Professed Beliefs of a Teaching Assistant of an Introductory Proof Course

T. Royce Olarte
University of California Santa Barbara

Micah Swartz
Texas State University

Sarah A. Roberts
University of California Santa Barbara

It is known that teachers' beliefs influence how they filter new knowledge and understanding of pedagogies and can directly impact their classroom practices. Moreover, the context can shape beliefs, and thus it is imperative to examine the beliefs of teaching assistants (TAs) of introductory proof courses because they play important roles in supporting student learning at this crucial mathematical junction. This preliminary study explored the professed beliefs of Lisa, a second-year, mathematics doctoral student. We qualitatively analyzed her responses in a semi-structured interview - with a particular emphasis on exploring her beliefs about teaching and beliefs about introductory proof courses. Overall, she believed that introductory proof courses pose new challenges and demands for undergraduate students. We saw connections to her beliefs about how TAs should deliver content and support students. Critical examination of TAs' beliefs can inform how mathematics departments prepare graduate students to be teaching assistants.

Keywords: Teaching Assistants, Beliefs, Introductory Proof Courses

Introduction

In the present preliminary study, we examined the professed beliefs (Speer, 2005) of a teaching assistant (TA) of an introductory proof course. Introductory proof courses mark a critical junction in the academic trajectories of many undergraduate students pursuing mathematics degrees. Students are confronted with significant challenges in proof-construction (e.g., Moore, 1994; Weber, 2001), because the demands associated with proof-construction are unlike those of courses such as calculus and linear algebra. Graduate students who serve as TAs play important roles in supporting student learning during this transition to upper division mathematics courses that heavily rely on proof-construction competencies. It is imperative that we better understand what mathematics TAs believe about students, learning, and teaching at this important junction. These beliefs can not only impact their current instructional practices (e.g., Pajares, 1992; Goldin et al., 2009), but they can also filter how TAs learn about and develop their pedagogies (Brousseua et al., 1988) to teach upper division coursework.

Prior work has illustrated how teachers of different domain areas (e.g., STEM, humanities, etc.) have described and exhibited differences in beliefs about aspects of their instruction (e.g. Patterson et al., 2016; Roothooft, 2019), and we posit that the specific content areas within the mathematics discipline (e.g., calculus, linear algebra, etc.) can uniquely influence what TAs believe. To date, there is limited work that is specific to examining the beliefs of TAs of introductory proof courses. As we move forward, findings from studies of this nature can inform how higher education institutions and mathematics departments can better support graduate students' professional development and teaching practices in proof-based courses. If we are to positively develop these dimensions of teaching and instruction, it is important that we first identify and examine the beliefs that graduate students bring into these courses and develop as they serve as teaching assistants or early instructors of record. The research question that guided this study was: How did a mathematics teaching assistant discuss their beliefs about teaching and mathematics in an introductory proof course?

Framework

We drew on a categorization of professed teacher beliefs (Calderhead, 1996; Carter & Norwood, 2010; Torff, 2011) to frame the present exploratory study. Research on teaching and educational psychology have previously described beliefs as being professed or attributed (Calderhead, 1996; Putnam & Borko, 2000). Speer (2005) stated, "professed beliefs are defined as those stated by teachers, while attributed beliefs are those that researchers infer based on observational or other data" (p. 361). We consider the beliefs of the focal TA as primarily professed beliefs because we as researchers did not observe their classroom practices nor inferred beliefs from observed actions. We built upon the work of Speer (2001) who previously connected teaching assistants' beliefs to their teaching practices in reform-oriented calculus courses. Speer described and categorized teaching assistants' *belief profiles* to encompass 1) what the teaching assistants believed about their students, 2) what they believed about teaching, 3) what they believed about learning, and 4) what they believed about mathematics.

Other scholars have similarly categorized beliefs as a way of identifying and assessing teachers' professed beliefs (e.g., Carter & Norwood, 2010; Voss et al., 2013). Although beliefs are extremely interconnected, categorizing them is helpful in making sense of an individual's broader belief system. Voss et al. (2013) provided a rationale for why researchers often classify and categorize teacher beliefs, writing: "These detailed taxonomies are helpful and necessary when it comes to addressing theoretical questions about specific components or painting a coherent picture of belief systems" (p. 252). In this preliminary study, we focus on two primary dimensions: beliefs about teaching and beliefs about mathematics. More specifically, we sought to identify how beliefs about teaching and mathematics are related to introductory proof courses and the extent to which the focal TA's beliefs about her teaching and mathematics is shaped by the course content and her perceptions of the demands of introductory proof courses.

