

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

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Abstract

Teaching-related professional development (TPD) projects aimed at aspiring college/university educators (ACEs) have emerged in the US in last decade, partially in response to calls for colleges and universities to play a more prominent role in improving science, technology, engineering, and mathematics (STEM) education and increasing the number of STEM graduates. We report on the effects of TPD during doctoral and postdoctoral training (“pre-service”) on the attitudes, knowledge, teaching practices, and career trajectories of ACEs in the STEM fields. Findings pertain to the value of investment in pre-service TPD programs in light of the experiences of ACEs who are still in training and who are transitioning into their first professional positions, and to the factors associated with these outcomes.

Illustrative Stories

Andrea. 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 became apprehensive about 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 of pursuing a faculty position, she took advantage of teaching-related professional development (TPD) activities that were available to her as a postdoctoral researcher. 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 is using her TPD in developing and teaching her first courses.

Elaine. Are STEM doctoral students who want to benefit from the knowledge of educational 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 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 to practice TPD knowledge and skills learned in graduate school, her TPD experiences led others to seek her advice regarding teaching and learning and 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.

Mike. Roughly 50 percent 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 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 Ph.D., 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 (TPD) during doctoral and postdoctoral (pre-service²) training have on the attitudes, knowledge, teaching practices, and career trajectories of aspiring college/university educators (ACEs)³ in the STEM fields as they prepare for and move into their early careers? We explain here 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 concerns that the US may be losing its competitive and creative edge in STEM undergraduate education and to 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; US Department of Education, 2006; US Office of Science and Technology Policy, 2006). Those who initiate TPD programs believe that better training of post-secondary 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 three 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, 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 (docs/postdocs), 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

² We borrow the term "pre-service" 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.

³ 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 docs and postdocs who expect teaching or outreach to be a component of their work in postsecondary institutions.

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, sometimes devastating, 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 various programs for providing TPD to STEM ACEs. These individuals, whom we call “TPD advocates,” have successfully 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 (GK-12) Fellowship Program (Gilmer, Granter, & Butler, 2005).; the Preparing Future Faculty (PFF) program (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 pre-service 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 ACEs negotiate challenging academic job markets and balance their teaching and research responsibilities (DeNeef, 2002). However, this study does 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 move through doctoral programs and postdoctoral appointments (an often overlooked stage of ACE preparation) and into their early career positions, whatever those may be. 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 the University of Wisconsin-Madison. All (51) ACEs in the study participated or are still participating in the Delta Program in Research, Teaching and Learning, which is part of the National Science Foundation-funded CIRTL program.⁴ Many study participants also participated in some other form of TPD while at UW-

⁴ The CIRTL project is funding the first 3 years of our study, in part because they want to benefit from findings about the effectiveness of their program. Accordingly, all the members of our study sample are ACEs who have participated in some way in the Delta program.

Madison, such as the Wisconsin Program for Scientific Teaching (WPST, funded by the Howard Hughes Medical Institute), the UW project of the National Science Foundation's GK-12 program initiative, or national endeavors such as the Mathematics Association of America's "Project NEXT." (In addition, many participated in some form of teaching assistant training, but because almost all interviewees described these as providing little professional development value, we do not consider these as TPD programs in the sense used in this paper.) Since relatively few ACEs within 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).

Both Delta (<http://www.delta.wisc.edu>) and WPST (<http://scientificteaching.wisc.edu>) 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 through the use of approaches akin to scientific disciplinary research, a process that Delta dubs *teaching-as-research* (Mathieu, 2004) and that WPST calls *scientific teaching* (Handelsman, Miller, & Pfund, 2006). Delta began in 2003 and 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, over 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. Since inception, approximately 400 graduate students and postdocs in the life sciences have participated in WPST, 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. Eighteen (18) interviewees had participated in some other STEM-specific TPD at UW-Madison, including WPST.

In order 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 cross sectional analysis of all 51 of our interviewees. The sample was selected to represent the academic status, 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)

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

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 (Table 2, below). We grouped participants into these categories:

- Early doctoral student: interviewees in their first or second year of doctoral study;
- Mid doctoral student: interviewees who passed their preliminary exams but are one or more years away from completing their Ph.D.;
- Late doctoral student: dissertators who expect to complete their Ph.D. within one year;
- Postdoctoral scholar: interviewees holding a doctoral degree and employed as a postdoctoral fellow, postdoctoral trainee, or research associate at UW-Madison.

