Longitudinal Study of FUTURE STEM SCHOLARS

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Key Points

This brief discusses findings from a sub-study of the LSFSS that examined the impact of teaching development (TD) programs on early-career academics' college teaching self-efficacy. Independent variables included TD participation, TD type, TD engagement levels, race, and gender. The study found that TD participation was a significant positive predictor of teaching self-efficacy, especially for women, and the effect was greater as TD program intensity and engagement increased.

LSFSS Study

The Longitudinal Study of Future STEM Scholars is exploring the short- and long-term impact of teaching-focused professional development on STEM doctoral students and early-career academics. Since 2009, the study has used repeated surveys and interviews to follow an initial cohort of 3,060 late stage doctoral students.

STEM College Teaching: Building Confidence through Teaching Development

According to a report from the President's Council of Advisors on Science and Technology, the United States' ability to compete in the global economy depends on colleges and universities increasing both the number and the diversity of people graduating with STEM undergraduate degrees.[1] However, 56% of undergraduates who start college with a declared major in STEM switch to non-STEM majors within six years.[2] One reason why talented undergraduates leave STEM degree programs is the uneven quality of instruction in STEM courses. As a result, policymakers and funders are strongly advocating for teaching development (TD) programs that prepare faculty more effectively as undergraduate educators.

Although efforts to improve postsecondary instruction have generally focused on current faculty, more attention is being paid to how *future faculty*—namely, doctoral students and postdoctoral scholars with academic aspirations—are being prepared as undergraduate educators. Providing teaching development to future faculty could accelerate reform efforts since doctoral students and postdoctoral scholars could acquire pedagogical training prior to entering faculty positions and would not need to "unlearn" ineffective classroom practices.

[1] President's Council of Advisors on Science and Technology (PCAST) (2012). *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics.* Washington, D.C.: Author.

[2] Chen, X. (2009). *Students who study science, technology, engineering, and mathematics (STEM) in postsecondary education* (NCES 2009-161). Washington, D.C.: U.S. Department of Education, National Center for Education Statistics.

Since the early 1990s, many U.S. universities have created programs for preparing future faculty, ranging from local institutional offerings to large national projects such the NSF-funded Center for the Integration of Research, Teaching, and Learning (CIRTL).[3] Yet, aside from small evaluation studies, little is known about the short- and long-term impact of TD programs.

We argue that TD programs provide opportunities to develop confidence in one's ability to implement effective teaching practices; this confidence is otherwise known as *college teaching self-efficacy.* Research has shown that self-efficacy is a strong predictor of successful future performance. In addition, higher levels of teaching self-efficacy have been found to have numerous benefits for teachers, such as increased enthusiasm, commitment, and use of varied pedagogical methods.

This brief reports the results of a sub-study of the *LSFSS* that explored the effect of three variables on early-career academics' beliefs about their college teaching abilities: (1) whether they participated in TD, (2) how much they participated in TD, and (3) what types of TD programs they engaged. The study also examined how gender and race influence the relationship between college teaching self-efficacy and the three independent variables. For the full study, see Connolly and Lee (2015).

Methods

Data were collected using two survey instruments that followed 3,060 late-stage doctoral students at three universities. The first survey (2009, n = 2,163, 75% response rate) asked about TD experiences,

Participation in TD programs is positively related to stronger self-efficacy beliefs in multiple aspects of college teaching.

and the second (2011, n = 1, 445, 67% response rate) asked about current employment and teaching self-efficacy beliefs.

The study's outcome variables consisted of six domains of college teaching self-efficacy: (1) course planning, (2) teaching methods, (3) creating learning environments, (4) assessing student learning, (5) interacting with students, and (6) mastering subject knowledge. A panel of experts reviewed the outcome measures to address content validity; and exploratory and confirmatory factor analyses indicated that the items measuring these outcomes were reliable and belonged together. See Table 1 for a complete list of outcome variables.

The independent variables included TD participation (yes or no), TD engagement (none, low [1–10 contact hours], low-moderate [11–25 hours], high-moderate [26–55 hours], and high [> 55 hours]), and TD type (non-intensive, intensive, and formal course). The study also controlled for 12 covariates that could affect college teaching self-efficacy beliefs, such as gender, race, level of teaching experience, and interest in becoming a faculty member.

