

Providers of Professional Development for Novice College Mathematics Instructors:
Perspectives and Values About Teaching and Learning

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Those who lead the preparation and assessment of novice college mathematics instructors for teaching (Providers) do their work in many ways (e.g., course coordination, seminars, workshops). Using data from a large national survey, this study examined reporting among 95 Providers about the structures of their departments, their goals for the professional development work they do, and their relative valuation among goals. Respondents completed a sorting and ranking activity about professional development goals and answered an open-ended question describing their sorting decisions. Qualitative coding identified six main themes for the respondents' 285 descriptions. Quantitative analysis used the rankings of goals within respondents' sorting categories to examine how Providers describe and value professional development goals related to professional community, classroom and department culture, and instructor response to students within their classrooms.

Keywords: Mathematics Graduate Student Instructors, Teaching Assistants, Professional Development, Pedagogy, Community, Q-Sort Methodology

Introduction

A significant and continuing challenge to undergraduate student success is the nature of instruction in college mathematics courses (Freeman et al., 2014; Laursen & Rasmussen, 2019). The last decade has seen several national efforts aimed at addressing this well-known problem, including online repositories of activities for use in the preparation of graduate students for teaching (i.e., CoMInDS), online professional learning opportunities for faculty to focus on student learning, and the release of student-centered policy documents like the Mathematical Association of America's (MAA) *Instructional Practices Guide* (IPG). Higher education leaders are now looking to departments to improve the preparation of college mathematics instructors (CMIs); particularly novice CMIs who are graduate students beginning their teaching journey as mathematics graduate teaching assistants (teaching in sessions adjacent to a primary course) and graduate teaching associates (teaching as instructor-of-record). Here, we use **GTA** to refer to both groups collectively and, as needed, distinguish between them with Lab-TA for teaching assistant and GSI-TA for teaching associate. These new CMIs are a critical subgroup because: (1) they teach thousands of undergraduates (Belnap & Allred, 2009), (2) many start as LabTAs, and (3) most have little or no preparation for teaching. In addition, there are many variations in type of institution (e.g., master's granting, doctoral granting) and structure within departments around professional development (PD). Depending on location, GTAs will be offered learning opportunities that may include short orientation workshops, teaching seminars, pedagogy courses, mentoring, or course coordination. Thus, mathematics departments have reached the point where they are asking which resources they should use, and how, to help their graduate students' learn to teach. They know the ingredients exist and are looking for the recipe for their local departmental use.

Context of the Study

This study is part of the CMI Preparation Project. The overarching goal for the project is to document and extend the use of effective professional learning about teaching for a variety of institutional and instructional contexts by generating a CMI Design Tool for use by departments. This study focuses on the findings from a national Needs and Uses Survey with the aim to understand how communities are described and discussed by providers. Analyses from the survey are informing the development of the tool.

Within this survey, respondents were *Providers*: those who work with novice CMIs to support learning about teaching undergraduate mathematics. In the survey, Providers answered questions about their department structure and the design of the professional development available locally to novice CMIs. The survey used a variant of the *Q-sort methodology* (Willig & Stanton-Rogers, 2017) where **Goals** for professional development were *sorted* and *ranked* into up to three **buckets** which were then *titled*. The Goals offered in each activity were developed in the project's earlier work by eight expert Providers from diverse backgrounds (e.g., from private and public, masters and doctoral granting institutions) who merged and distilled critical topics of CMI PD from their experience and research.

Each of the 15 Goals (Table 1) had an associated exemplar (when a respondent hovered over the Goal). Each respondent was asked to sort the 15 Goals into three buckets, rank each Goal within that bucket, and then provide a title and justification for that bucket's title.