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

Point in Career	<i>Number</i>	<i>Percent</i>
Early doctoral student	12	24
Mid doctoral student	13	25
Late doctoral student	14	27
Postdoctoral scholar	12	24
Total	51	100

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). 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) plan 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 often or as little as they wish. To account for the experiences of those participating at differing levels, we have established/calculated/derived a measure of Delta “engagement” (the total number of hours a person participated in activities of the Delta program) for our interviewees. Table 3, below, shows that we grouped the participants into engagement categories based on contact hours:

- Low (from 1 hour to 8 hours): interviewees at this level participated in Roundtable dinners, workshops, and/or brownbag events. (No participants have between 9-29 hours because of the big jump in contact hours associated with taking a Delta course.)
- Moderate (from 30 hours to 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 (from 60 to 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.

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

<i>Level of Delta Engagement</i>	<i>Number</i>	<i>Percent</i>
Low (1 to 8 hours)	17	33
Moderate (30 to 58 hours)	22	43
High (60 to 109 hours)	12	24
Total	51	100

We chose a sample that is biased toward individuals with moderate (43% compared to 19% for the full group) and high (24% compared to 9% for the full group) levels of exposure to Delta because 2005 interviews with people who had low engagement (no course participation) with Delta 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. Moderate- and high-engagement level 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 our 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 with respect to

only 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 (1) the kinds of career paths that ACEs take when leaving doctoral or postdoctoral training positions and (2) whether TPD influences their choice of job and their early adjustment experiences, especially related to teaching-related responsibilities.

Table 4 (below) provides information on the major type and level of TPD that each of these 8 people had 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, which includes participation in WPST. We classified overall participation as either low, moderate, or high using a rubric. (Contact author for rubric.) Seven of the 8 people who had transitioned to new positions were classified as having high levels of overall TPD participation at UW-Madison, while one was classified as having a low level.

Table 4
Attributes of ACEs Sample Experienced Position Transition between 2005 and 2006

Pseudonym	Andrea	Curtis	Bill	Karen	Mike	Linda	Elaine	Andrew
Sex	Female	male	male	female	male	Female	female	Male
Academic field	Envir Engr	Bo- tany	Med Phy- sics	Bacteri- ology	Mater Sci/ Engr	Envir Toxi- cology	Envir Toxi- cology	Math/ Math Ed
Point in career at 1st interview	Post- Doc	Post- doc	Post- doc	Post- doc	Doc Stu- dent	Doc Stu- dent	Doc Stu- dent	Doc Student
Current Position	Asst Prof	Asst Prof	Post- doc	Post- doc	Acd Staff	Acd Staff	Acd Staff/ Post- doc	Asst Prof
Major Type of TPD	Delta, WPST	Delta	Delta Other Non- UW	Delta	Delta	Delta, WPST	Delta, WPST	Delta, Other UW
TPD Level	High	High	High	Low	High	High	High	High

Table 4 also indicates that these 8 study participants are evenly distributed by sex, (4 women, 4 men) but represent only 3 of the fields in our sample (2 engineering, 2 mathematics, and 4 biology). 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 are distributed into new positions as follows: 3 assistant professors, 2 academic staff, 2

postdocs, and 1 academic staff/postdoc.

Our annual semi-structured, 90-minute interviews collected in the spring semesters of 2005 (only 22 participants due to funding constraints) and 2006 (all 51 participants) provide the primary source of data. (We are currently engaged in the last round of spring interviews and will report on these findings as they available). The interview protocols used in both years focused on the same themes. (Contact author for interview protocols.) 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 inter-coder agreement measures in order to control for the reliability and validity of the coded data as best 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 only provide a partial measure of overall TPD effect for our interviewees, experience for those interviewees who have 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 semi-structured interview protocol allows interviewees 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, in order to provide readers 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: 3-9 *few*, 10-25 *some*, 26-35 *a majority*, 36-45 *most*, 46-51 *virtually all*.

Findings

We organize the self-reported impact of TPD on all 51 interviewees into 5 types of impact that emerged from our interview analysis as the most salient. The 5 types are: (1) *cognitive* (knowledge and skills) impact; (2) *affective* impact; (3) impact on *practice and application* (including material outcomes); (4) impact of participation in *networks*; and (5) 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 4 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.