To estimate how TD programs might affect college teaching self-efficacy beliefs, we used ordinary least squares (OLS) regression to measure the relationships between outcome and independent variables.

[3] For more information about TD programs, see Hill, L., Connolly, M.R., & Savoy, J.N. (April, 2015). The anatomy of teaching development programs: A taxonomic dissection. *LSFSS Brief Series No.2.* Madison, WI: Wisconsin Center for Education Research, University of Wisconsin-Madison.

[4] Connolly, M. R., & Lee, Y.G. (2015). *The effects of doctoral teaching development on early-career STEMscholars' college-teaching self-efficacy* (WCER Working Paper No. 2015-1). University of Wisconsin–Madison, Wisconsin Center for Education Research. http://www.wcer.wisc.edu/publications/workingPapers/papers.php

TABLE #1: COLLEGE TEACHING SELF-EFFICACY VARIABLES

Teaching Domain	Questionnaire Items
Course planning	• Setting learning goals • Selecting reading materials • Designing assignments • Planning class activities • *Determining grading criteria*
Teaching methods	• Using various teaching strategies • *Clearly communicating expectations to students* • Engaging students in learning • Providing students with opportunities to practice skills • Promoting student collaboration
Creating learning environments	• Encouraging students to ask questions • Encouraging students to express ideas • Encouraging participation from women and minorities • *Encouraging students to respect one another* • *Managing student-instructor disagreements*
Evaluating student learning	• *Developing assessments consistent with learning goals* • Accurately assessing students' knowledge • Grading assignments using criteria • Providing students with constructive suggestions • Providing students prompt feedback
Interacting with students	• Fostering students' independent thinking • Addressing sensitive issues in ways that help students to deal with them maturely • Fostering students' confidence in ability to learn • *Working with problem students outside of the classroom* • *Recognizing students who are not achieving to their fullest potential*
Mastering subject knowledge	• Providing students an overview of discipline • Demonstrating passion for teaching • Staying current in subject knowledge • Helping students understand the relevance of learning • Enriching teaching with research

Note: Items in italic items were dropped from further analysis folllowing our validation process.

Results

Our study found a significant positive relationship between early-career academics' participation in doctoral TD programs and their college teaching self-efficacy. See Table 2 for a summary of our results.

Participation

Any amount of participation in TD programs, regardless of program type, was positively related to stronger self-efficacy beliefs in multiple aspects of college teaching. For example, after controlling for covariates, TD program participation had a significant positive impact on early-career academics'

Women who participated in TD programs, even non-intensive or low-engagement activities, reported higher confidence in college teaching over women non-participants.

confidence in using certain teaching methods, course planning, and mastering subject knowledge.

Engagement

We found that the more an individual participated in TD programs, the greater the impact on their college teaching self-efficacy beliefs. After controlling for covariates, high-moderate and high-engagement levels had statistically significant positive relationships to teaching self-efficacy beliefs.

Participating in 10 or fewer hours of TD, however, had about as much effect on college teaching self-efficacy as not participating at all. Low-moderate TD engagement levels had positive effects on only a few teaching domains, but they were short of statistical significance. This makes sense because low engagement activities (e. g., workshops, brownbag seminars) often focus on a select teaching concept or practice and do not provide comprehensive pedagogical training, or opportunities to practice teaching. High-moderate and high engagement levels had greater gains in self-efficacy beliefs regarding more advanced instructional activities such as course planning and student learning assessment.

Regardless of engagement level, however, TD engagement had no significant effect on confidence in interacting with students, possibly because doctoral students typically do not interact with undergraduates in TD activities. This finding supports not only the complementary role of teaching experience but also the need for TD offerings that provide opportunities to interact with undergraduates.

Type

For this study, TD activities were classified into non-intensive, intensive, and formal courses. Similar to our engagement findings, non-intensive activities had very little effect on teaching self-efficacy, whereas intensive activities contributed to self-efficacy beliefs about using specific teaching practices. Formal courses had the greatest impact, contributing to both teaching methods and more advanced practices, such as course planning and learning assessment. Overall, intensive activities and formal courses significantly impacted an early-career academic's teaching self-efficacy beliefs. We also found that actual teaching experience during graduate school had a positive impact on self-efficacy beliefs.

