



Mathematics Graduate Students' Teacher Identity Development: Examining Roles Within the Teaching Assistant Position

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Abstract: The ways that serving as a teaching assistant (TA) influences the teacher identity development of mathematics graduate students is still a largely undertheorized area of postsecondary mathematics education research. Drawing on sociocultural theories and role identity theories, we qualitatively examined how interactions within the mathematics TA position prompted graduate students to take up a multitude of role identities. We found that different interactions uniquely positioned participants to assume roles, such as instructor, supporter, mentor, and learner. Some role identities were only situated within specific interactions, while others were evident across multiple interactions. Teacher identity is a complex, multidimensional construct, and we found that serving as a TA supported the teacher identity development of mathematics graduate students through opportunities to take up a myriad of role identities. Understanding the nuances and complexities of the identities and experiences of mathematics graduate students can equip mathematics departments and higher education institutions to better support their transition to the mathematics professoriate.

Keywords: Mathematics Graduate Students, Teaching Assistants, Role Identities, Teacher Identities

DOI: <https://doi.org/10.31756/jrsmtte.316SI>

Introduction

Graduate students in mathematics frequently serve as teaching assistants (TAs), a position that is pivotal not only for the functioning of academic departments but also for the professional development of the graduate students themselves. In this work, we explored the various roles that mathematics graduate students assumed while serving as TAs and how these roles contributed to the development of their multifaceted teacher identities. Understanding this process is crucial for improving graduate education, supporting the development of teaching practices, and preparing future educators for their careers in academia. From an exploratory and descriptive perspective, we analyzed the role identities TAs took up, offering insights into the process of teacher identity development and how graduate programs can better support and enhance the preparation of future educators.

Graduate education is recognized as an important period of socialization and professional identity development for graduate students (Tierney & Rhoads, 1993; Weidman et al., 2001). Beisiegel and Simmt (2012) wrote, "After all, it is through the formative experiences of graduate school that mathematics graduate students' identities are shaped as mathematicians, researchers, teachers, or more generally as professors of mathematics" (p. 35). One such formative experience is graduate students serving as TAs for undergraduate mathematics courses. The position of a TA encompasses a diverse array of responsibilities, including teaching, grading, providing student support, and

sometimes even curriculum development (Winstone & Moore, 2017). These responsibilities compel TAs to navigate multiple roles and identities simultaneously (van Lankveld et al., 2017). Over time, repeatedly enacting these roles solidifies them as part of an individual's self-concept, leading to a more stable identity (McCall, 2003; Winstone & Moore, 2017). For graduate students, like the faculty many aim to develop into, being a teacher will be one of the most prominent dimensions of their professional identities (Clarke et al., 2013).

Although research on mathematics graduate students has increased over the last few decades, the day-to-day complexities and ways that serving as a TA develop graduate students' teacher identities (Beijaard et al., 2000; 2004; Solari & Ortega, 2020), and more broadly their professional identities (Clarke et al., 2013), is still relatively understudied and undertheorized. Across the majority of graduate programs in the United States, there is no set of requirements for coursework on pedagogy or mandatory teaching experience prior to taking up faculty positions (Foote, 2010; Hancock & Walsh, 2016). There are also minimal institutionalized professional learning opportunities that are specifically aimed at developing these burgeoning scholar-teachers' identities as higher education faculty (Austin & McDaniels, 2006; Friedberg, 2005; Jensen, 2011). Foote (2010) explained:

In the US, graduate students do gain experience in the classroom as teaching assistants and even lead courses as the primary instructor, but usually this is learning by example. Relatively few receive any formal training in course design, learning theory or active pedagogy. (p. 8)

Extant literature on mathematics TAs has tended to focus on the structure and content of professional learning experiences, such as trainings and workshops (e.g., Deshler et al., 2015), TAs' development of instructional practices (e.g., Friedberg, 2005), or how interventions with TAs impact undergraduate students (e.g., Bent et al., 2020). Examining graduate students' teacher identity development is theoretically important, because of the gap in the literature, and it is practically important because this knowledge can inform how mathematics departments and institutions support graduate students as TAs and as future faculty (Kendall et al., 2013). Acknowledging that the collective experiences of graduate education can inform their teacher identities (Bale & Anderson, 2022), we focus on graduate students' experiences as TAs to examine the complexity of this position and how the interactions with others and roles TAs take up are contributing to their teacher identity development.

To guide our investigation, we drew on sociocultural perspectives of teacher identity development in higher education (Beauchamp & Thomas, 2009; Clarke et al., 2013; Solari & Ortega, 2020) and role identity theory (Jazvac-Martek, 2009; McCall & Simmons, 1978). These perspectives recognize the salience of the social domains that mathematics TAs navigate, the interactions with members of their community, the multitude of roles they assume, and the intrapersonal domains, or identities they assign to themselves. The guiding research questions of our study were: (1) What roles did mathematics graduate students take up as they served as teaching assistants? and (2) From which relationships and interactions within the teaching assistant position did their roles and identities emerge?

Conceptual Framework and Literature Review

Our conceptual framework draws on sociocultural perspectives of teacher identity development in higher education and role identities theories, which we describe here. Embedded within the first two sections of our conceptual framework is a brief literature review as well. The final section is an overview on recognized roles of TAs.

