An Efficient and Coherent Pipeline for Graduate Student and Postdoctoral Scholar Educational Development

Daniel Mann
University of California, Irvine, dmann@uci.edu

Matthew Mahavongtrakul
University of California, Irvine

Ashley Hooper
University of California, Irvine

An Efficient and Coherent Pipeline for Graduate Student and Postdoctoral Scholar Educational Development

Daniel Mann, Matthew Mahavongtrakul,
and Ashley Hooper

Abstract

As higher education shifts toward a culture of evidence-based teaching practices, future faculty are seeking opportunities to develop their pedagogical knowledge and skills. Many centers for teaching and learning (CTLs) have not proportionally grown in resources to meet the demand for graduate student and postdoctoral scholar programming (e.g., teaching certificates and pedagogy seminars). This article presents a model of a wide-ranging, coherent pipeline of educational development for graduate students and postdoctoral scholars managed by a CTL with modest staffing.

Keywords: graduate student, postdoctoral scholar, efficiency, pipeline, educational development, centers for teaching and learning

Despite numerous national efforts to shift higher education toward more evidence-based teaching practices (e.g., American Association for the Advancement of Science, 2011; Association of American Universities, 2013; President's Council of Advisors on Science and Technology, 2012), faculty continue to experience many barriers to

implementing evidence-based teaching practices, including lack of training, time, and incentives (Brownell & Tanner, 2012; Lund & Stains, 2015; Stains et al., 2018). One promising approach to increase evidence-based teaching practices is pedagogical training for future faculty (Connolly et al., 2018; Wurgler et al., 2014).

Beginning in the 1980s, greater research attention and institutional support has been directed toward developing programs that train graduate students in teaching skills (Austin & Wulff, 2004). These programs have continued to evolve to provide ongoing pedagogical training to support graduate students in their development as teaching assistant (TA) instructors and as future faculty (Austin & Wulff, 2004; Border & von Hoene, 2010; Nyquist & Wulff, 1996). Despite growing attention to train graduate student instructors, many still receive minimal training, such as an initial orientation to teaching and/or occasional guidance from faculty supervisor (Prieto & Altmaier, 1994; Prieto & Meyers, 2001), even though TAs assist with approximately 30% to 40% of undergraduate courses at a majority of major universities (Nyquist et al., 1991). Beyond serving as TAs, a lack of training may leave recent doctoral graduates feeling unprepared for the evolving teaching-related responsibilities expected of new faculty (Austin & Wulff, 2004). For example, a recent study found that only half of newly hired faculty members in economics agreed that their graduate school adequately prepared them to teach (Allgood et al., 2018). By providing doctoral students and postdoctoral scholars with pedagogical training and skills in evidence-based teaching practices, universities can positively affect the educational experiences of their undergraduates (Austin, 2011; Hill et al., 2019). Research institution leadership, graduate students, and postdocs are all demanding more opportunities for future faculty teaching development (FFTD) (Goodwin et al., 2018). These FFTD programs are typically managed by centralized university structures such as centers for teaching and learning (CTLs) or a graduate school/division and are rarely part of the departments' curricula, particularly in science, technology, engineering, and mathematics (STEM) programs

(Connolly et al., 2016; Vergara et al., 2014). If there is any mandatory teaching training for graduate students, it is typically only an introductory orientation to being a teaching assistant. These teaching assistant trainings vary widely in their length and their curricula, and many focus more on policies than pedagogy (Parker et al., 2015; Tanner & Allen, 2006). In addition to overseeing the teaching assistant training, many CTLs offer FFTD programs such as course design institutes, certificates in college teaching, pedagogy seminars, Preparing Future Faculty programs, instructor of record training, and workshop series. Research suggests that participation in these programs can benefit doctoral students and postdoctoral scholars by strengthening their teaching efficacy and teaching practices (Connolly et al., 2016; Hill et al., 2019).

The most effective FFTD programs are not short one-offs but long-term ongoing training, ideally forming a pipeline of development (Connolly et al., 2018; Feldon et al., 2017). Connolly et al.'s (2018) study demonstrated that graduate teaching development programs improve college teaching self-efficacy, with a particularly strong effect for women. Some evidence links teacher self-efficacy with positive impacts on instructional practices such as organization, enthusiasm, and persistence (Hoy, 2003–2004). Connolly et al. also found that graduate students highly engaged with teaching development had positive long-term effects such as the likelihood of receiving a faculty position and positive teaching practices after completing their degrees.

While perceptions of the teaching/research trade-off persist, there is growing evidence that there is actually synergy that enhances research performance and publication counts (Shortlidge & Eddy, 2018). Relatedly, there is a common concern that investing time into teaching development programs would affect time to graduate degree completion; however, Connolly et al. (2018) showed that these programs had no effect on degree completion for STEM graduates.

