

Identifying Changes for Student-Centered Instruction in Graduate Student Teacher Professional Development Across Mathematics Departments

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Providers of teaching-focused professional development (TPD) for novice college mathematics instructors (e.g. graduate students) are a critical part of undergraduate education. Yet, little is known about the work done by Providers, including their local efforts to change TPD. We seek to capture details, summarizing a departmental change journey in a succinct advice packet, so other departments might leverage that advice in their own TPD. This preliminary study used a four frames model (people, power, symbols, structure) with two dimensions (process and product) to document TPD change in 10 mathematics departments. Through qualitative analysis of semi-structured interviews and member-checking with Providers, we identified interactions among key change elements. Preliminary findings suggest attention to certain interactions (e.g. people and power) was more common in successful change than others. Examination of the products and processes of change at the granularity reported here shows promise for sharing across departments for program improvement.

Keywords: Novice College Mathematics Instructor, Teaching-Focused Professional Development, Provider, Systemic Change

For over 30 years, evidence has continued to build the case that student-centered curriculum and instructional practices are effective for students' success in undergraduate mathematics education (Friedlander et al., 2014; Gehrtz et al., 2022; Smith et al., 2021). Productive methods include active inquiry-oriented approaches where collaboration among students is common (Laursen & Rasmussen, 2019). A large proportion of undergraduates' first (and sometimes only) experience with post-secondary mathematics is in classes taught by graduate students (Blair et al., 2018). Graduate students who teach, as assistants for sections adjacent to lectures and as instructor-of-record, are essential in spreading the use of student-centered instructional practices. Recent national initiatives have taken a closer look at teaching-focused professional development (TPD) and the work among faculty who provide that TPD (CoMinDS, 2020; Hauk et al., 2024; National Academies, 2023; Smith et al., 2021). Providers of TPD play a crucial role in shaping the teaching of college mathematics instructors (CMIs), particularly graduate student novice instructors. A *novice* instructor is anyone with fewer than 1,000 hours of classroom experience (e.g., five or fewer years).

The most common forms of TPD include some combination of at least three of the following: pre-semester orientation, seminars, pedagogy courses, course coordination meetings (Yee et al., 2023a; Braley et al., 2023). Providers are change agents – they are on the front lines of their department's changes in undergraduate mathematics education because they are responsible for helping novice CMIs implement those changes. Research on how Providers initiate and/or navigate systemic changes is limited. Each mathematics department has its own profile of characteristics of TPD (e.g. seminar, course, coordination meetings) and institutional context (e.g. master's or doctoral granting, private or public). Here we report on our efforts to identify and disseminate findings about systemic change that is rooted in departments' efforts in novice instructor TPD.

Context and Theoretical Framework

This study is part of a larger federally funded project that initially implemented a national survey to identify information about Providers and the TPD they offer (Yee et al., 2023a, 2023b). The aim of the larger project is the development of an online “Design Tool” (currently in beta-testing) where one can go to see what other departments with similar characteristics are doing with/about TPD for novice instructors. In addition, the tool offers advice from the field from Providers that goes beyond *what* a department has done to succinctly describe *how* it was accomplished. “Advice Packets” include how Providers have designed and implemented opportunities for novices to learn about student-centered instruction, and describe the changes needed to arrive at their current state of TPD, whatever it may be. Each three-page Advice Packet includes a two-page description of the department’s TPD change journey as well as a final table about the components of change. Creating these tables has allowed us to explore similarities and differences across TPD programs. Developing the table required a theoretical framework flexible enough to recognize and document the critical factors of systemic change.

Reinholz and Apkarian’s (2018) revision to Bolman and Deal’s (2008) four frames for systemic change provided a theoretical framework that was both flexible enough and structured enough to meet the needs of the study. Originally constructed to model organizational change, Reinholz and Apkarian tailored the names and descriptions of the four frames to support seeing and describing change in STEM fields in higher education (structures, symbols, power, people):

Structures are the roles, routines, and practices of a department; their enactment and meaning are dependent on *symbols*, which are the norms, values, and ways of thinking in a department; changes are ultimately enacted by *people* whose individuality impacts their intentions and perceptions; and the distribution of *power* determines who makes certain decisions and influences interactions (p. 5).