Sociocultural Perspectives of Teacher Identity in Higher Education

We broadly view one's identity as being grounded in a sociocultural perspective; that is, identity is: "a dynamic view of self, negotiated in a specific social context and informed by past history, events, personal narratives, experiences, routines, and ways of participating" (Bishop, 2012, p. 38). It is widely recognized that teacher identity encompasses one's sense-of-self as a teacher (Sachs, 2001; 2005), and how they are recognized as such (Berger & Lê Van, 2018; Trede et al., 2012). Beijaard et al. (2000) conceived of teachers' professional identity as "how they perceive themselves as teachers and what factors contribute to these perceptions" (p. 751). They also described that an important aspect of teachers' self-perceptions are the ways they negotiate the meanings that others attribute to them (Beijaard et al., 2000; 2004). Identities are not developed in isolation, and the role of others in constructing and making sense of one's identity is paramount. In higher education, some factors that influence teacher identity development include the direct work environment, the wider context of higher education, interactions with students, and staff development activities (van Lankveld et al., 2017). Graduate students' teacher identities evolve as they navigate the range of experiences within graduate education.

Additionally, we align our work with the perspective that teacher identity is multidimensional and complex. Mockler (2011) conceptualized teacher professional identity as a "plurality of identities" (p. 125) involving the constant negotiation and renegotiation of personal and professional dimensions (i.e., the intersectionality of identities such as race, gender, identity as a teacher, identity as a researcher, etc.). Similarly, Trede et al. (2012) described how teachers navigate a "multiplicity of worlds or communities" (p. 378). The multidimensional nature of teacher identity has been approached through categorizations of what constitutes and informs teachers' professional identities. For example, Beijaard et al. (2000) described teachers' identities in terms of expertise and what teachers privilege in their classroom instruction. Berger and Lê Van (2019) additionally attempted to connect more affective factors (e.g., motivation, self-efficacy, etc.) that have historically been seen as independent and highlight how such factors constitute teachers' identities. We support the notion of a multifaceted teacher identity through the lens of role identities.

Role Identity Theory

Role identity theory (McCall & Simmons, 1978) emerged as a way of explaining the fluidity of identity and how individuals take up and enact roles depending on the situation and context. This theory asserts that interactions and negotiations with others leads to the assumption of different roles (McCall, 2003), aligning with the notion that teacher identities are multidimensional, and socially embedded and legitimized. Role identity theories have been utilized to examine the experiences of doctoral students (Jazvac-Martek, 2009) and graduate teaching assistants

(Winstone & Moore, 2017), because graduate students have historically been considered to hold an intermediate status that encompasses a range of roles and identities (e.g., student, teacher, researcher, etc.). In their study of doctoral students, Jazvac-Martek found that participants oscillated between student roles and academic roles, and features of their interactions with others strengthened their professional identities. For example, the participants in Jazvac-Martek's study described notable interactions with faculty, where their academic roles were acknowledged and supported. Winstone & Moore (2017) more specifically situated role identity theory to examine graduate teaching assistants. They found that these TAs adopted professional identities as prospective faculty and did not always completely abandon their other roles and identities (e.g., as students). Making sense of the expectations of staff, faculty, and students often led TAs to be malleable with their identities to fit the demands of different situations (Winstone & Moore, 2017).

A Myriad of Roles

Graduate students embody a number of different role identities. We provide a literature review to examine some of these roles, which aligns with codes that emerged during our analysis, shown in Figure 2 in our Methods. We share two sets of these role identities. The first of these roles are those associated with teaching and engaging with students. The most commonly associated role with graduate TAs is that of a teacher. Features of this role encompass practices related to instruction, including preparing and delivering lectures, facilitating discussions, and assessing student performance (e.g., Lee, 2019; Mesa et al., 2014; Speer et al., 2010). Other TA roles include: connecting and building community with and amongst their undergraduate students (Camarao & Din, 2023; Olarte et al., 2021), mentoring (Brown & Sheerin, 2018; McAlister et al., 2022), and supporting peers and undergraduate students (Bowles et al., 2018; Staton & Darling, 1989; Syrnyk, 2018). For example, Brown and Sheerin (2018) described the ways that graduate students enacted different forms of mentorship, ranging from informal mentoring with no set goals or timelines to more formal mentoring. Additionally, graduate students engage in the role of supporters through such practices as sharing information and providing emotional support to fellow graduate students (McAlister et al., 2022; Staton & Darling, 1989) and supporting undergraduate students by offering socioemotional support and attending to their students' diverse needs (Bowles et al., 2018; Syrnyk, 2018).

The second area of roles extend beyond teaching or specific practices. First, graduate students take up roles as learners beyond their graduate coursework (e.g., Kajfez & McNair, 2014; McAlister et al., 2022). Sprague and Nyquist (1989) described early graduate TA positions as "senior learners," or TAs who "tend to identify more with the students in their classes than with the instructors they are assisting" (p. 44). Secondly, scholars have examined TAs' demeanor in the classroom and undergraduate students' perceptions of TAs. For example, TAs have been viewed as approachable, enthusiastic, and accessible to students (Kendall & Schussler, 2012), and TAs have expressed the desire to be perceived as fair and approachable (Gunn, 2007) or humorous (Stirling, 2004).

Lastly, dominant narratives and storylines surrounding the TA position, such as long-held beliefs regarding the TA and faculty relationship, can influence the roles that TAs assume (e.g., Flora, 2007; Janssen, 2012). Within these

relationships, graduate students engage in interactions and experiences that serve to reinforce and socialize them into what is perceived as standard practices and behavior in higher education (Anderson & Louis, 1994; Austin & McDaniels, 2006; Staton & Darling, 1989). For example, Nasser-Abu Alhija & Fresko (2020; 2021) examined TAs' experiences and professional interactions; they highlighted the significance of TAs experiencing agency and autonomy, because TAs are often positioned as subordinate and lack status in classrooms (Flora, 2007). Others have noted that factors, such as department structure, department climate, and faculty mentorship influence graduate students' identification and understanding of norms in academia (Anderson & Louis, 1994), illustrating further how graduate students come to understand the dominant narratives and storylines within academia. These higher-level discourses are significant, yet often overlooked, dimensions of graduate students' role identities and their broader teacher identities (Staton & Darling, 1989).