Given all of the advantages of educational development for graduate students and postdocs, many CTLs are expected to offer more and more FFTD programs even if staffing and resources do not increase accordingly (Brinthaupt et al., 2019). As demands for such programming increases, the question emerges: How can a CTL keep up with the workload and create an organized curriculum out of it all? In addition to leveraging campus partnerships and collaborations for CTL success (Brinthaupt et al., 2019), at the University of California, Irvine (UCI), we have developed our FFTD pipeline for efficiency and coherence by emphasizing two main strategies: (1) implementing a cascading mentorship model for program development and facilitation and (2) leveraging the most successful programs.

Graduate Student and Postdoctoral Scholar Educational Development at UCI

Context

UCI, as of fall 2018, enrolled 5,654 graduate students in the general campus and 1,352 graduates in the health sciences. As of fall 2019, UCI employed 381 postdocs. UCI's CTL is the Division of Teaching Excellence and Innovation (DTEI), and we primarily serve the general campus with some minor support for the health sciences. DTEI has two main staff involved with programming for graduate students and postdocs: the Director of Graduate Student and Postdoctoral Scholar Instructional Development (full-time) and the DTEI postdoc (~75% of full-time position dedicated to FFTD programs and assessment). In addition, two administrative staff allocate small percentages of their time to supporting the financial processing, space reservations, and catering requests for these programs. The director reports to the associate dean of DTEI in the Office of the Vice Provost of Teaching and Learning.

The Pipeline
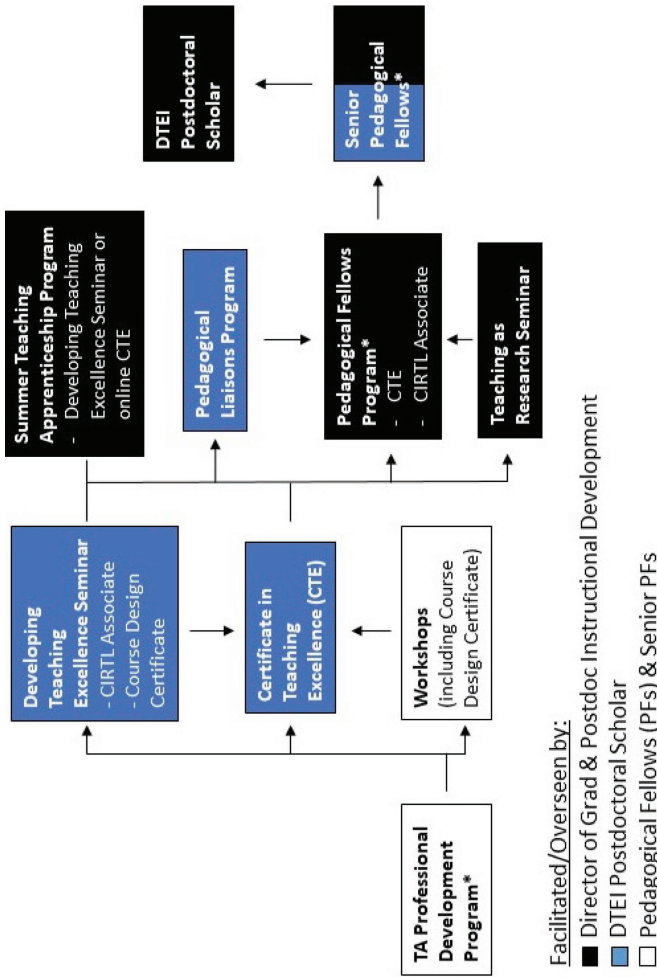
Figure 1. Graduate Student and Postdoctoral Scholar Educational Development Pipeline at University of California, Irvine

Note: Figure 1 illustrates how our primary programs are connected and facilitated in our pipeline of educational development for graduate students and postdocs. While the arrows indicate a typical pipeline with some embedded prerequisites, it is possible for participants to explore the programs in a slightly different order, particularly in the latter stages of the pipeline.

Primary Programs

All graduate student TAs are required to have TA training before they enter the classroom. For all but five departments campuswide, their TAs are trained during our TA Professional Development Program (TAPDP): a 12-hour training on pedagogy, practical teaching skills, getting to know our students and campus resources, and general professional development. Using our TAPDP learning outcomes, experienced graduate students (pedagogical fellows, described below) develop and facilitate a customized training, which is both departmental and university specific. Workshop topics within the TAPDP training program commonly cover the following topics: lesson planning and active learning (e.g., how to write and assess student learning objectives, how to engage students using active learning techniques), grading (e.g., how to create and use a rubric), office hours (e.g., how to prepare for common office hour scenarios), diversity and inclusion (e.g., how to support an inclusive teaching environment), and TA roles and responsibilities (e.g., how to perform duties in a professional manner). TAPDP participants are also given the opportunity to practice facilitating in a "micro-teaching" workshop. TAs receive structured peer feedback on these short sessions.