Table 1. Goals Sorted by Providers

A: learn how to notice and manage challenges to equity, access, and success among undergraduates
B: learn how to initiate and sustain a productive classroom culture
C: learn about ways for students to build their math learner identities
D: learn strategies to promote and facilitate collaborative learning
E: get feedback on their teaching from peers
F: learn about students thinking and analyze how it reflects instructional decision-making
G: learn how to foster student in-class engagement
H: create a community of instructors and are supported in its creation
I: build knowledge on how students learn
J: learn methods for promoting whole-class discussion
K: learn how to recognize teaching practices that create a sense of belonging among students
L: learn how to implement self-assessment in teaching
M: plan and prepare lessons
N: learn how to develop teaching portfolios
O: learn about and promote student use of outside-of-class learning resources

This qualitative sorting methodology was chosen because prior research in ranking of such PD goals had illustrated that it was difficult to disassociate the judgment of value of teaching method from the logistical expectations of a department (Yee et al., 2018). To address this, for this survey, respondents had choice in how to assign goals to buckets, could freely rank within buckets, and were asked to give and explain bucket titles. There were three of these bucket activities (each having the participant sort Goals into three buckets) in the survey, each on its own page. This report is focused on the bucket activity that emphasized community and how PD

Providers view communities within teaching (Gobstein, 2016; CoMInDS, 2020; Yee et al., 2022). This sub-study addressed the questions

RQ1: How do Providers describe Goals that focus on community?

RQ2: How do Providers value Goals focusing on community?

Background and Theoretical Perspectives

Multiple calls for action to include inquiry-based mathematics education (Laursen & Rasmussen, 2019) and active-learning methods (Braun et al., 2017) have been on the forefront of suggestions for the professional development of CMIs. Recent research and development in collegiate mathematics education has attended to professional communities in several ways. The *Student Engagement in Mathematics through an Institutional Network for Active Learning* (SEMINAL) project (Gobstein, 2016) is expanding use of collaborative learning methods through active-learning. Additionally, the *Promoting Success in Undergraduate Mathematics through Graduate Teaching Assistant Training* (PSUM-GTT) project (Haddock et al., 2018) is diversifying multiple uses of peer-mentoring, training, and seminar courses for CMI professional development. With all of these resources and suggestions, it is easy for a mathematics department to be overwhelmed (Pengelley & Sinha, 2019).

In fact, although 70% of departments in a recent national study indicated they provide some kind of instructional development for novice CMIs, the nature of it varies widely (Ellis et al., 2016; Speer et al., 2017). Novice CMIs today are the very instructors who will play key roles in addressing the nation's need to improve student enrollment, retention and persistence in science, technology, engineering, and mathematics (STEM) courses and majors (Holdren & Lander, 2012; Laursen & Rasmussen, 2019). The opportunity and need coalesce in the first two years – where undergraduates first encounter college mathematics and novice CMIs are most likely to be teaching (Belnap & Allred, 2009). Clear from the proposers' and colleagues' work in developing, offering, researching, and disseminating ideas about professional learning in college mathematics instruction, central to success is strengthening novice CMIs' understanding of student thinking (Roach et al., 2013; Speer & Wagner, 2009; Wagner et al., 2007). Specifically, GTAs are a critical focus of novice CMI professional development.

Bragdon and colleagues (2017) categorized approaches in 120 different master's and doctoral-granting departments into nine models for PD focusing on GTAs. However, a challenge still remains: how to leverage and communicate about these characteristics with and in mathematics departments. To be able to do this we need to understand (1) how department members, including Providers, describe their Goals and (2) how they value their Goals. Research into CMI preparation has demonstrated how Providers' goals for novice CMIs significantly overlap with topics of secondary and primary mathematics methods courses (Yee et al., 2022). Yee et al., (2018) analyzed touchstones in methods courses from two perspectives: those of teacher educators and those of in-service teachers. The focus of this national study was phrased in terms of perceived importance: "Please tell us how important you feel it is for each of the following content items to be valued and addressed by secondary mathematics methods courses for preservice teachers." Although a very valuable study, what respondents valued was conflated with departmental expectations. To get around that, this project used a Q-sort methodology that more clearly isolated respondents' values from their departmental expectations by not only having respondents sort and rank the Goals, but also create and justify a *title* for each bucket, so that we can see the respondents' language and values directly.

