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Doctoral and Postdoctoral STEM Teaching-Related Professional Development: Effects on Training and Early Career Periods

Jana Bouwma-Gearhart,[1] Susan Millar, Shihmei Barger, and Mark Connolly

Illustrative Stories

Vignette 1. How do we encourage those talented and committed young scholars who are apprehensive about teaching to take up roles as college educators? Upon realizing during graduate school in engineering that no significant opportunity to learn the craft of teaching was available to her, Andrea[2] became apprehensive about embarking on a faculty career and began planning a career in industry, where she would not have to perform a role for which she was untrained. Yet, on the off-chance that she might ultimately pursue a faculty position, she took advantage of teaching-related professional development (TPD) activities that were available to her as a postdoctoral researcher (postdoc). Through these TPD experiences, Andrea not only obtained the formal training she sought, but also became excited by new pedagogical theories, tools, and methods; developed confidence through opportunities to practice; and decided that a faculty career was right for her after all. Andrea is now a new assistant professor at a research university, where she seeks out colleagues who are interested in teaching and learning issues and where she is using her TPD in developing and teaching her first courses.

Vignette 2. Are STEM doctoral students who want to benefit from the knowledge of education researchers able to negotiate the disciplinary barriers (Becher & Trowler, 2001) that separate the STEM and education fields? Planning to become a science professor at a research-intensive university, Elaine sought out TPD opportunities as a doctoral student at the University of Wisconsin–Madison (UW-Madison). The TPD communities in which she participated offered opportunities to understand the value of education research and to comfortably discuss issues of faculty life and commitments and the struggles and triumphs of teaching. Now Elaine holds a part-research, part-teaching postdoctoral position at a major research university. While she has had few true teaching opportunities in which to practice TPD knowledge and skills learned in graduate school, her TPD experiences have led others to seek her advice regarding teaching and learning and to nominate her to a prestigious teaching academy. And, during her search for a postdoc, potential employers viewed her as a "science education specialist." She believes that her graduate TPD experiences led to these unexpected opportunities. She expects to help develop a TPD program upon becoming a science professor.

Vignette 3. Roughly 50% of those who begin doctoral programs leave without receiving a PhD degree (Bair & Haworth, 2004; Golde & Dore, 2001). What happens to STEM doctoral students who participate in TPD and then leave their doctoral programs? Mike began a doctoral program in engineering at UW-Madison, with the goal of becoming a professor at a small liberal arts college. While maintaining good standing in

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[2] Participants' names have been replaced by pseudonyms to protect confidentiality.

his research program, he participated in many TPD activities and earned a teaching certificate. He also became involved in various teaching and outreach activities, such as teaching science courses at a local technical college. Unfortunately, Mike's doctoral research project was abruptly terminated by his advisor. Left to identify and complete a new project to finish his PhD, he chose instead to parlay his master's degree into a full-time education outreach specialist position for a STEM education reform project. Mike is now exploring options for teaching courses at small colleges as academic staff. When he lost his doctoral research project, TPD enabled Mike to pursue options that otherwise would not have been available to an engineering graduate student.

The stories of this assistant professor, postdoctoral researcher, and university outreach specialist begin to provide insight into our larger research question: *What effect does teaching-related professional development during doctoral and postdoctoral (preservice)*[3] *training have on the attitudes, knowledge, teaching practices, and career trajectories of aspiring college/university educators (ACEs)*[4] *in the STEM fields as they prepare for and move into their early careers?* In this paper, we explain why we believe this research question is of interest to higher education change and policy makers, as well as higher education researchers. After providing background information on a longitudinal study of ACEs who have had TPD, we describe our research methods and report on early findings that address our research question. We conclude by discussing implications for pre- and in-service TPD programs and for future research.

Background and Purpose

TPD projects have emerged in the last decade as one response to (a) concerns that the U.S. may be losing its competitive and creative edge in STEM undergraduate education and (b) calls for colleges and universities to play a more prominent role in improving STEM education and increasing the number of STEM graduates (Committee on Science Engineering, and Public Policy, 2006; U.S. Department of Education, 2006; U.S. Office of Science and Technology Policy, 2006). Those who initiate TPD programs believe that better training of postsecondary educators can directly result in improved undergraduate STEM education. At the same time, some university leaders are aware that they have an excellent opportunity, as their post-WWII faculty hires retire (Sugar, Pruitt, Anstee, & Harris, 2005; National Research Council, 1991), to hire new STEM faculty who have knowledge of teaching and learning.

However, attempts to train ACEs in teaching may not be welcomed by university administrators, doctoral programs, or the employers of postdocs. For at least the last 3 decades, doctoral and postdoctoral training at research universities has focused heavily on research, often to the exclusion of training for teaching and other faculty responsibilities (Boyer Commission,

[3] We borrow the term *preservice* from the K–12 education sector, which uses the term for college students who are training for careers as teachers. When these students move into their first teaching positions, they are viewed as *in-service* educators. Their first 2–3 years as new educators are often referred to as their *induction period*.

[4] Because instructional academic staff provide a significant proportion of undergraduate instruction, we use the term *aspiring college/university educators*, which is more inclusive than *future faculty*, to describe doctoral students and postdoctoral researchers who expect teaching or outreach to be a component of their work in postsecondary institutions.

2002), even though faculty positions in most colleges and universities are primarily devoted to teaching (Lindholm, Szelenyi, Hurtado, & Korn, 2005) and the relatively few positions available in research universities entail increasingly high expectations for teaching excellence (Boyer Commission, 2002; Kuh, 2004; Evans, Grace, & Roen, 2005). In general, STEM ACEs, whether doctoral students or postdoctoral researchers, find that their apprenticeships for faculty careers focus heavily on research at the expense of participating in training for other aspects of faculty work. Reflecting on this situation, Golde and Dore (2001) concluded that there is a three-way misalignment among (a) doctoral students' *goals* to be good educators, (b) their actual *training*, and (c) their subsequent *careers*. ACEs afforded opportunities to teach often do so without effective training and tend to teach "naively" (Cross, 1990)—that is, by choosing a teaching approach not because they know it fosters deep student learning, but because it mimics how they were taught. Such naive approaches often rely on inaccurate assumptions about teaching and learning. In short, as a result of this pervasive training-career misalignment, many ACEs are ill prepared to function effectively in the diverse settings in which they will work.

To mitigate this crisis of the professions and address concern about the national need for more effective STEM undergraduate education, a number of influential higher education leaders, faculty, and staff are implementing programs for providing TPD to STEM ACEs. These individuals, whom we call *TPD advocates*, have garnered substantial public and private funding to support their efforts. All of them are offering programs that are informed by research on learning and that use tested and often innovative teaching methods. Examples of these TPD programs include the Center for the Integration of Research, Teaching, and Learning (CIRTL; http://cirtl.wceruw.org/proposal); the Wisconsin Program for Scientific Teaching (WPST; Handelsman, 2003); the Graduate Students in K–12 Fellowship Program (GK–12; Gilmer, Granter, & Butler, 2005); the Preparing Future Faculty program (PFF; Gaff, Pruitt-Logan, Sims, & Denecke, 2003); the Carnegie Initiative on the Doctorate (Golde & Walker, 2006); and the Responsive Ph.D. Program (Woodrow Wilson National Fellowship Foundation, 2005). All of these preservice TPD programs share a common goal—to provide aspiring college educators at research universities with exposure to research-informed knowledge and skills, attitudes, and practice in hopes of enabling them to more effectively teach undergraduates.

The only substantive research available on the success of TPD programs for ACEs is a study that investigated the overall impact of the national PFF program. This study identified 129 alumni of PFF programs who were subsequently hired in faculty positions and found that PFF participation helped these alumni negotiate challenging academic job markets and balance their teaching and research responsibilities (DeNeef, 2002). However, this study did not present participant views on the value of their newfound pedagogical knowledge and skills or attempt to understand the effects of TPD on participants as they moved through doctoral programs and postdoctoral appointments (an often overlooked stage of ACE preparation) and into their early career positions. Here, we attempt to provide preliminary information of this type. We believe that this paper, and the larger study on which it is based, will be of interest to people who are implementing or considering implementing pre- and in-service TPD programs, and to policy makers, funders, and researchers who focus on improving undergraduate STEM education.