In 2018 to 2019, over 700 new teaching assistants were trained in a discipline-specific manner in an average class size of 23 students. See Table 1 for participation data across our programs (please note that there may be some participant overlap across programs). We also require an additional international TA training for international students who have no experience teaching or studying at a US university. These TA orientation programs are the most common entry point for graduate students in our educational development pipeline; however, postdocs enter the pipeline in various other programs described below. The departments who do not participate in TAPDP have their own TA training, often in the form of an introductory seminar early in their graduate programs.

We provide campus-wide workshops approximately four times per quarter, with each of the following modules represented annually: How People Learn, Active Learning, Inclusive Teaching and Diversity, Collaborative Learning, Instructional Technology, Assessment, and the Course Design Certificate Program. The Course Design Certificate Program has been one of our most popular workshop series (eight hours of training time) for over a decade, with around 100 participants annually. Participants learn about the following topics:

- how to construct a course using backward design methods (i.e., creating measurable student learning outcomes aligned with broader course goals) (Wiggins & McTighe, 2005);
- how to organize course information and materials (e.g., thematically, chronologically, and/or in ascending complexity);
- how to design and use summative and formative assessments (e.g., using low-stakes assignments to assess learning throughout the course);
- how to establish different grading systems (e.g., norm referenced vs. criterion referenced);
- how to use active and inclusive instructional methods (e.g., incorporating universal design and active learning); and
- how to write and design a course syllabus (e.g., including course student learning outcomes, grading scales, strategies for student success, and/or campus resources).

By the end of the program, participants will have a peer-reviewed syllabus for a new course as well as a background in the foundations of course design. Due to demand, we run this course design program four to five times per year. In addition to our campus-wide workshops, we also facilitate customized presentations for various departments and offices. For example, we provide professional workshops for graduate students and postdocs (e.g., how to write a teaching statement) as well as workshops that address important topics in teaching (e.g., how to support diversity and inclusion in the classroom).

Our Certificate in Teaching Excellence can be completed in a self-paced manner using our learning management system, Canvas, or in our introduction to pedagogy course, University Studies 390X: Developing Teaching Excellence. Irrespective of the format (i.e., self-paced on Canvas or in the 390X pedagogy course), students study a series of course modules and complete peer observations. Module topics mirror the workshop series that we provide and cover a series of pedagogy topics: neurobiological processes of learning, active learning and lesson planning techniques, inclusive teaching and universal design, collaborative and group learning, assessment and course design, and using instructional technology. Peer observation requirements include observing a peer's teaching and providing feedback during three class periods and being observed during three class periods and reflecting on the peer feedback. Peers meet prior to observations to discuss class expectations, goals and objectives for the class, students' preparation prior to the class session, and any specific requests for feedback (e.g., lecture pacing, student engagement). Observers complete a detailed form that includes time-stamped, detailed observations (e.g., instructional strategies being used, organization and clarity of PowerPoints, rapport and interaction with students, general class atmosphere) as well as corresponding comments and feedback (e.g., lecture slides were clear and easy to read, instructions were difficult to hear). Following the observation, peers meet to discuss positive aspects of the class as well as areas needing improvement. Through the process of earning the Certificate in Teaching Excellence, participants learn and practice evidence-based pedagogical practices, receive peer feedback on their use of these techniques, and learn how to give others effective teaching feedback.

As mentioned previously, the University Studies 390X: Developing Teaching Excellence seminar is our introductory pedagogy course. The unit-bearing, graduate course is open to students from across the university, resulting in a multidisciplinary cohort composed of students interested in teaching. While not receiving course credit, postdocs can audit the class. The quarter-long course meets for three hours a week

for 10 weeks, covering each of the modules in the Certificate in Teaching Excellence Program as well as a session on "teaching as research" (i.e., scholarship of teaching and learning). University Studies 390X only requires one set of peer observations; however, some students complete all three sets in one quarter to earn the Certificate in Teaching Excellence.

