"Competency-based design and experiential learning fosters science identity."

I almost dropped out during my first semester in college. I was the youngest of three from a low-income family and although my parents were determined to see me be the first of them to finish college, I felt overwhelmed as I sat amongst my well-prepared peers. Unbeknownst to me at the time, much of my hesitation was due to my unfamiliarity with academia's hidden curriculum for success since my parents had minimal exposure to college norms. A string of mentors and early research experiences, however, fostered the confidence and "science identity" I needed to continue in academia and become a successful researcher and educator. Looking back, I now understand how experiential learning and mentorship contributed to my persistence in science and the immense impact it can have on both traditional and underrepresented students. Fundamental to my teaching philosophy is that experiential learning and a mosaic of mentorship is essential to cultivating the science identity necessary for students to overcome the challenges seen in STEM.

The first year of college is rather precarious, especially for nontraditional students in STEM [1]. Even the most prepared experience self-doubt that can drive them out of biology or college altogether. Science identity, defined as whether a student "feels like a scientist", strongly correlates with retention and success by fostering a sense of belonging [2]. Cultivating science identity requires students to participate in science, either through problem-based learning or research experiences. However, biology curricula rely heavily on lecture-based classes devoid of active-learning. This is especially true for the first two years of college when retention is most unstable. Thus, experiential learning even in the first semester can be a powerful tool for developing science identity and improve biology retention and student success.

The development of science identity is even more vital to students underrepresented in the biomedical sciences. In these groups, a lack of representation, financial stress, and the awareness/opportunity/achievement gaps decrease science identity and retention [3]. First-gen/low-income students, for example, often struggle with imposter syndrome on campus and alienation at home as they straddle dual identities in a transition through social classes [4]. They may also find it hard to navigate academia's "hidden curriculum", including unspoken college norms, effective study strategies, office hours, or competing for coveted spots in a lab. Fostering science identity is an essential component to making biology education more equitable and inclusive, and it requires a focus on the individual student's unique challenges and needs.

The evolution of my focus on science identity.

Although I wasn't familiar with the term "science identity" early in my career, I found myself working to empower ownership of identities such as "scientist" or "biologist". Soon after graduating college, I began tutoring math and recognized that many students were not necessarily bad at it. Instead, they were struggling to overcome a fear of it. I would openly discuss this fear and frame it with a growth mindset by changing their "math identity" from someone who is "bad at math" to someone who would "eventually be good at math." Instead of math being a hurdle to fear, it became just another obstacle to overcome in their careers. During my PhD, I explored how the identity of "academic scientist" vs "industry scientist" can impede career growth and published recommendations for improving mentorship in graduate programs [5].

During my NIH K12 IRACDA Penn-PORT postdoctoral fellowship, I came to understand that my efforts were actually part of a well-studied area of science identity within the discipline-based education research field. Given that the goal of this unique three-year, independently-funded K award is to develop faculty with equal interests in research, teaching, and mentorship, I was immersed in opportunities to cultivate science identity [6]. As part of this program, I had two mentored teaching experiences at minority-serving partner institutions, Rutgers Camden (RUC) and Delaware Country Community College (DCCC). At RUC, I developed and taught a new neuroscience course focused on the basic science behind how chronic pain contributed to the opioid epidemic and at DCCC, I taught Anatomy & Physiology I.

In both classes, there was a wide range of student expertise; while some had extensive science training, others were still new to basic concepts. I found that openly discussing the growth of my own science identity from a student who almost dropped out to a well-published faculty member helped them recognize that while some were more advanced than others, we're all along a continuum in developing as biologists. With recognizing that experience was what separated mastery instead of inherent ability, I could encourage science identity is all students. While there were still those who struggled in these classes, they could each accept that with sufficient training, experience, and time, they would continue to grow toward becoming well-skilled biologists.

Fostering science identity put into practice.

I utilize three mechanisms to foster science identity with experiential learning: 1) a personalized "course-based undergraduate research experience" (a CURE, called PPBR), 2) a traditional research experience I've coined as "bite-sized authentic research experiences" (B-SARE), and 3) Problem-Based/Project-Based Learning that focuses on skill development within a lecture period.

In PPBR, second-year students identify, develop, and carry out independent research projects of their choosing. We don't limit them to a specific organism or area of research, and we provide them with a budget for supplies. Unlike competitive research experiences where not all students are accepted, this course is open to any dedicated biology major and provides a research experience baked directly into their curriculum. This is especially important because many of our students have part-time jobs and can't volunteer in labs, as is traditionally done, to attain necessary research experience. To give them a greater taste of academic science, we also have students submit successful projects to our internal peer-reviewed Undergraduate Journal of Biological Sciences.

