Shifting Faculty Approaches to Pedagogy through Structured Teaching Postdoc Experiences

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Many studies confirm the benefit of active learning in STEM teaching. However, many faculty have been slow to adopt such practices, perhaps due to limited time to learn and implement new approaches. One way to address this deficit is to offer structured teaching postdoctoral experiences to trained scientists who want to enter academia. We outline the benefits of providing pedagogical training at the postdoctoral level and present a framework for structuring an impactful teaching postdoc program.

INTRODUCTION

Teaching is a continuously evolving practice that can shape students’ lives. In the United States, there are consistently calls for increasing the number of STEM professionals (1), and high-quality teaching can increase student retention in STEM fields (2–5). Studies have shown that, in STEM disciplines, active learning produces learning gains significantly above traditional lecturing, including closing the achievement gap between prepared and socioeconomically disadvantaged students (6–7). Implementing course-based undergraduate research experiences (CUREs) also increases content knowledge and student retention (reviewed in 8). Numerous workshops and online resources have answered these national calls for reformed STEM teaching (1, 9–10). However, faculty have been slow to embrace these reforms (11–13), possibly due to resistance to change or lack of time and/or incentive to overhaul courses.

Although STEM faculty at most higher education institutions are expected to teach, most do not receive formal training on how to teach prior to starting their positions. As a result, newly hired faculty members often take four to five years to meet institutional expectations for teaching (14). Several studies have shown that having a teaching mentor can decrease this time (reviewed in 15). An alternative to this on-the-job faculty training is the applicant having received formal pedagogical training from a teaching mentor during a teaching postdoctoral fellowship. This extended training period allows dedicated time for scientists to become familiar with and gain authentic experience implementing best practices in higher education.

The Biotechnology Program at NC State (16–17) has maintained a teaching postdoc training program for fifteen years. Postdocs typically enter our program after they have completed a research postdoc. This allows trainees to bring in more research expertise and increases competitiveness on the STEM faculty job market. Our three-year training program outlines specific expectations for each year (Fig. 1). Each teaching postdoc is primarily responsible for teaching between one and three combined lecture/laboratory courses per semester, including a novel CURE-based course completely designed by the postdoc and related to an area of their research (Table 1). Our postdocs also collect data about their course and publish in a field-specific educational research journal (see examples in 18–23). Below, we outline our recommendations for this training process; these

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FIGURE 1. Outline of activities performed during a three-year teaching postdoctoral training period in the BIT program at North Carolina State University. CURE = course-based undergraduate research experience; SoTL = scholarship of teaching and learning.
recommendations are based on our direct experiences training 13 postdocs.

Training description

To obtain holistic training as an educator, teaching postdocs should be mentored through specific pedagogical activities, including receiving instruction on evidence-based teaching methods, independently teaching courses, and performing education research. We outline these steps here:

1. **Mentoring:** Each teaching postdoc should be assigned an experienced faculty mentor who is dedicated to improving teaching methodologies. The mentor should train postdocs about pedagogical best practices and support trainees as they implement such practices. Mentors also provide feedback about classroom teaching and assist trainees with publishing educational studies. Receiving constructive feedback from an experienced mentor is a critical component of becoming a better educator (12, 15).

2. **Defined length:** Teaching postdocs should not be hired simply as a cheap alternative to teaching faculty. A position length of two to four years should be made explicit at the time of hire, and the mentor should ensure that there is a clear plan for the postdoc to move on to a permanent position. For an example of a three-year plan, as implemented in our program, see Figure 1.

3. **Instructor-of-record:** There is no better way to learn how to teach than by doing. Each teaching postdoc should independently teach undergraduate courses in the appropriate program or department. We recommend at least one course per semester, and a reiteration of at least one course to give postdocs the opportunity to revise their teaching style, classroom management skills, and lesson plans. This is consistent with findings from other postdoc mentoring programs (12) and also allows the opportunity for participation in educational research (below).

4. **Pedagogical training:** Many PhD-level scientists are unaware of the education literature available in their field. Teaching postdocs should be introduced to the Scholarship of Teaching and Learning (SoTL) and Discipline-Based Education Research (DBER) through seminars, journal clubs, webinars, and conferences. Many colleges and universities have a teaching support office that can be a useful resource for these activities. Teaching postdocs should also be encouraged to conduct their own SoTL studies on their courses, including receiving Institutional Review Board (IRB) approval, designing and implementing effective assessments, analyzing the data, and presenting at local and national meetings. SoTL studies are strengthened through additional data collection, which ties into being able to teach the same course multiple times. Having the support of a mentor experienced in SoTL, which often employs social science data analysis techniques unfamiliar to STEM researchers, is also important for properly preparing publications.

