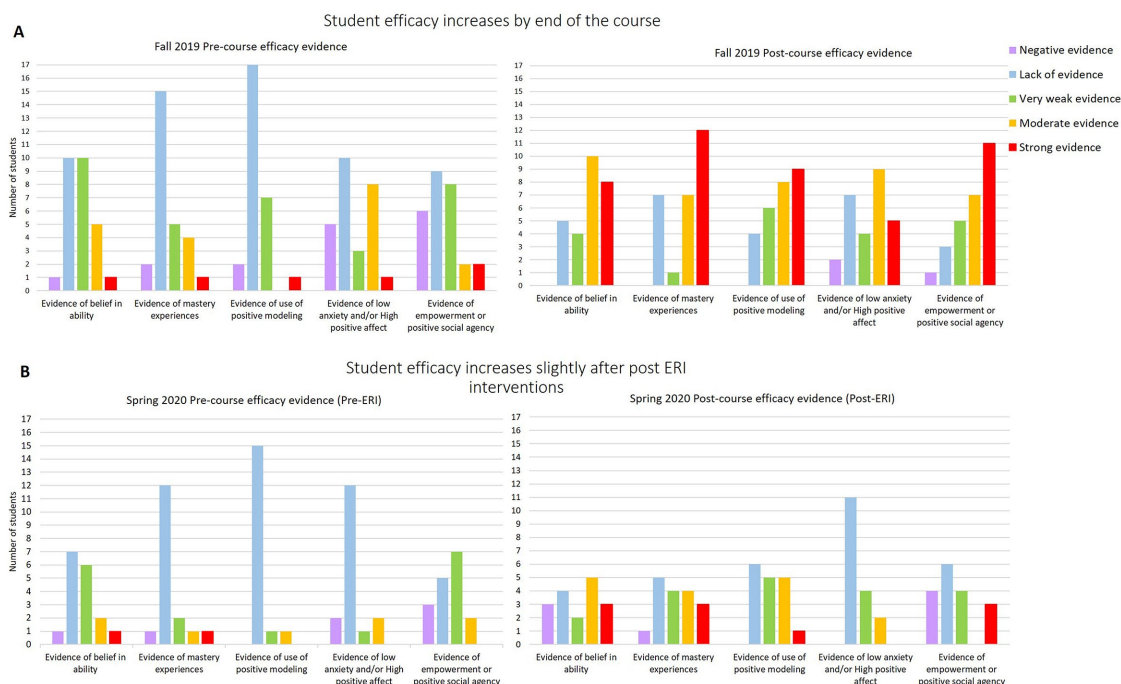


FIGURE 5. Student efficacy scores increase slightly post ERI. (A) Comparison of disaggregated Schiller Fall 2019 cohort student efficacy scores from pre- to postcourse reveals large increases in efficacy in all areas measured. (B) Comparison of disaggregated Schiller Spring 2020 cohort student efficacy scores from pre- to postcourse reveals only slight increases in efficacy and a loss of efficacy in the anxiety category.

Spring 2020 student mid-semester efficacy scores show decreases in evidence in social domains

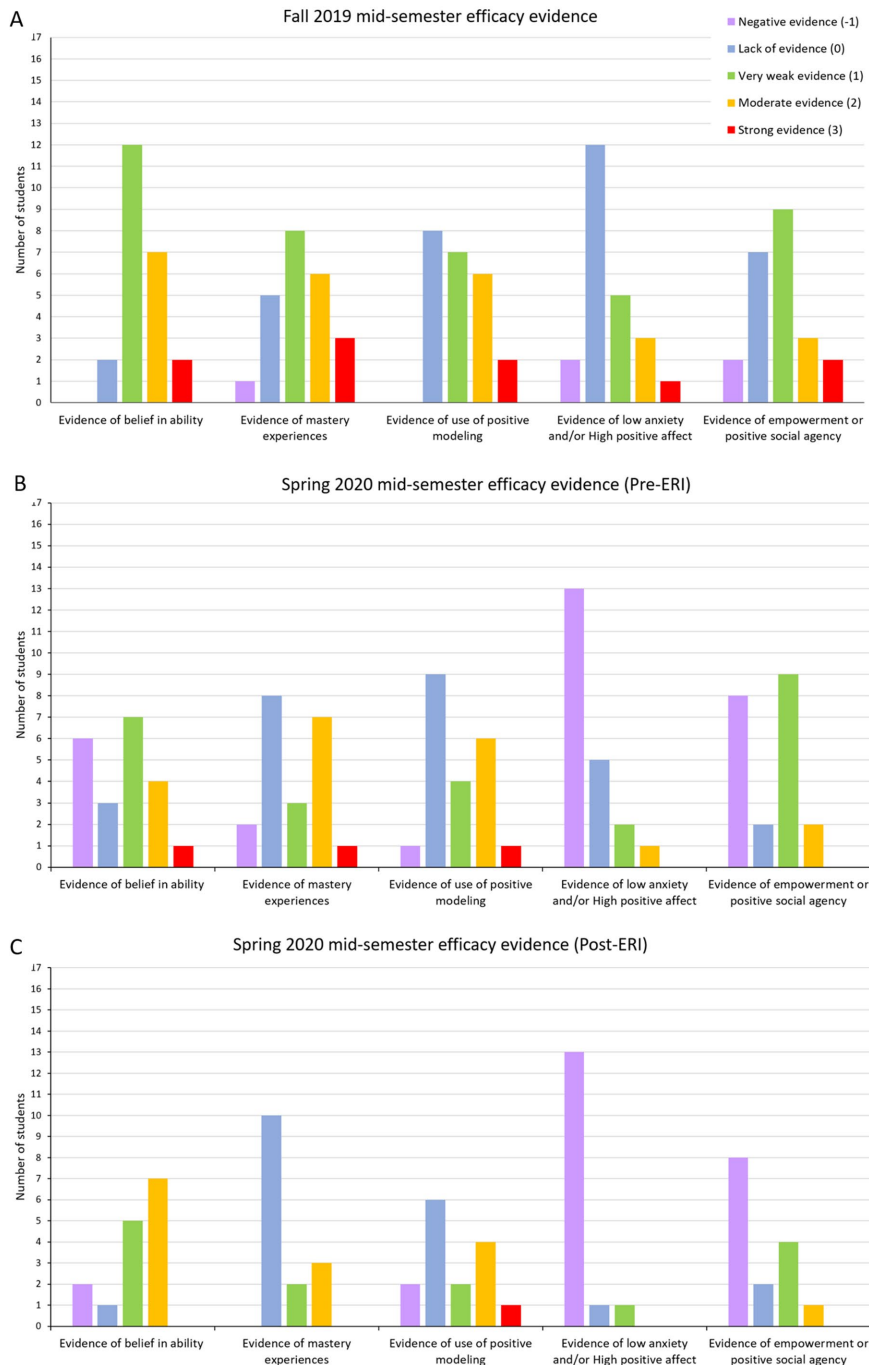


FIGURE 6. Schiller Spring 2020 student midsemester efficacy scores show decreases in evidence in social domains. (A) Comparison of disaggregated Fall 2019 cohort student midsemester efficacy scores reveals increases in efficacy evidence in all areas measured (compare with Figure 5A). (B) Disaggregation of Spring 2020 cohort midsemester (pre-ERI) student efficacy scores reveals increases in negative evidence in the categories of belief in ability, high positive affect, and positive social agency (compare with Figure 5B). (C) Disaggregation of Spring 2020 cohort midsemester (post-ERI) student efficacy scores reveals increases in evidence of the students' belief in ability along with continued negative evidence in the high positive affect and positive social agency categories (compare with Figure 5B, and B in this figure).