The origin of B-SARE evolved from my goal of integrating undergraduates into my chronic pain research. To do this, I complement my rodent research with Drosophila, a model organism very accessible to undergraduates. I then design what might be traditionally a years-long project conducive to graduate students and postdocs as several semester-long "bite-sized" projects that have a discrete end-goal an undergraduate can tackle. By approaching my research in this way, I can provide students with an experience that still advances my research goals.

In more traditional courses, I use problem- and project-based learning to cultivate science identity through fostering critical thinking and skill development. To do this, I've completely flipped my Neuroscience I course with pre-recorded lectures that students engage with prior to coming to class. During lecture, we focus on discussions and a series of problem-based learning activities that reinforce key concepts. Using backwards design, I focus on not just content mastery, but also skill development by exposing students to common techniques and tools in the field such as the Allan Brain Atlas, Flybase, and the computational program NEURON. I also modified my Neuroscience of the Opioid Epidemic course to work well with first-year students and introduced a semester-long project-based learning experience where they received a Drosophila-based "lab-in-a-box" to test the effects of chronic pain on the development of addiction. Funded by the ASCB PALM Network, this adaptation increased science identity and was published in JMBE [7]. In my Communicating Biomedical Science course, students choose a single research article of their interest and generate a range of common materials found in academia that most of us just stumble in the dark to learn – manuscripts, review articles, news articles, posters, chalk talks, journal clubs, public lectures, and graphical abstracts. They are also introduced to the world of academic Twitter where they form connections with a valuable network of trainees, researchers, and faculty.

In all of my classes, I first ask myself what information, skillsets, and experiences would allow a student to thrive in this discipline. I then direct my grading, activities, and efforts toward building these core competencies. Importantly, while I have developed these courses with an eye for increasing undergraduate training, I also include graduate students by supplementing the course with activities beneficial to their career development, such as submitting journal club review articles to the Journal of Neuroscience, a popular peer-reviewed article type for trainees in neuroscience.

Developing a computational neurophysiology course and obtaining funding.

Although I have already developed the traditional core courses in neuroscience here at RUC, I have received training to expand offerings. At the University of Missouri, I learned how to develop a course in computational neuroscience using the open-access program NEURON that can test computational models of neurons and networks. At Cornell University, I learned how to use electrophysiology with Drosophila and Crawfish in the classroom and so I envision a unique Computational Neurophysiology Course offered to undergrad/graduate students in Biology and CCIB. Given that I have already integrated my research into several classes, these activities can serve as a foundation or complement to grant proposals. I plan to resubmit a $500K NSF-UBE grant to create a local Philly-based pain research network for undergraduates, and I'm waiting for review of a $500K NIH-NCI-YES grant that establishes a pipeline from high school to college in cancer and pain research. With the support of these funding mechanisms, I hope to continue growing experiential learning opportunities for both undergraduate and graduate students.

References

1. Olson, S. & Riordan, D. G. Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics. Report to the President. (Executive Office of the President, 2012).
2. Stets, J. E., Brenner, P. S., Burke, P. J. & Serpe, R. T. The science identity and entering a science occupation. Soc. Sci. Res. **64**, 1–14 (2017).
3. Estrada, M. et al. Improving Underrepresented Minority Student Persistence in STEM. CBE Life Sci. Educ. **15**, (2016).
4. Verdín, D. & Godwin, A. First in the family: A comparison of first-generation and non-first-generation engineering college students. in 2015 IEEE Frontiers in Education Conference (FIE) 1–8 (2015). doi:10.1109/FIE.2015.7344359.
5. Talati, P. G., Hoang, D. T., Fried, N. T. & Fineberg, M. S. M. and J. D. A Perspective on PhD Career Outlook: Training, Mentoring and Utilizing a New Generation of STEM Doctoral Degrees. Technology Transfer and Entrepreneurship http://www.eurekaselect.com/122500/article (2014).
6. Uno, J. & Walton, K. L. W. Young Investigator Perspectives. Teaching and the postdoctoral experience: impact on transition to faculty positions. Am. J. Physiol. Gastrointest. Liver Physiol. **306**, G739-740 (2014).
7. Waddell, E. A., Ruiz-Whalen, D., O’Reilly, A. M. & Fried, N. T. Flying in the Face of Adversity: a Drosophila-Based Virtual CURE (Course-Based Undergraduate Research Experience) Provides a Semester-Long Authentic Research Opportunity to the Flipped Classroom. J. Microbiol. Biol. Educ. **0**, e00173-21.