1. Cognitive changes

Cross sectional analysis. When asked open-ended questions about what participants learned overall from their TPD activities, many of our interviewees (23) indicated that they either learned pedagogical knowledge and skills. Some interviewees (17) stated that TPD participation had changed how they think about teaching; for example, thinking that teaching should be learning focused and student centered. These 17 interviewees told us that through their TPD participation, they now know that there is not just one way to teach—there are other non-traditional methods and tools in teaching (e.g., active learning, backwards design, information mapping, 3-D visualization, Student Assessment of Learning Gains on-line evaluation) and that they think it is important to keep trying new strategies and activities. A few (8) said that they have learned some “nuts and bolts” about teaching, such as how to design a course, how to handle the first day of class, how to establish a classroom community, how to facilitate discussion and student learning, how to interact with students, and how to engage large student audiences and evaluate a large class. A few (7) explained that their TPD experiences helped them become more aware of pedagogical theories and philosophies. Findings on cognitive change by level of Delta engagement are presented in Table 5, below. 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 low level engagement are more likely to report only early stage (“awareness” and “informational”) changes, while those with moderate and high levels of engagement are more likely to report both early and middle (“What do I need in order to use this?”) stage changes (Louckes-Horsley, 1996).

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

<i>Interviewee Responses Regarding Cognitive Change Pertaining to Teaching in General</i>	<i>Delta Engagement</i>			<i>Total N = 51</i>
	<i>Low N = 17</i>	<i>Mod N = 22</i>	<i>High N = 12</i>	
<i>Early Stage Changes</i>				
Realized that teaching is something that evolves over time	2	3	4	9
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
<i>Middle Stage Changes</i>				
Learned pedagogical knowledge and skills	5	6	12	23
Now understands that there are non-traditional methods and tools for teaching	0	4	4	8
Now understands 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
Now understands teaching should be learning focused and student centered, and interactions among students and teachers are important	0	2	1	3

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 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) claimed 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 knew where to find them when they need them. Two said that they know how to use educational research and teaching resources to improve teaching. This finding is consistent with the importance placed by the TPD programs on understanding that there is an established knowledge base on effective teaching strategies.

Higher level Delta engagement seems to be associated with a better understanding of the notion of teaching-as-research. In addition, those with higher engagement seem to have a better idea of how to implement teaching-as-research in their teaching, such as using teaching resources and student feedback to improve their teaching (see Table 6). We know that those with higher Delta engagement claim to have had more opportunity practice what they had learned, as discussed below under the section labeled *practice*, and this may explain a discrepancy between low- and higher-engagement interviewees with respect to implementing teaching-as-research, or its counterparts, in their teaching.

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

<i>Interviewee Responses Regarding Teaching-as-Research</i>	<i>Delta Engagement</i>			<i>Total N = 51</i>
	<i>Low N = 17</i>	<i>Mod N = 22</i>	<i>High N = 12</i>	
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 educational research and teaching resources to improve teaching	0	1	1	2

One of the objectives of the Delta Program is to promote learning-through-diversity, meaning that educators should: 1) be aware of the diversity of students' experiences, backgrounds, and skills and the implications for learning, 2) employ a variety of teaching approaches to reach all students, and 3) 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?"

We found that 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' backgrounds, experiences, and knowledge can bring diverse perspectives and viewpoints to the learning environment. A few others (8) acknowledged that gender, race, 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 are 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 of them still do not feel that they are well-prepared to teach in diverse classes. Of those who felt they need for more preparation, nine (9) said that they do not have practical means or strategies to deal with diversity in the classroom, and three (3) mentioned that they have not had any chance to apply what they learned about diversity into practice. A few interviewees (10) explicitly said they either did not learn or learned only a little from their TPD activities about the implications of diversity in teaching and learning.

We found that interviewees with high Delta engagement 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 who had low or moderate Delta engagement (see Table 7).

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

<i>Interviewee Responses Regarding Diversity</i>	<i>Delta Engagement</i>			<i>Total N = 51</i>
	<i>Low N = 17</i>	<i>Mod N = 22</i>	<i>High N = 12</i>	
Became aware of different learning styles and their implications for learning	2	8	7	17
Realized that diversity is indeed 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, race, 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
Stated that they lack strategies to deal with diversity in teaching	2	7	0	9
Wished for an opportunity to practice what they learned about diversity	0	1	2	3

Analysis of position transition cases. Of the 8 cases of position transition, all 7 who have high-levels of exposure to TPD 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 mentioned most often and by 6 of 7 individuals. Participants often mentioned discovering newfound methods and skills that would allow them to promote deeper student understanding, as Andrea illustrated by 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, was newfound knowledge and skills pertaining to diversity, and knowledge of and how to find and use pedagogical vocabulary and resources, including other individuals interested in problematizing issues of teaching and learning. Curtis illustrated how participants described this type of knowledge when he said, "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."

2. 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 section above), they often expressed emotion with respect to ideas (including the idea that teachers and their practice are not static or ever 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), values (including the value of being committed to and caring about student learning and diversity in the learning environment), and new realizations (such as the understanding that there is an academic field focused on education).

