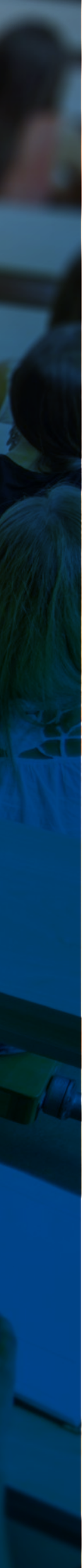
Innovative STEPS

Toward Enhancing Inclusive Undergraduate Science Education



Think back to lectures you attended in college. Do you recall sitting in class, intensively taking notes while the professor talked about a slideshow or wrote on the board? Did you struggle to focus or stay awake during class? Or did you simply show up to class and leave the rest to osmosis (if only it were this easy)?

For the majority of us (arguably all of us), passive intake of information is not the most effective way to learn. Additionally, the teacher-centered learning scenarios described above are major contributors to achievement gaps for underrepresented minorities in STEM majors.[1] This problem comes into sharp focus as we work to enhance diversity in the science fields, based on studies showing that diversity increases group performance. Groups with diverse members ask different questions and develop more innovative solutions.[2] So, if diversity is essential in STEM, but teacher-centered learning strategies stifle diversity, then we have an opportunity—indeed a moral obligation—to shift our educational practices.

You may be wondering, what's the alternative to lecturing? It turns out that there are many better approaches to teaching students. Collectively, we often refer to these as student-centered approaches, which support active rather than passive learning. These research-based methods focus on students and on how they most effectively learn. Examples of active learning strategies include jigsaw groups, in which students work to become an "expert" on a topic and then teach their peers[3,4]; and gallery walks,[5] in which students rotate in small groups around the room, answering posted discussion prompts and adding to answers from other groups.

Higher education is experiencing a shift toward increased use of such active learning strategies, which have been shown to enhance student performance and to narrow achievement gaps for underrepresented minorities in STEM fields.[6,7] Students are exposed to other students' diverse methods for approaching a problem, and this exposure to wide ranging ideas builds a more successful classroom community. Teachers can also couple active learning with strategies such as random call,[8] which involves randomized selection of students to share their thinking with the class, to promote further inclusion in the classroom.

This shift in educational methods sounds wonderful in theory, but how do we implement it? Transitioning a lecture-based course into one that relies on active student learning is time-consuming (although research shows that the time is well worth it because students benefit). In actual practice, it's easier for faculty to learn and implement these strategies early in their careers.[9] An innovative program at the University of Washington has worked to provide this training, and the results so far have been encouraging and illuminating.

STEP: The Program

The Science Teaching Experience Program, or STEP, is a University of Washington program that focuses on training the next generation of educators, including graduate students and postdoctoral fellows. As stated on the STEP website, "Future generations of scientists will come from our classrooms, and STEP is preparing the next generation of instructors to be ready for them."