- Students were connected to support services via online access rather than in-person tours.

Unfortunately, due to the time constraints imposed by the abrupt switch to remote instruction, several resilience interventions were discontinued or modified: in-class written reflections for exams; second, third and final exam wrappers for metacognition were modified to be digitally included as nongraded questions on the online exams.

For Sustaining Engagement

- Given the increase in student anxiety scores, the students were given a written, highly detailed, and transparent transition plan (Supplemental Material 5).
- Students were also given weekly updates and reminders on due dates sent on both the course learning management system (LMS) page and in the class Discord server, a dedicated real-time communication server (www.discord.com).

For Creating Sense of Belonging

- The microflipped classroom design was maintained using asynchronous lectures and the Discord communication server, coupled with a LMS discussion board.
- Discord maintained a sense of community outside class and captured any asynchronous teachable moments.

Both the instructor and the peer educator had access to all team channels to provide assistance during task completion. In this way, students had instant, asynchronous, access to the instructor and their peer classmates via either a smart device application or Web browser.

Student teams were preserved and given extended deadlines to complete the team tasks that previously occurred in class.

Student teams actively communicated through their team Discord channel and posted their completed tasks each week to the LMS discussion board.

Dedicated interactions with the peer educator continued but were reduced to once a week through Zoom rather than three times a week face-to-face in a classroom. Attendance at these virtual sessions by commuter students increased from pre-ERI.

Thematic Coding. Thematic assessment of student narratives allowed us to identify any additional motifs that may not have been captured by the rubric scores. Comparing the language students used to describe their self-beliefs in the narrative assessment efficacy surveys allowed us to see the positive trajectory in Fall 2019, the hit their self-beliefs took in Spring 2020 after ERI, and their subsequent partial recovery. [Note: all collection of material from human subjects has been IRB approved.]

Fall 2019. The primary themes identified in the narratives were tied to anxiety, sense of agency, sense of belonging, and help-seeking behaviors. Over the course of the semester they show a positive trend. To exemplify themes expressed by many and to honor student voice and agency, we share verbatim quotes from student writing. Additionally, to avoid redundancy, midcourse survey quotes are not reported in all categories, unless specifically noted, as they show emerging themes that become more robust in the postcourse efficacy surveys

Anxiety

Precourse: “I feel that my biggest weakness is how much I stress out to ask questions or inform anyone that I need help and do not know what I am doing.”

As one would expect, multiple precourse narratives mentioned stress over content, workload, and exam style. The students often had a mixture of excitement mixed in with their anxiety. However, in some, the anxiety was the only theme in the narrative. By midsemester, the theme of anxiety was no longer present in the student narratives and did not emerge in the postcourse surveys. This theme was often replaced with a sense of belonging.

Sense of Agency

Precourse: “I don’t do very well with vocab sometimes in Bio because a lot of things sound similar or work together so I may get confused with a few vocab but overall I do pretty well with vocab. I also may need people to explain different processes in more than one way and or with pictures to help.”

Postcourse: “I think while taking this class my confidence in my scientific ability has increased. I am now willing to ask questions and I now even study more adequately. I’ve sharpened the way I study, used tips on how better to use those tools, and I think they’ve helped me a lot in terms of becoming a better biology student.”

An interesting theme that emerged at the start of the semester and became more salient as the semester progressed was around the students’ sense of agency. During the precourse surveys many students reported either a dependency on someone else to do the work for them or a lack of faith in their ability to manage their own time. By the midsemester survey, the students started to express an emerging sense of agency with emerging self-reliance and self-regulation. By the end of the semester, students were expressing strong feelings of agency.

Help-Seeking Behaviors

Precourse: “I don’t like being perceived as dumb, so sometimes I don’t seek help.”

Postcourse: “Good at finding and getting help. Able to find resources.”

An unexpected theme that was identified from the precourse surveys involved help-seeking behaviors. Multiple students expressed their reluctance to ask for help. Most indicated that they understood that it was important; however, their statements often undermined the importance with self-justification as to why they did not seek help. By midsemester, the narratives reveal emerging positive help-seeking behaviors with end-of-semester narratives often expressing pride in the ability to seek help.

Sense of Belonging

Midcourse: “My strengths would probably be teamwork and talking/strategizing things out to help me figure out the problem.”

Postcourse: “As a biology student, my strength is with my team. Working together and sharing our own personal knowledge has helped spark learning. SI [supplemental instructor] sessions with [the peer educator] have shown that before a test the best strategy for me is to close my notes and ask myself questions with the answer only based on my knowledge. This will tell me what I do and do not know.”

Sense of belonging was not a theme that emerged at the start of the course but became an increasingly significant theme by the middle and end of the course. Students tended to find value in their community and expressed their appreciation for the role of the peers in their success.

Spring 2020 (ERI). Thematic assessment of student narratives both pre- and midcourse 1 in the Spring 2020 semester, pre-ERI, revealed themes that echoed those from the beginning of the Fall 2019 semester. Midsemester surveys (midcourse 2), post-ERI, captured immediate losses of any gained mediated-efficacy with loss of emerging positive themes. By the end of the semester, student themes resembled those themes identified at the start of the course. Overall, they did not exhibit the same growth trajectory as in 2019. These written narratives provided a valuable window into student experiences and show that the nature of their concerns post-ERI were distinct from those at the start of the course, when, for example, anxiety might have been about grades and course content, whereas at midpoint 2, their anxiety was about self-regulation without their instructor setting tasks, familial distractions, and responsibilities at home. These narrative windows allowed instructors to adjust support accordingly. To honor student voice and agency, quotes are verbatim.

Anxiety

Precourse: “My weakness as a biology student would be that when I feel stressed or overwhelmed I can shut down and let things go such as my grades.”

Midcourse 1 (pre-ERI): “Weakness: Still overthinks answers to questions I know, confusing terms. Still stress and overwories for exam grades.”

Midcourse 2 (post-ERI): “Weakness—I may face distractions due to me being at home, may not understand some topics due to me doing them on my own.”

Postcourse (post-ERI): “Weaknesses I personally struggle with technology so I was very nervous for classes to go online in general as I thought that would be a major downfall for me, also just being home not just for me but many kids is hard as some family’s don’t understand how much time we need to devote to our school work. This for me has probably been the hardest thing.”