Methods

This study used embedded mixed methods where qualitative thematic coding of bucket titles was embedded within the quantitative analysis of the ranking and frequency of Goals within bucket descriptive themes (Creswell, 2017). Respondents for the survey were recruited because they provided professional development about teaching to novices in their departments. The survey was sent to 242 people, 95 of whom completed the sorting activity. These 95 responses, with three descriptive bucket titles each, formed the data pool of 285 bucket titles used for the analysis shared here. Respondents came from a variety of academic positions (see Table 2).

Descriptive analysis along with central tendencies provided a context for interpreting the Community bucket activity data (Table 2). To answer RQ1, thematic coding was used on the descriptive titles created by respondents for their buckets. The goal for the thematic coding was to examine and characterize the language that was used by the respondents (see Table 3). For example, respondents' language suggested one theme be described as "learn how to foster student in-class engagement" – this *in vivo* title represents Provider language (alternatively, the researchers could have abbreviated this as "active learning"). However, we *purposefully* capture respondent language so that we can make sure the content is accessible by people who are not educational researchers, such as those in mathematics departments who will (one day) use the CMI Design Tool for which the survey is a first step.

Researchers went through four stages of thematic coding of the 285 bucket titles by (1) generating a modified word cloud of all titles to generate a preliminary set of themes, (2) collaboratively coding 30 bucket titles into themes and revising themes together, (3) choosing 30 new bucket titles of the 255 uncoded buckets and coding them individually then comparing the codes and revising themes and coding, (4) each researcher then coded each of the remaining 225 bucket titles, then met to discuss revisions until consensus was reached (100% agreement) amongst the bucket titles being coded and the wording used for the themes. It is important to note that for this study the Goals within each bucket were not considered when identifying the themes of the titles, only the titles.

To answer RQ2, we embedded the themes into the quantitative analysis of Goals' within-bucket and weighted rank (see Table 4). Thus, with each theme, we could see what value (weighted rank) was given to that Goal within that theme. Because few buckets had more than six ranked Goals, we wanted to weight the Goals accordingly. We chose to use harmonic progression (reciprocal progression) so that rank 1 of a Goal within a theme was weighted as 1, rank 2 was weighted as $\frac{1}{2}$, rank 3 was weighted at $\frac{1}{3}$, and so on. These weighted rankings were then added together for each Goal within each theme to generate a "heat map" (Table 4).

Findings

We first describe the contexts for Providers who did the survey, then how the bucket titles were themed, and finally how the Goals were valued within each theme. Providers identified, on average, 38 novice CMIs out of an average of 84 mathematics instructors for each of the departments. Those novice CMIs accounted for (on average) 45% of the teaching done within a department (median 49%). Additionally, Providers stated, on average, that graduate students were 30 of the 38 novice CMIs, suggesting 78% of novice CMIs within their departments were graduate students (median 74%). We also asked about a Provider's position and the target group for their PD. Among respondents, 40 were teaching faculty, 33 tenure-track research faculty, 3 tenure-track teaching faculty, and 16 "other" (described as former/current department chair, directors in Math department, non-tenure track teaching/research faculty, lecturer, and postdoc).

This suggests the largest group taking the survey were teaching faculty, followed by research faculty. Together these two groups constituted 80% of all respondents. The novice CMIs target groups were graduate students who were either LabTAs (e.g., recitation instructors, $N=36$) or GSI-TAs (i.e., instructors of record, $N=35$). Together graduate students made up 76% of the target groups for the respondents. Table 2 illustrates the respondents' departmental information relative to the teaching workforce.

Table 2. Structure of Departmental Teaching Workforce and CMI PD (out of 95 responses)

	Median	Mean	SD		
# of people teaching mathematics for the department	70	84	55		
# of above group who are novice CMIs	34	38	31		
# of novice CMIs who are graduate students	25	30	26		
Role within the CMI Professional Development	Teaching Faculty	Research Faculty	Adjunct Faculty	Other	
	43	33	2	16	
Target group for CMI Professional Development	LabTA	GSI-TA	NFI*	ULA**	Other
	36	35	7	1	14

*NFI=non-faculty instructor and **ULA=undergraduate learning assistant.