Method

Purposeful sampling (Miles et al., 2020) was used to recruit graduate students of an introductory proof course at a Minority-Serving Institution in California. It was part of a larger study about transfer students' experiences in a department intervention involving a set of courses to help transfer students transition to a four-year university. The focal introductory proof course, Math A, was one of these courses. Participants were mathematics doctoral students who were TAs for the course during the Fall 2020 quarter. We focus on Lisa (a pseudonym) as a case for this preliminary study because she was revelatory (Yin, 2016) about nuanced professed beliefs regarding teaching and mathematics that were also related to the context of the introductory proof course. She self-identified as female and was a 2nd year doctoral student pursuing a degree in mathematics. Moreover, at the time of data collection, Lisa had two quarters of experience as a TA for the introductory proof course. The research team qualitatively analyzed her responses to a semi-structured interview protocol (Rubin & Rubin, 2011). The following questions guided our categorization, coding, and analysis of Lisa's professed beliefs: (1) What does Lisa believe about her teaching practices and role as a TA? (2) What does Lisa believe about mathematics and introductory proof courses? We pair-coded the interview transcript, discussed our codes, and wrote memos throughout this preliminary analysis of themes in her professed beliefs. Code charting (Saldaña, 2021) using matrices was used to organize the categorization of her beliefs and this afforded insight into themes across the various dimensions of her beliefs.

Findings

We present initial findings highlighting themes in Lisa's professed beliefs about introductory proof courses and her role in teaching and supporting student learning. Lisa expressed some beliefs unique to the context of and circumstances around introductory-proof courses (e.g., it is a course mainly for mathematics majors, it is the gatekeeper to upper division courses, etc.). She also expressed beliefs related to characteristics and key practices of what she believed makes a successful TA of such courses.

Beliefs about Teaching

Lisa expressed beliefs related to her role as a content-deliverer and as someone who is a supporter of her students. Regarding the dimension of her teaching related to content-delivery, she recognized the constraints of her role as a teaching assistant and believed that she should reinforce the material already presented by the professor - but make it more personable and approachable for the students. She described the importance of being "less scary" than the professor and recognized the impact that instructors' demeanors can have on student learning and engagement. She said:

> I guess, I kind of view it as like I'm someone to reinforce the material that the professor is doing. So just like it can be more personal, reinforce ideas, because they're very abstract when they're first given to students. And then, just to be someone who is less scary than the professor. My job is just to be approachable.

Lisa frequently returned to this notion of being personable. She reflected on how she introduced herself to students at the beginning of the semester. Her goal was to convey the message: "I care about you as a person and I'm going to take the time to try and show it." She believed TAs should be clear about their intentions to support students and that this should be explicitly communicated. Another key belief associated with teaching and content delivery was her belief that a TA should present material in a way that is digestible and understandable for students, especially with material they had not seen before. She said, "I think knowing how to present the material in a way that you know someone who's just seen upper division math for the first time can do it, can understand it." Lisa understood that many students struggle in making sense of proof-construction and believed that TAs should strive to make material accessible and understandable to all students. This included actions such as exhibiting patience, breaking down complex concepts, and scaffolding students' proof construction by first showing easy examples, and moving to "hard interesting problems." She recalled noticing a difference in students' engagement and interactions when she expressed that she cares for them. She said, "I tried really hard to like, start off being with like, 'Okay, I care about you as a person and I'm going to take the time to try and show it to you.' and I think that worked well." Overall, Lisa believed that a TA needs to make the content relatable and accessible while also providing support and demonstrating care for students.

Beliefs about Mathematics and Introductory-Proof Courses

In examining her beliefs about teaching, we saw that there were some connections to her beliefs about the mathematical difficulties associated with introductory proof courses. Lisa primarily expressed beliefs about the nature of these courses - specifically that they mark a junction in the content, problem-solving, and sense-making demands that students encounter in these courses and beyond. She believed that constructing mathematical proofs are unique from

the mathematics that students have previously seen and that this poses challenges that many students may not yet have faced. She said, "They've never been into, like a proof-writing, class everything's really different." Moreover, in reflecting on her position as a teaching assistant for the Math A course, she expressed a concern and critique about the focus of introductory proof courses. Lisa believed that the emphasis of such courses is on the correctness of the final proof, rather than a deeper understanding of the conceptual and logical underpinnings of constructing proofs. She commented,

> I think my biggest thing about Math A is there's such, still such an emphasis on like the correct answer in Math A. But like ideally, from my point of view, [the] Math A goal should be: "Do you know how to write a proof?" So I think a lot more emphasis on like writing proofs well, and like having students actually get graded feedback.