Study Context

To answer our research question, we designed a 3-year qualitative longitudinal study of STEM ACEs who participated in at least one TPD program at UW-Madison. All (51) ACEs in the study participated or are still participating in the Delta Program in Research, Teaching and Learning (http://www.delta.wisc.edu), which is part of the National Science Foundation–funded CIRTL program.[5] Many study participants also participated in some other form of TPD while at UW-Madison, such as the Wisconsin Program for Scientific Teaching (funded by the Howard Hughes Medical Institute; http://scientificteaching.wisc.edu); the UW project of the National Science Foundation's GK–12 program initiative; or national endeavors such as the Mathematical Association of America's Project NExT. (In addition, many participated in some form of teaching assistant training, but because almost all interviewees described such training as having little professional development value, we do not consider it as a TPD program in the sense used in this paper.) Since relatively few ACEs in our sample participated in these other TPD programs, we provide context on just the two programs that attract the most participants at UW-Madison: Delta (in which all of our interviewees participated) and WPST (in which some of our interviewees participated).

Delta and WPST provide STEM and life-science ACEs, respectively, with TPD opportunities that emphasize innovative, research-based teaching practices, and help participants integrate their research and teaching. Both programs aim to foster among participants a habit of examining their teaching practices using approaches akin to scientific disciplinary research, a process dubbed *teaching-as-research* by CIRTL (Mathieu, 2004) and *scientific teaching* by WPST (Handelsman, Miller, & Pfund, 2006). Launched in 2003, Delta currently offers six semester-long courses, three small-group facilitated programs, internships, roundtable dinners, a certificate program, targeted workshops, and discussion groups. WPST also offers courses and regular workshops as part of its Teaching Fellows Program focused on graduate students and postdocs in the life sciences. Sharing purposes and a target audience, WPST and Delta collaborate through course offerings, conferences, and resource sharing. As of 2006, more than 1,000 people had participated in Delta, including 658 doctoral students and 165 postdocs, making it UW-Madison's most prominent TPD program for STEM individuals. Approximately 400 graduate students and postdocs in the life sciences have participated in WPST since its inception, making it a significant TPD initiative for ACE life scientists at UW-Madison.

Study Sample and Methods

As noted above, we selected a sample of 51 STEM ACEs (39 doctoral students and 12 postdoctoral researchers) who participated in the Delta program. Of these, 18 had participated in some other STEM-specific TPD at UW-Madison, including WPST.

To answer our main research question pertaining to the effects of TPD on ACEs as they prepare for *and* transition into their early professional roles, we report on our cross-sectional analysis of all 51 of our interviews. The sample was selected to represent the academic status,

[5] The CIRTL program is funding the first 3 years of our study, in part because it wants to benefit from findings about the effectiveness of the program. Accordingly, all the members of our study sample are ACEs who have participated in some way in the Delta program.

field of study, and gender distribution of all STEM ACEs at UW-Madison, modified to also reflect distribution within the Delta participant database. (See Table 1.)

To better gauge changes in teaching perceptions and behaviors, career choices, and career readiness, participants also were selected according to their point in career at the time of their first interview in spring 2005 (Table 2). We grouped participants into these categories:

- *Early doctoral student:* Interviewees in their 1st or 2nd year of doctoral study
- *Mid doctoral student:* Interviewees who had passed their preliminary examinations but were 1 or more years away from completing their PhDs
- *Late doctoral student:* Interviewees who expected to complete their PhDs within 1 year
- *Postdoctoral scholar:* Interviewees holding a doctoral degree and employed as a postdoctoral fellow, postdoctoral trainee, or research associate at UW-Madison

As of spring 2006, the 51 participants represented a wider range of situations relative to completing their work at UW-Madison. Of 22 who had left or were about to leave UW-Madison, 8 had transitioned to a position at a different institution, 6 had accepted a new position for fall 2007, and 8 were actively seeking a new position elsewhere. The remaining 29 were continuing in their positions at UW. Of these, most expected to complete their doctorate in either 2007 (10 respondents) or 2008 (8 respondents). We learned that 4 expected to finish between 2009 and 2011. We do not have clear information about when the other 7 (1 postdoc and 6 doctoral students) planned to complete their degree or their postdoctoral appointment. Based on this information, we anticipate learning during our spring 2007 interviews that a large proportion of our interviewees have moved to a new position.

Although WPST requires that most of its attendees participate in an established sequence of activities, the Delta program is designed to allow doctoral students and postdoctoral scholars to participate in any of its multiple activities and as much or as little as they wish. To account for this variability in participation, we calculated a measure of Delta *engagement* (the total number of hours a person participated in activities of the Delta program) for our interviewees. Table 3 shows that we grouped the participants into engagement categories based on contact hours:

- *Low engagement* (*LE*; 1–8 hours): Interviewees at this level participated in roundtable dinners, workshops, and/or brownbag events. (No participants had between 9 and 29 hours because of the big jump in contact hours associated with taking a Delta course.)
- *Moderate engagement* (*ME*; 30–59 hours): Interviewees at this level took at least one graduate course and may also have participated in an internship, discussion groups, roundtable dinners, workshops, or brownbag events.
- *High engagement* (*HE*; 60–109 hours): Interviewees at this level took at least two graduate courses and may have received a Delta certificate or participated in various other Delta activities.

We chose a sample that is biased toward individuals with ME (43% compared to 19% for the full group) and HE (24% compared to 9% for the full group) because people with LE (no course participation) interviewed in 2005 tended to have relatively little to say about their experience with Delta. Additionally, we found engagement was the most important criterion with respect to TPD effects on participants. ME and HE interviewees, on average, claimed more TPD impact, and we felt the need to interview more of these interviewees in order to support generalizations about people with high TPD engagement and to provide better insight into the particularities of experiences of those engaged in TPD. In line with our initial assessment that it is important to understand the effects of TPD in terms of level of engagement, we present our 2 years of findings on TPD effects in terms of low, moderate, and high levels of Delta engagement. We are aware that Delta engagement provides only a partial measure of overall TPD experience for those interviewees who have substantial engagement with other TPD programs. Although we intend to provide analysis that takes into account the effect of these other programs, this has not yet been completed for all 51 of our interviewees. Thus, while we refer in the Findings section to the overall impact of other UW-Madison TPD programs that interviewees reported, our cross-sectional analysis provides information about interviewees' level of engagement *only* with respect to the Delta program.

We also present findings from a longitudinal case analysis of the 8 members of our sample who made a significant professional transition between our 2005 and 2006 interviews. These 8 cases of *position transition* allow us to examine TPD effects on career trajectories, including (a) what kinds of career paths ACEs take when leaving doctoral or postdoctoral training positions and (b) whether TPD influences their choice of job and their early adjustment experiences, especially related to teaching-related responsibilities.

Table 4 provides information on the major type and level of TPD that each of these 8 people had experienced by the time they transitioned into their first professional positions. In contrast to our process for reporting on levels of engagement for our cross-sectional analysis, we have had the opportunity to classify the 8 people whose cases we studied by their *overall* TPD participation levels, including participation in WPST. We classified overall participation as low, moderate, or high using a rubric.[6] Of the 8 people who had transitioned to new positions, 7 were classified as having high levels of overall TPD participation at UW-Madison, while one was classified as having a low level.

Table 4 also indicates that these 8 study participants were evenly distributed by sex (4 women, 4 men) but represented only four of the fields in our sample (4 biology, 2 engineering, 1 mathematics, and 1 physical science). Three transitioned from postdoc roles: Andrea and Curtis took assistant professor positions, and Karen took an academic staff position that was reclassified as a postdoc. Five transitioned from graduate student roles: Andrew took an assistant professor position, Linda and Mike took academic staff positions, and Elaine and Bill took postdoc positions. Overall, these 8 people were distributed into new positions as follows: 3 assistant professors, 2 academic staff, 2 postdocs, and 1 academic staff/postdoc.