Some interviewees claimed that their Delta or other TPD experience resulted in an increase in their confidence (20) (6 low, 8 moderate, 6 high) or excitement (12) (3 low, 3 moderate, 6 high) with respect to teaching. In addition, a few (3) (1 low, 1 moderate, 1 high) interviewees stated that Delta had increased their confidence regarding their current or future careers, had a better sense of what faculty life is like or, generally, felt 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 (2005). The survey findings suggest that TPD participants have more positive attitudes and beliefs about teaching than people who have not participated in any professional development activities or have participated in other professional development activities that were offered by 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 moderate, 2 high) when asked to reflect on how Delta impacted their attitudes and feelings about learning about teaching and learning. These included feeling put off by Delta’s jargon (3 moderate, 1 high) or organizational structure (3 moderate) and feelings of isolation or anger because their newly acquired teaching and learning stance was not being appreciated outside of Delta (2; 1 moderate, 1 high). While these findings are important and informative to Delta and other TPD programs, especially in light of the familiarity of these moderate- and high-engagement 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 low-engagement interviewees claimed that Delta had no effect on their personal affect with respect to teaching and learning.

Analysis of the 8 position transition cases. Upon analyzing the data from the 7 people who transitioned to a new position and who had high levels of exposure to TPD, we found that these 7 people 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 have learned in TPD wherever they go. Four (4) 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,” illustrates 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, stands in direct contrast to those with more TPD experience in that Karen also expressed a low sense of teaching efficacy.

However, not all affective change was as positive. Two of these 7 high-level TPD interviewees expressed a 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 may encounter when implementing more innovative teaching practice in the classroom in front of more “traditional” reviewers and others who may be assessing a new professor for tenure.

3. Practice and application.

Cross sectional analysis. Golde and Dore (2004) surveyed doctoral students in the arts and sciences, and they 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.” Our interviewees indicated that their TPD participation had, in fact, helped their process of forming and understanding teaching. Yet, do they know how to utilize their new knowledge or skills on teaching practice? Do they have a chance to implement what they learned in teaching practice?

Most of our interviewees (45) were still doctoral students (34) or postdoctoral scholars (11) upon our last interview with them. As a result, some of them (11) said that although they have acquired pedagogical knowledge, strategies, and tools from their TPD and thus have had little chance to put them into practice yet, they look forward to implementing what they have learned in real teaching situations in the future. For example, one interviewee noted that in the Delta Instructional Materials Development course they talked about different learning styles and the approaches one can take to engage students with different learning styles. He then added that he has not really put any of that into practice, either as a TA or in designing the course. As a TA, he was constrained in terms of what he could do. But he said this is something he will think about in the future.

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

Only a few of our interviewees (6) now have a teaching position either as an instructor or

assistant professor. All but one of these individuals claimed to be practicing what they learned from their TPD experiences. One of these people, now an assistant professor, said that not only did he use the teaching portfolio when applying for academic positions, but that he is also using many of the teaching strategies he learned from his TPD to engage students and assess their learning. Another interviewee who currently is a college instructor told us that she shares teaching strategies with her colleagues at monthly brownbag meetings. She also meets with her students individually to learn how to best assist their learning and obtain feedback. Another first-year assistant professor told us that she is not sure how much of her TPD learning she will be able to implement in the near future.

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

As shown in Table 8, interviewees across all levels of Delta engagement (12) told us they wished they could have more opportunities to teach, either through Delta or elsewhere in the university. Three (3) interviewees with high Delta engagement 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 (3) moderate-engagement interviewees wished that Delta would provide ways other than an internship for graduate students to practice teaching, such as the opportunity to create classes from scratch and evaluate teaching activities. Three (3) interviewees (one low, one moderate, and one high Delta engagement) felt UW-Madison should provide graduate students with more teaching training and more opportunities to practice teaching.

Table 8
Interviewee Responses Regarding Actual Teaching Practice by Delta Engagement

<i>Interviewee Responses Regarding Actual Teaching Practice</i>	<i>Delta Engagement</i>			<i>Total</i>
	<i>Low</i>	<i>Mod</i>	<i>High</i>	
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

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. Six of these 7 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 they had learned in TPD. Bill cautioned that he had not had enough chance to practice what he learned from Delta while at UW-Madison. Both indicated a strong desire to finally put their new learning further to test. In addition, 6 of the 7 people described applications of TPD that take a material form. Of these, 2 people had earned the Delta Certificate in Teaching, 4 had developed a teaching philosophy statement, and 2 had developed instructional materials.