Pre- and post-course assessments indicate that after the 390X course, students learn and utilize a variety of additional active learning techniques (e.g., think-pair-share, in-class worksheets), inclusive teaching strategies (e.g., gender-neutral language, incorporating diverse scholarship in syllabi), collaborative learning approaches (e.g., group discussion, assigning collaborative projects), and instructional technology tools (e.g., Canvas, Kahoot!, ePortfolio, Google Docs, iClickers, and Poll Everywhere). Furthermore, students discuss additional forms of evaluating student learning through formative assessments (e.g., in-class, quizzes, reading reflections, weekly worksheets) and summative assessments (e.g., research papers, final portfolios). Pre- and post-course questionnaires also indicate that 390X students improve their understanding of a variety of pedagogical concepts. When comparing the percentage of correct responses in pre- and post-assessments across fall 2018, winter 2019, and spring 2019 cohorts (as seen in Figure 2), student learning improved in a variety of topics: engaging introverted students (87% vs. 92%), defining universal design (40% vs. 94%), identifying summative assessments (42% vs. 86%), identifying formative assessments (55% vs. 84%), planning backward design (77% vs. 96%), and identifying a measurable learning objective (79% vs. 96%). Furthermore, in addition to equipping students with pedagogical tools and knowledge, the 390X course improved perceived quality of life in multiple ways. For example, students commonly stated that the course created an inclusive community of peers and improved their self-confidence in teaching/mentoring students and entering the academic job market. Completion of the 390X seminar also grants students the Course Design Certificate and the Center for the Integration of Research, Teaching, and Learning (CIRTL) associate
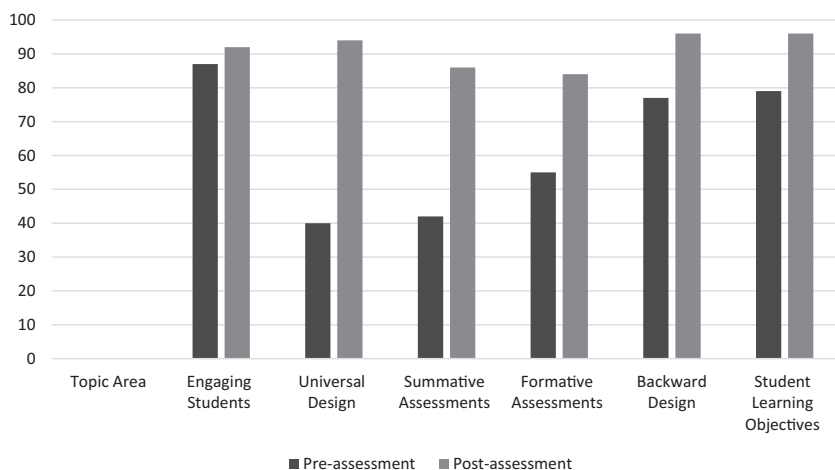
Figure 2. Percentage of Correct Responses in Pre- and Post-Course Assessments for 390X Students
Note: The figure illustrates the percentage of correct responses to questions assessing knowledge of different pedagogical topic areas, across fall 2018, winter 2019, and spring 2019 cohorts of 390X students. The figure presents percentages of correct responses for pre- and post-course assessments.

level (CIRTL, n.d.). CIRTL offers many resources to member campuses such as UCI, but membership itself requires a monetary institutional commitment, and membership is only open to institutions with large amounts of graduate students and postdocs. While the primary CIRTL network is STEM focused, the CIRTL community at UCI and other institutions is open to all disciplines. By embedding multiple certification programs into our 390X seminar, we have been able to sustain interest and participation.

Participants who complete the 390X seminar or the Certificate in Teaching Excellence may apply for the Pedagogical Liaisons Program. Enrollment in this program is not limited, and participants are asked to provide a minimum of 10 hours of service in educational development for their department or school. Pedagogical Liaison projects vary widely, from working with faculty mentors to co-develop course

materials and lesson plans, to facilitating a series of pedagogy work-shops for their department colleagues, to working with our university writing center to create instructional resources for TAs leading dis-cussion sections in writing-intensive courses. Individuals have been primarily motivated to participate in this program as they receive an automatic interview for the Pedagogical Fellows (PF) Program.

If a graduate student has completed the Certificate in Teaching Excellence or University Studies 390X, they are eligible to apply for the PF Program. The PF Program is composed of three quarters of gradu-ate seminars (three hours a week) and two full days of training over the summer. Two of these seminars cover a variety of topics in advanced pedagogy (e.g., incorporating radical or feminist pedagogy techniques for inclusive instruction, designing service-learning courses), and one addresses academic job preparation (e.g., writing teaching and diver-sity statements). The seminars are active, collaborative, and discussion based, with continual opportunities for modeling/practicing evidence-based teaching techniques and providing/receiving peer feedback. By the end of the program, pedagogical fellows (PFs) are able to develop and refine advanced pedagogical skills for use in higher education; create and implement a discipline-specific TAPDP for new graduate student TAs; participate in an interdisciplinary community of graduate students focused on improving pedagogical practices; and prepare competitive application materials for the academic job market. PFs also receive a $2,000 stipend.

In program evaluations, PFs frequently characterize the program as one of their best experiences in graduate school. PFs commonly describe the program as equipping them with a series of new peda-gogical skills and tools, creating an inclusive and supportive community of friends and peers, improving their self-confidence in teaching/men-toring students and entering the academic job market, and providing emotional support through times of difficulty. Furthermore, only a few PFs in the 2018 and 2019 cohorts mentioned challenges in balancing research obligations with the PF courses and TAPDP responsibilities; even these students felt that benefits of the program outweighed any

difficulties. Anecdotal evidence suggests that PFs are competitive in the academic job market, in both teaching and research-focused institutions. Furthermore, PFs have been successful in acquiring jobs in educational development careers (e.g., directing community learning initiatives). We plan to study job placement of PFs as compared to the general graduate student population in the future, in order to empirically assess the value of the PF Program for career opportunities.