We leverage this breadth of research to examine the multiple role identities within the mathematics TA position. Serving as a TA is one of the most influential experiences for graduate students, and the roles taken up as they negotiate meaning with others provide a glimpse into their developing teacher identities. TAs enact and switch between multiple roles and navigate a complex network of students, faculty, and other TAs, all situated within an institutional context and the mathematics discipline. These factors have the capacity to influence the roles that TAs assume (Bale & Anderson, 2022).

Methods

Context

This study was conducted at a Minority-Serving Institution in California during the Fall 2020 term. It was part of a larger multi-year program evaluation project that examined a mathematics department intervention involving a set of courses intended to support transfer students' transition to a four-year university. The set of courses included an introductory proof course, which we call Math A, and two other, non-mathematics content courses more specifically designed to provide resources and support to transfer students. With the shift to remote instruction brought upon by the COVID-19 pandemic, we broadened the scope of the evaluation project to examine how instructors and TAs navigated the remote instructional context. In addition to continuing to examine their understanding of their positions, roles, and the ways they supported students, we also sought to understand how they made sense of the shift to remote instruction. The focus of the present article is on the TAs of Math A. Math A involved asynchronous lectures from the instructors/faculty, and the TAs facilitated synchronous sections and office hours via Zoom.

Participants

Convenience sampling (Creswell, 2013) was used to recruit five mathematics PhD students who served as TAs for Math A as that was the focal introductory proof course of the larger project: Kaitlyn, Lisa, Federico, Nestor, and Wyatt (pseudonyms used for all proper nouns, see Table 1 for their profiles). At the time of data collection, participants were in the 2nd or 3rd years of the doctoral program, and all had prior experiences as TAs. The

institution shifted to remote instruction during the Spring 2020 term, so all participants had at least one term of online TA experience - with some participants also serving as online TAs for summer courses.

Table 1

Participant Profiles

Name	Year in Program	Prior Experiences as Math A TAs	Prior Experiences as a TAs
Federico (he/him)	2nd	No prior experience	Lower division courses
Kaitlyn (she/her)	3rd	No prior experience as a Math A TA, had prior experience as a grader.	Lower division courses
Lisa (she/her)	2nd	Served as an online TA of Math A during the summer	Lower division courses
Nestor (he/him)	3rd	No prior experience	Upper division courses (i.e., primarily held office hours)
Wyatt (he/him)	3rd	No prior experience	Lower division courses

Data Collection

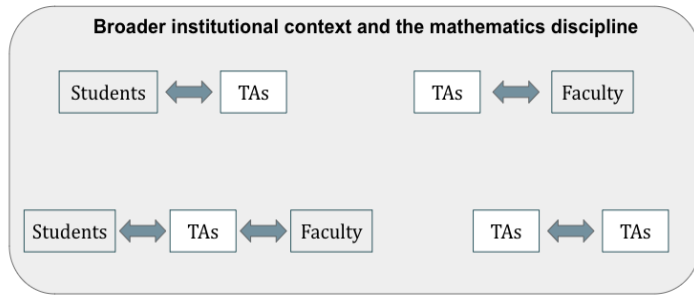
We conducted single, one-hour, semi-structured interviews (Rubin & Rubin, 2011) with the participants (4 total interviews because Kaitlyn and Nestor were interviewed together) over Zoom that focused on their experiences and roles as TAs, how they navigated remote instruction, and their perceptions of their identities as early-career educators. We used the participants' interview responses as the primary source of data (See Appendix A for interview protocol).

Data Analysis

The research team first open-coded (Miles et al., 2020) the TAs' interview responses together and identified the interactions that the participants most often cited in their reflections to get a sense of the salient characters with whom participants most often negotiated their roles and identities. That led us to three initial interactions: (1) TAs' interactions with students (referred to as the Student-TA relationship); (2) TAs' interactions with the instructor or faculty (i.e., the TA-Faculty relationship); and (3) TAs' interactions with other TAs (i.e., the TA-TA relationship). As a team, we discussed the interactions and reconciled any disagreements. Through continued analysis, we found that participants positioned themselves as someone who more intentionally mediated students and faculty. Some of their reflections involved navigating interactions and negotiating meaning and roles with *both* students *and* faculty, which led us to consider a fourth configuration of interactions that involved TAs positioning themselves (Arvaja, 2016) between students and faculty (i.e., Student-TA-Faculty relationship). We then coded the entire corpus of the data using the four critical interactions (see Figure 1).

Figure 1

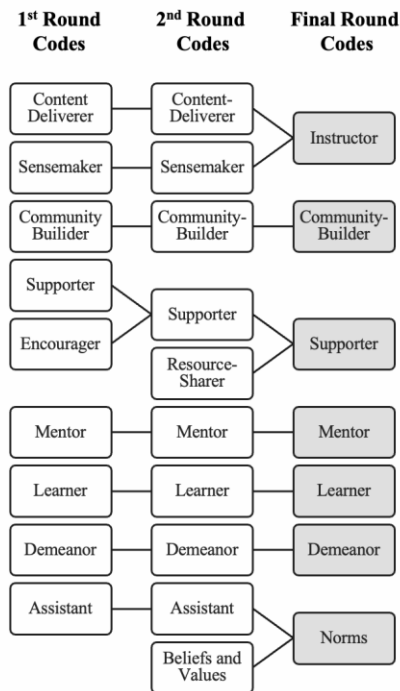
Configurations of TAs' Interactions



After we coded the data for the interactions, we examined the ways that participants negotiated and made sense of their roles as they discussed the key characters with whom they interacted. Taking an exploratory and descriptive approach, we drew on existing characterizations of TAs' roles and were also open to new insights in how participants reflected on their roles. The team discussed and reconciled our interpretations of the participants' roles across three rounds of coding. See Figure 2 for our process of coding the data, and the ways that the research team allowed for the emergence of new codes in each round as well as the consolidation of codes (e.g., *supporter*, *encourager*, & *resource sharer* encompassed by the final supporter code).