Predictably the theme of anxiety was highly present in the precourse surveys and was rarely present in the midcourse 1 (pre-ERI) surveys. Yet, unlike the narratives in the Fall 2019 cohort, the prevalence of narratives reflecting anxiety increased dramatically just 1 week after the midcourse 2 survey, 1 week after ERI. The prevalence of anxiety in the narratives was still strongly present by the end of the semester. However, as previously noted, the sources of anxiety changed pre-ERI to post-ERI.

Sense of Agency

Precourse: “This class is hard for me to fully understand and I learn things slow but I truly want to do better.”

Midcourse 1 (pre-ERI): “Strengths: I am more prepared and focused on studying. The notes have really helped explain and understand new concepts and information. Studying/improved note taking. Applying information to figure out other questions.”

Midcourse 2 (post-ERI): “Weaknesses: online is definitely not my strongest talent. Time management with everything work wise. Making sure I can get the time devoted to what I need to study to be able to meet deadlines and knowing the information that is needed. Stressful but I definitely want to finish this course as strong as I possibly can! Even with all the craziness that is going on school is very important to me!”

Postcourse (post-ERI): “My strengths as a biology student are being able to make connections between different topics, knowing how to reinforce information that I learned and learning how to study effectively in a primary self-taught environment.”

Narratives related to the students’ sense of agency appeared to be the most sensitive to loss. At the start of the semester, narratives contained considerably less confidence in self-reliance and self-regulation, with marked improvements by midcourse 1 (pre-ERI). However, any progress that was gained in agency was lost within 1 week, with an overwhelming majority of narratives reverting back to a sense of lost reliance and lost self-regulation by midcourse 2. Some of this loss was reversed by the end of the semester, but not at the levels of the Fall 2019 cohort.

Help-Seeking Behaviors

Precourse: “Another of my weakness are that when I am struggling I usually do not seek for extra help and I just try to pull through on my own.”

Midcourse 1 (pre-ERI): “Strengths: Reviewing notes and powerpoints after class, studying key vocabulary until I properly understand it, creating a quizlet to review key terms, Asking more questions when I don’t understand a topic, attending office hours.”

Midcourse 2 (post-ERI): “Weakness: Lacking the confidence to speak up, and ask questions.”

Postcourse (post-ERI): “My strength has grown throughout this course. I can take good notes and take advantage of sources such as the library, SI, tutoring. I am also able to piece things more together and connect them to get a better picture; especially, with the learning outcomes that helped me know what to focus on and guided me when it came to the material and lessons. During this new learning format, I find that I can attend these SI much easier since I don’t have to worry about driving back on campus or suddenly having an emergency which results in me missing these sessions. I have also been able to better track and keep up a proper schedule. My only weakness still, but not as much as before, is over guessing my answers or overthinking current questions. However, I am slowly losing that ‘habit’ thanks to this course and you.”

Similar to sense of agency, help-seeking behaviors had a bifurcated pattern in the narratives. Narratives at the start of the semester exhibited negative help-seeking behaviors and improved by midsemester, only to revert back to negative help-seeking behaviors 2 weeks after completion of midcourse efficacy survey 1 (pre-ERI), 1 week after ERI transition. Fascinatingly, by the end of the semester the acknowledgment of positive help-seeking behaviors became a dominant theme. These statements often included positive comments on the community.

Sense of Belonging

Precourse: “I don’t seem to learn a lot when teacher interaction is limited.”

Midcourse 1 (pre-ERI): “Strengths: Group assessments, Group work. SI sessions [with peer educator] help give extra practice”

Midcourse 2 (post-ERI): “For the remainder of the class I’m open to began classes in the online world but I feel better being in class having the help when needed on standby for my classmates and professors.”

Postcourse (post-ERI): “Having to do online classes taught me that I struggle in answering short answer questions. In class we could bounce ideas off other group members which made it easier but on my own it’s hard for me to put my thoughts down in complete sentences.”

Sense of belonging trended similarly to the Fall 2019 cohort, with overwhelming value placed on members of the community by midsemester. However, after the emergency transition to online instruction, the student narratives reflected their fear of loss of this valuable component, a loss that was still pronounced at the end of the course.

Interpretations. Students in the ERI cohort lost any gains in positive affect and social agency that they had at midsemester

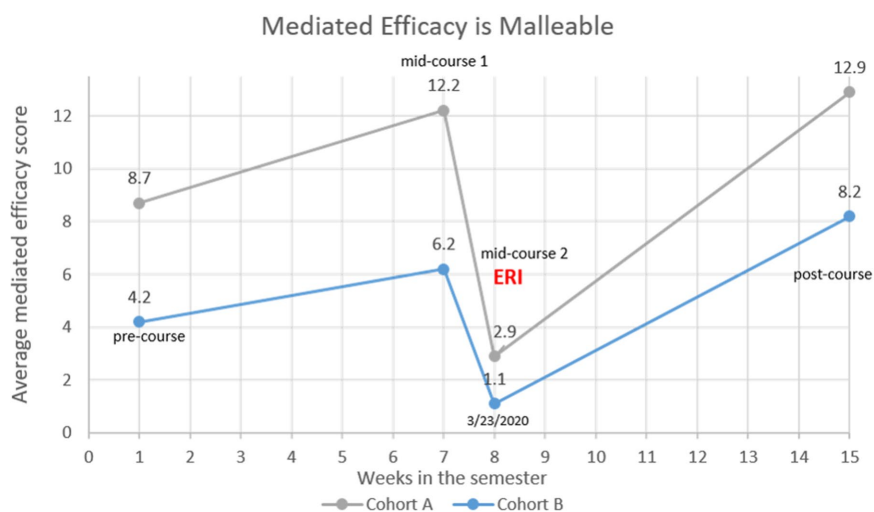


FIGURE 7. The two cohorts of Land Spring 2020 students represented in this figure have very different profiles. The cohort of 24 students with complete student sets of surveys (cohort A) earned final course grades of “A”, “B”, or “C”. This included four “advantaged” students who were enrolled in Pacific’s accelerated pre-health majors. Cohort B represents the entire class ($N = 77$).

within 1 week of the emergency transition (Figure 6 compared with Figure 5). This rapid loss indicates a fragility of these newly learned cognitive behaviors in first-year college students. Additionally, the increased negative emotion and decreased sense of agency may explain the loss of the ability to successfully predict exam scores (independent from exam performance); however, there is insufficient evidence to make this correlation claim definitively at this time.