The PFs provide a substantial service to the university by facilitating the previously described TAPDP training. To help prepare PFs in leading the TAPDP, the fellows write a thorough draft of each workshop that includes the following: an abstract summary, learning outcomes, activities to assess learning outcomes, needed supplies and preparation, a schedule of workshop segments, and a written narrative of what the PF intends to say. The director of DTEI and a postdoc then review each workshop draft and provide extensive feedback (e.g., suggestions for timing, activities, and/or content). In addition, PFs practice a select workshop with their PF cohort; this gives PFs an opportunity to participate in a workshop for each topic covered (e.g., active learning, holding office hours) as well as the opportunity to receive peer feedback on their own workshop style and approach. As additional support, PFs are able to review an archive of prior TAPDP workshop drafts and adapt these materials for their own purposes. Participant feedback of the TAPDP trainings are highly positive. For example, out of 615 survey responses for the 2019 TAPDP, 53% of TAs rated the TAPDP training as *excellent*, 34% rated the training as *very good*, and 9% rated the training as *good*. Only 2% rated TAPDP as *fair*, and less than 1% rated the training as *poor*.

The experience of developing curriculum for and facilitating TAPDP introduces PFs to the field of educational development. Some PFs particularly enjoy the work of training TAs and volunteer to facilitate the DTEI workshops including the Course Design Certificate Program for a small, one-time stipend. When PFs choose to do at least 10 hours of educational development service beyond the one-year program, they are designated as senior PFs. We regularly re-hire a small group of

senior PFs to cover our TA training needs in departments in which we do not have a representative PF in any given year.

After learning from the education literature throughout our programs, some 390X students and PFs get interested in conducting similar research on their teaching and choose to take University Studies 395: Teaching as Research Seminar. The director teaches this seminar, and the class meets for one hour a week over the 10-week quarter. The seminar helps prepare students to conduct a pedagogy-focused research project and draft a research proposal. Students review education research within their disciplines, identify research questions to address, and then design a simple "teaching-as-research" project within their discipline. Within the course, students create an Institutional Review Board application for their research project. Furthermore, students conduct classroom observations, identify validated survey instruments within their disciplines, create their own survey instruments, and practice managing data sets with sample data. Those who actually implement a study and share their results via publication or presentation, including at venues such as the CIRTL Forum and other pedagogy conferences, are able to earn the CIRTL practitioner and scholar levels of achievement.

Our newest offering is the Summer Teaching Apprenticeship Program. This program infuses faculty mentorship and DTEI training in order to prepare graduate students and postdocs to teach as the instructor of record for a course during the following summer. Even though there is no prerequisite related to experience with DTEI, participants are required to enroll in the Developing Teaching Excellence seminar or the online Certificate in Teaching Excellence and have regular check-in meetings with the director. In addition to this involvement with DTEI, participants receive mentorship from a faculty member who has taught this class, and participants work as TAs for the course or shadow the instructor as part of the training experience. This program offers a unique and significant practicum aspect that promotes and prepares graduate students for teaching as instructors of record. We recently had nine graduate students participate in the first iteration of this program.

Our DTEI postdoc position is the final step in our FFTD pipeline. The individual currently in the position was a senior PF; oversees the workshops (including the Course Design Certificate), Certificate in Teaching Excellence, Pedagogical Liaisons Program; and teaches the quarterly 390X seminar. In addition to the previously described graduate student and postdoc programs, the DTEI postdoc also works on some faculty development programs, including our New Faculty Teaching Academy and Active Learning Institute. For example, the postdoc conducts teaching consultations with faculty, facilitates course design workshops for incoming faculty, and leads workshops pertaining to assessments and other topics as needed. With the success of this first DTEI postdoc, we expect to continue to fill this postdoc position with senior PFs, providing an entry point into the broader field of educational development. Since there are many indirect pathways into educational development (Cohen, 2010; McDonald, 2011), we are intentional about providing a clear starting point into this career path. The DTEI postdoc position offers this through multiple training and networking opportunities. For example, the DTEI postdoc is encouraged to pursue pedagogical research, present at international conferences, and facilitate programs and courses as instructor of record both in pedagogy and in their home discipline.

In addition to the primary programs described above, we offer travel grants, frequent one-on-one consultations, and other customized trainings, which also serve as entry points into this educational development pipeline.