Bolman and Deal (2008) argued, “Like maps, frames are both windows on a territory and tools for navigation” (p. 13). The purpose of the four frames in Reinholz and Apkarian’s framework is to be a department’s “analytic tool for understanding change” (p. 2). We have combined the metaphor of frames as windows on a territory and tools for navigation with Reinholz and Apkarian’s focus on undergraduate STEM education. This allows us to describe departments’ systemic change as well as providing a means to attend to and compare aspects of local departmental culture to support others in navigating in similar landscapes.

Research Questions

Reinholz and Apkarian (2018) describe a framework with both *process* and *product* components for each framing concept. Both the actors and actions must be taken into account. Reinholz and Apkarian say, “The four frames speak to both *what* aspects one may try to change (i.e., the product) and *how* they go about changing it (i.e., the process)” (p. 3). Our research questions parallel this structure:

RQ1: What aspects and frame(s) (if any) are prevalent in Provider reporting about their department’s TPD change experience?

RQ2: How do certain aspects and frame(s) appear to interact or influence each other in Provider reports of navigating TPD change?

In RQ1, we use prevalence to focus on which frames and aspects within the frames frequently show up as key elements for a Provider of process and product. In RQ2, we are looking to see how the frames and aspects within those frames interact, seeking to see patterns across different Provider/department characteristics and ways of navigating change.

Methods

We report here on analysis of data from 10 Providers (of 95 for whom we have some data). Data sources include responses to our national survey, video-recorded semi-structured interviews, and member-checking feedback on Advice Packet drafts. Provider interviewees were chosen to ensure diversity of national survey responses, instructional characteristics, and geographical location. Of the 10 Providers included here, 2 were at private and 8 at public universities with 7 doctoral- and 3 masters-granting.

Data Collection

Data from the national survey provided information prior to the interview about the size of the department, as well as formats, topics, and activities of local TPD (Yee et al., 2023a). The interview included targeted discussion of (1) department goals for TPD, (2) Provider objectives, (3) drivers of change/stasis in local TPD, (4) specific instructional practices focused on in TPD, (5) description of the current TPD state or completed change, (6) departmental history of change, (7) critical factors for completed changes, (8) interactions of critical factors necessary for change, (9) MAA instructional practices (MAA, 2018) regularly addressed in the TPD.

Data Analysis

As each online semi-structured interview was completed, members of the research team watched the recording of the interview and, in consultation with the interviewer, composed a first draft of the Advice Packet. Using narrative analysis (Atkinson & Delamont, 2010), the research team categorized and summarized the details across Providers' interview and survey responses. The summary aimed for a granularity of description that satisfied the goal of differentiating among Providers and for succinct communication in the Advice Packet for the target audience (other Providers). Thematic analysis across the 9-part structure of the interview used inductive coding based in the four frames, broken into processes and products. Analysis for each Provider was synthesized in a table of process and products of change. This table (referred to as the *four frames table*) summarizes the change journey in the Advice Packet using the Reinholz and Apkarian (2018) framework. Subsequently, we did a constant comparative analysis across all 10 four frame tables to look for patterns across TPD programs.

Preliminary Findings

A critical aspect to the validity of our Advice Packets' trustworthiness is Provider feedback on their Advice Packet. This member-checking is currently ongoing, thus the preliminary nature of this report and a limitation ($n=10$) on the aggregate analysis of four frames tables. Next, we share details in a vignette and a four frames table that has been member-checked.

Vignette of Big State University (BSU)

Big State University (BSU) is a doctoral-granting institution in the midwestern United States with 60 to 75 graduate students working in instructional positions (as graduate teaching assistant, GTA, or instructor-of-record, GSI). Over a decade of work resulted in the current state of TPD at the institution. Like nearly half of programs in the national survey, the format for TPD included pre-semester orientation, a course on teaching, and regular course coordination meetings. At the same time, this university's program had uncommon characteristics, including the development and sharing of curriculum and instruction materials that generated revenue to support the costs of offering TPD. Some aspects, like shared values development, came from the Provider using the people lens, meeting the needs, skills, and motivations of individuals within the TPD program.

Also through the people lens, and that of power, the interviewed Provider talked about an integration of TPD and course coordination that was led by mathematics education professors within the department.

Table 1. BSU Table of Process and Products of Sustainable Cultural Change Using the Four Frames.