Case Study 2: University of the Pacific, Dr. Kirkwood Land

Land Context. At University of the Pacific, pre-health majors such as dentistry and pharmacy dominate the enrollment in introductory biology. These students tend to be extremely well prepared and high achieving, whereas students who are biology majors with no declared professional track traditionally have had lower entering test scores and lower high school grade point averages, as well as unmet fundamental skills requirements. Co-mingling these disparate student cohorts tended to disadvantage biology majors, because grades were adjusted/curved based on class norms. Therefore, attempts to decouple the student populations were undertaken, and pedagogical practices were adjusted to support those students who needed modeling and incentives to seek help. In Spring 2020, biology majors, as well as biochemistry and health exercise/sports sciences majors, were grouped in Land’s Principles of Biology (ecology, evolution, and biodiversity) course, with only four pre-dental and pre-pharmacy students. In other words, the Spring 2020 cohort was predicted to need additional support to succeed and persevere.

Land Performance and Persistence Interventions (Pre-ERI). Building upon previous work (Camfield *et al.*, 2020), Land focused on cognitive and noncognitive domains of learning and supported students through multiple pedagogies. For example, on exams, he offered multiple-choice questions,

written short answers, and out-of-class essay writing to give students multiple opportunities to demonstrate their learning. He also created a community of individuals eager to support students: the professor, a collegiate learning instructor, the manager of general tutoring services, supplemental instruction leaders, and student writing center mentors. Maintaining strong relationships was the hallmark of Land’s course. The instructor emphasized the value of SI sessions by attending the first few minutes of the first few SI meetings to increase student accountability and to model the desired help-seeking behavior. The rationale was that strong relationships within the community provided modeling, optimized mastery experiences, and increased resistance against external forces that may diminish learning (e.g., financial concerns, interpersonal relationship stress). An additional desired benefit of the instructor-diffused responsibility among this network was that students might recognize that these networks persist long after a course is over (i.e., they can still go to the tutoring center, etc.).

Land Methods. As with the Wingate case study, the Pacific students also completed narrative assessment efficacy surveys. Similar scoring techniques were employed to generate numeric and thematic data. The results of the numeric scoring are presented in two cohorts: 1) a disaggregated set of those students who completed the semester *and* all four ME surveys and 2) an aggregated set of all data received, including those of students who withdrew.

Results of Land Interventions on Student-Mediated Efficacy.

Numeric Self-Efficacy Scores from Narrative Surveys. In Spring 2020, there were 77 students originally enrolled, and 71 completed the course. However, there were only 24 complete sets of surveys (pre, mid1, mid2, and post).

Figure 7 depicts students in cohort A and cohort B (note: cohort A is a subset of cohort B). Students in cohort A completed all four sets of narrative surveys and earned course grades of “A”, “B”, or “C”. Cohort B includes students in the D/F/W grade range, and as they also did not complete the entire set of four surveys, their efficacy trends could not be completely analyzed. However, most of the students earning D/F/W completed at least the first two data surveys, and their surveys showed a decreasing efficacy trend. Over the course of the semester, four students completely stopped engaging in both lecture and lab despite multiple attempts to reach them (and subsequently earned the grade of “F”); they never formally dropped the course or requested P/NC grading or to withdraw.

So, why only 24 students with fully completed sets? Perhaps many others stopped participating because Land did not incentivize completion, as Schiller did. However, it might also be significant that all 24 with of the fully completed surveys (cohort A) came from students who had followed Land from the

previous Fall semester course, which was part 1 of the two-part introductory survey course. In other words, none who followed from Fall failed to complete all four parts. Therefore, we speculate these had started to build mediated-efficacy and a personal sense of commitment to Land (i.e., they trusted him to use their data to improve their course experience).

It is also worth noting that these 24 started the semester with an average efficacy score of 8.7, as opposed to the class average of all students at 4.2. If you remove these 24 students from the overall class count, the remaining 53 students had a baseline efficacy of 2.16. This is comparable to our previous findings (Camfield *et al.*, 2020) and the Wingate baseline (Figure 4), suggesting that many first-year biology students begin the semester with low efficacy.

Disaggregated Scores. As with the Wingate case study, perhaps a more meaningful way of discussing the changes in scores emerged when we disaggregated student responses in each of the subcategories of the rubric. In doing so, we observed that, in 2019, along with an overall strong trend of improved efficacy, students made gains in agency, help-seeking behaviors, and sense of belonging. Whereas, when we did a similar analysis of subcategories for Spring 2020, we observed student losses in help-seeking behaviors and sense of belonging (unpublished data).

Thematic Coding of Narrative Surveys. As with the Schiller cohorts, Land gathered open-ended written narratives from students at four distinct points in the semester (precourse, midcourse 1 [March 4, 2020], midcourse 2 [March 23, 2020] after change to ERI, and postcourse). For our thematic analysis, we only examined the 20 students with a fully completed set of narrative surveys (pre, mid1, mid2, and post) who were not in pre-health programs and were working on bachelor's degrees in biology, biochemistry, bioengineering, and sports science.

The open-ended narrative style of the self-efficacy surveys was an effective means for Land to observe how the students were feeling about their standing in the course: academically, socially and personally. He was able to note that the alarming drop in self-efficacy after the shift to ERI appeared to be caused by 1) the loss of their sense of community and worry that without peer/SI support and accountability pressure they would flounder and 2) anxiety that a remote environment would hinder their learning. This latter was something of a surprise to Land, as he had always thought “digital native” students would be comfortable with educational technology, but that was not the case. Thus, narratives allowed students space to voice issues that can challenge instructor assumptions. (Of course, there is the possibility that a student might not be completely truthful or upfront in such writing, as can occur with any survey, but reading narratives from the entire course allowed trends to emerge that offset any skew that one person's feedback might cause.) Overall, the themes that emerged from Land's students aligned with the dominant themes that emerged at Wingate, and Land's student comments mirrored many shared in the Schiller section. So, in the interests of brevity and concision, we will not repeat these discussion points here. However, we will share some thoughts on the value of collecting student narratives for assessment.

Reading in Real Time: Responsiveness to Emerging Needs. Significantly, unlike in previous semesters, in Spring 2020, Land serendipitously decided to read the narratives in real time (as opposed to at the end of the semester). The instructor scored these surveys within a few days after administering them to students. This quick read allowed him to report back to the class the themes he observed and how he planned to address them. Thus, he could respond in “real time” and communicate a sense of caring to his students.

Land Performance and Persistence Interventions to ERI Disruptions (Post-ERI). Noting the alarming change in their narratives post-ERI compelled the instructor to intervene with some changes. After ERI, the syllabus schedule, expectations, and assessment were changed as noted in the following sections.

For Optimizing Resilience.

- The instructor continued the pre-existing resilience-coaching “morning pep talks” as daily written posts in the LMS (Canvas).

For Sustaining Engagement.

- A written transparent transition and communication plan for the rest of the semester was sent to all students before classes resumed.
- To decrease anxiety, the instructor increased the number of lower-stakes activities for credit (e.g., lecture wrappers), instead of solely relying on high-stakes exams for evaluation of student learning.

For Creating Sense of Belonging and Community.

- Points were allocated for class participation.
- Synchronous SI sessions were maintained. Points were also allocated for attending SI. Because of this, students remained active at attending SI well beyond the transition to remote learning.