Figure 2

Coding Process



Findings

We found that participants took up various role identities as they interacted with students, faculty, and other TAs. A goal of the present work was to investigate the range of roles TAs enacted to illustrate the multifaceted nature of teacher identity and to highlight the importance of the TA position. Teacher identity is a complex construct, and the interactions were unique sites through which role identities were enacted, reaffirmed, and challenged. Table 2 visualizes the role identities within each interaction and across all the participants. In the subsequent sections, we highlight the prominent role identities that emerged within each interaction.

Table 2

Roles Identities Across Interactions in the Teaching Assistant Position

Role Identities	Key Interactions			
	<i>TA-Student</i>	<i>TA-Faculty</i>	<i>Student-TA-Faculty</i>	<i>TA-TA</i>
Instructor	X	X	X	-
Community-Builder	X	-	-	-
Supporter	X	X	X	X
Mentor	X	-	-	-
Learner	-	X	-	-
Demeanor	X	-	X	-
Norms	X	X	X	-

Role Identities Emerging from the Student-TA Interaction

We found that participants most reported taking up multiple roles as a result of making sense of their interactions with students. We hypothesized as such because the participants interacted with students more often than with faculty or other TAs. The prevalent role identities that TAs assumed were: *instructor*, *community-builder*, *supporter*, *mentor*, and *demeanor*.

Instructor

The prominent role identity that participants took up as they made sense of their relationships with students was that of an instructor. The instructor role identity encompassed instructional practices, such as lecturing and facilitating group work (Smith et al., 2005), participants' understanding of students' learning, and participants' navigation of instructional challenges. TAs often reinforced the traditional forms of instruction faculty instructors enacted,

whether by presenting the same content instructors had previously lectured on or by reviewing material from previous classes. For instance, Wyatt explained, “I found that I’m more effective as a TA when I can just cover a lot of material because my strength is being able to explain it in a digestible way.” Wyatt identified his effectiveness in presenting the mathematics content differently than the instructor and making it more accessible to students. Nestor described a slightly different sentiment, saying, “I should just be like a - not literally, but, like, a bit of a copy-paste of what the professor has said in lecture. Sometimes [I’m] just repetition.” Wyatt and Nestor demonstrated role identities of traditional instructors through their explanation of content and emulation of the professors with whom they worked.

Another aspect of their roles as instructors involved making sense of students’ needs and adapting instruction. For example, participants adapted instruction to meet the cognitive demands and challenges of Math A. Kaitlyn said, “I think there's also an intensity that comes with Math A that makes students feel a little bit more, I don't know, fearful about doing perfect in the class.” Kaitlyn identified how proof-based courses at the university brought a level of intensity that students may have not have previously encountered. She described her efforts to combat this intensity by spending time in her sections reiterating what the professor had presented in lecture to allow students to revisit material and to develop a deeper understanding of the content. Additionally, an important aspect of their role identities as instructors involved developing awareness of students’ abilities and accommodating multiple ways of thinking. Wyatt described how a successful TA should be able to leverage students’ strengths and understand their idiosyncratic approaches to proof-construction. He shared:

A successful math TA is somebody who can accommodate multiple ways of thinking and to find out what a student's strengths and weaknesses are, and to speak to those strengths and weaknesses, instead of just giving a wholesale one-size-fits-all answer.

Other participants echoed the notion that it is the TAs’ responsibility to support multiple ways of engaging with mathematics. Federico explained, “There’s always two kinds of students. A TA should be able to help both of them.” Later, he mentioned, “A good TA is good at balancing these things.” To Federico, a successful instructor is able to support students who come into Math A with varying levels of proof-construction experiences. Overall, we found that the instructor role identity was the most articulated dimension and one that all participants took up as they interacted with students.

Community-Builder

The community-builder role identity was exemplified by facilitation of social communities and professional networks amongst the students or between the students and TAs. For example, Lisa commented, “I tried to do a lot more breakout sections and try to get students to talk to each other, because I was, like, ‘You don't ever see each other. [You should be] trying to talk to each other.’” Lisa made efforts to encourage her students to interact with one another and become more familiar with each other. She described beginning class with a question to get to know

what and how her students were doing outside of the classroom. She expressed that she was able to best engage with students on a personal level during office hours: “I’ll mostly be, like ‘Anyone do anything fun on the weekend?’ and then usually be met with silence. But in office hours, I had students linger around and talk to me, so that was fun.” Lisa’s interactions with students represented other participants’ experiences with building community. Efforts to connect students during section and to have informal conversations during office hours were the most cited practices - with participants often articulating affordances and constraints of these social contexts (e.g., students being more talkative during office hours). It is important to acknowledge that many of the above-described efforts related to building community were in response to the challenges presented by the COVID-19 pandemic and participants shared that building community online was one of their most difficult tasks.