	Change Products	Change Processes
Structures	● TPD includes multi-day pre-term orientation, 1 Pedagogy Course, and weekly Course Coordination meetings. ● Online library of tested resources for Providers, Coordinators, and GTA/GSIs.	● First-Year director initiated a structure where coordination was supported by GTA/GSI creation of workbooks. ● Active-learning centered room changes due to larger classes with GTA/GSI teaching nine credits per year for stipend.
Symbols	● Workbooks from GTA worksheets created royalties to help run GTA TPD. ● Value of modifying classrooms to be student-centered supported by data justifying utility of active learning through curricular changes	● Collected data to refine workbooks/texts for improving instructional practices. ● Textbook adoption moved to open-source textbooks for all math classes. ● Graduate students not unionized; report feeling valued by course release.
People	● Administration and teaching faculty develop a shared vision about curricular coherence with graduate students ● GTAs/GSIs get “course buyouts” when taking the pedagogy course.	● Instructors retain relative pedagogical autonomy; agency for initiatives remains with department members. ● People in leadership valued efforts and time of teaching faculty and GTA/GSIs.
Power	● Director of First-Year teaching faculty elevated to department leadership. ● TPD of graduate students is considered not only important pedagogically, but also administratively.	● Leadership in administration was committed to these efforts by having changes in leadership. ● Change in classroom size, structure, and workbooks initiated by external funding.
*	<i>GTA=Graduate Teaching Assistant, GSI=Graduate Student Instructor-of-record</i>	

Table 1 illustrates that the people and power dynamics of change were strongly connected. Administrative **power** advocated for resources to improve TPD that supported the Provider’s role. The **people** placed in positions of power made this possible because they valued the Provider’s use of data-driven education research and valued novice instructors’ ability to improve curricular resources for teaching. The respect of the administrators within the department was the strongest **symbol** when the Provider’s role impacted decision-making, which allowed for changes in TPD **structure** with the provider taking a leadership position. Thus, for RQ1, the frames of people and power were more prevalent for BSU, and the aspects of textbooks, worksheets, and administrative support were critical for the systemic change.

Preliminary Connections

Two other departments out of the 10 had similar changes, with Providers indicating a view of connection between people and power. Other department Advice Packets illustrate different connections. Analysis of the four frames tables across all 10 Providers is ongoing (currently member-checking for connections). However, so far, all Providers explicitly spoke to at least two connections among ways of navigating change (i.e., frames). A preliminary analysis across all 10 Advice Packets resulted in Table 2, summarizing which pairs of frames were connected.

Table 2. Number of Connections between Four Frames among All 10 Advice Packets

Connections	Power	People	Symbols	Structures
Power	-	7	0	6
People	7	-	4	2
Symbols	0	4	-	1
Structures	6	2	1	-

In Table 2, notice that people and power was the most frequent connection between two frames ($N=7$) with power and structure being the second ($N=6$). Also noteworthy is the absence of discussion of how symbols and power might be connected. Table 2 suggests pathways for answering RQ2. Once member-checking is complete we will explore the stories behind how Providers indicated the connections happened (e.g., the very short vignette of BSU, above, can be expanded into a case story that illustrates the mechanisms of connections and change at BSU).

Discussion and Questions

These preliminary findings illustrate the viability of using the four frames (Reinholz & Apkarian, 2018) not only for self-analysis of STEM departmental change, but as a means to compare and discuss multiple department changes within and across “window frames” (Bolman & Dean, 2008). Specifically, the summary table from BSU illustrated that the four frames can provide means to identify critical change levers within frames (RQ1), while giving a means to compare connections among ways of navigating change (frames) and across departments (RQ2).

The basic questions related to “What works” have been answered in many ways, including in post-secondary TPD for novice CMIs. The question now is “How to make what works, work for us?” Inherent to addressing this question is that it is an iterative process rather than a destination. What holds promise is *scaling across*: “releasing knowledge, practices, and resources, and allowing them to circulate freely so that others may adapt them to their local community” (Wheatley & Frieze, 2011, p. 34). This is in distinction to the idea of reproductive scaling-up that dominates many western educational reforms. This is not to imply that the structures, values, and resources found in one department are not like those found in others. But similarity is not identity. Singular “best practices” do not exist across the different environments. As Wheatley and Frieze note, “scaling across invites communities to learn from one another and solve their own problems in their own particular way” (p. 36). They would also use the term “trans-local” to describe what happens when people carry an idea from one place (e.g., an Advice Packet) to let it loose in a new environment, often nurturing its growth into something quite different. Understanding the products and processes of change can support preparation for scaling across.

Questions for attendees at the session will focus on this idea and include: *How else might we look for connections between the four frames that would better align with how you would naturally investigate a Provider-described change to TPD? What infographics might be useful?*

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