To increase students' sense of agency and mattering, Land included student-written questions on exams. This was perhaps the most important and impactful change post-ERI (and was not something Land had anticipated incorporating). As part of instruction on metacognition, the class had been learning about Bloom's taxonomy and self-quizzing as a study skill all semester. To be transparent in his teaching (see Winkelmes *et al.*, 2019), Land had also been describing his use of Bloom in writing exam questions. Post ERI, on their online discussion boards, students collaborated to develop exam questions, justifying the type and category of question based on Bloom's scale. Together, students peer reviewed one another's questions and answers and subsequently refined them. Land then chose from their question bank for the exams (reserving the right, of course, to not use any of them, or to modify ones they wrote). This elevated student involvement and engagement, as evidenced in narrative commentary collected at the end of the semester and as reflected in the improved final efficacy scores.

The combination of Land's improved awareness of his students' challenges and his real-time changes in the course as it progressed seem directly linked to his student's recovery of

mediated-efficacy. Maintaining engagement and belonging was critical for helping students to finish the course, and this was reflected in the final narratives, in which students celebrated their own resilience and persistence. However, as noted previously, Land's interventions appeared to have differential impacts on various student cohorts. Those with the most developed efficacy before ERI appeared best able to benefit from these interventions and rally (see Figure 7).

DISCUSSION

There has been much discussion about first-year students as dependent learners and the instructor's task being to support students in becoming independent learners (Hammond, 2014). Similarly, we posited that first-year students' self-efficacy is also initially more dependent on instructors than the term *self-efficacy* implies. This was confirmed in the narratives, in which students described that those elements of efficacy most directly under instructor influence (i.e., mastery experiences and modeling) remained more stable post-COVID-19 ERI than their more internal/subjective states of being (i.e., emotions and sense of agency). As such, this shines a light on at least three particular mechanisms that contribute to mediated-efficacy and points toward aspects of instructor best practices.

Figure 8 demonstrates the flow between the instructor inputs (discussed in the literature review, depicted in Table 1, and described in the case studies) of mindset coaching, active-learning techniques, and positive relationship building to foster student resilience, engagement, and sense of belonging. As these three dispositions incubated within relationships with their instructors, students reported in their narratives increased confidence in their capacity to succeed in biology class. Conversely, the students' loss of their instructors' inputs at ERI appeared to undercut their emerging efficacy (see Figures 5 and 6 for Schiller and Figure 7 for Land). Therefore, we depict mediated-efficacy as

a dotted-line circle on Figure 8, because it can expand or shrink according to student access to instructor inputs. Put another way, our work suggests mediated-efficacy is an important but malleable step before students develop fuller agency and more stable independence as learners. As Gannon (2020) tells us:

Our advocacy of a better future, as well as our mission of empowering our students to help create it, depends on praxis. Hope is aspirational, but also depends on agency. For our students to see themselves as active, empowered learners—as people who can and should participate in the processes of knowledge creation and scholarly discourse—they need to work within learning spaces that cultivate that understanding. The work we should be about, then, is to create these spaces throughout whichever part of the higher educational landscape we find ourselves in. (p. 151)

In a similar vein, our analysis suggests that activating student engagement, sense of belonging, and resilience coaching foster the kind of efficacy that may be critical for persistence in times of crisis. However, this kind of efficacy is not the agency of radical individualism but is more akin to the agency of community cultural wealth (Yosso, 2006). Such a reconceptualization of “community-based agency” as a key component of academic identity points toward mediated-efficacy being something of a heretofore missing link in educational theory. Mediated-efficacy connects Bandura's *sociocognitive* framework—which emphasizes intellectual interpretations as the primary mechanism by which individuals construct reality—and Vygotsky's model of *sociocultural* learning—which rests on the belief that “all the higher functions originate as actual relationships between individuals” (1978, p. 57). By emphasizing the importance of emotion and relationships as key forces in student learning, mediated-efficacy also aligns with Rendón's (2009) call for *sentipensante* pedagogy.

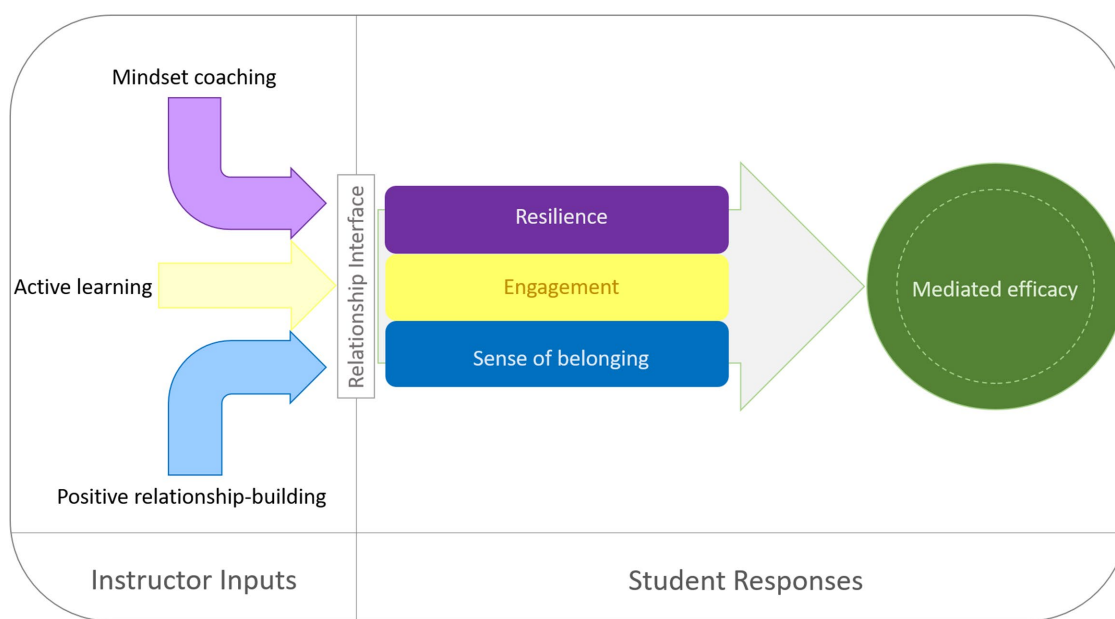


FIGURE 8. Mediated-efficacy flowchart. Visual depiction of how instructor inputs fostered student resilience, engagement, and sense of belonging, all of which contribute to mediated self-efficacy. The dotted-line circle indicates that mediated self-efficacy can expand or shrink according to student access to instructor inputs, as we observed in the case of ERI.

While these concepts are not totally alien to humanities and social sciences teaching, STEM instruction has tended toward pure cognitivism in its reliance on traditional instruction practices, like lecture. Our study shows not just how the pedagogy of radical individualism can fail first-year STEM students, but how important noncognitive dispositions are, by demonstrating the ways those elements were disrupted in the Spring of 2020 during the shift to ERI due to the COVID-19 pandemic and what that cost students. For example, our analysis of student narratives revealed that ERI damaged students' emerging efficacy by increasing their anxiety, which appeared to undercut their capacity for engagement, sense of belonging, and resilience. In short, while "productive discomfort" may be an important part of the learning process (Hammond, 2014), overwhelming anxiety appears to undermine agency. This finding also aligns with other studies that suggests negative emotions (e.g., fear and anger) decrease agency (Christensen *et al.*, 2019).