Supporter

Participants took up the role identity of supporter as they encouraged students, provided socioemotional support, attended to students’ diverse needs, and advocated for their students. They recognized that part of their teacher identities included attending to students’ affect and emotions, and they were committed to providing students with support throughout the term. Given the remote instruction brought upon by COVID-19, TAs recognized that it was an extremely difficult time for students, and they often positioned themselves as being someone to whom students could talk, beyond the mathematics content of the course. For example, Nestor recalled having a conversation with a student about aspects of each other’s lives that did not directly relate to the mathematics content. He shared, “I don’t know exactly how we ended up there, but I guess she just needed someone to talk to that night, and I was the one for whatever reason, because in Zoom you can’t really reach out to anybody else. Right?” He recognized the student’s need and provided timely, socioemotional support.

Kaitlyn also took up the role identity of supporter, however, through her recognition of the unique challenges related to students’ diverse experiences and prior knowledge coming into the Math A course. She said, “It [Math A] does tend to involve a lot of writing and I think sometimes there is a difficulty, like if English isn’t your first language. That can be a bit of a problem in this course.” Kaitlyn recognized that not all students in her section were native English speakers and understood how the emphasis on using English in proof-construction posed inequitable challenges to some students. To support these students, Kaitlyn explained, “You have to spend a little bit extra time trying to interpret what they’re saying.” She spent extra time grading students’ work to assess their thinking more carefully, exemplifying the supporter role by adapting certain practices to specifically attend to students’ diverse experiences.

Lastly, participants supported students through advocacy. Federico described listening to students’ requests and complaints during office hours and relaying that information to the instructor of the course. He felt that students may not feel confident enough to go directly to the instructor, and his conversations with them provided insight into their experiences and needs. Through advocacy, offering encouragement, attending to students’ needs, and overall, showing care, we found that participants supported students throughout the term.

Mentor

Participants assumed the mentor role identity by providing their students with insights into progressing through the mathematics major and by offering career and professional advice. Lisa explained that she often found her students initiating conversations and asking questions such as: “How are you? How are you doing? What are you studying? Where did you go for your undergrad?” In these instances, students positioned Lisa to take up the mentor role as they sought insights into her own academic journey. Lisa described these exchanges as “conversations about life,” where her goal was to provide them with advice beyond the course (i.e., conversations about their futures and academic lives after Math A). Nestor likewise found personal enjoyment in his role as a mentor. He said:

I like the mentor aspect, especially Math A where you kind of help these kids open the door to a higher level math, that's kind of a rewarding feeling. Now, I don't think I'm necessarily the best at it, but I try, and so, that's kind of like, if I could help one person, then I guess I'm happy with that.

Nestor articulated that being a TA for an introductory-proof course allowed him to mentor students at a critical point in their mathematical trajectories as they continue to “higher level math.” Similarly, Federico considered his mentor role to involve talking to mathematics majors about the sequence of future coursework and offering insight and guidance on what graduate school may entail. For most TAs, mentorship often occurred during office hours interactions, because this was a space where students felt more comfortable asking for advice. Kaitlyn explained, “I think office hours are a place where they feel a little bit more comfortable talking to you about how they're doing in the class and, like, maybe looking for some extra advice or emotional support or whatever.” Overall, this role identity of mentorship was exemplified as providing advice on coursework, graduate school, and professional endeavors.

Demeanor

We conceptualized the demeanor dimension as intertwined with graduate students' other role identities. However, the demeanor role identity more specifically referred to the ways participants behaved and expressed themselves and how they hoped to be perceived by students. Although we found this dimension to complement other role identities, such as instructor and supporter, we highlight the explicit instances that participants mentioned being more personable and approachable - which were the most frequently cited demeanors. TAs' conveyed the importance of portraying themselves as personable (i.e., friendly, warm, and inviting), so that they were more approachable to students. Wyatt recalled attempts to communicate to students that, “I'm like you. I'm not [a] scary big professor. I'm just trying to gauge where you all are at and help you get through.” In this instance, Wyatt reflected on how students usually perceive professors and was cognizant of adopting a demeanor that would help students feel less afraid. Additionally, he reported that he “tried to be as un-intimidating as possible, because people do feel intimidated in math classes.” Here, Wyatt exhibited an awareness of how students may generally feel in mathematics classrooms and worked to offset negative emotions by being accessible and affable. Similarly, Nestor shared:

So you answer in a way that's not, you're not judging them right? So they feel comfortable to keep asking questions, I think that's the key. If your students are comfortable then they're going to ask questions and then from there, you can kind of see where their understanding is at.

Nestor viewed teaching as a social activity, such that students' perception of him as non-judgmental could impact their learning and willingness to participate in class. Altogether, we found that an awareness of students' perceptions of TAs led participants to adopt more approachable and personable demeanors that supported their other role identities (e.g., being an instructor).

Role Identities Emerging from the TA-Faculty Interaction

We focused on participants' interactions with the faculty instructors of the Math A course. The role identities that most emerged from their interactions with faculty were that of learners and the establishment of norms. Participants described that serving as a TA allowed them to learn from the instructor. Additionally, interactions with faculty solidified norms regarding the dynamics between instructors and TAs. We found that their role identities also often reflected a desire to mimic or contradict what they observed from the faculty. This aligns with existing conceptualizations of role identity theories because the participants assumed roles from making sense of the faculty's behaviors and expectations.

Learner

We observed that the role identity of learner only emerged from interactions with faculty. Some graduate students described that an advantage of being a TA was that they could gain new insights about the content and pedagogy for teaching that content. For example, Nestor described his experience of learning in new ways, noting, "I feel like every time I revisit a concept... I always learned something new, just for myself or like a different perspective, different angle, because the professor looks at it from a different, in a different way." Nestor considered himself a learner as he experienced the content through the lens and approaches adopted by the instructors, and this was one of the most enjoyable aspects of serving as a TA. The TA position allowed participants to be learners, and for their developing teacher identities, leveraging this role identity can support their pedagogical development.