Our annual semistructured, 90-minute interviews collected in the spring semesters of 2005 (only 22 participants due to funding constraints) and 2006 (all 51 participants) provide the

[6] Contact author for rubric.

primary source of data. (We are currently engaged in the last round of spring interviews and will report on these findings as they become available). The interview protocols used in both years focused on the same themes.[7] All interviews were recorded, transcribed, and then analyzed inductively using a grounded theory approach. Working as a team, we developed a structured codebook to provide a stable frame for the dynamic analysis of textual data. The codebook was imported into NVivo, a software package for qualitative data analysis that enabled us to jointly code the textual data. We established intercoder agreement measures to control for the reliability and validity of the coded data to the extent possible.

We emphasize that our findings must be interpreted in light of four limitations. First, as stated above, we are aware that Delta engagement can provide only a partial measure of overall TPD effect on those interviewees who had substantial engagement with other TPD programs. Second, because our findings depend on interviewee self-report, we recognize that their comments may be subject to social desirability bias. Third, we recognize that self-reported experiences recalled from memory may be filtered or modified by the very act of narration. And fourth, while a semistructured interview protocol allows interviewees to freely choose to present what is most salient, important, or memorable to them, we recognize that respondents' *failure* to mention a topic does not imply that the topic was not relevant or of concern to them. Thus, when we report counts for each detailed finding, it is important to remember that only interviewees who volunteered information specifically related to the theme or pattern were counted; we cannot infer the opinions of the interviewees who did not volunteer information on the subject. Given these circumstances, it is not appropriate to provide quantitative data at the level of detail that is justified when reporting on forced-choice responses. Therefore, to provide an understanding of the *relative* numbers of respondents who made specific points, we use the following verbal quantifiers to indicate what proportion of our 51 interviewees made specific points: *few* (3–9), *some* (10–25), *a majority* (26–35), *most* (36–45), and *virtually all* (46–51).

Findings

We categorize the impact of TPD as reported by all 51 interviewees into five types: (a) *cognitive* impact (knowledge and skills); (b) *affective* impact; (c) impact on *practice and application* (including material outcomes); (d) impact of participation in *networks*; and (e) impact on *career trajectories*. Cross-sectional findings are presented first, followed by findings from the case-based analysis of the 8 position transition interviewees. Quotes associated with each of these five categories of findings tend to be drawn from the case-based analysis. Note that all numbers refer to individuals who made a claim, not to the number of mentions that individuals made about a claim.

Cognitive Changes

Cross-sectional analysis. When asked open-ended questions about what they had learned overall from their TPD activities, many of our interviewees (23) indicated that they had gained pedagogical knowledge and skills. Some interviewees (17) stated that TPD participation had changed how they thought about teaching (e.g., thinking that teaching should be learning-

[7] Contact author for interview protocols.

focused and student-centered). These 17 interviewees told us that as a result of their TPD participation, they now knew that there is not just one way to teach—there are other nontraditional methods and tools (e.g., active learning, backwards design, information mapping, 3-D visualization, Student Assessment of Learning Gains online evaluation)—and that they thought it important to keep trying new strategies and activities. A few (8) said that they had learned some "nuts and bolts" about teaching, such as how to design a course, handle the first day of class, establish a classroom community, facilitate discussion and student learning, interact with students, engage large student audiences, and evaluate a large class. A few (7) explained that their TPD experiences had helped them become more aware of pedagogical theories and philosophies. Findings on cognitive change by level of Delta engagement are presented in Table 5. We organized these findings into groups, in line with a proven model for how individuals change, the Concerns-Based Adoption Model (CBAM; Hall & Hord, 1987). Note that interviewees with LE were more likely to report only early-stage ("awareness" and "informational") changes, whereas those with ME and HE were more likely to report both early- and middle-stage changes ("What do I need in order to use this?") (Loucks-Horsley, 1996).

By contrast, when asked a specific question about *teaching-as-research*, some (13) participants stated that they had a good understanding of the meaning of the processes to which this Delta term—or the related WPST term, *scientific teaching*—refers. In particular, these 13 interviewees had learned to use research methods to develop and implement teaching practices. Consistent with the important role that assessment plays in both the Delta concept of teaching-as-research and the WPST concept of scientific teaching, the topic that was emphasized most often by the majority of interviewees was the importance of student assessment. When asked specifically about teaching-as-research, about half of interviewees (23) reported that they were aware of various assessment approaches, techniques, and tools that are available for student assessments. However, only a few (6) stated that they knew how to use these methods to assess what students are actually learning. In addition, some (14) spoke of their awareness of the value of constantly and purposefully assessing student learning. Some of the interviewees (16) told us that Delta had introduced them to teaching resources and literature, and thus they knew where to find them when they needed them. Two said that they knew how to use education research and teaching resources to improve teaching. These findings are consistent with the importance the TPD programs place on understanding that there is an established knowledge base on effective teaching strategies.

HE seemed to be associated with a better understanding of the notion of teaching-as-research. In addition, those with HE seemed to have a better idea of how to implement teaching-as-research in their teaching—for example, by using teaching resources and student feedback to improve their teaching (see Table 6). We know that those with higher Delta engagement reported having had more opportunity to practice what they had learned, as discussed in the Practice and Application section below, and this may explain a discrepancy between low- and higher engagement interviewees with respect to implementing teaching-as-research in their teaching.

One of the objectives of the Delta Program is to promote *learning-through-diversity*, meaning that educators should (a) be aware of the diversity of students' experiences, backgrounds, and skills and the implications of these for learning, (b) employ a variety of teaching approaches to reach all students, and (c) strive to create equitable and inclusive learning environments. To gain insight into this Delta objective, we asked the interviewees, "Have you

learned anything about how to work with the differences among students in college classrooms?" Some of our interviewees acknowledged that diversity is an important issue in designing learning environments, as it can affect how well and what students learn. In particular, 17 reported that they were aware of different learning styles and the importance of incorporating diverse teaching strategies, assessment techniques, and learning activities to reach to all students. Some (11) also indicated that they were aware that students of different backgrounds, experiences, and knowledge bring diverse perspectives and viewpoints to the learning environment. A few others (8) acknowledged that gender, racial, social, religious, and cultural diversity may affect teaching and learning. It may be important to note, then, that most of our interviewees who had something to say about learning-through-diversity indicated they were only at the *awareness* level with respect to this topic. Even though the majority of the interviewees said they were aware of the issues and implications of student diversity in teaching, some still did not feel they were well prepared to teach in diverse classes. Of those who felt they needed more preparation, 9 said that they did not have practical means or strategies to deal with diversity in the classroom, and 3 mentioned that they had not had any chance to apply what they had learned. A few interviewees (10) explicitly said they either had not learned or had learned only a little from their TPD activities about the implications of diversity for teaching and learning.

We found that interviewees with HE were more aware of the effects of diversity and its implications for teaching and learning. They also had more confidence in their ability to use a variety of strategies to deal with diversity in teaching than those with LE or ME (see Table 7).

Analysis of the 8 position transition cases. Of the 8 cases of position transition, all 7 with HE reported a change in their knowledge and skills as a result of their TPD experience. This general outcome was, in fact, the type most often cited. Methods for obtaining feedback data and other teaching processes (e.g., course design and development) were specified most often and by 6 of 7 individuals. Participants often mentioned discovering new methods and skills that would allow them to promote deeper student understanding, as Andrea illustrated in this comment:

> [TPD activities] introduced me to different approaches to teaching that I had never seen before and really resonated with me, and that I'm excited about, like *just-in-time teaching*, the idea of monitoring the student's feedback and progress. I've adjusted lectures based on problems I can see that they're having.

Mentioned somewhat less often, but still by 6 of 7 participants, were newfound knowledge and skills pertaining to (a) diversity and (b) the identification and use of pedagogical vocabulary and resources, including other individuals interested in problematizing issues of teaching and learning. The following comment by Curtis illustrates how participants described this type of knowledge:

> Now I have, more of a vocabulary—*pedagogy*, *interactive learning*, *assessment*. I feel like I can walk over to the School of Education and have a conversation with people over there about research in teaching projects.