How ERI Disrupted Mediated-Efficacy Development

Our first research question queried the specific impact, relative to efficacy development, of the COVID-19 ERI disruption to our pedagogical interventions aimed at optimizing student success, as modeled in Figure 8, further elaborated here. At Wingate and the University of the Pacific, student narrative writing revealed that mediated-efficacy development was disrupted by the lack of access to instructor-modeled and instructor-fostered inputs of resilience, engagement, and sense of belonging. As triggered by logistics, reflected in their written narratives, and observed through other course metrics (e.g., peer educator/SI attendance), after ERI, students expressed a kind of grief-like loss—whereas in previous years the focus was on gains. These losses center around three key areas and were expressed by students as dismay over three types of disruption.

ERI Disruptions of Resilience

- Lost strength: Students felt vulnerable and wanted to be "taken care of" (but perhaps *not* by their parents).
- Lost confidence: Students exhibited layers of self-doubt regarding technology and globalized thinking akin to "learned helplessness."
- Lost self-regulation: Students expressed fears about time management, which exacerbated the pattern of dependent learning and further fueled anxiety. (Note: their perception was not necessarily reality; most students kept up on their work in a timely manner.)
- Lost metacognitive elements: Students no longer had the tools to reframe failure.

ERI Disruptions of Engagement

- Decreased help-seeking behaviors. While these behaviors had been emerging, after ERI, they diminished and seemed correlated to lost sense of belonging. Students were still help-seeking, but they were not talking about it, reinforcing the behavior, and understanding the impact of what that help did for them. Students who most needed help (e.g., those receiving low scores on exams) were least likely to seek it.

- Lost access to the instructor: Students no longer had the direct modeling and opportunities to ask questions provided through face-to-face interactions.
- Loss of opportunity to learn in preferred modality: Many felt they could not learn well through online instruction.

ERI Disruptions of Sense of Belonging

- Lost campus community: Students commented in particular about loss of access to their peer teams and/or SI.
- Lost autonomy: Many students had to move back in with their parents, and this felt like a regression, often exacerbated by lack of familial support/understanding.

SIGNIFICANCE: WHY DOES UNDERSTANDING EFFICACY MATTER?

Our second research question addressed the effects of the ERI disruption in terms of more generalized student support needs. This study underscores the overall malleability of mediated/self-efficacy. Students in both cohorts in the two case studies saw a drop in mediated-efficacy within 1 week of a global crisis (see Figure 4 for Schiller and Figure 7 for Land). This malleability suggests mediated-efficacy is a coconstructed and community-driven phenomenon. Being prematurely separated from the instructors they depend on can unravel students' developing agency (Hammond, 2014). If in 1 week in one semester we saw a backslide, imagine what happens to our students after they leave our classrooms? Notably, the lost efficacy was regained by the end of the semester, largely due to the immediate empathetic reactions of the instructors to the student narratives. Further, Land's 24-student cohort that followed him from the previous semester started with higher mediated-efficacy scores and exhibited persistence in survey completion and higher end-of-semester mediated-efficacy scores. This points to a need for instructors and student support services to pay attention to areas where student self-efficacy can be fostered and mediated by the community—because for students with fragile efficacy, *every semester is a pandemic*.

While the COVID-19 event was unique, ERI highlighted the elements of crisis that impact some students in *every semester*: students regularly experience loss, disruptions, and setbacks. These elements of crisis are even more accentuated in first-generation and low-income students. Further, the cognitive load of a first-year, first-generation, low-income student consists of navigating campus without a mentor, an average of five courses, new financial demands, culture shifts, identity shifts, and social dynamics. This load reduces the available cognitive and emotional bandwidth available to students to survive and persist in the face of a crisis (Verschelden, 2017). By mediating the development of student efficacy through modeling effective mechanisms of engagement, sense of belonging, and resilience coaching, instructors can help expand the available bandwidth for the students, allowing them to find value in their community and persist at the university.

Recommendations

Student narratives allowed instructors to learn directly from the students what they needed (as opposed to having to invent a strategy out of thin air) and then reflect on how to build courses

around student needs. This active empathetic response to students built trust. Additionally, empathy for students' experiences motivated instructors to help, with clear direction on how to provide that help supplied by the narratives. This type of responsive empathy can lead to iterative and culturally responsive change to build mediated-efficacy. Therefore, by creating systems of empathetic responsiveness, universities can move beyond the culture of emergency "911" responses to students who are failing one or more classes to provide pre-emptive care. This form of empathetic responsiveness is fostered through collection of information (i.e., open-ended narratives) about student experiences and reflection on those experiences. To help foster such reflection, we offer recommendations for institutions and departments, instructors, and students.

For Institutions and Departments

- Acknowledge the mediation of student efficacy is the responsibility of the entire campus community.
 - Land was able to mediate large gains in student efficacy (Figure 7) due to the active involvement of multiple institutional partners, whereas Schiller was able to show smaller gains (Figure 4 compared with Figure 7) in student efficacy by personally directing the involvement of institution partners. It is hypothesized that with more active university partnership with instructors, larger gains in student efficacy could be accomplished.
- Use efficacy assessment data to inform institutional and pedagogical practice.
- Build a coherent and articulated departmental plan to foster student mediated-efficacy (to lessen the sense of personal responsibility to "save" students carried by individual instructors).
- Encourage and incentivize instructors to communicate ways they have worked to foster mediated-efficacy so that instructors in subsequent courses can build from that foundation.
- Have disciplinary discussion about the "pre-existing conditions" students bring to class and develop a comprehensive plan for reducing bandwidth overload. Interrogate assumptions about academic rigor and student "fitness."
- Recognize the compounded academic experiences students have when taking multiple gateway courses.
- Understand the way structural racism shifts blame to individuals instead of addressing how systems work to undermine success by reinforcing silos and destabilizing community.
- Create networks of support services, especially in gateway courses.
- Use academic support services staff to help students develop "scripts" for how ask for help or access other resources.

For Instructors

- Partner with campus-wide student success community members: coaches; tutoring, counseling, and health services; financial planning; academic advisors; and other faculty. Invite these campus partners to join you in class or review sessions.
 - One key issue that emerged from this study is the danger of instructor burnout. At Pacific, Land activated a networked community of student support, which required

less of a heavy lift for the instructor, and obtained similar student results to Schiller with less instructor burnout.