Norms

The interactions with faculty reaffirmed what the TAs understood to be typical storylines and dynamics between instructors and TAs (Flora, 2007; Janssen, 2012). Across all participants, the idea of a TA being strictly assistants to the faculty was cemented. They reported noticing a clear "boundary" between faculty and TAs and being aware of the general expectations that faculty had for TAs. Participants saw themselves as individuals whose primary role was to assist or serve the faculty, often referring to themselves as a "helper" or "grader." For instance, Lisa shared, "[I] just do some of the grunt work of the grading and background work that needs to get done. You know, it shouldn't lie fully on the professor's hands. Just a helper, a solid helper." In this instance, Lisa gave merit to helping and assisting the faculty she worked with through grading exams and doing background work. Kaitlyn analogously

commented about the expectations placed on TAs and said, “As far as the professor goes, you know, they expect you to go through homework problems and answer questions that students have and grade a little bit” highlighting the TAs’ role in assisting with homework and grading. Additionally, Federico described his relationship with the course instructor noting, “He told me things to do. That’s what I did.”

The recurring theme of the TA position being solely about completing assigned tasks was evidenced by reflections such as, “He told me things to do,” and the TA position involved “grunt work.” Negotiating expectations and making sense of their relationships with faculty solidified the storyline and norm that TAs have less agency and autonomy in their position. With agency and ownership of courses recognized to positively impact graduate students’ teacher identities, future exploration of how departments can position TAs as collaborators on courses in addition to their expected contributions (i.e., grading, running sections) is necessary. For example, Slack and Pownall (2023) found that treating TAs as colleagues and not as “spare parts” positively contributed to their identity development, and our finding suggests that interactions with faculty may perpetuate perspectives that TAs are accessory.

Role Identities Emerging from the Student-TA-Faculty Interaction

We distinguish the Student-TA-Faculty interaction from the Student-TA and the TA-Faculty interactions, because we found instances when participants described themselves as individuals who bridged and mediated students and faculty. We considered this configuration to uniquely inform the roles that TAs assumed because nuances of certain role identities resulted from sensemaking and reconciling the various expectations, perceptions, and demands of *both* students and faculty. As Kaitlyn noted, “It’s kind of exactly what it seems: like you’re this middle ground between the professors and the students.” Albeit more limited, participants reported some role identities emerging from the Student-TA-Faculty interactions (e.g., instructor and supporter). However, we highlight the role identity related to the TAs’ demeanor, as it was the most commonly cited dimension that resulted from making sense of both students and faculty.

TAs recognized students’ negative perceptions of faculty, leading them to portray themselves in ways that differed from faculty. When asked about her primary goal, Lisa said, “Just to be someone who is less scary than the professor. My job is just to be approachable.” Here, Lisa noted that approachability was an important consideration for TAs because of the common perception that professors were “scary.” Similarly, Kaitlyn shared, “I think part of our role as a TA is just to, sort of, be that middle ground between the scary professor and any intimidation.” The ways Lisa and Kaitlyn expressed themselves, particularly as caring and approachable to students, were taken up to alleviate fear and intimidation. While this dimension of teacher identity is like the role of supporter, we observed that TAs went beyond presenting themselves as nice and explicitly mentioned their unique position in between students and faculty. They were aware of how their presence and demeanor can combat students’ negative perceptions of mathematics classrooms.

Role Identities Emerging from the TA-TA Interaction

TAs' least cited role identity configuration was interactions with other TAs. We note that there might have been fewer TA-TA interactions because of the COVID-19 pandemic, but we conjecture that interactions with peers and colleagues still influence the role identities that graduate students take up. In the present study, we found that as participants interacted with other TAs, they only took up the role identity of supporter. Navigating the shift to remote instruction during the Fall 2020 term likely contributed to the prevalence of this role. Kaitlyn described how the TAs in the mathematics department supported each other by giving advice and using various online platforms to share resources to address the challenges of facilitating sections online. She explained:

I think we gave advice to each other, and we have a Discord [online platform] for our math grads, so people talked about teaching advice and...what programs they like to use, apps they like to use to teach. Yeah, lots and lots of back and forth about those kind of things with other grad students, just because, you know, we're all sort of going through the same stuff.

Kaitlyn was cognizant of what her fellow TAs were experiencing and displayed a shared sense of comradery in navigating remote instruction. Participants mentioned supporting each other by offering advice and directing each other to teaching resources. These interactions highlighted the role identity of supporter particularly towards other TAs. We posit that this sense of collegiality positively contributes to participants' teacher identities and sense of selves as prospective faculty.

Discussion

Drawing on sociocultural perspectives and role identity theory, we provided an in-depth analysis of how specific configurations of interactions led graduate students to take up a myriad of roles as they served as TAs. Our findings illustrated the complexity and multidimensionality of the mathematics TA position, highlighted by the participants assuming roles that went beyond teaching the mathematics content. The present study aligns with existing literature emphasizing the salience of the context and the role of others in teacher identity development (e.g., Clarke et. al, 2013; Solari & Ortega, 2020), but we offer new insights through a closer examination of how TAs made sense of and negotiated meaning with others and the resulting roles they took up (See Table 2). Extending beyond scholars who have examined specific roles that graduate students take up, such as being a teacher (e.g., Speer et al., 2010) or mentor (e.g., Brown & Sheerin, 2018; McAlister et al., 2022), our study offers a more comprehensive set of roles and dimensions within the TA position and how these roles interact with other positions in a mathematics department, yielding a possible conceptual foundation for continued examination of mathematics graduate students' teacher identity development.