Affective Changes

Cross-sectional analysis. Many interviewees expressed emotion when they described how they became more aware of new ideas pertaining to teaching and learning as a result of their TPD experiences. We classified as *affective changes* those instances where participants presented new ideas as "ah ha!" moments or in other ways that indicated the new awareness had substantial affective meaning for them. For example, as participants described new awareness regarding teaching (as mentioned in the Cognitive Changes section above), they often expressed emotion with respect to (a) ideas (e.g., teachers and their practice are not static or perfect but instead evolve over time; (disciplinary) research methods can be used to assess teaching and learning; teaching does not have to occur in isolation; and continual or authentic assessment of learning is important), (b) values (e.g., being committed to and caring about student learning and diversity in the learning environment), and (c) new realizations (e.g., the understanding that there is an academic field focused on education).

Some interviewees stated that their Delta or other TPD experience resulted in an increase in their confidence (20; 6 LE, 8 ME, 6 HE) or excitement (12; 3 LE, 3 ME, 6 HE) with respect to teaching. In addition, a few interviewees (3; 1 LE, 1 ME, 1 HE) stated that Delta had increased their confidence regarding their current or future careers, given them a better sense of what faculty life is like, or generally helped them feel more empowered in fulfilling this future role.

Our findings from our interview analysis are consistent with the descriptive findings of a survey of the perceptions of and interest in teaching of STEM doctoral students and postdoctoral scholars at the UW-Madison, conducted by Barger and Webb (2006). The survey findings suggested that TPD participants had more positive attitudes and beliefs about teaching than those who had not participated in any professional development activities or who had participated in TPD programs other than Delta. Moreover, many of the TPD participants in our interview study told us that their positive attitudes and beliefs about teaching were in fact introduced, changed, or enhanced by their experiences in one or more TPD programs.

Some negative affective outcomes were cited by a few of our interviewees (7; 5 ME, 2 HE) when asked to reflect on what impact Delta had on their attitudes and feelings about learning about teaching and learning. These outcomes included feeling put off by Delta's jargon (3 ME, 1 HE) or organizational structure (3 ME) and feeling isolated or angry because their newly acquired teaching and learning stance was not being appreciated outside of Delta (2; 1 ME, 1 HE). While these findings are important and informative to Delta and other TPD programs—especially in light of the familiarity of these ME and HE interviewees with various aspects of the program—it is also important to note that all of these interviewees had a strongly positive assessment of Delta's impact on their knowledge of teaching and learning. Also of note, 2 LE interviewees asserted that Delta had no effect on their personal affect with respect to teaching and learning.

Analysis of the 8 position transition cases. Of the 8 people who transitioned to new positions, the 7 with high-level TPD participation frequently described changes in attitudes, feelings, and values. We heard 4 describe how they became committed to continuing to participate in TPD at their new institutions and to using what they had learned in TPD wherever

they went. Four expressed notably more confidence in their ability to teach. Elaine illustrated this when she commented:

> I think [my confidence] increased significantly. I think it was really empowering to be able to talk about and have knowledge of what pedagogy means and know what sorts of teaching strategies are available.

In addition, 3 people described greater excitement about teaching. Andrea's simple remark, "I'm excited about teaching now," illustrated this type of change. In fact, our findings on these 7 interviewees appear to suggest a strong correlation between a high level of TPD experience and a heightened sense of efficacy in teaching. Karen, who had a low level of TPD, stood in direct contrast to those with more TPD experience in that she expressed a low sense of teaching efficacy.

However, not all affective change was so positive. Two of these 7 high-level TPD interviewees expressed concern about how to meet very high external or internal expectations as a result of their TPD experience. And Bill spoke of the resistance he might encounter when implementing innovative teaching practices in the classroom in front of more traditional reviewers assessing him for tenure.

Practice and Application

Cross-sectional analysis. In a survey of doctoral students in the arts and sciences, Golde and Dore (2001) found that "ideally, students who aspire to become faculty should take progressively more responsible roles in teaching (as many do in research), but slightly fewer than half of the students (49.8%) reported that such opportunities were available" (pg. 22). Our interviewees indicated that their TPD participation had, in fact, helped their process towards understanding teaching. Yet, did they know how to utilize their new knowledge or skills in their teaching practice? Did they have a chance to implement what they had learned?

Most of our interviewees (45) were still doctoral students (34) or postdoctoral scholars (11) at the time of our last interview with them. Some of them (11) said that they had thus far had little chance to put the pedagogical knowledge, strategies, and tools they had acquired from their TPD into practice, but that they looked forward to doing so in the future. For example, one interviewee noted that in the Delta Instructional Materials Development course they had talked about the approaches one can take to engage students with different learning styles. He then added that he had not really put any of what he had learned into practice, either while working as a teaching assistant (TA) or while designing the course. As a TA, he had been constrained in what he could do. But he said learning styles were something he would think about in the future.

Only a few of the interviewees said that they were able to incorporate what they had learned from TPD into teaching practice through their TA positions, Delta internships, or lecturer or faculty positions. A few (6) had implemented assessment in the courses they worked on as TAs or collected student learning data in other ways. Interviewees who had been TAs also reported other approaches they had taken to implement their learning, such as working with their advisors and others to revise course materials, design a project, and develop lab processes.

As of our 2006 interviews, only a few of our interviewees (6) had teaching positions as instructors or assistant professors. With one exception, all of these individuals stated that they were practicing what they had learned from their TPD experiences. One of these, now an assistant professor, said that he had used the teaching portfolio when applying for academic positions and was now using many of the teaching strategies he had learned from his TPD to engage students and assess their learning. Another interviewee who was now a college instructor told us that she had shared teaching strategies with her colleagues at monthly brownbag meetings. She also had met with her students individually to learn how to best assist their learning and obtain feedback. On the other hand, another first-year assistant professor told us that she was not sure how much of her TPD learning she would be able to implement in the near future.

Two of the interviewees said they had been able to practice their learning in Delta courses. One had helped to run the Delta College Classroom course evaluations, and the other had helped to teach the second round of the Delta Teaching with Technology course.

As shown in Table 8, interviewees across all levels of Delta engagement (12) told us they wished they could have had more opportunities to teach, through Delta or other programs in the university. Three HE interviewees felt that Delta had not provided them with many opportunities for practice; they speculated that Delta would be even more popular if participants were given opportunities to teach. Three ME interviewees wished that Delta would provide avenues other than internships for graduate students to practice teaching, such as the opportunity to create classes from scratch and evaluate teaching activities. Three interviewees (one LE, one ME, and one HE) felt UW-Madison should provide graduate students with more teaching training and more opportunities to practice teaching.

Analysis of the 8 position transition cases. All 7 people who transitioned to a new teaching or postdoc position and who had high levels of exposure to TPD commented on opportunities to practice or apply their TPD learning, and all expressed an interest in having more practice opportunities. Of these 7, 6 described applying their new skills in different settings (courses, laboratories) and applying different techniques, such as active learning, or fostering learning communities. Elaine said she had not yet had significant opportunities to practice what she had learned in TPD. Bill cautioned that he had not had enough chance to practice what he had learned from Delta while at UW-Madison. Both indicated a strong desire to finally put their new learning to the test. In addition, 6 of the 7 people described applications of TPD that took a material form—for example, the Delta Certificate in Teaching (2), a teaching philosophy statement (4), and instructional materials (2).

Networks

Cross-sectional analysis. One of Delta's goals is to bring people together in learning communities in order to support them in pursuing the shared learning goal of improving teaching and learning. The expectations Delta leaders have for learning communities, according to one study (Brower, Carlson-Dakes, & Barger, 2007), are that (a) every member has something to offer to enhance the learning of others; (b) members develop shared language, shared practices, and shared identity; and (c) members recognize themselves as being part of the community and have a feeling of ownership of and responsibility to the community.

To ascertain how our interviewees felt about Delta as a community, we asked them to what extent they felt connected with and included and valued by Delta (Table 9). We found that most of our interviewees (38) thought that Delta provided an open, safe, and accepting learning community that made people feel included, valued, and welcomed. Of these 38, 30 claimed that they felt connected to the Delta community only when participating in Delta activities, not afterwards. Two LE interviewees described themselves as an "occasional participant of Delta" and "user of Delta service." One HE interviewee said he felt that only Delta offered him a community on campus. Another HE interviewee said she gravitated to Delta because it provided opportunities that her department did not provide, such as interacting with others regarding teaching.