Bucket Title Themes

To answer RQ1, themes were refined three more times as two researchers expanded, revised, and refined the initial themes to cover the most bucket titles and to best reflect respondents' choice of language. For example, the word "Knowledge" in Th3: (Teaching and Classroom Skills, Strategies, and Knowledge) had similar uses within the respondents' title justifications as use of the word "skills" when referencing teaching. This is important to note: "knowledge" and "skills" for teaching were not distinguished by Provider respondents. The six themes reported here covered 92% of all Goals that were sorted into buckets. Altogether, buckets with titles that fell under Th1, Teaching Community and Culture, contained 106 Goals, 9% of all Goals sorted by all Providers while Th2 bucket titles contained 240 (19%) of all sorted Goals (see Table 3).

Table 3. Bucket Title Themes, Frequencies, and Relative Frequencies

Theme Code	Theme Title	Goal Count	% Sorted Goals
Th1	Teaching Community and Culture	106	9%
Th2	Individual Teacher Development such as Assessment, Feedback, and Reflection on Teaching	240	19%
Th3	Teaching and Classroom Skills, Strategies, and Knowledge	263	21%
Th4	Student Learning, Support, Engagement, and Identity	256	21%
Th5	Classroom Identity, Community, Environment, and Culture	168	14%
Th6	Pedagogical Diversity, Equity, and Inclusion/Belonging Especially in the Classroom	100	8%

The survey asked respondents to briefly justify their bucket titles. Bucket justifications were only used when struggling to thematically code a bucket title. Overall, only 23 of the 285 bucket titles had more than one identified theme.

Goals Valued within Themes

With respect to RQ2, weighted rankings were assigned relative to the Provider's chosen rank for each Goal within each bucket. Table 4 provides a heat map coloring the Goals within each theme (row) – the highest weighted value in green and the lowest rated value in red. For example, for all respondents who had a bucket title that was coded under Th3, the most highly weighted value was 19 on Goal M: plan and prepare lessons. Goals (column headings) were ordered across the top to group greens and reds (see Yee, 2022 for more on the method).

Table 4. Heat Map of Goals within Each Theme According to Weighted Ranking

Goal: Theme	E	N	L	H	A	B	K	M	I	F	O	G	D	J	C	Total
Th1	11	8.6	7.6	18	0.3	1	1.2	2.4	0.5	0.6	1	0	0	0	0	52
Th2	25	16	20	20	2.1	1.3	3.1	7.8	8.3	7.6	2	1.3	0.5	0.5	1	117
Th3	4.4	3.4	2.9	5.5	11	8.6	3.1	19	7.7	4.7	5.1	15	8.8	7.5	3.9	110
Th4	1.3	0.4	0.8	0.8	7.8	7.5	5.9	9.9	17	11	8.5	13	12	7.7	9.9	113
Th5	0	0	0.1	1.1	13	13	7.9	3.5	1.7	2.2	2	6.7	5.9	7.7	4.1	69
Th6	0	0.2	0.2	0.4	12	9.4	6.3	1	1.6	1.4	1.4	1.5	1.6	1	6.4	44
Total	41	29	32	46	45	41	27	43	36	28	20	38	29	24	25	505

In the Total Row, adding up all weighted rankings of single columns, we see Goals H (46), A(45), M(43), B(41), and E(41) were the highest valued across all six themes. Goals A and B focused on classroom community among students while H and E focused on community around instructors. We also see that Goal O: learn about and promote student use of outside-of-class learning resources, had the lowest weighted ranking total (20). When looking across all rows, we see that every Goal but one, O, was in some themes' top five highest valued Goals. This suggests that Goal O was not highly valued for the participating Providers.