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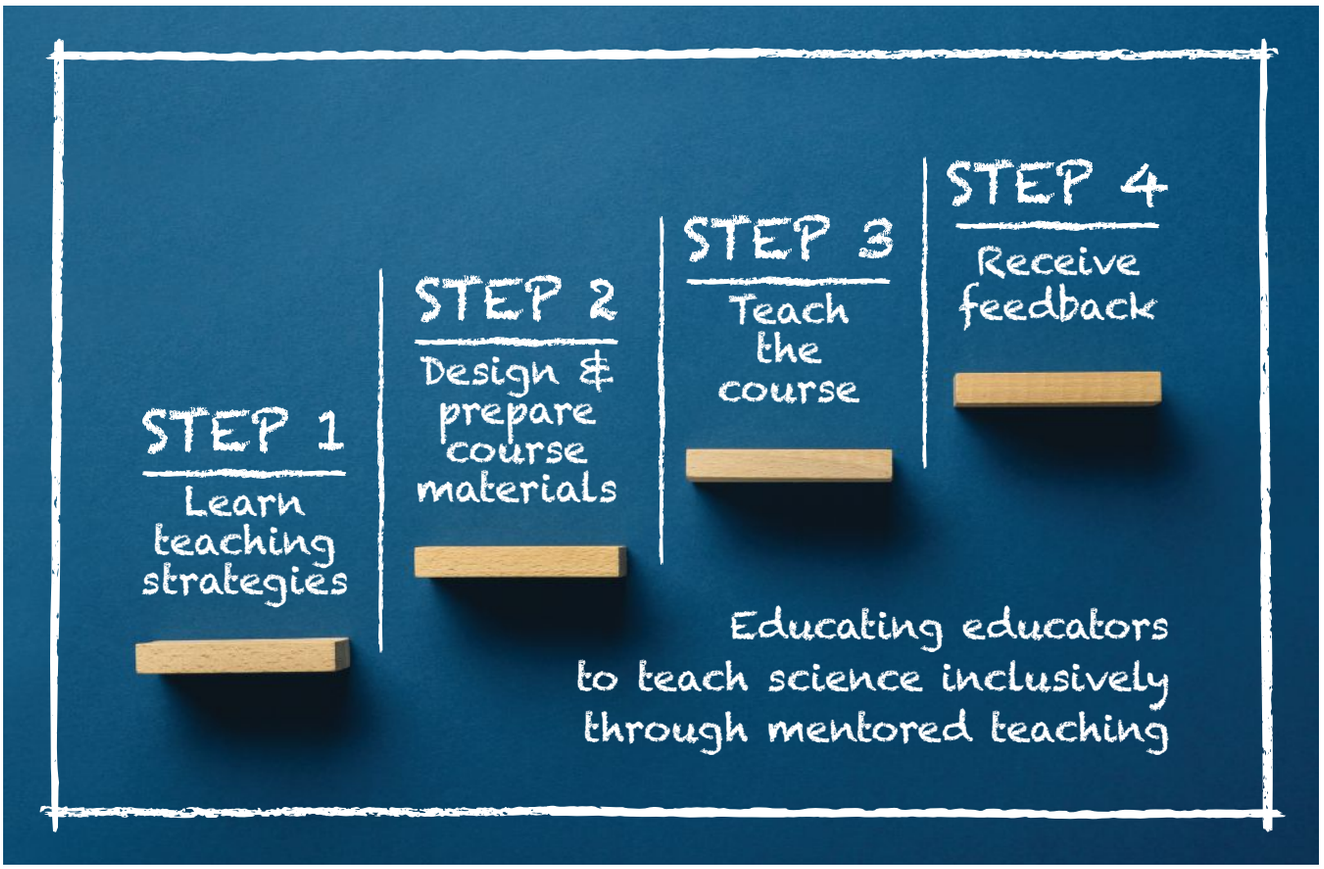

Figure 1. Steps taken by postdocs and graduate students during Science Teaching Experience Program (STEP) backed by mentored support.

The branch of STEP focused on training postdoctoral fellows—Science Teaching Experience Program – Working In Science Education (STEP-WISE)—graduates about 24 fellows annually and a total of 186 fellows since 2011. The branch focused on training graduate students—Science Teaching Experience Program for Upcoming PhDs (STEP-UP)—began in 2017 and has an average cohort size of 5–10 students, with a total of 12 trainees in the first two cohorts. Both programs introduce fellows and trainees to active-learning and inclusive educational strategies from a student perspective prior to fellows designing and co-teaching a seminar-style course based on their own area of scientific expertise. Throughout the process, fellows receive advice and feedback from peers and a mentor. Because graduate school and postdoc work are usually busy and stressful times in one's life, STEP is designed to fit in with fellows' other responsibilities.