- Use open-ended narrative writing as an assessment tool to understand the lived experiences of students in your classes.
- Collect data at multiple points during the semester to note student progress.
- Build in rewards that value students "asking for help" (e.g., points on exam or course grade); nudges have an impact.
- Allow space for students to talk about all issues going on in their lives and coach SI/peer educators to do the same.
- Do not assume that "digital native" students will be adept at use of learning technologies.
- Build in "teams" in face-to-face and/or virtual environments to aid in the modeling of resilience and encouraging a sense of belonging.

For Students

- Access resources to help you identify those who are in the best position to help you.
- Build a support network with those people.
- Share your story with others so they can understand your plight and path.
- Practice empathy and self-compassion; be supportive of others and yourself.

Limitations of Our Study

As with any research, our study has certain limitations that must be acknowledged. First, our sample sizes were relatively small (at Pacific: cohort A, $N = 24$; cohort B, $N = 77, 58, 62, 32$; at Wingate: Fall 2018, $N = 37$; Fall 2019, $N = 30$; Spring 2020, $N = 19$). However, multiple narrative surveys were collected from those cohorts of students, suggesting that our findings may be robust, if not entirely generalizable to other campuses. Additionally, the statistical analysis of Schiller's students' exam prediction capabilities is somewhat inconclusive, as we only tested information gathered from three very different semesters: without assigned writing (Fall 2018), with assigned writing (Fall 2019), and with assigned writing during ERI (Spring 2020). Readers may also have noticed that the Spring 2020 cohort started out with more accurate exam predictions, on average, compared with both Fall cohorts, but they did not improve as much in their ability to predict. It remains to be seen whether this lack of improvement was caused by ERI damage to emerging efficacy, or whether the average accuracy of most entry-level biology students caps around the 8% mark. More research into this form of metacognition is needed.

Further, there are other puzzles that have yet to be fully resolved. One that may initially confuse the reader is why in Spring 2020 Wingate had better persistence (with all students completing the course) compared with Pacific (with four students not completing the course). We speculate that the differences in relative class sizes may have confounded the results. In other words, the smaller classes at Wingate may have contributed to increased completion rates, as described in Scott *et al.* (2016). However, while at Pacific a 5% attrition rate over the course of the semester is fairly typical in that course, 70% of the class did not complete all of the four narrative assessment surveys. This might be just a question of lost engagement.

However, as previously discussed, the 24 students who carried over with Land from Fall semester all completed the surveys, all did well in the course, and all demonstrated strong recovery of mediated-efficacy. This suggests that students who struggle may also be less likely to participate in and persist with performance interventions unless incentivized. (Note: Schiller offered 5 extra points on the final exam, 1.5% of the grade, for survey completion; Land did not.) Whether this translates to long-term persistence in the major or at the university remains to be seen.

Another query might be about the relatively lower midpoint 1 scores at Wingate. This may be attributable to the fact that students at Wingate wrote their midpoint 1 efficacy narratives a week after students at Pacific wrote theirs. Even though ERI had not yet commenced, the threat of COVID-19 may have been more widely understood by Wingate students, so their lower scores are likely the beginning of the “COVID dip.” Finally, even though students in Spring 2020 seemed to be falling apart emotionally, most completed the courses and did fine on the final exam. This may seem to contradict our claim that lowered self-efficacy might negatively impact performance and persistence. However, readers must not dismiss Schiller’s and Land’s recovery interventions once they read the student narratives and understood student post-ERI needs. Moreover, there seems to be a more widespread phenomenon (anecdotal at this point) of students academically performing well overall during remote instruction semesters. What remains to be seen is the social and emotional toll the isolation and stress of the pandemic will leave behind and how that may impact future enrollment.

Another limitation of the study was the ERI lockout of faculty offices and access to data. Land was unable to access specific Pacific data from previous years due to campus access issues. This created a missed opportunity in this current study, as we do not have those specific numbers and narratives to use for longitudinal comparisons. We call attention to this not just as a limitation of our study but as a caution to other researchers to be sure to have multiple backups of data or use cloud-based servers that can be accessed remotely.

FUTURE DIRECTIONS AND CONCLUSION

Along with the recommendations we developed for other campuses and colleges, there are new areas of future study that Spring 2020 suggests. Based on the flowchart developed from this study, the loss of instructor inputs that fostered resilience, engagement, and sense of belonging appeared to reduce the students’ efficacy. We propose to explore this further and to add all three inputs as categories in the scoring rubric in order to quantitatively capture these dimensions of the students’ efficacy development, allow disaggregation, and ultimately guide future instructional choices.

Also, tracking persistence of students who have mediated-efficacy gains/losses in college is an important angle to consider for future work. Because sense of belonging was a component of our students’ mediated-efficacy, it may be that they will also place more value on the campus community and use social networks to sustain their success. Tracking whether this is so and unpacking the potential relationship between mediated-efficacy, community, and persistence is an important direction for future research.

Additionally, the work captured here shows the value of reflective practice and personal data collection by the instructor. Both

Schiller and Land read student narratives in real time and reflected on those narratives side-by-side with their own notes regarding how their course was progressing throughout the semester. These qualitative data enabled them to effectively respond in the face of a crisis and plan for future semesters. This responsiveness could be strengthened and better understood by capturing an instructor’s own mediated efficacy development as the semester progresses using the same scoring rubric and an instructor’s personal narrative. This practice would be ideal for use with novice STEM faculty. It might also provide value to more veteran instructors who want to embark on course redesign with new pedagogical tools but who are lacking self-efficacy for execution.

Finally, we observed ways resilience, engagement, and sense of belonging were not just important for students but were also important for the two instructors involved in this study. Deeper exploration of this might illuminate a more dialectical nature of the instructor–student efficacy relationship, shining a light on the value of mediated-efficacy relationships for instructors. Our students cried out for more connection after our shift to ERI. Faculty seem to have been doing the same on social media, as the Facebook group Pandemic Pedagogy, with 32,000+ members, attests. With enhanced institutional valuing of these kinds of communal relationships, we may all be better prepared for whatever the future may bring.