Beauchamp and Thomas (2009) wrote that identity "is shaped and reshaped in interactions with others in a professional context" (p. 178), and we found that the instructional context of Math A and the different social relationships led TAs to assume a wide range of role identities, echoing the notion that teachers' identities are

multidimensional (e.g., Berger & Lê Van, 2019; Clarke et al., 2013). We observed that certain role identities were more frequently enacted in specific interactions, such as being a community-builder most often occurring within the Student-TA interactions, and being a learner most often occurring within the TA-Faculty interactions. However, other role identities and dimensions of TAs' developing teacher identities, such as instructor and understanding of norms, were evident in multiple interactions (i.e., Student-TA, TA-Faculty, and Student-TA-Faculty interactions). Interacting with students led TAs to take up the most role identities, confirming the notion that contact with students significantly drives teacher identity development in university settings (e.g., van Lankveld et al., 2017). Some role identities only emerged in one type of interaction (e.g., mentor in the Student-TA interaction, and learner in the TA-Faculty interaction), suggesting that some role identities are more socially legitimized within specific dialogic interactions. Table 2 makes visual the role identities taken up by the participants, but we acknowledge that other role identities may emerge in other contexts.

Further illustrating the complexity and nuance of the mathematics TA position, although the essence of each role identity was generally the same across the interactions (e.g., supporter referring to providing socioemotional support, showing empathy, etc.), the enactment of a role depended on the person with whom an individual interacted. For example, being a supporter to students often meant providing socioemotional support and advocacy. On the other hand, being a supporter to fellow TAs came in the form of sharing pedagogical resources and fostering a sense of comradery with navigating remote instruction. Interestingly, we found the supporter role identity to challenge some of the existing notions of liminality and fluidity of graduate students' identities and roles (Bale & Anderson, 2022; Winstone & Moore, 2017). This role identity was taken up across the four key interactions, suggesting that the participants were strongly anchored onto this dimension of their teacher identity (Mockler, 2011). This may indicate participants' internalization of this role identity as a significant component of their teacher identity. Given the difficulties associated with proof-based courses in concert with remote instruction, they may have approached the TA position with a general sense of solidarity and care for students, faculty, and other TAs.

The TA Position: A Critical Site for Teacher Identity Development

Although the TA position is often considered just one of many roles that graduate students perform (Jazvac-Martek, 2009), our findings suggest that the TA position affords teacher identity development through opportunities to enact a plethora of role identities. As TAs continue to negotiate meaning with others and repeatedly take up role identities, over time, these will lead to more stable self-concepts and identities as prospective mathematics faculty (McCall, 2003; Winstone & Moore, 2017). Within the broader process of socialization, we contend that serving as a TA is a valuable experience that can develop graduate students' professional identities beyond their identity as an instructor and educator. As TAs, graduate students are prompted to make sense of others' expectations, the instructional contexts, and the beliefs and values of the discipline. This leads them to assume role identities that may ultimately be internalized into a more stable teacher identity as they serve as TAs throughout their graduate programs. Our work highlights how the TA position is conducive to developing different facets of graduate students' teacher and professional identities.

Insights into Dominant Storylines and Norms

Dominant storylines and norms within undergraduate mathematics classrooms can shape TAs' experiences and the roles and identities they assume (Flora, 2007; Janssen, 2012). Our examination yielded evidence of TAs making sense of these storylines and norms, and how some roles were taken up to confirm their understanding of the dynamics between students, faculty, and TAs. The assumption of role identities, with explicit awareness of storylines and norms, demonstrated how graduate students perceived the relationships between faculty and TAs. The findings coincide with Bale and Anderson's (2022) observation that TAs' conceptualization of the TA role itself was shaped by negotiations with students, faculty, and staff. In their study, a participant compared the TA position to a "flight attendant" (p. 8) and others understood the TA position to "support both the lecturer and the students" (p. 9). We observed similar characterizations. For example, Lisa saw the TA position to signify being a "solid helper" and Kaitlyn understood the position to denote that, "you're this middle ground between the professors and the students." A prevalent storyline was that TAs are accessory to the instructor and have little ownership and agency. This exhibited participants' socialization as they reconciled and internalized beliefs about TAs. Slack and Pownall (2023) highlighted the importance of treating TAs as peers and colleagues, as opposed to "spare parts" (p. 1272), and our findings reveal that graduate students may be internalizing the belief that TAs are secondary and ancillary in undergraduate mathematics courses. Seeing and engaging TAs as marginal collaborators can significantly impact their broader professional identities and how they conduct themselves as future faculty.

Limitations and Future Research

Constraints of the study included the limited number of participants (five) serving as TAs for the same introductory proof course. However, we sought to engage with these participants in a way to prompt them to reflect richly on their experiences as TAs for Math A during the Fall 2020 term, through qualitative interviewing. This was furthermore during remote instruction, and the environment may have elicited role identities that contrast those in in-person instructional contexts. Future research can examine more TAs across a broader range of courses (e.g., calculus, linear algebra, etc.) and examine the roles they take in in-person instruction to provide a more comprehensive scope of role identities and dimensions of teacher identities. Additionally, we focused on four configurations of interactions, but TAs interact and negotiate meaning with many other individuals (e.g., peers in other departments, staff, colleagues outside of the institution, etc.). It is important to acknowledge that factors outside of the institutional context, mathematics discipline, and the four interactions we identified in the present analysis (e.g., family, relationships, stress of the profession, etc.) influence their role identities and broader teacher identity development. The complexity of TAs' networks warrants future examination because they may assume roles that extend beyond those examined in this study.