STEP-WISE: The Program for Postdocs

The mission of the postdoc program STEP-WISE is "to engage a diverse pool of postdoctoral fellows at the University of Washington and affiliate institutions in a closely mentored apprenticeship to learn how to teach scientifically with inclusive, demonstrably effective, student-centered pedagogies."

Dr. Rebecca Price has been the Executive Director of STEP-WISE since 2014 and has been directing the program since 2011. She envisions continued growth for the program and says, "We are especially trying to recruit a diverse pool of STEP fellows, to help diversify the professoriate." Dr. Price shares why she values STEP-WISE: "I really cherish the opportunity to work with postdocs. I have the opportunity to work with the

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next generation of scientists and help them launch their careers as faculty members, research scientists, science communicators, etc."

STEP-UP: The Program for Graduate Students

The mission of the graduate student program STEP-UP is "to engage advanced graduate students in STEM fields at the University of Washington in learning and implementing inclusive teaching methods that support all students, especially those from minoritized backgrounds."

Dr. Ben Wiggins, Director of STEP-UP, notes, "We are trying to raise the floor for new professors to hit the ground running and to be able to challenge their students more equitably in their first day on the job. . . . Teaching is largely a human performance, like conducting an orchestra. Literature helps, guidance helps, feedback helps ... but practice is the key. STEP-UP is a place to get that practice in a real and supported way."

In addition, Dr. Wiggins says, "If the goal is to live up to the standards of teaching from prior generations, then we don't really need STEP-UP. But if you think that the scientific problems we are facing right now are more difficult, more complicated, and require more different kinds of minds to be activated, then going beyond what we've always done is completely necessary. STEP-UP... has huge potential to change how generations of students are brought into science careers and knowledge."

What Fellows and Trainees Say

Dr. Honyin Chiu, currently a Postdoctoral Fellow at Seattle's Benaroya Research Institute, was a STEP-WISE fellow in 2020. She co-taught a course titled "Taming Jekyll and Hyde: Exploring the Past, Present, and Future of Immunomodulatory Therapeutics," and she shares the following insights from her personal STEP-WISE experience:

"I was able to secure teaching employment directly after I defended my thesis," and she attributes this largely to STEP-UP. "I think there is a ton of untapped demand for these kinds of programs. [We] need to get better about training future educators."

"I was first introduced to student-centered teaching practices during graduate school as a [teaching assistant], but training as a STEP fellow took it further, because we read published scientific papers showing evidence for how these practices were helpful to students. . . . I really started seeing the value [of active learning] for my students in [my] course when they began using their understanding of the material and critical thinking to start asking their own high-level questions. This experience brought to my attention the inequalities in lecture-based teaching strategies and how this can perpetuate current systemic racism. It also gave me the confidence and skills to implement student-centered, inclusive teaching practices important for both educating and mentoring students."

Two STEP-UP trainees from 2017–2018, **Dr. Laura Taylor** and **Dr. Lisa Voelker**, co-taught a course with Dr. Claire Williams titled "The Life Cycle of a Neuron."

Sharing her perception of the benefits of the STEP-UP program, Dr. Taylor says, "I've noticed that my students are more engaged in the class content when they feel that they are being seen and understood by their instructor. Students who never would have considered a career in the sciences come back to me and tell me that they have switched their major to biology and how being encouraged in the classroom was monumental in their future career aspirations. . . . The [STEP-UP] program helped to solidify my desire to pursue a teaching career. I am now an Associate Professor at Northern Marianas

College in Saipan, CNMI [Commonwealth of the Northern Mariana Islands], and I love that I get to utilize the skills from [STEP-UP] to engage my students. Incorporating active learning is not widely done in this community, and students often come out of my classes inspired to better understand science instead of [feeling] daunted by the concepts."

Her fellow trainee, Dr. Voelker, describes the value of STEP-UP in her education and career when she says, "Learning about how to better realize my [course] learning goals through thoughtful course design was invaluable. I think the biggest benefit, aside from being given the tools to think more deeply about the goals of my teaching, was the mentored teaching experience. Getting feedback every step of the way from multiple people in designing and executing a course was incredibly useful."