REFERENCES

- Aelenei, C., Lewis, N. A., & Oyserman, D. (2017). No pain no gain? Social demographic correlates and identity consequences of interpreting experienced difficulty as importance. *Contemporary Educational Psychology*, 48, 43–55.
- Ajjawi, R., Dracup, M., Zacharias, N., Bennett, S., & Boud, D. (2020). Persisting students’ explanations of and emotional responses to academic failure. *Higher Education Research & Development*, 39(2), 185–199. <https://doi.org/10.1080/07294360.2019.1664999>
- Ambrose, S. A., Bridges, M. W., DiPietro, M., Lovett, M. C., & Norman, M. K. (2010). How do students become self-directed learners? In Ambrose, S. A., Bridges, M. W., DiPietro, M., Lovett, M. C., & Norman, M. K. (Eds.), *How learning works: Seven research-based principles for smart teaching* (pp. 188–216). San Francisco: Jossey-Bass.
- Anderson, R. C., Graham, M., Kennedy, P., Nelson, N., Stoolmiller, M., Baker, S. K., & Fien, H. (2019). Student agency at the crux: Mitigating disengagement in middle and high school. *Contemporary Educational Psychology*, 56, 205–217.
- Bandura, A. (2008). An agentic perspective on positive psychology. In Lopez, S. J. (Ed.), *Positive psychology: Exploring the best in people* (Vol. 1, pp. 167–196). Discovering human strengths. Westport, CT: Greenwood.
- Borchardt, J., & Bozer, A. H. (2017). Psychology course redesign: An interactive approach to learning in a micro-flipped classroom. *Smart Learning Environments*, 4(10). <https://doi.org/10.1186/s40561-017-0049-3>
- Camfield, E. K. (2016). Mediated-efficacy: Hope for “helpless” writers. *Journal of Developmental Education*, 39(3), 2–11. Retrieved June 17, 2020, from <https://files.eric.ed.gov/fulltext/EJ1130186.pdf>
- Camfield, E. K., Beaster-Jones, L., Miller, A. D., & Land, K. L. (2020). Using writing in science class to understand and activate student engagement and self-efficacy. In Mintzes, J. J., & Walter, E. M. (Eds.), *Active learning in college science: The case for evidence-based practice* (pp. 89–105). New York: Springer-Nature.
- Cavanagh, A. J., Chen, X., Bathgate, M., Frederick, J., Hanauer, D. I., & Graham, M. J. (2018). Trust, growth mindset, and student commitment to active learning in a college science course. *CBE—Life Sciences Education*, 17(1), ar10. <https://doi.org/10.1187/cbe.17-06-0107>
- Centers for Disease Control and Prevention. (2020, July 24). *Health equity considerations and racial and ethnic minority groups*. Retrieved December 19, 2020, from www.cdc.gov/coronavirus/2019-ncov/community/health-equity/race-ethnicity.html

- Christensen, J. F., DiCosta, S., Beck, B., & Haggard, P. (2019). I just lost it! Fear and anger reduce the sense of agency: A study using intentional binding. *Experimental Brain Research*, 237, 1205–1212. <https://doi.org/10.1007/s00221-018-5461-6>
- Claro, S., Paunesku, D., & Dweck, C. S. (2016). Growth mindset tempers the effects of poverty on academic achievement. *Proceedings of the National Academy of Sciences USA*, 113(31), 8664–8668.
- Creech, L. R., & Sweeder, R. D. (2012). Analysis of student performance in large-enrollment life science courses. *CBE—Life Sciences Education*, 11(4), 386–391. <https://doi.org/10.1187/cbe.12-02-0019>
- Destin, M., Hanselman, P., Buontempo, J., Tipton, E., & Yeager, D. S. (2019). Do student mindsets differ by socioeconomic status and explain disparities in academic achievement in the United States? *AERA Open*, 5(3), 232858419857706.
- Dweck, C. (2007). *Mindset: The new psychology of success*. New York: Ballantine Books.
- Gannon, K. M. (2020). *Radical hope: A teaching manifesto*. Morgantown: West Virginia University Press.
- Hammond, Z. N. (2014). *Culturally responsive teaching and the brain: Promoting authentic engagement and rigor among culturally and linguistically diverse students*. New York: Corwin Publishing.
- Hanauer, D., & Bauerle, C. (2012). Facilitating innovation in science education through assessment reform. *Liberal Education*, 98(3). Retrieved May 22, 2020, from www.aacu.org/publications-research/periodicals/facilitating-innovation-science-education-through-assessment
- Health Professionals for Diversity Coalition. (2012). *Fact sheet: The need for diversity in the health care workforce*. Retrieved May 20, 2020, from www.aapcho.org/wp/wp-content/uploads/2012/11/NeedForDiversityHealthCareWorkforce.pdf
- Hodges, L. C. (2020). Student engagement in active learning classes. In Mintzes, J. J., & Walter, E. M. (Eds.), *Active learning in college science: The case for evidence-based practice* (pp. 27–41). New York: Springer-Nature.
- IBM Corporation. (2017). *IBM SPSS Statistics for Windows, Version 25.0*. Armonk, NY.
- McGuire, S. Y. (2015). *Teach students how to learn: Strategies you can incorporate into any course to improve student metacognition, study skills, and motivation*. Sterling, VA: Stylus Publishing.
- Michaelsen, L. K., Davidson, N., & Major, C. H. (2014). Team-based learning practices and principles in comparison with cooperative learning and problem-based learning. *Journal on Excellence in College Teaching*, 25(3–4), 57–84.
- National Center for Education Statistics. (n.d.) *College Navigator: Data for University of the Pacific and Wingate University*. Retrieved May 22, 2020, from <https://nces.ed.gov/collegenavigator>
- Pajares, F. (1996). Self-efficacy beliefs in academic settings. *Review of Educational Research*, 66(4), 543–578.
- Pedaste, M., Mäeots, M., Siiman, L. A., Jong, T. de, van Riesen, S. A. N., Kamp, E. T., ... & Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review*, 14, 47–61. <https://doi.org/10.1016/j.edurev.2015.02.003>
- Rendón, L. I. (2009). *Sentipensante pedagogy: Educating for wholeness, social justice, and liberation*. Sterling, VA: Stylus Publishing.
- Scott, A., McNair, D. E., Lucas, J., & Land, K. (2016). From gatekeeper to gateway: Improving student success in an introductory biology course. *Journal of College Science Teaching*, 46(4). https://doi.org/10.2505/4/jcst17_046_04_93
- Shapiro, D., Dundar, A., Huie, F., Wakhungu, P., Yuan, X., Nathan, A., & Hwang, Y. A. (2017). *Completing college: A national view of student attainment rates by race and ethnicity—Fall 2010 cohort* (Signature Report No. 12b). Herndon, VA: National Student Clearinghouse Research Center.
- Strayhorn, T. (2012). *College students' sense of belonging: A key to educational success for all students*. New York: Routledge Press.
- Tinto, V. (2017). Reflections on student persistence. *Student Success*, 8(2), 1–8. Retrieved September 1, 2020, from <https://studentsuccessjournal.org/article/view/495>
- University of the Pacific. (2019). *Fast facts*. Retrieved May 22, 2020, from www.pacific.edu/about-pacific/administration-offices/institutional-research/fast-facts-2019.html
- Verschelden, C. (2017). *Bandwidth recovery: Helping students reclaim cognitive resources lost to poverty, racism, and social marginalization*. Sterling, VA: Stylus Press.
- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.
- Wieman, C. (2014). Large-scale comparison of science teaching methods sends clear message. *Proceedings of the National Academy of Sciences USA*, 111(23), 8319–8320.
- Wingate University. (n.d.) *Quick facts*. Retrieved May 22, 2020, from www.wingate.edu/about/overview
- Winkelmes, M., Boye, A., & Tapp, S. (2019). *Transparent design in higher education teaching and leadership*. Sterling, VA: Stylus Publishing.
- Yosso, T. J. (2006). *Critical race counterstories along the Chicana/Chicano educational pipeline*. New York: Routledge Press.