5. **Legacy project:** In addition to traditional research and teaching activities, postdocs also take the opportunity to provide a larger, lasting contribution to the department or program. These often include course redesigns, outreach activities, grant proposals, and new collaborations. In our program, postdocs have updated the experiments and research questions in our multi-section molecular biology course and established a collaboration with the North Carolina School for the Deaf (Morganton, NC). The legacy project benefits both the program or department and the postdocs, who then have an additional experience to set them apart and potentially bring to their next institution.

Together, these activities address the skills expected of a teaching position, including the ability to teach both traditional courses and unique advanced courses, having an authentic teaching experience, learning about pedagogical techniques and implementing them, and involving undergraduates in research (24).

**TABLE 1.** Examples of laboratory courses developed by NCSU BIT teaching postdocs.

| Course Title               | Description                                                                 |
|----------------------------|----------------------------------------------------------------------------|
| Virus Biotechnology        | Students detect frog virus 3 in field samples of North Carolina ectotherms  |
| High-Throughput Discovery  | Students design and perform high-throughput experiments to determine inhibitory concentrations of novel antibiotics and growth conditions for wild yeast by programming automated liquid handlers. |
| Epigenetics                | Students map epigenetic markers related to iron metabolism in *Medicago truncatula* |
| Protein Interactions       | Students observe and quantify interactions between SSB, DNA, and partner proteins |
| Protein Engineering        | Students design their own engineered cytokines and use forward genetic screens to identify advantageous mutations |

NCSU = North Carolina State University; SSB = Single-strand DNA-binding protein.
Outcomes

Although 75% of biomedical graduate students indicate that they want to pursue a career in academia, 84% of graduates will need to choose another career due to the scarcity of tenure-track faculty positions (25–26). While graduate students may anticipate being hired immediately upon graduation, the majority of academic faculty hires have post-graduation experience, usually as a postdoc. For example, in the extensive California State University system in 2018, 54.9% of faculty hires were between zero and four years post-graduation, and 21.9% were five to nine years out (27) (national data not available). Providing a dedicated period of pedagogical training in the form of a teaching postdoc adds significant value to faculty candidates, who are then prepared to immediately implement high-impact teaching practices, including CUREs. These trainees could also serve as leaders in their departments for connecting existing faculty to the literature and community of SoTL research.

A recent analysis of STEM teaching in North American universities specifically advocated for providing “effective pedagogical training for the current and future professoriate, similar to the level provided for research” (11) (emphasis added). Teaching postdoctoral programs such as ours are able to directly address this recommendation. By introducing a dedicated step of teaching training to scientists who have spent many years at the bench, we can ensure that faculty are prepared to perform all of the duties of a full-time faculty member without experiencing a steep learning curve in the classroom that could disadvantage an entire cohort of students.

The number of such training programs is expanding, with some offering part-time training to research postdocs (FIRST IV [12], HHMI https://www.summerinstitutes.org/) and others employing teaching postdocs full-time (NCSU BIT [16], ROSE Network [28], and Cornell Investigative Biology http://investigativebiology.cornell.edu/) (see Table 2). The National Institutes of Health (NIH) also offers Institutional Research and Academic Career Development Awards (IRACDA) (https://www.nigms.nih.gov/Training/CareerDev/Pages/TWDInstRes.aspx) grants, which fund combined research/teaching postdoc positions (FIRST [29], SPIRE [30]). While we do not have data on other programs, teaching postdocs completing our three-year training program typically receive multiple offers from a variety of institutions of higher education. Most of our postdocs were also on the academic job market prior to joining our program and did not obtain faculty positions at that time, indicating increased competitiveness after completing the teaching postdoc position. Expanding this trend is an effective way to address the need for a prepared STEM workforce, including increasing student retention, narrowing the achievement gap, and improving scientific thinking skills.

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TABLE 2.
Selected examples of teaching postdoc programs in the United States.

| Program                                      | Length         | Pay                          | Requirements                                                                 |
|----------------------------------------------|----------------|------------------------------|------------------------------------------------------------------------------|
| Cornell Investigative Biology                | 1 year renewable | Commensurate with NIH suggested minimum salary | Teach/oversee a large enrollment CURE-based biology lab course, perform SoTL research |
| FIRST IV (12) @Michigan State University      | 2 years        | Travel only (employed as a research postdoc) | Summer workshops on teaching methods, develop and teach an introductory biology course |
| HHMI Teaching Biology @UW-Madison             | 1 year         | None (employed as a research postdoc) | One-semester course on educational literature, team-teach introductory biology survey course |
| NCSU BIT (16)                                | 3 years        | Commensurate with NIH suggested minimum salary | Develop/implement novel course, mentor research students, publish SoTL work (see Fig. 1) |
| SPIRE @University of North Carolina          | 3 years        | Commensurate with NIH suggested minimum salary | Mentored research experience at minority serving institution, teaching seminars/workshops, mock job talks |

CURE = course-based undergraduate experience; SoTL = scholarship of teaching and learning; FIRST = Faculty Institutes for Reforming Science Teaching; HHMI = Howard Hughes Medical Institute; NCSU = North Carolina State University.
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