She adds, "I was able to secure teaching employment directly after I defended my thesis," and she attributes this largely to STEP-UP. "I think there is a ton of untapped demand for these kinds of programs. [We] need to get better about training future educators."

I, myself, was a STEP-WISE trainee in 2018 and co-taught a course titled "Disease Treatment from Protein Blueprint to Production and Operation." Not only was my STEP-WISE experience crucial for obtaining my current position as a lecturer at the University of Washington, Tacoma, but it provided me with knowledge and skills that I use daily. I am able to share concepts and skills I learned in STEP-WISE with colleagues, thereby spreading this knowledge. Similar to dropping a stone into a pond, the knowledge ripples and spreads throughout my academic community, enhancing undergraduate science education, an impact that will continue to ripple outward as these undergraduates enter science fields. ✪

Dr. Katie Mitzelfelt *is currently a biology lecturer at the University of Washington, Tacoma. She completed the STEP-WISE fellowship in 2018–2019, while working as a postdoc at the University of Washington, Seattle, on cardiac regeneration. Her PhD is in biochemistry from the University of Utah.*

Primary Research Articles on or from STEP:

- Joy, J.P. and Price, R.M. "Harnessing the power of the immune system: Influenza vaccines." CourseSource, 2021.
- Kao, R.M. "Beyond the lab bench: Pathways in inclusion, equity, and diversity in biology education and social justice." *Developmental Biology 459*(1):49-51, 2020.
- McCullough, E.A. et al. "STEP Forward: Combining formal and informal education to develop communication skills that augment postdoctoral training." *Journal of STEM Outreach 3:1-10*, 2020.
- Schindler, A.G. and Price, R.M. "Bad Science: Exploring the unethical research behind a putative memory supplement." *CourseSource*, 2018.

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Citations:

1 Freeman, S., and Theobald, E. "Is lecturing racist?" Inside Higher Education, 2020.
2 Hong, L., and Page, S.E. "Groups of diverse problem solvers can outperform groups of high-ability problem solvers." PNAS 101 (2004): (46) 16385–16389.
3 Aronson, E., and Bridgeman, D. "Jigsaw groups and the desegregated classroom: in pursuit of common goals." Personality and Social Psychology Bulletin v5 (1979): 438–446.
4 Theobald, E.J., et al. "Student perception of group dynamics predicts individual performance: Comfort and equity matter." PLOS ONE (2017): 1-16
5 Francek, M. "Promoting discussion in the science classroom using gallery walks." Journal of College Science Teaching v36 (2006): 27–31.
6 Freeman, et al. "Active learning increases student performance in science, engineering, and mathematics." Proceedings of the National Academy of Sciences 111 (2014): (23) 8410-8415.
7 Theobald, et al. "Active learning narrows achievement gaps for underrepresented students in undergraduate science, technology, engineering, and math." Proceedings of the National Academy of Sciences 117 (2020): (12) 6476-6483.
8 Waugh, A.H., and Andrews, T.C. "Diving into the details: Constructing a framework of random call components." CBE-Life Sciences Education v19 no.2 (2020): 1-17.
9 Ebert-May, D. et al. "Breaking the cycle: Future faculty begin teaching with learner-centered strategies after professional development." CBE-Life Sciences Education v14 no.2 (2015):1-12.

Learn More:

STEP website: https://depts.washington.edu/stepuw/

STEP-UP promotional video: https://www.youtube.com/watch?v=z5Om7zQEDrU&feature=youtu.be

STEP informal blog on teaching by fellows: http://depts.washington.edu/stepuw/blog/

Esser, D. "Helping postdocs step up to teaching." University of Washington Bothell, 2017.

Esser, D. "A STEP from postdoc to professor." University of Washington Bothell, 2020.