4. Networks

Cross sectional analysis. One of Delta's goals is to bring people together in teaching and 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 et al, 2006), are that every member has something to offer to enhance the learning of others; members develop shared language, shared practices, and shared identity; and members recognize themselves as being part of the community and have a feeling of ownership and responsibility to the community.

To ascertain how our interviewees felt about Delta as a community, we asked them how connected with Delta they currently feel and to what degree they feel included and valued by Delta. We found that most of our interviewees (38) thought that Delta provided an open, safe and accepting learning community that makes people feel included, valued, and welcomed. Of these 38, 30 claimed that they only felt connected to the Delta community when participating in Delta activities, not afterwards. Two low-engagement interviewees described themselves as an "occasional participant of Delta" and "user of Delta service." One high-engagement interviewee said he felt that only Delta offered him a community on campus. Another high-engagement 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 the Delta community as a place to find support for teaching, to interact with others who care about teaching, and to talk about teaching and learning. They appreciated the opportunity to connect with others about their teaching experiences and to talk with an interested person in academia about teaching. For example, one of our interviewees said that Delta provides a good community and that she was introduced to several people with whom she can talk about teaching. Another interviewee said that Delta is the safest place to talk about issues on teaching and learning. Two participants think Delta helps its participants establish a teaching network.

These findings are consistent with the findings from Nyquist and others' (1999) study on how graduate students develop into teaching scholars and faculty members. Graduate students "speak of the need to create safe havens in which to discuss teaching issues that otherwise would evoke a yawn or scorn"; they seek real intellectual and emotional engagement with others about teaching.

We also learned that some Delta participants have enjoyed the opportunity to participate in shared learning and have developed shared language in the activities in which they have been involved. A few (5) reported that they have learned as much from other participants as from instructors or

presenters. One interviewee said that the community and the interactions among people who value teaching are the most important functions of Delta. Another told us that she has picked up teaching ideas from others in Delta and now has the means to communicate better with others about teaching. Yet another said that Delta provided her with a place to talk about teaching and learning on campus. Similarly, three other interviewees recognized Delta for helping them find others who are interested in teaching and who may be able to help with teaching and learning issues. Although only two of the interviewees voluntarily reported that they developed pedagogical vocabulary through 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 high-level Delta engagement are acknowledging the importance of a learning community that focusing on teaching. One said that Delta is like a “saving grace” because it provides a venue where people who really care about teaching in a research-dominated environment can 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 to try new things.”

Three (3) interviewees alluded to future participation in a community such as Delta, stating that they intended to seek out other teaching professional development communities in the future. However, these people also expressed some reservation regarding how other programs would ultimately “stack up” to Delta. One interviewee, an assistant professor, is now seeking out other teaching professional development 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 is interested in disseminating and replicating the Delta program in his new working environment.

Table 9
Interviewee Responses Regarding Learning Communities by Delta Engagement

<i>Interviewee Responses Regarding Learning Communities</i>	<i>Delta Engagement</i>			<i>Total</i>
	<i>Low</i>	<i>Mod</i>	<i>High</i>	
Delta provides 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
Delta is 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 did from instructors or presenters	0	3	2	5

Interested in participating in other learning communities like Delta	0	2	1	3
Hope 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

Analysis of the 8 position transition cases. All 7 of the high-level engagement individuals spoke of the importance of the pre-service TPD networks, overall, in which they had participated. All but one claimed to feel valued by these communities. All commented that they valued and enjoyed these communities, particularly for the informal opportunities they provided to reflect with others who are 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 one 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.

5. TPD Effects on 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, whereas only 74% of non-participants planned to work in education. In contrast, Nerad and Cerny (2002), who surveyed roughly 6,000 Ph.D. 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 *kind* of careers that respondents were currently pursuing or planning to pursue. To address this question, we examined the differences between their 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 aspiring college/university educators is best informed by the 8 interviewees who have made a significant position transition. Accordingly, we also report on this subset of data in this section.

Cross sectional analysis.

Pre-training Career Aspirations. We asked our 51 interviewees to describe when they first developed their overall interest in teaching. For many of our participants, interest in teaching pre-

dates both grad school and develops independent of TPD. Of our interviewees:

- 14 “had always been interested”
- 19 were interested as a result of undergraduate experiences
- 8 acquired interest during their graduate student experience
- and for 10, information was unclear or unavailable.