Some of the interviewees (11) referred to the Delta community as a place to find support for teaching, to interact with others who cared about teaching, and to talk about teaching and learning. They appreciated the opportunity to connect with others in academia about their teaching experiences. For example, one of our interviewees said that Delta provided a good community and that she was introduced to several people with whom she could talk about teaching. Another interviewee said that Delta was the safest place to talk about issues of teaching and learning. Two participants thought Delta helped its participants establish a teaching network.

These findings are consistent with those from the study of Nyquist et al. (1999) on how graduate students develop into teaching scholars and faculty members. Graduate students seek real intellectual and emotional engagement with others about teaching and seek out safe environments in which to engage in conversations about teaching and learning.

We also learned that some Delta participants had enjoyed the opportunity to participate in shared learning and had developed shared language in the activities in which they had been involved. A few (5) reported that they had learned as much from other participants as from instructors or presenters. One interviewee said that the community and the interactions among people who valued teaching were the most important functions of Delta. Another told us that she had picked up teaching ideas from others in Delta and now had the means to communicate better with others about teaching. Yet another said that Delta had provided her with a place to talk about teaching and learning on campus. Similarly, 3 other interviewees recognized Delta for helping them find others who were interested in teaching and might be able to help with teaching and learning issues. Although only 2 of the interviewees voluntarily reported having developed pedagogical vocabulary though their participation in Delta, we have observed changes in the way many interviewees talk about teaching and learning issues, using common "Delta language" like *teaching-as-research* and *learning community*.

In short, interviewees with HE acknowledged the importance of a learning community that focused on teaching. One said that Delta was a "saving grace" because it provided a venue where people who really cared about teaching in a research-dominated environment could find support for their orientation. Another said:

> I am now aware of people—on this campus and in the greater academic community—who are trying to change teaching and learning on university campuses and [who do] not feel constrained to teach the way that I was always taught, and that there are people who are sort of breaking the molds and experimenting and [trying] new things.

Three interviewees alluded to future participation in a community such as Delta, stating that they intended to seek out other TPD communities in the future. However, these people also expressed some reservation regarding how other programs would ultimately "stack up" against Delta. One interviewee, an assistant professor, is now seeking out other TPD communities at his new institution. He said:

> I try to save some time, interest, and energy for institution building—and not just things in my own classroom—making sure I find the group of faculty who are interested in practicing [these new approaches to teaching] . . . [and] taking a little time to . . . see what we can do as a community.

He was one of the 3 new assistant professors in our sample who voluntarily told us that he was interested in disseminating and replicating the Delta program in his new working environment.

Analysis of the 8 position transition cases. All 7 of the individuals with high-level TPD participation spoke of the importance of the preservice TPD networks in which they had participated. All but 1 reported feeling valued by these communities. Moreover, all commented that they themselves valued and enjoyed these communities, particularly for the informal opportunities they provided for reflection with others interested in pedagogy. As Andrew put it:

> It wasn't as much about learning particular things as being involved in a community and having conversations with other people in the community.

Three carried their appreciation of TPD networks to their future positions. Andrea, Curtis, and Elaine (2 new professors and 1 new postdoctoral researcher) spoke of their plans to create or sustain similar TPD networks at their new institutions, as illustrated by Curtis' comment:

> Hopefully, we're still on Delta's radar [as a partner institution]. I would like to help facilitate that. There are little things that I can do to keep things like that moving along until I'm in a position where I can do more institution building.

These 3, and Bill, were participating in TPD programs at their new institutions.

Career Trajectories and Current Position Transition

The primary goal of the Delta Program, WPST, and related TPD programs is to prepare doctoral students and postdoctoral scholars for teaching as faculty. A study conducted by Barger and Webb (2006) for CIRTL/Delta found that 92% of Delta participants planned to work in education, in contrast to 74% of nonparticipants. Nerad and Cerny (2002), who surveyed roughly 6,000 PhD recipients from 61 research universities 10 to 14 years after degree completion, found that only 50% of the respondents aspired to faculty positions. We are thus interested in how, if at all, TPD programs affect participants' choice of career. That is, apart from whether TPD affected participants' knowledge, skills, and attitudes about teaching and knowledge about career options, we want to know whether TPD influenced the *kinds* of careers respondents were currently pursuing or planning to pursue. To address this question, we examined the differences between respondents' career aspirations before starting graduate school and their current plans.

Analysis of *actual* career trajectories for a larger proportion of our sample of 51 ACEs will be better informed by our spring 2007 interviews. For now, we report on the effect of TPD on our sample's general motivation and interest with respect to career plans, teaching, and TPD. Our information regarding actual impact of TPD experiences on the post-training careers of ACEs is best informed by the 8 interviewees who had made a significant position transition. Accordingly, we also report on this subset of data in this section.

Cross-sectional analysis of pre-training career aspirations. We asked our 51 interviewees to describe when they first developed their overall interest in teaching. For many, interest in teaching predated graduate school and developed independently of TPD. Of our interviewees:

- 14 had "always been interested";
- 19 were interested as a result of undergraduate experiences; and
- 8 had acquired interest during their graduate student experience.

For 10, information was unclear or unavailable.

We also asked our interviewees to describe the career aspirations they held upon first entering graduate school. Of the 51 respondents:

- 15 attested to a strong interest in research-focused institutions, and of these:
  - 7 desired to teach at a research-focused university; and
  - 8 hoped to get a research position;
- 10 initially wished to work outside of academia (government, industry);
- 9 had a strong interest in teaching at a teaching-focused university;
- 7 reported wanting to become a professor and teach but did not specify the type of institution or indicate if they wished to focus more on teaching or research; and
- 4 wanted to teach at an institution strong in both teaching and research.

Cross-sectional analysis of motivation for initial TPD participation. It may not be surprising that our interviewees linked their TPD participation with their teaching interest and anticipation of their future roles as educators. When asked about their motivation to initially participate in Delta or other TPD programs, 14 (3 LE, 8 LE, 3 HE) specifically alluded to a desire to improve their knowledge and skills in teaching and learning. For instance, one LE interviewee said he participated in Delta activities because he wants to be good at all that he does. He added:

> I'm very cognizant of the fact I'm not going to get a graduate degree in teaching and very aware from my own undergraduate and graduate experience that a great research

> professor does not necessarily make a great teacher. I have an obligation to at least be on the cutting edge of how to teach science and math.

Some (19; 4 LE, 11 ME, 4 HE) specifically addressed some *unmet need* they hoped TPD programs could meet with respect to preparing for their future roles as educators. A few (5; 1 LE, 1 ME, 3 HE) stated they hoped that the programs would help them prepare for a career at an institution where teaching might be a greater focus (in contrast to a research institution like UW-Madison.) While we cannot firmly attribute the desire to be better prepared to teach to TPD participation, our data may show correlation between this feeling and higher TPD participation, as demonstrated by the lower numbers of LE and ME interviewees making such statements as compared with HE interviewees. We acknowledge that this apparent correlation may indicate a tendency for higher engagement interviewees to judge their former lack of pedagogical knowledge and skills most harshly.

Sixteen interviewees (4 LE, 12 ME) talked of marketability issues when discussing initial motivation, with a majority of these (10; 2 LE, 8 ME) speaking explicitly of their hopes that their TPD involvement would reflect positively on them as a candidate in future job searches. Others (5; 1 LE, 4 ME) talked of the hope that their TPD participation would increase their chances of obtaining grants for research. Interestingly, most of our interviewees who discussed TPD participation and marketability issues were at the ME level, perhaps indicating their perception (and, perhaps, related reality) that lower engagement would not afford them what they needed to make themselves more marketable and that higher engagement was not necessary.

Cross-sectional analysis of motivation for continued TPD participation. We asked those who continued their participation in Delta or other TPD programs what motivated this participation. Twenty-eight had comments. Not surprisingly, a majority of these interviewees (18; 5 LE, 8 ME, 5 HE) stated they continued participating in TPD because they found their past participation meaningful or helpful in some way. Some of these interviewees (7; 3 LE, 3 ME, 1 HE) reported that other people involved in TPD programs encouraged their continued participation. For example, Chris summed up his thinking by saying:

> I think the people who are interested in teaching and learning are really exciting and dynamic and motivated.

A few interviewees (5; 4 LE, 1 ME) cited the diversity of participants in TPD programs as a factor that motivated their continued participation.