Race and Gender

Race did not have a statistically significant interaction with self-efficacy beliefs in our study. With respect to gender, women STEM early-career academics were less confident in five of the six components of college teaching when compared to men. However, being a woman and participating in any amount of TD had positive, significant interaction effects in predicting confidence in course planning, teaching methods, assessing student learning, and interacting with students.

There were also positive interaction effects for women, especially for those who reported high-engagement participation. For TD type, the study found that with respect to non-intensive activities (which had little effect overall), women still had positive gains in teaching self-efficacy over non-participants in areas such as course planning, teaching methods, and interacting with students. In summary, positive interaction effects were generally found between gender and TD participation, TD engagement, and TD type. Women who participate in TD programs, even in non-intensive or low-engagement activities, report higher confidence in college teaching over women non-participants.

TABLE #2: SUMMARY OF MAJOR FINDINGS

Variable	Impact on College Teaching Self-Efficacy
TD Program Participation	• Positive statistical relationship found in multiple aspects of college teaching.
Engagement Level	• As engagement increased, the impact on self-efficacy became stronger. • Participating <10 hours was equivalent to non-participation. • High-moderate/high engagement levels had the greatest impact.
Program Type	• Non-intensive activities had little effect on self-efficacy. • Formal courses had the greatest impact and contributed to most of the six college teaching domains.
Gender	• Women reported less confidence than men in most college teaching domains. • Women TD participants, even non-intensive or low engagement activities, reported higher confidence in college teaching over women non-participants.
Race	• No significant relationship was found.

Teaching Development is a Good Investment

This study shows that participation in TD is a good investment of doctoral students' time and effort because it has a significant impact on early-career academics' confidence in STEM teaching. Moreover, as engagement increases, the benefit to the participant likewise increases.

However, participation in TD programs can be stigmatized in STEM fields, sometimes leaving doctoral students and postdocs without the necessary support to develop as teachers as well as researchers. Therefore, faculty, graduate deans, department chairs, and other important stakeholders connected to the development of future faculty should do more to encourage participation. Likewise, more should be done to help to future faculty and their advisors to understand the significant return on investment in TD.

Teaching Development Helps Women Academics

Due to the high attrition rates of women STEM doctoral students and the challenges encountered by early-career women academics, support for women doctoral students must improve. TD programs provide opportunities for women to develop their college teaching abilities and to engage with likeminded peers, both in and outside of their own departments. Thus, TD programs can potentially reduce attrition, address gendered disparities in STEM, and ease faculty career transitions.

Teaching Development Should Be Combined with Actual Teaching Experience

TD activities alone are not sufficient to develop college teaching self-efficacy. Teaching experiences also

promote self-efficacy beliefs because they provide real world opportunities to try teaching methods and gain proficiency. However, not all teaching experiences provided to doctoral students are created equal.

Just as TD activities range in intensity and engagement, teaching experiences vary in their ability to positively affect teaching self-efficacy. Opportunities range from being the instructor of record for a course to performing support roles such as grading exams. Ideally, TD programs should combine high-intensity learning activities with extensive real world teaching experiences that allow future faculty to link practice with theory. Therefore, program leaders should help doctoral students intentionally link their participation in TD programs with teaching opportunities for application and practice. It would be better yet if TD program leaders were to partner with those who coordinate teaching opportunities for doctoral students so as to make such efforts more meaningful.

The Impact of TD Programs

Participation in TD programs positively impacts early-career academics' teaching self-efficacy. As time spent in TD increases, so does the benefit to the participant. This study also showed the importance of TD for women and how a mix of TD activities and teaching experiences provide greater impact to the development college teaching self-efficacy. Future faculty and those who support in their professional development should acknowledge that TD participation is well worth the time for doctoral students and contributes to national goals of improving STEM undergraduate education.

The more an individual participates in TD programs, the greater the impact on their college teaching self-efficacy beliefs.

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