Table 1. Graduate and Postdoctoral Program Participation in 2018–2019 Academic Year

Program	Participants
TA professional development program & international TA training	738
Workshops	391
Certificate in Teaching Excellence	26
Developing Teaching Excellence seminar	51
Pedagogical Liaisons Program	12
Pedagogical Fellows Program	30 (2018), 23 (2019)
Teaching as Research seminar	14
One-on-one consultations	136
Total	1,421

Strategies for Efficiency & Cohesion

Every context is unique, but the general principles laid out in this framework may be transferable to educational development at other institutions:

1. Implement a cascading mentorship model.
2. Leverage the most successful programs.

In order to create extensive programming with limited staff, we were required to be efficient with our resources. To begin with, the majority of our program facilitation is through the pedagogical fellows (and senior PFs) and the DTEI postdoc. This frees up the director to focus more on bigger picture goals, external collaborations, and leadership opportunities. By implementing a cascading mentorship model for the majority of the TA training and future faculty programs, we believe that the efficacy of our programs increases for both the facilitators and participants. In order to maintain the quality of these trainings, the director and postdoc require prepared lesson plans aligned with strong learning outcomes and relevant activities. In addition, the director or postdoc attend the majority of workshops facilitated by our senior PFs in order to provide feedback and shape future programming. The director and postdoc also regularly collect data from participants to assess the outcomes of each program. When possible, participants are asked to conduct pre- and post-program surveys related to learning objectives to assess gains in knowledge and skills. Similarly, for our pedagogy courses, we administer pre- and post-course surveys, covering a range of topics from knowledge of pedagogical concepts and tools to perceptions of a supportive pedagogy community. Virtually all program and course questionnaires include Likert scale survey questions in addition to open-ended questions, allowing for statistical and qualitative analysis. For example, in each program (e.g., workshops, trainings) participants are asked to submit a feedback form; these forms often ask participants to assess their facilitators (e.g.,

preparedness, instruction) as well as evaluate the content and structure of the program. Participants are asked to explain which aspects of a program were most effective, to rate the overall quality, and to explain how we can make a program more useful or helpful. Finally, facilitators are asked to provide a reflection of their experience leading their programs (e.g., what strategies worked well, what aspects could be changed). Additionally, facilitators have the option to meet with the director and postdoc to discuss recommendations for improving programs going forward. These frequent and comprehensive forms of feedback allow for continually improving less successful components of programs and courses as well as establishing frameworks for continuing and expanding upon successful strategies.

For small CTLs interested in the process of beginning to delegate responsibilities and establish facilitators for existing programs, we recommend carefully identifying partners who are (or can be developed into) pedagogy experts and align with the CTL's mission and values. For example, our recruitment of the PFs is an intensive process considering the prerequisites and application/interview processes; however, this allows us to confidently entrust the fellows with facilitating our campus-wide TA training, DTEI workshops, and peer observations. Oversight of this delegation is non-trivial, but it should be less demanding than running the programs on your own. This is a critical step in building a robust pipeline of educational development.

Once a CTL identifies a successful program, it can serve as a launching point and tie together prerequisites or next levels to begin building the CTL program pipeline. At UCI, this was our Pedagogical Fellows Program, and we were able to boost the Developing Teaching Excellence seminar (390X), Pedagogical Liaisons Program, and Senior Pedagogical Fellows Programs as a result. The success of the PF Program also has created a pipeline to our enormously valuable DTEI postdoc position. After the Developing Teaching Excellence seminar (390X) became popular and a critical component of our pipeline, it was logical to embed it into our CIRTL programming, Certificate in Teaching Excellence, and Summer Teaching Apprenticeship Program.

UCI's pipeline is cohesive because the prerequisites help clarify the order in which one should explore our programs, and there is more overlap than there is redundancy in the curriculum. We offer additional advice for how to approach our programs on our website, during information sessions, and through email or one-on-one consultation. This combination of options for graduate students and postdocs to learn about our programs has resulted in less confusion as we elaborate on our communication strategies.

Our goal is to continue to expand and improve upon the pipeline at each point. For example, we have developed a new seminar course that aims to guide participants through preparation of all the materials for an upcoming course. In this course, 390Z: Advanced Course Design for Instructor of Record, graduate students prepare materials (e.g., syllabus, lesson plans, assessments) for a class they are confirmed to teach in the future. As of publication, one cohort has completed this course. The workload on the team will remain balanced by replacing one quarter of the Developing Teaching Excellence seminar with this new course. As long as the team keeps a close eye on managing workload through prioritization and optimization strategies, we expect to be able to gradually expand and improve our offerings to graduate students and postdocs.

Challenges

An ongoing challenge is faculty resistance to supporting educational development at a research university. Their personal resistance affects the way that they mentor graduate students and postdocs who are struggling with an increasingly competitive academic job market in which educational development is often an asset. Tensions with faculty cause many graduate students and postdocs to feel conflicted or even secretive about their educational development. At UCI, we do see signs of a culture shift that is more supportive of teaching. This culture shift is partially evidenced by the increased hiring of professors of teaching, a unique tenure-track teaching focused

position within the UCI system, and institutional commitments to developing buildings and classrooms designed for active and collaborative learning. We also find a core audience of both research and teaching faculty who are proactively seeking and engaging in educational development programs. We aim to leverage these faculty to increase awareness and support of our graduate student and postdoc programs.