Some of these 28 interviewees (7; 1 LE, 3 ME, 3 HE) characterized their continued participation in TPD as a response to marketability pressures. One LE interviewee, Scott, said he was interested in taking more Delta courses because,

> When schools are evaluating potential hires, whatever they say about someone's research, what they really want, especially at the onset, is someone who can teach specific classes and not necessarily just introductory classes. . . . I am looking for a way to demonstrate that in addition to saying that I can teach things and being able to maybe do a little song and dance when I visit, that I actually have learned about this and I don't

necessarily have an education degree but I've made a sustained effort in becoming a better teacher.

Three who had recently made a position transition recognized that TPD experience was desired by institutions at which they would eventually take jobs. Interestingly, most of our interviewees who characterized their continued TPD participation as a response to job market pressure were at the moderate and high participation levels, perhaps indicating their perception (and, perhaps, related reality) that any lower participation in TPD would not afford them what they needed to make themselves more marketable.

A few (5; 4 ME, 1 HE) stated that Delta's or another TPD program's scheduling, learning format, or environment encouraged and facilitated their continued participation.

Additionally of note, half (4 out of 8) of the interviewees who had made significant position transitions during our study reported continuing to seek out TPD opportunities in their new positions as assistant researchers (2) and postdocs (2) as a result of their participation with Delta. These interviewees had high-level TPD participation, and their continued quest to engage in TPD indicated that they might want to continue to improve their pedagogical knowledge and skills.

Cross-sectional analysis of effect of TPD on career aspirations. We asked respondents (a) whether their career plans had changed during graduate school and (b) what impact, if any, Delta had had on these changes. Table 10 illustrates the relationship between the two types of responses. Of the 51 respondents, 21 said that Delta *had* influenced their career aspirations, 22 said that Delta *had not* influenced their aspirations, and 8 either were not certain or did not say.

Somewhat independent of Delta's influence on career plans are the changes in career plans that come simply with being a graduate student. In Table 10, the numbers in the columns under "Did Delta participation influence career aspirations" shows that 27 of the respondents changed career plans during graduate school. These respondents' career plans changed in the following ways:

- From a research-oriented institution to a teaching-oriented institution: 15
- From industry to academia: 5
- From academia to industry: 2
- Plans now also include informal education: 2
- From a smaller institution to a research university: 1
- From teaching: 1
- Plans now also include industry: 1.

Because of the interaction between these two effects—(a) Delta's influence on career plans and (b) the reconsideration of career plans that often occurs during the course of graduate

education—it is difficult to discern the direct effects of Delta or other TPD programs on career plans. For example, one HE engineer explained that, although his plans to work at a national laboratory had never changed, he was managing a "two-body problem,"[8] and—as a result of his involvement with Delta—he would now consider a teaching-related job. Thus, his career plans had not changed, but Delta involvement had given him more options if he had to consider other employment for the sake of his partner's career. A number of respondents still were unclear or undecided about their career plans and therefore could not yet say whether their plans had substantively changed and whether Delta participation had influenced those changes. In short, it is difficult to tell from our data which comes first: the change in career plans or Delta participation.

Breaking out these results by level of Delta engagement (Table 11), we see that changing career plans does not really vary by engagement group—that is, regardless of level of Delta engagement, roughly half were considering or had assumed a position different from that to which they had aspired at the beginning of graduate school. However, looking at respondents' assessments of Delta in particular, we see that 20 of 34 ME and HE participants believed the program had affected their career aspirations, in contrast to only 1 of 17 LE respondents.

Cross-sectional analysis of TPD effect on career preparedness. We attempted to examine whether respondents felt ready or prepared for their intended careers and whether TPD participation contributed to a sense of career readiness. However, as we have found elsewhere, some respondents had a difficult time linking certain outcomes, such as readiness or preparedness, to particular programs or activities. Therefore, although all respondents participated in Delta and, perhaps, other activities, not all of their career-related skills can be attributed to TPD participation. Table 12 lists the skills that respondents mentioned when asked to identify the aspects of their careers for which they felt most—and least—ready or prepared. The skill set mentioned most frequently related to teaching. LE participants felt most ready for research and least ready for teaching. In contrast, ME and HE participants felt most ready for teaching. For the respondents who said they felt unready for teaching, no single skill or role stands out as one they felt least ready to handle. From these data, it appears that participants with higher levels of engagement in Delta activities generally felt most ready for teaching-related responsibilities.

Analysis of the 8 position transition cases. As summarized in Table 13, our findings on the 8 position transition cases allow preliminary observations about the kinds of career paths ACEs may take upon leaving their preservice positions. We begin by noting, as we did in the cross-sectional analysis, the ways in which these participants altered their original institutional and primary professional focus. Upon starting graduate school, 5 had planned to focus primarily on conducting research. Of these 5, 3 were still pursuing their original professional aspirations at the time of their 2006 interviews. Andrea was an assistant professor at a research institution, and Elaine was pursuing her original aspiration in her new postdoc position at a research university. Bill was at a research institution, but in a postdoc position that had him conducting disciplinary and education research. Karen, at a master's institution, was more tenuously pursuing research in an academic staff/postdoc position. By contrast, Linda was pursuing an aspiration different than

[8] This term is used when both members of a domestic couple are seeking faculty positions. See Wolf-Wendel, Twombly, and Rice (2004).

that she originally intended in a temporary academic staff position at a master's institution. Upon starting graduate school, a sixth person, Curtis, had planned to focus on both teaching and research, and in 2006 he was on track to achieve this aspiration as an assistant professor at a research institution. The 2 others had originally planned to focus on teaching in a postsecondary institution, and in 2006 they were realizing this ambition: Andrew was an assistant professor at a master's institution, and Mike was focusing on STEM education in an academic staff position at a research institution.

Our interview data clarified the ways in which TPD affected the professional aspirations of the 7 interviewees with high-level TPD participation. For these 7, there appeared to be a strong correlation between TPD experience and their assessment that TPD expanded their career options, sometimes in unanticipated ways. Mike reported that TPD had allowed him to think creatively about alternative options when his dissertation research was unexpectedly terminated. Andrea stated that TPD had led her to seek a position in academia rather than industry. Bill stated that he had begun thinking about pursuing more of a teaching emphasis when he hit a "typical" point where graduate students begin to doubt a research career and to explore other options, and that at this point Delta provided a positive view of a faculty teaching career. Elaine said that TPD had expanded her view of the faculty role, and Linda reported that she was now considering taking a job at a community college. Of these 7 high-level TPD interviewees, 5 said they were currently playing, or considering playing, a role in higher education different from the one they had had in mind upon starting graduate school. Bill was enjoying his postdoc position conducting disciplinary and education research at a research institution with a history of educational innovation. Curtis' comment, below, highlights the numerous positions he would now consider accepting at a research institution:

> [Without TPD experience] I think I would still want to be a professor at a Research I–type of university, but [because of TPD] I can imagine having a larger portion of my job someday involving graduate and postgraduate education, or maybe writing a training grant with somebody like [a science education specialist], or trying to be a bridge person between people in biology and people in education. I mean, it wouldn't change the fact that I wanted to be at a place like [my current research university], but it may change what I do while I'm there.

Table 13 also highlights the possibility that TPD may play a role in helping ACEs secure their future positions, as it did for at least 6 of our participants.

In addition, all of these 7 participants explained that their TPD experiences directly affected *the transition they were currently experiencing* (20 mentions). All described positive types of impact (17 mentions), including (a) change in prospective employers' views of job options for the candidate; (b) confidence in ability to undertake the new position; (c) affirmation of and inspiration for the position; (d) overall change in approach to teaching; (e) use of diverse new teaching practices in the new situation; (f) interest in participating in science outreach at the new location; and (g) interest in creating a TPD community or providing TPD for graduate students in the new context. Negative types of impact on the current transition (3 mentions by 3 participants) included lack of preparation for working in a master's institution environment, awareness of being insufficiently prepared to use assessment in the new situation, and dissatisfaction with TPD at the new institution. The last two of these negative impacts indicate

that preservice TPD activity raised participants' expectations of their own practice and of resources at their receiving institution.