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

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

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 low, 8 mod, 3 high) specifically claimed they desired to improve their knowledge and skills regarding teaching and learning. For instance, one “low-level Delta engagement” interviewee 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 at the cutting edge of how to teach science and math.” Some (19; 4 low, 11 mod, 4 high) specifically addressed some *unmet need* they hope TPD programs could offer with respect to preparing for their future roles as educators. A few (5; 1 low, 1 mod, 3 high), stated they hoped that the programs would help them prepare for a career, specifically, at an institution where teaching may be a greater focus (as opposed to at a research institution like UW-Madison.) While we cannot firmly attribute 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 low- and moderate- compared to high-engagement interviewees making such statements. 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 low, 12 mod) talked of marketability issues when discussing initial motivation, with a majority of these people (10; 2 low, 8 mod, 3) speaking explicitly of their hopes that their TPD involvement would reflect positively on them as a candidate in future job searches. Others (5; 1 low, 4 mod) talked of the hope that their TPD participation would increase their chances at obtaining grants for research. Interestingly, most of our interviewees who discussed TPD participation and marketability issues were of the moderate-engagement level, perhaps indicating their perception (and, perhaps, related reality) that any lower engagement with

TPD would not afford them what they needed to make themselves more marketable but that any higher engagement was not necessary needed.

Motivation for continued TPD participation. We asked those who continued their participation in Delta or other TPD programs what motivated this participation. Twenty-eight (28) had comments. Not surprisingly, a majority of these (18; 5 low, 8 mod, 5 high) interviewees claimed they continued participating in TPD because they found their past participation meaningful or helpful in some way. Some of these interviewees (7; 3 low, 3 mod, 1 high) claimed that other people involved in TPD programs encouraged their continued participation. For example, Chris summed up this thinking with, “I think the people who are interested in teaching and learning are really exciting and dynamic and motivated.” A few (5; 4 low, 1 mod) cited the diversity of participants in TPD programs as a factor that motivated their continued TPD participation. Of note, these interviewees had lower-level engage.

Some (7; 1 low, 3 mod, 3 high) of these 28 interviewees attributed their continued TPD participation to response to marketability pressures. One low-engagement interviewee, Scott, said he’s 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 cited their continued TPD participation as response to job market pressure were at the mod- and high-engagement levels, perhaps indicating their perception (and, perhaps, related reality) that any lower engagement with TPD would not afford them what they needed to make themselves more marketable.

A few (5; 4 mod, 1 high) claimed that Delta’s or another TPD program’s set-up encouraged their continued participation, in that the program made it easy to participate in terms of scheduling or provided a learning format or environment that was comfortable for them. Not surprisingly, those who continued their Delta participation to the higher levels made such claims. Additionally of note, as a result of their participation with Delta, half (4/8) of the interviewees who have made significant position transitions during our study continue to seek out TPD opportunities in their new positions as assistant researchers (2) and postdocs (2). These interviewees had high-level engagement and their continued quest to engage in TPD indicates that they may want to continue to improve their pedagogical knowledge and skills.

Effect of TPD on Career Aspirations. We asked respondents whether (a) their career plans had changed during graduate school and (b) what role, if any, Delta had in changes in their career plans. Table 11 shows the relationship between the two types of responses. Analysis of

interviews suggests that 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.

Table 11
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

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 11, the numbers in the columns under "Did Delta participation influence career aspirations" show that 27 of the respondents changed their career plans during graduate school. Of these, career plans changed in the following ways:

- from a research-oriented toward a teaching-oriented institution - 15
- from industry to academia - 5
- from academia to industry - 2
- plans now also include informal education - 2
- from smaller institution to 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 common reconsideration of career plans that often occurs during the course of one's graduate education—it is difficult to discern the direct effects of Delta or other TPD program on career plans. For example, one engineer with high-level engagement explained that, although his plans to work at a national laboratory had never changed, because he was now managing a 'two-body' problem he would now consider a teaching-related job at some point as a result of his Delta involvement. Thus, his career plans have not changed, but Delta involvement has given him more options if he must consider other employment for the sake of his partner's career. Additionally, a number of respondents still were unclear or undecided in their career plans, and therefore could not yet say whether their plans have substantively changed and whether Delta participation 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, we see that changing one's career plans does not really vary by engagement group—that is, regardless of whether one had low, moderate, or high Delta engagement, roughly half were considering or had assumed a different kind of position compared with when they started graduate school. However, when considering respondents' reports of whether Delta in particular affected their career aspirations, we see that only 1 of 17 respondents with low-level engagement indicated that Delta participation affected

their career aspirations. In contrast, 20 of 34 participants with high- or moderate engagement said that Delta affected their career aspirations.