Due to limited and temporary funding for staff, we apply for external funding opportunities in order to maintain our small team. This limited funding restricts us to having a postdoc rather than a permanent position such as an assistant director. With this temporary postdoc position, we will need to restart the training process every two years; however, there is the benefit of periodically inviting fresh perspectives and ideas. We attempt to reduce some of the onboarding challenges by targeting the pool of senior pedagogical fellows for our postdoc recruitment. CTLs with less funding may have even greater challenges in incorporating a similar number of programs and services; however, there are several possibilities for ameliorating financial limitations. In addition to applying for external revenue sources, CTLs could partner with departments and schools to share the costs of the stipend for PFs. These stipends primarily compensate PFs for their work in administering the TAPDP training, which provides a service to departments/schools. Furthermore, the stipend could possibly be lowered if needed, due to the facilitators' perceived value of the professional and instructional experience of leading TAPDP and participating in the PF Program.

Summary

It is possible to manage efficient and coherent educational development programs with a small staff. This pipeline of graduate student and postdoc development, including some of our challenges, may help guide others in building a similar pipeline at their institutions. By

increasing our capacity to support instructors, we enable them to do more for our students and institutions as a whole.

Biographies

Daniel Mann is the Director of Graduate Student and Postdoctoral Scholar Instructional Development at the Division of Teaching Excellence and Innovation (DTEI) at the University of California, Irvine. Daniel holds a Ph.D. in Cognitive Science, and his research interests focus on assessment of educational development, graduate student development, and the cognitive science of learning.

Matthew Mahavongtrakul is a Postdoctoral Scholar with the Division of Teaching Excellence and Innovation (DTEI) at the University of California, Irvine. He was the facilitator for the Developing Teaching Excellence and Advanced Course Design courses and currently provides formal pedagogical training to graduate students, postdoctoral scholars, and faculty. Matthew holds a Ph.D. in Biological Sciences.

Ashley Hooper is a Postdoctoral Scholar with the Division of Teaching Excellence and Innovation (DTEI) at the University of California, Irvine. In her current position, she teaches graduate level pedagogy courses and supports doctoral students and postdoctoral fellows in their career development. Her current research interests focus on the potential for pedagogy training in alleviating 'imposter syndrome' and fostering supportive academic peer groups. She holds a Ph.D. in Urban and Environmental Planning and Policy.

Acknowledgments

References

Allgood, S., Hoyt, G., & McGoldrick, K. (2018). The role of teaching and teacher training in the hiring and promotion of Ph.D. economists. *Southern Economic Journal*, *84*(3), 912–927. https://doi.org/10.1002/soej.12252

American Association for the Advancement of Science. (2011). *Vision and change in undergraduate biology education: A call to action.* https://live-visionandchange.pantheonsite.io/wp-content/uploads/2013/11/aaas-VISchange-web1113.pdf

Association of American Universities. (2013). *Framework for systemic change in undergraduate STEM teaching and learning.* AAU Undergraduate STEM Education Initiative.

Austin, A. E. (2011, March 1). Promoting evidence-based change in undergraduate science education. https://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_072578.pdf

Austin, A. E., & Wulff, D. H. (2004). The challenge to prepare the next generation of faculty. In D. H. Wulff & A. E. Austin (Eds.), *Paths to the professoriate: Strategies for enriching the preparation of future faculty* (pp. 3–16). Jossey-Bass.

Border, L. L. B., & von Hoene, L. M. (2010). Graduate and professional student development programs. In K. J. Gillespie & D. L. Roberston (Eds.), *A guide to faculty development* (2nd ed., pp. 327–346). Jossey-Bass.

Brinthaupt, T. M., Cruz, L., Otto, S., & Pinter, M. (2019). A framework for the strategic leveraging of outside resources to enhance CTL effectiveness. *To Improve the Academy*, *38*(1), 82–94. https://doi.org/10.1002/tia2.20089

Brownell, S. E., & Tanner, K. D. (2012). Barriers to faculty pedagogical change: Lack of training, time, incentives, and . . . tensions with professional identity? *CBE—Life Sciences Education*, *11*(4), 339–346. https://doi.org/10.1187/cbe.12-09-0163

Center for the Integration of Research, Teaching and Learning (CIRTL). (n.d.). *Learning outcomes.* https://www.cirtl.net/about/learning_outcomes

Cohen, M. W. (2010). Listen, learn, lead: Getting started in faculty development. In K. J. Gillespie & D. L. Roberston (Eds.), *A guide to faculty development* (2nd ed., pp. 67–82). Jossey-Bass.