Table 13 also shows that 4 of these 8 individuals reported (without being asked) that their career trajectory had been affected by what we call *external* (to academia) *or unexpected factors*. In particular, Karen, Linda, and Andrew reported that the two-body problem was a significant obstacle in their efforts to achieve their professional aspirations. The fourth, Mike, had experienced a completely unexpected obstacle when his PhD project was canceled. Considering the external/unexpected factor in light of the "satisfaction with current position" factor, we note that 2 of the 3 people with a two-body problem reported ambivalence or dissatisfaction with their current position.

Discussion

Our interviewees confirmed the basic premise put forth by TPD advocates that doctoral and postdoctoral preparation does not address the full scope of faculty roles and responsibilities, and is especially weak with respect to the scholarship of teaching (Austin & McDaniels, 2006). Our study participants relied on TPD to help them become more effective educators, and, overall, they felt that their TPD experiences were enabling them to meet this goal.

Although our findings would be more robust and reliable if we had longitudinal data following all 51 of our interviewees into their first professional positions, the early findings reported here nonetheless indicate that TPD can have a substantial positive impact on ACEs as they work towards and assume their first professional roles. To begin with, we found that TPD expands ACEs' view of the types of academic roles they could fulfill and the types of institutions that interest them. A majority of our interviewees (27) said their career plans changed during graduate school, and about half claimed that participation in TPD had affected their career aspirations. The relationship between these two findings is not clear and a smaller proportion of LE respondents reported their career plans were affected by TPD than ME and HE respondents. Yet what is certain is that a majority of our interviewees reported being interested in teaching in the future and, as evidenced by hiring patterns across higher education, those who become faculty will have teaching as their main professional responsibility. That a majority of our interviewees asserted that their TPD experience resulted in an increase in their confidence and/or excitement with respect to teaching is a positive finding. Of note, there was a marked difference in the relative percentage of LE and ME interviewees, compared to HE interviewees, who made these statements. Our data may point to a correlation between TPD engagement and confidence and interest in the kind of teaching-intensive careers that many ACEs may in fact pursue.

Our data suggest that preservice TPD may further aid ACEs as they prepare for their future careers as educators, as TPD seems to affect ACEs' cognition and attitudes (and to a lesser degree their level of practice) regarding issues of teaching and learning, and almost always in positive ways. Somewhat confounding this finding are the cross-sectional findings pertaining to interviewees' recognition of their level of overall preparedness for their possible future careers as educators. Overall, TPD participation appears correlated for ACEs with a greater sense of efficacy in teaching and with the belief that they are better prepared than they otherwise would have been to meet their future responsibilities as educators. Many of our 51 interviewees, including the 6 position transition interviewees who had the opportunity to apply their newfound

pedagogical capacities, indicated increased excitement, confidence, or commitment to further developing their new teaching stance in the future. Of note, with respect to career readiness, an almost equal number of interviewees said they felt most ready (13) or least ready (10) for teaching. Interview data provide information on how to interpret this seeming contradiction: some Delta participants felt more ready for teaching than for other faculty roles (e.g., research), whereas others, as a result of their Delta experience, had come to understand how demanding and difficult good teaching can be and thus ended up feeling underprepared for the teaching role. Most notably, perhaps, high-level TPD participants who transitioned to positions as educators expressed views that TPD enabled them to gain *useable* knowledge and skills related to teaching and helped them adjust effectively and creatively to the teaching-related demands of their new positions. Many of our interviewees, including all 7 HE people in our group of ACEs who transitioned to new positions, expressed appreciation for TPD communities. They felt valued by these communities and saw them as providing informal and safe opportunities to reflect with others interested in teaching issues and practices and to develop new educator identities.

Although our 8 position transition cases allow only very limited generalizability to the experiences of all STEM ACEs, we believe that our findings are robust enough to indicate that the broader goal of TPD programs for STEM ACEs can be realized for individuals who have high levels of exposure to TPD. Our early data from these 8 cases also provide valuable insight into the complexity of the ACE position transition experience and into how both pre- and in-service TPD affects how ACEs manage this complexity. For example, most of these 8 interviewees indicated that their preservice TPD experiences not only helped prepare them for multiple possible trajectories, but also expanded their knowledge of, interest in, and preparation for a greater variety of career options. It also appears that TPD experiences were particularly meaningful to those 4 of the 8 who did not follow a research university trajectory. This finding confirms the value of preservice TPD activities designed to prepare ACE participants for a wider variety of possible careers. Those interviewees who had transitioned to positions at different institutions indicated that their preservice TPD was a factor in obtaining their current positions. Moreover, once in their new positions, some of these participants expressed a strong desire to participate in, or even help create, TPD communities. Data from the 8 interviewees who made significant position transitions clearly indicate that TPD can be a major positive factor for ACEs as they move into their first professional positions. In particular, those with high-level participation in TPD expressed how much they valued their new educator identities and felt that, in Andrea's words, they could "never go back" to a more traditional stance regarding their roles as educators. We suggest that this new stance is of great value, especially when adopted by ACEs who, over the course of their careers, likely will teach many thousands of undergraduates in STEM courses.

We believe our findings speak to improvements that can be made not only at the preservice (graduate and postdoctoral) institutions that prepare people aspiring to be college educators, but also at those "in-service" institutions that receive them. Our data from the 8 position transition interviewees indicate that people with high levels of preservice TPD experience some dissatisfaction with the quality of, and access to, TPD networks at their receiving institutions. Therefore, preservice TPD programs may want to incorporate coaching for ACEs who may soon find themselves teaching at institutions that are ill equipped to support their research-informed pedagogical orientation. Both preservice and receiving institutions could help make visible to early adopters (using a term introduced by Rogers, 1962) who "cannot go back"

the idea that they, even as relative novices, can act as "brokers" who introduce new practices into their communities. In addition, receiving institutions may want to assess the norms within their communities for welcoming both new faculty and non-faculty teaching staff.

Our findings also speak to a need to continue research on the longer term value of TPD for STEM ACEs. Does participation in preservice TPD really affect the professional dispersal patterns of ACEs? What level of preservice TPD engagement affords the most benefits to ACEs? Are ACEs who pursue non-faculty options as effective as faculty in acting as agents of change within receiving institutions? Last, but of great importance, will ACEs who engage in preservice TPD be better at fostering the learning of their students? These are just some of the questions we hope to pursue in the remaining year of our longitudinal study.

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Table 1
Comparison of Characteristics of Sample and Total Delta Participants

Attribute	*Characteristic*	*Sample: 51 interviewees*		*Population: Delta participants*	
		Number	*Percent*	*Number*	*Percent*
Academic status	Graduate student	39	76	511	77
	Postdoctoral	12	24	154	23
	Total	51	100	665	100
Field of study	Biological sciences	26	51	293	44
	Engineering	10	20	124	19
	Math and statistics	1	2	15	2
	Physical sciences	14	27	140	21
	Social sciences	0	0	62	9
	Unknown	0	0	31	5
	Total	51	100	665	100
Gender	Female	33	65	373	56
	Male	18	35	289	43
	Unknown	0	0	3	1
	Total	51	100	665	100

Table 2
Point in Career for the 51 Interviewees Upon Selection (Spring 2005)

Point in career	*Number*	*Percent*
Early doctoral student	12	24
Mid doctoral student	13	25
Late doctoral student	14	27
Postdoctoral scholar	12	24
Total	51	100

Table 3
Level of Delta Engagement by Spring 2006 for the 51 Interviewees

Level of Delta engagement	*Number*	*Percent*
LE[a] (1–8 hours)	17	33
ME[b] (30–59 hours)	22	43
HE[c] (60–109 hours)	12	24
Total	51	100

[a]Low engagement. [b]Moderate engagement. [c]High engagement.

Table 4

Attributes of ACEs Who Experienced Position Transition Between 2005 and 2006

Pseudonym	*Andrea*	*Curtis*	*Bill*	*Karen*	*Mike*	*Linda*	*Elaine*	*Andrew*
Sex	F	M	M	F	M	F	F	M
Academic field	Envir engr	Botany	Medical physics	Bacteri-ology	Materials sci/engr	Envir toxi-cology	Envir toxi-cology	Math/ Math ed
Point in career at first interview	P[a]	P	P	P	DS[b]	DS	DS	DS
Current position	AP[c]	AP	P	P	AS[d]	AS	AS/P	AP
Major type of TPD	Delta, WPST	Delta	Delta, non-UW	Delta	Delta	Delta, WPST	Delta, WPST	Delta, other UW
TPD level	High	High	High	Low	High	High	High	High

[a]Postdoc. [b]Doctoral student. [c]Assistant professor. [d]Academic staff.