She suggested that providing students with feedback, rather than just a grade would help attend to the concern and overemphasis on correct answers and proofs. Lisa believed that introductory proof courses should better prepare students to construct proofs – not just in rote and procedural ways, but rather with a deeper understanding that can support them as they continue to more advanced mathematics.

Discussion

Overall, we observed that Lisa placed importance on being approachable as a TA and engaging in practices that allow all students to access the mathematics content. Lisa believed that TAs should make content digestible and understandable and that the emphasis of Math A should be on supporting students' deep and conceptual understanding of proof-construction. Altogether, we can infer that she believed that affect-oriented practices that attend to students' motivation and fostering positive perceptions of TAs can support student learning in introductory proof courses. Wiesman (2012) previously found that some teachers believed that students' motivation in the classroom are impacted by teacher actions and that demonstrating care can have positive impacts on academic achievement. This idea is echoed in Lisa's reflections on how she should foster safe classroom environments where students feel supported and cared for. Also, Lisa's consideration of students' perceptions of TAs and providing more socio-emotional support is consistent with aspects of the work of Beijaard et al. (2000) who characterized some teachers as *pedagogical experts*, or those who base their sense of selves as teachers on supporting students' social and emotional development. Ultimately, our preliminary findings of Lisa's beliefs are consistent with existing research on how beliefs may be categorized (e.g., Ernest, 1989; Speer, 2001; Carter & Norwood, 2010; Voss et al., 2013) but are still interconnected and influence each other (e.g., Pajares, 1992) to form larger belief systems.

We also recognized that some of the professed beliefs were explicitly connected to introductory proof courses, which supports the notion that beliefs are informed by the mathematical contexts and domains. For example, her belief that proof-construction poses challenges and introduces a level of cognitive demand many students have not yet faced (i.e, a belief directly related to the specific course she was a TA for) was a significant part of her reflections on why she should be more personable and approachable to students. We also saw preliminary findings illustrating how course contexts can impact beliefs. We may expect a TA in a precalculus course and a TA in an introductory-proof course to have nuanced beliefs about mathematics and teaching that are reflective of their different experiences and content areas. Lastly, we also highlighted Lisa's belief regarding the nature of introductory proof courses and

their overemphasis on rote proof-construction and the correctness of the final answer. This belief can have implications for how Lisa develops her own pedagogies and practices as a TA and a potential faculty later in her career because it can serve as a lens through which she adopts or rejects new pedagogies. She may make the effort to combat the traditional emphasis on correctness and procedural understanding and make conscious effort to develop practices that better support deeper learning.

Limitations and Implications

One limitation of the study is that we only focused on the beliefs of one TA, which did not allow for a comparison of professed beliefs across multiple participants. Future work could perhaps examine more participants (i.e., more TAs of introductory proof courses) or more TAs across multiple courses (i.e., examine TAs of calculus, linear algebra, introductory proof courses, etc.) Secondly, a key limitation of research on beliefs is the extent to which participants can convey and articulate their beliefs. Future research should examine other dimensions of TAs' beliefs (e.g., beliefs about how students learn) or observe how TAs facilitate their sections to identify any connections between observed practices and their professed beliefs. A richer understanding of TAs' beliefs, uniquely situated in specific courses, has important implications for practice and research. It can inform department-level training, coursework, and other professional development opportunities for graduate students, and this can expand our understanding of the belief systems of individuals involved in undergraduate mathematics instruction.

Conclusion

We consider research on TAs' beliefs an important, yet under-researched, dimension of undergraduate mathematics education, especially in courses like introductory proof courses which are foundational to students' success in upper division coursework. Our preliminary findings highlight connections between a TA's beliefs about introductory proof courses and mathematics and her beliefs about teaching, and this sheds light on the complexity and interconnectedness of beliefs. A richer understanding of the beliefs of TAs of these courses can also be resources for mathematics departments because they afford insight into students' experiences from the perspective of those who often, more frequently, interact with students and see firsthand the challenges they encounter. With many graduate students continuing on to become faculty and may later teach proof-based courses, critically examining their beliefs when they serve as teaching assistants can inform how institutions and mathematics departments prepare them for careers as post-secondary educators.

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