Connolly, M. R., Lee, Y.-G., & Savoy, J. N. (2018). The effects of doctoral teaching development on early-career STEM scholars' college teaching self-efficacy. *CBE—Life Sciences Education*, *17*(1), Article 14. https://doi.org/10.1187/cbe.17-02-0039

Connolly, M. R., Savoy, J. N., Lee, Y.-G., & Hill, L. B. (2016). *Building a better future STEM faculty: How teaching development programs can improve undergraduate education.* Wisconsin Center for Education Research, University of Wisconsin–Madison.

Feldon, D. F., Jeong, S., Peugh, J., Roksa, J., Maahs-Fladung, C., Shenoy, A., & Oliva, M. (2017). Null effects of boot camps and short-format training for PhD students in life sciences. *Proceedings of the National Academy of Sciences, 114*(37), 9854–9858. https://doi.org/10.1073/pnas.1705783114

Goodwin, E. C., Cao, J. N., Fletcher, M., Flaiban, J. L., & Shortlidge, E. E. (2018). Catching the wave: Are biology graduate students on board with evidence-based teaching? *CBE—Life Sciences Education, 17*(3), Article 43. https://doi.org/10.1187/cbe.17-12-0281

Hill, L. B., Austin, A. E., Bantawa, B., & Savoy, J. N. (2019). Factors of success: Building and sustaining teaching professional development opportunities for doctoral students and postdocs. *Higher Education Research & Development*, *38*(6), 1168–1182. https://doi.org/10.1080/07294360.2019.1616677

Hoy, A. W. (2003–2004). Self-efficacy in college teaching. *Essays on Teaching Excellence*, *15*(7), 165–184.

Lund, T. J., & Stains, M. (2015). The importance of context: An exploration of factors influencing the adoption of student-centered teaching among chemistry, biology, and physics faculty. *International Journal of STEM Education*, *2*(1), Article 13. https://doi.org/10.1186/s40594-015-0026-8

McDonald, J. (2011). Charting pathways into the field of educational development. In J. McDonald & D. Stockley (Eds.), *Pathways to the profession of educational development* (pp. 37–45). Jossey-Bass.

Nyquist, J. D., Abbott, R. D., Wulff, D. G., & Sprague, J. (1991). *Preparing the professoriate of tomorrow to teach: Selected readings in TA training*. Kendall/Hunt Publishing.

Nyquist, J. D., & Wulff, D. H. (1996). *Working effectively with graduate assistants*. Sage Publications.

Parker, M. A., Ashe, D., Boersma, J., Hicks, R., & Bennett, V. (2015). Good teaching starts here: Applied learning at the Graduate Teaching Assistant Institute. *Canadian Journal of Higher Education*, *45*(3), 84–110.

President's Council of Advisors on Science and Technology. (2012, February). *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics.* https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_2-25–12.pdf

Prieto, L. R., & Altmaier, E. M. (1994). The relationship of prior training and previous teaching experience to self-efficacy among graduate teaching assistants. *Research in Higher Education*, *35*(4), 481–497.

Prieto, L. R., & Meyers, S. A. (Eds.). (2001). *The teaching assistant training handbook: How to prepare TAs for their responsibilities*. New Forums Press.

Shortlidge, E. E., & Eddy, S. L. (2018). The trade-off between graduate student research and teaching: A myth? *PLoS One, 13*(6), Article e0199576. https://doi.org/10.1371/journal.pone.0199576

Stains, M., Harshman, J., Barker, M. K., Chasteen, S. V., Cole, R., DeChenne-Peters, S. E., Eagen, M. K., Jr., Esson, J. M., Knight, J. K., Laski, F. A., Levis-Fitzgerald, M., Lee, C. J., Lo, S. M., McDonnell, L. M., McKay, T. A., Michelotti, N., Musgrove, A., Palmer, M. S., Plank, K. M., . . . Young, A. M. (2018). Anatomy of STEM teaching in North American universities. *Science, 359*(6383), 1468–1470. https://doi.org/10.1126/science.aap8892

Tanner, K., & Allen, D. (2006). Approaches to biology teaching and learning: On integrating pedagogical training into the graduate experiences of future science faculty. *CBE—Life Sciences Education, 5*(1), 1–6. https://doi.org/10.1187/cbe.05-12-0132

Vergara, C. E., Urban-Lurain, M., Campa, H., Cheruvelil, K. S., Ebert-May, D., Fata-Hartley, C., & Johnston, K. (2014). FAST-Future Academic Scholars in Teaching: A high-engagement development program for future STEM faculty. *Innovative Higher Education, 39*(2), 93–107.

Wiggins, G., & McTighe, J. (2005). *Understanding by design.* Association for Supervision and Curriculum Development.

Wurgler, E., VanHeuvelen, J. S., Rohrman, S., Loehr, A., & Grace, M. K. (2014). The perceived benefits of a Preparing Future Faculty program and its effect on job satisfaction, confidence, and competence. *Teaching Sociology, 42*(1), 50–60. https://doi.org/10.1177/0092055x13507782