Table 5
Cognitive Change Pertaining to Teaching in General, by Level of Delta Engagement

Interviewee responses regarding teaching in general	*Delta engagement*			*Total* N = *51*
	LE[a] N = *17*	*ME*[b] N = *22*	*HE*[c] N = *12*	
Early-stage changes				
Realized that teaching is something that evolves over time	2	3	4	9
Was introduced to pedagogical issues and the "nuts and bolts" of teaching	2	2	4	8
Became aware of pedagogical theories and philosophies	2	3	2	7
Became aware of issues of diversity in learning environments	1	1	3	5
Became aware of the academic field of education	0	0	3	3
Gained an understanding of the importance of assessing learning	1	1	1	3
Realized that teaching does not have to occur in isolation	2	0	0	2
Middle-stage changes				
Learned pedagogical knowledge and skills	5	6	12	23
Learned that there are nontraditional methods and tools for teaching	0	4	4	8
Learned the importance of being committed to and caring about student learning	1	1	5	7
Discovered that research methods can be utilized to assess teaching and learning	1	1	5	7
Learned that teaching should be learning-focused and student-centered, and interactions among students and teachers are important	0	2	1	3

[a]Low engagement. [b]Moderate engagement. [c]High engagement.

Table 6
Cognitive Change Pertaining to Teaching-as-Research or Scientific Teaching, by Level of Delta Engagement

Interviewee responses regarding teaching-as-research or scientific teaching	*Delta engagement*			*Total* N = *51*
	LE[a] N = *17*	*ME*[b] N = *22*	*HE*[c] N = *12*	
Became aware of various approaches, techniques, and tools for student assessment	0	15	8	23
Became aware of teaching resources and literature	1	7	8	16
Recognized the importance of constantly and purposefully assessing student learning	3	6	5	14
Achieved a sense of what teaching-as-research is about	1	7	5	13
Recognized the importance of continually evaluating and reflecting on one's teaching	2	3	2	7
Learned how to assess what students are learning	0	6	0	6
Learned that research skills can be applied to teaching	0	2	2	4
Discovered that technology can assist with student assessment	0	1	3	4
Realized that teaching, like research, is an iterative process that changes and evolves over time	1	0	1	2
Learned how to use education research and teaching resources to improve teaching	0	1	1	2

[a]Low engagement. [b]Moderate engagement. [c]High engagement.

Table 7
Cognitive Change Pertaining to Issues of Diversity, by Level of Delta Engagement

Interviewee responses regarding diversity	*Delta engagement*			*Total* N = *51*
	LE[a] N = *17*	*ME*[b] N = *22*	*HE*[c] N = *12*	
Became aware of different learning styles and their implications for learning	2	8	7	17
Realized that diversity is an important issue in teaching and learning	4	4	5	13
Recognized that students' backgrounds and knowledge bring diverse perspectives to the learning environment	3	4	4	11
Learned that gender, racial, social, religious, cultural diversity affect teaching and learning	1	2	5	8
Gained an awareness of the issues of working with students with physical disabilities	0	1	1	2
Either learned nothing or learned little about the implications of diversity in teaching and learning	4	5	1	10
Perceived lack of strategies to deal with diversity in teaching	2	7	0	9
Wished for an opportunity to practice what had been learned about diversity	0	1	2	3

[a]Low engagement. [b]Moderate engagement. [c]High engagement.

Table 8
Interviewee Responses Regarding Actual Teaching Practice, by Level of Delta Engagement

Interviewee responses regarding actual teaching practice	*Delta engagement*			*Total*
	LE[a]	*ME*[b]	*HE*[c]	
Wished they could have more opportunities for teaching	2	6	4	12
Learned about teaching, but haven't had many opportunities to put it to practice	3	5	3	11
Practiced Delta learning in faculty or staff positions	0	3	3	6
Implemented assessment in courses as a teaching assistant	0	4	2	6
Practiced teaching in Delta	0	1	1	2

[a]Low engagement. [b]Moderate engagement. [c]High engagement.

Table 9
Interviewee Responses Regarding Learning Communities, by Level of Delta Engagement

Interviewee responses regarding learning communities	*Delta engagement*			*Total*
	LE[a]	*ME*[b]	*HE*[c]	
Thought Delta a safe, open, accepting learning community that makes people feel included, valued, welcomed, and part of the community	14	15	9	38
Felt part of a learning community while participating but did not feel connected afterwards	12	12	6	30
Thought Delta a place to find support for teaching, to interact with people who care about teaching, and to talk about teaching	4	4	3	11
Learned as much from other participants as from instructors or presenters	0	3	2	5
Became interested in participating in other learning communities like Delta	0	2	1	3
Hoped to continue to contribute to the Delta community	0	0	2	2
Helped establish a teaching network	0	1	1	2
Developed shared pedagogical vocabulary	0	2	0	2

[a]Low engagement. [b]Moderate engagement. [c]High engagement.

Table 10
Delta Impact on Career Aspirations

		Did Delta participation influence career aspirations?			
		Yes	*No*	*Not clear*	*Total*
Did career plans change in grad school?	*Yes*	15	10	2	27
	No	6	11	4	21
	Not clear	0	1	2	3
		21	22	8	51

Table 11
Career Aspirations, by Level of Delta Engagement

	Did Delta affect career aspirations?			
Engagement	*Yes*	*No*	*Not clear*	*Total*
HE[a]	7	4	1	12
ME[b]	13	6	3	22
LE[c]	1	12	4	17
	Did career plans change during graduate school?			
Engagement	*Yes*	*No*	*Not clear*	*Total*
HE	6	5	1	12
ME	13	8	1	22
LE	8	9	0	17

[a]Low engagement. [b]Moderate engagement. [c]High engagement.

Table 12
Readiness for Career, by Level of Delta Engagement

Career-related skills for which respondents felt most *ready or prepared*	*LE*[a]	*ME*[b]	*HE*[c]	*Total*
Assuming teaching-related roles and responsibilities	2	7	4	13
Assuming research-related roles and responsibilities	6	1	0	7
Working with students	0	2	2	4
Developing a course	0	2	0	2
Doing both teaching and research	0	1	0	1
Assessing student learning	1	0	0	1
Career-related skills for which respondents felt least *ready or prepared*	*LE*	*ME*	*HE*	*Total*
Assuming teaching-related roles and responsibilities	7	2	1	10
Assuming research-related roles and responsibilities, including publishing	2	1	1	4
Dealing with academic politics	0	1	1	2
Assessing student learning	0	2	0	2
Developing a course	0	1	1	2
Writing proposals for external funding	1	0	1	2
Making public presentations	0	1	1	2
Making informed career choices	1	1	0	2

[a]Low engagement. [b]Moderate engagement. [c]High engagement.

Table 13

Career Plans, TPD Levels, and Early Career Outcomes Reported by ACEs Who Experienced Position Transition Between 2005 and 2006

Pseudonym	*Andrea*	*Elaine*	*Karen*	*Linda*	*Bill*	*Andrew*	*Mike*	*Curtis*
Pre-PhD career plans	R'er[a]	R'er	R'er	R'er	R'er	E[b]	E	E/R'er
Current position	AP[c]	P[d]	AS[e]/P	AS	P	AP	AS	AP
Current institution type	R[f]	R	M[g]	M	R	M	R	R
TPD level	High	High	Low	High	High	High	High	High
TPD a factor in getting current position	Y	Y	N	Y	?[h]	Y	Y	Y
Satisfied w/ current position	Y	Y	N	?	Y	Y	Y	Y
Career affected by external/ unexpected factors	No mention	No mention	Two-body problem	Two-body problem	No mention	Two-body problem	PhD project canceled	No mention

[a]Researcher. [b]Educator. [c]Assistant professor. [d]Postdoc. [e]Academic staff. [f]Research. [g]Master's. [h]Not sure.