Table 12:
Career Aspirations

	<i>Did Delta Affect Career Aspirations?</i>			
Engagement	Yes	No	Not Clear	Total
High	7	4	1	12
Moderate	13	6	3	22
Low	1	12	4	17
	<i>Did Career Plans Change During Graduate School?</i>			
High	6	5	1	12
Moderate	13	8	1	22
Low	8	9	0	17

TPD Effect on Career Preparedness. We attempted to examine whether respondents felt ready or prepared for their intended career, and whether TPD participation contributed to any sense of career readiness. However, as we have found elsewhere, some respondents have 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 these skills can be attributed only to TPD participation. Below (Table 13) is a list of the skills that respondents mentioned when asked which aspects of their career they feel most ready or prepared for. The skill set mentioned most frequently was related to teaching. Conversely, some respondents indicated that they felt especially unready or under-prepared for certain roles.

Table 13
Readiness for Career by Delta Engagement

<i>Career-related skills for which respondents feel <u>most</u> ready or prepared</i>	<i>Low</i>	<i>Mod</i>	<i>High</i>	<i>Total</i>
Teaching-related roles and responsibilities	2	7	4	13
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
Effectively assessing student learning	1	0	0	1
<i>Career-related skills for which respondents feel <u>least</u> ready or prepared</i>	<i>Low</i>	<i>Mod</i>	<i>High</i>	<i>Total</i>
Teaching-related roles and responsibilities	7	2	1	10
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

Interestingly, also mentioned most often were skills related to teaching. Looking across both tables by level of Delta engagement, it appears that participants with low levels of engagement feel most ready for research and least ready for teaching. However, participants with moderate and high levels of engagement feel most ready for teaching. Although a few of these people said they feel unready for teaching, no single skill or role really 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 feel most ready for teaching-related responsibilities.

Analysis of the 8 position transition cases. These findings allow preliminary observations about the kinds of career paths that ACEs may take upon leaving their pre-service positions. These findings are summarized in Table 14, below. We begin these observations by noting as we did in the cross sectional analysis, how (if at all) the 8 people who made position transitions altered the type of institution and primary professional focus they originally had in mind. Upon starting graduate school, 5 planned to focus primarily on conducting research. Of these 5, 3 are still pursuing their original professional aspirations. Andrea is now an assistant professor at a research institution, and Elaine is pursuing her original aspiration in her new postdoc position at a research university. Bill is at a research institution, but in a postdoc position that has him conducting disciplinary and educational research. Karen, at a “master’s institution,” is more tenuously pursuing research in an academic staff/postdoc position. By contrast, Linda pursues an aspiration different than she originally intended in a temporary academic staff position at a master’s institution. Upon starting graduate school, a sixth person, Curtis, planned to focus on both teaching and conducting research and is on track to achieve this aspiration as an assistant professor at a research institution. The 2 others, upon starting graduate school, planned to focus on teaching in a postsecondary institution and are realizing this teaching focus: Andrew is now an assistant professor at a master’s institution, and Mike is academic staff focusing on STEM education at a research institution.

Table 14
Career Plans, TPD Levels, and Early Career Outcomes Reported by ACEs Who Experienced Position Transition between 2005 and 2006

Pseudo-Nym	Andrea	Elaine	Karen	Linda	Bill	Andrew	Mike	Curtis
Pre-PhD Career Plans	Rscher	Rscher	Rscher	Rscher	Rscher	Educ	Educ	Educ/Rscher
Current Position	Asst Prof	Postdoc	Acad Staff/Postdoc	Acad Staff	Postdoc	Asst Prof	Acad Staff	Asst Prof
Current Inst type	Research	Research	Masters	Masters	Research	Masters	Research	Research
TPD Level	High	High	Low	High	High	High	High	High

TPD a Factor in Getting Current Position	Yes	Yes	No	Yes	Not sure	Yes	Yes	Yes
Satisfied w/current position	Yes	Yes	No	Ambivalent	Yes	Yes	Yes	Yes
Career Affected by External/ Unexpected Factors	No mention	No mention	Two-body Issue	Two-body Issue	No mention	Two-body Issue	PhD project cancelled	No mention

Our interview data clarified in what ways TPD affected the professional aspirations of the 7 people with high-level TPD. For these 7, there appears to be a strong correlation between TPD experience and participants’ assessment that TPD expanded their career options, sometimes in unanticipated ways. Mike reported that TPD allowed him to think creatively about alternative options when his dissertation research was unexpectedly terminated. Andrea stated that TPD led her to change her mind from seeking a position in industry to seeking one in academia. Bill claimed 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 about faculty teaching life. Elaine said that TPD expanded her view of the faculty role, and Linda reported that she now considers taking a job in a community college. Five of these 7 said they are now playing, or considering playing, different roles (e.g., a science education research position) within higher education than they had in mind upon starting graduate school. Bill enjoys his postdoc position conducting disciplinary and educational research at a research institution with a history of educational innovation. Curtis’s comment, below, highlights the numerous positions he would now consider playing at a research institution:

[Without TPD experience] I think I would still want to be a professor at a Research One 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.
 -Curtis

Table 14 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: change in prospective employers’ views of job options for the candidate; confidence in ability to undertake the new position; affirmation of and inspiration for the position; overall change in approach to teaching, use of diverse new teaching practices in new situation; interest in participating in science outreach at new location; and interest in

creating a TPD community or providing TPD for graduate students in new context. Negative types of impact (3 mentions by 3 participants) on the current transition include: lack of preparation for working in a master's institution environment; awareness of being insufficiently prepared to use assessment in their new situation; and feeling dissatisfied with TPD at new institution. The last two of these negative impacts indicate that pre-service TPD activity raised participants' expectations of their own practice and of resources at their receiving institution.

Table 14 also shows that 4 of these 8 individuals reported (without being asked) that their career trajectory was affected by what we call "external (to academia) or unexpected factors." In particular, Karen, Linda, and Andrew reported that the "two-body problem" is a significant obstacle in their efforts to achieve their professional aspirations. (This term is used when both members of a domestic couple are seeking faculty positions. See Wolf-Wendel et al, 2004.) The fourth, Mike, experienced a completely unexpected obstacle when his PhD program was cancelled. Upon considering the "external/unexpected" factor in light of the "satisfaction with current position" factor, we note that 2 of the 4 people with a two-body problem reported ambivalence or dissatisfaction with their current position.

Discussion

Our interviewees confirm 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 and McDaniels, 2006). Our study participants relied on TPD to help meet their goals of becoming more effective educators and, overall, our participants felt that their TPD experiences are 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 said that participation in TPD has affected their career aspirations. How these influences interact is not clear. And a smaller proportion of low-engagement respondents reported their career plans were affected by TPD than moderate- and high-engagement respondents. Yet, what is for sure is that a majority of our interviewees currently state that they are interested in teaching in the future and, as hiring patterns tell us across higher education, those who become faculty will have teaching as their main professional responsibility. That a majority of our interviewees claimed 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 low- and moderate-engagement interviewees, compared to the high-engagement interviewees, who made these statements. Our data may point to a correlation between TPD engagement and confidence for and interest in the kind of teaching-intensive careers that many ACEs may, in fact, pursue.

Our data suggest that pre-service 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 is 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 with a greater sense of efficacy in teaching for ACEs and to the belief that they are better prepared than they otherwise would have been to meet their upcoming responsibilities as educators. Many of our 51 interviews, including the 6 position transition cases 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 feel more ready for the teaching role than for other faculty roles (e.g., research), while others, as a result of their Delta experience, also come to understand how demanding and difficult good teaching can be, and thus end 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 about teaching and helped them adjust effectively and creatively to the teaching-related demands of their new positions. Many of our interviewees, including all 7 high-engagement people in our group of ACEs who transitioned to new positions, expressed appreciation for TPD communities because they felt valued by them, and because these communities provided informal and safe opportunities to reflect with others who are interested in teaching issues and practices, and 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 pre-service 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 pre-service TPD activities designed to prepare ACE participants for a wider variety of possible careers. The people who had made position transition indicated that their pre-service TPD was a factor in obtaining their current position. Moreover, once in their new positions, some of these participants expressed a strong desire to participate in, or even help create, TPD communities. These 8 interviewees who made significant position transitions clearly indicate that TPD can be a major positive factors for ACEs as they move into first professional positions. In particular, those who had high-level engagement in TPD expressed how they valued their new educator identities, and that, in Andrea words, they could “never go back” to a more traditional stance regarding their roles as an educator. 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 pre-service (graduate and postdoctoral) institutions that prepare people aspiring to be college educators, but

also at those “in-service” institutions that receive them. Our data about the 8 position transition interviewees indicate that people with high levels of pre-service TPD experience some dissatisfaction with the quality of, and access to, TPD networks at their receiving institutions. Therefore, pre-service TPD advocates may want to structure TPD programs in order to provide coaching for ACEs who may soon find themselves teaching at institutions that are ill equipped to support people with research-informed pedagogical orientations. Both pre-service and receiving institutions could help make visible to early adapters (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 new faculty, as well as more peripheral individuals such as 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 pre-service TPD really affect the professional dispersal patterns of ACEs? What level of pre-service 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? Lastly, but of great importance, will ACEs who engage in pre-service TPD be better at fostering the learning of their students? These are just some of the questions our longitudinal study hopes to pursue in our remaining year.

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