Implications

Alongside prior scholars (e.g., Jazvac-Martek, 2009; Winstone & Moore, 2017), we propose that mathematics departments and institutions can benefit from a deeper understanding of the multitude of roles identities taken up by

graduate students. It is important to recognize a TA position as an important site of socialization and teacher identity development and not as an afterthought to other experiences such as coursework or research. Serving as a TA not only provides graduate students' opportunities to develop their pedagogical practices, but it impacts their professional identity development (Kendall et al., 2013). As described above, the TA position is a critical site for teacher identity development through the opportunities for sustained role identities. Mathematics graduate programs can reimagine TA professional development efforts to better equip TAs to enact multiple roles. In addition to supporting their pedagogical development and understanding of teaching practices, TAs should feel prepared to be mentors, supporters, community-builders, etc. These role identities are distinct from being instructors, and thus, require intentional focus in TA training and preparation efforts.

We further note that TA positions can perpetuate storylines and norms that not only shape how graduate students understand the mathematics faculty profession, but how they interact with students, faculty, and other TAs in the future. Mathematics departments should cultivate opportunities for graduate students to reflect on and discuss prevalent storylines and narratives, as these can influence the roles they assume and their overall teacher and professional identity development. Lastly, our work illustrated that relationships with faculty are particularly influential to teacher identity development and how faculty interact and treat TAs may perpetuate narratives that undervalue TAs. Mathematics faculty need to be supported in critically assessing long-held storylines and norms about graduate TAs and equipping them to better support, mentor, and advocate for TAs. Given that it is still rare to require courses on pedagogy or professional development as prospective faculty, the TA position is a feature of mathematics graduate education that necessitates more thoughtful design and resources to better support graduate students.

Conclusion

Mathematics graduate students navigate a multiplicity of identities, including: as students mastering advanced mathematical concepts, as teachers sharing and constructing knowledge with undergraduate students, and as emerging professionals integrating into the academic community. Serving as a TA is an experience shared by many graduate students; however, our understanding of how the TA position contributes to the development of their teacher identities and broader professional identities is still limited. This present study sought to add to this knowledge base and strengthen theory by examining the ways that interactions with others led TAs to take up multiple role identities. Understanding the nuances and complexities of the identities and experiences of mathematics graduate students can equip departments and institutions to better support their transition to the professoriate.

Acknowledgement

This project was funded by a research grant from the University of California, Santa Barbara Academic Senate Council on Research and a research grant from the Institute for Social, Behavioral and Economic Research Collaborative Research Initiative Grants Program at the University of California, Santa Barbara.

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Appendix A

Below are the main sections and key questions of our interview protocol. For a copy of the interview protocol, please contact the authors.

Section 1: Background

1. What is your name and year in the department?
2. With which professor did you TA Math A?
3. Have you TAed this course before?
 - i) Was your prior TAing online or in-person?
4. Tell me about how the course was taught.
 - i) How do you feel the professor sought to introduce university mathematics to the transfer students?
 - ii) What subject matter was covered?
 - iii) Was the faculty's lecture synchronous or asynchronous?
 - iv) How has the mode of instruction differed, if at all, from your prior experiences? (if applicable)
 - (1) What differences have you seen in this course when it is taught in person, rather than remotely? (if you have TAed previously)
5. Tell me about the structure and grading for the exams.
6. Tell me what material was easy for the students to understand? What material was challenging?

Section 2: Structure of Course/ Online Learning Implementation

1. Tell me about your experiences enacting a remote section in an online format.
 - i) What challenges did you anticipate encountering as a result of the online format as you were planning your section in the fall?
 - ii) How did you make changes/adapt to accommodate these anticipated challenges as you planned for your section?
 - iii) Were there any challenges that came up that you did not anticipate?
2. Describe the structure of your section (e.g., asynchronous, synchronous, office hours, etc.).
 - i) What successes did you face during the enactment of your section?
 - ii) What challenges did you face during the enactment of your section?
3. Tell me about how you fostered a sense of community in your students.
 - i) What successes/challenges did you experience in building community?
4. Tell me about any differences in participation that you saw in your students?
5. In regard to online teaching, tell me about any support you have received from the department.
 - i) From other TAs and peers?
 - ii) Tell me about any other support that you have received from faculty.
6. Overall, what did you find enjoyable about TAing the course?

Section 3: Perceived Roles

1. Broadly, please describe your role(s) as a teaching assistant.
 - i) What do you think is your primary role?
 - ii) Tell me how prepared you felt prior to the course starting.
2. How does the role of a TA in a remote teaching space compare to one in an in-person teaching space?
3. What makes a successful mathematics TA?
 - i) Please describe what you think is the most important characteristic that a math TA needs to have to be a successful TA?
4. Tell us some of the qualities that you most remember from your own TAs during undergrad.
5. Tell me about your interactions with the students.
 - i) How many students tended to have their cameras on?
 - ii) Do conversations tend to be around content or other topics?
 - iii) Do you check in with students about things other than content?
6. What concerns and/or praise about Math A did students communicate to you?
 - i) How did you and/or the professor address students' concerns in sections?
 - ii) How was feedback given to the instructor of record, if at all?

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Please Cite: Olarte T.R., Swartz, M., Roberts, S.A. (2024). Mathematics graduate students' teacher identity development: Examining roles within the teaching assistant position. *Journal of Research in Science, Mathematics and Technology Education*, 7(SI), 117-139. DOI: <https://doi.org/10.31756/jrsmt.316SI>

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Data Availability Statement: Due to the nature of this research, data is not available.

Ethics Statement: This study was approved under University of California Santa Barbara Protocol Number: 8-19-0452.

Author Contributions: All authors listed have made a substantial and intellectual contribution to the work and approved it for publication.

Received: March 02, 2024 ▪ Accepted: June 01, 2024