When looking at the Goals within each theme, we see some have higher values than others. Goal A “learn how to notice and manage challenges to equity, access, and success among undergraduates” was the highest weighted rank in Th5: Classroom Identity, Community, Environment, and Culture. This is interesting because Providers used the words that define Th5 and then associated this with Goal A. Specifically, equity, access, and success were encapsulated by Providers using the words Identity, Community, Environment, and Culture. These latter words may illustrate Providers seeing the outcomes of managing challenges around equity, access, and success as focusing on classroom environment and culture rather than the individual student. Goal H is a focus on the community of instructors and was the second highest valued in Th2 which focused on feedback and reflection. This may suggest Providers see a strong connection between teacher community, personal reflection, and assessment of teaching by others.

When comparing Th1 and Th2 in Table 4, we see Th2 had higher weighted ranks with Goal I and F, where the focus is on knowledge of how students learn, student thinking and how it affects instructional decisions. Th1 focused on community and culture while Th2 focused on individual development. Thus, Providers seemed to view Goals around student learning and thinking as less impactful to community development than to individual teacher growth.

When comparing and contrasting Th5 and Th6, we see these themes did not highly value Goals E, N, L, and H yet did value Goals A, B, and K highly. This aligns with the focus of Th5 and Th6 around the classroom. Goals D, G, and J had higher valued weighted ranking in Th5

over Th6. This suggests Providers who title buckets with Diversity, Equity, and Inclusion did not value engagement, collaboration, and whole-class conversation as much as those who titled their buckets with Identity, Community, Culture and Environment. More work is needed to understand this finding given that research in active learning has suggested that collaboration and engagement seem to encourage diversity, equity, and especially inclusion (Laursen et al., 2014).

Discussion

Overall, we found that Providers responding to the survey were primarily teaching faculty, followed closely by research faculty within mathematics departments. The Providers' departments had a workforce where on average 45% of all instructors were novice CMIs. These Providers focused primarily on the 75% of novice CMIs that were GTAs. In answering RQ1, we found that there were six dominant themes that captured the 285 bucket titles. Language chosen by the Providers was preserved within these themes illustrating important differences between how educational researchers use terms (such as knowledge and skills) and how Providers use these terms. These differences are important as we move forward in creating a Design Tool with language that is meaningful to its users. When looking across the themes, at how the Goals were sorted and ranked, certain distinctions about how themes and values varied illuminated additional challenges and opportunities for offering mathematics departments' guidance on Provider resources.

When comparing and contrasting weighted ranking of Goals within Th5 and Th6, Goals D, G, and J were all slightly higher with Th5 suggesting responding Providers associated student engagement, collaboration, and whole class discussion (Goals D, G, & J) within classroom identity, community, environment and culture (Th5), rather than within what Providers identified as "diversity, equity, and inclusion" (Th6). More investigation is needed on this. For example, it could be an artifact of assumptions about the nature of CMI influence on classroom culture, environment, and community as different or easier than that what Providers associate with diversity, equity, and inclusion (i.e., Providers were less inclined to connect engagement, collaboration, and whole-class discussion goals with Th6: Diversity, Equity, and Inclusion).

One of the largest implications is the need for clear distinction in the Design Tool between departmental values related to communities of undergraduates (e.g., a classroom community) and community among novice instructors (e.g., in a comparison of Th1 and Th2 versus Th5 and Th6 in Table 4). We see those Goals valued in Th1 and Th2 are not valued in Th5 and Th6. Moreover, the highest valued Goals overall (Table 4) were Goals H (46), A(45), M(43), B(41), and E (41). Goals H and E focus on the teacher community while Goals A and B focus on classroom culture and equity, access, and success with students (classroom community). Goal M, plan and prepare lessons, seemed to be the only Goal that was moderately valued across nearly all themes (Table 4) and had a high overall value. This may suggest that Providers can leverage planning and preparing lessons to bridge discussions among these communities. For example, when planning a lesson, the discussion can revolve around the student community, while discussion on how the lesson plan is used, by whom, and how, could connect conversation back to instructors' community.

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