Peer Mentoring Mathematics Graduate Student Instructors: Discussion Topics and Concerns

Kimberly Cervello Rogers
Bowling Green State University

Sean P. Yee
University of South Carolina

We developed and implemented a peer-mentoring program at two US universities whereby nine experienced mathematics graduate student instructors (GSIs) each mentored three or four first- and second-year GSIs (novices). Mentors facilitated bi-weekly small group meetings with context-specific support to help novices use active-learning techniques and augment productive discourse (Smith & Stein, 2011). Meeting discussion topics were informed by novices' interests, concerns raised by both mentors and novices, and ideas from other small groups. We examined what topics from small-group peer-mentoring meetings novices valued and timing of the topics that mentors suggested for future cycles. We qualitatively coded meeting topics and analyzed novices' ratings of topics discussed. Results indicate specific topics novices valued and the importance of timing some topics appropriately, informing future professional development for GSIs. These results offer insight and synergy between educating GSIs and improving undergraduate mathematics teacher pedagogy.

Keywords: Teaching Assistants (TAs), Professional Development, Peer-Mentoring

Mathematics graduate student instructors (GSIs)[1] teach hundreds of thousands of undergraduate mathematics students each semester, yet typically lack guidance and support to teach undergraduate students effectively (Rogers & Steele, 2016; Speer & Murphy, 2009). GSIs' initial teaching experiences represent a crossroad between how they teach in the short term in graduate school and in the long term as potential future faculty members (Lortie, 1975). Moreover, in this context, GSIs participate in professional development (PD) concurrent with their first couple semesters as instructors of record, responsible for the day-to-day interactions and content-delivery and assessments in undergraduate mathematics classrooms. That is, GSIs are uniquely positioned as a population of instructors who are simultaneously receiving and applying strategies and theories learned in PD seminars, courses, and other such opportunities. As researchers have documented (e.g., Belnap & Allred, 2009; Bressoud, Mesa, Rasmussen, 2015; Ellis, Deshler, & Speer 2016a; 2016b), PD opportunities and teaching assignments for GSIs vary significantly in mathematics departments and universities across the US, which makes it challenging to determine what and how PD for GSIs can be the most impactful and effective for improving student learning outcomes in undergraduate mathematics courses. In light of this challenge, we developed and implemented a peer-mentorship program to provide additional support for novice GSIs' learning to teach.[2] We saw this as a prime opportunity to study this undergraduate instructor population and find what pedagogical topics are perceived as valuable from GSIs' perspectives as novices discuss their teaching and concerns with one another and with peer-mentors in small-group meetings. Therefore, these topics, practically, inform the next iteration of the peer-mentorship program, but more broadly inform GSI education because it highlights topics of value and significance from the novices' perspective. We investigate the following two research questions:

---

[1] GSI was used instead of TA (Teaching Assistant) because GSI targets the specific set of graduate students who are instructors of record.

[2] Supported by a Collaborative IUSE NSF grant (Awards #1544342 & 1544346).

1. What value do novice mathematics GSIs place on pedagogical topics from peer-mentoring small group meetings?
2. What pedagogical topics, and in what order, do experienced, mentor GSIs suggest for future cycles of peer-mentoring small groups?

Related Literature and Framework

Secondary Teacher Education and GSI Teacher Education

To support mathematics GSIs' development as instructors, we draw upon and learn from the history of teacher education. Initially, in the U.S., novice secondary teachers were given a short three-to-five-day orientation and then thrown into the classroom with a sink-or-swim mentality (Portner, 2005). Educational policies (e.g., No Child Left Behind and emergency teacher certification) provide multiple avenues to teacher certification, limiting uniformity in teacher preparation programs (Ganser, 2005). Thus, secondary mathematics education researchers suggest that mentoring allows secondary schools to align teachers' prior experiences with their cultural and professional expectations increasing teacher support and retention (Portner, 2005).

Similarly, mathematics graduate students arrive at universities with diverse teaching backgrounds and teaching experience with many novices having no-prior-teaching experience and some may have extensive undergraduate teaching experience if they previously taught while completing a different graduate degree (Rogers & Yee, 2017). Morover, in a similar vein as noted in the secondary education setting, collegiate institutions vary regarding how they prepare and support novice undergraduate instructors, including brief orientations or seminars for PD or required PD courses. Although these forms of PD can be useful in helping novices recognize important issues within teaching, they do not provide one-on-one support that a mentor can to address each individual's needs (Yee & Rogers, 2017). In this research project, therefore, we incorporated mentoring with the intention being to help GSIs navigate the new teaching expectations at their new university and mathematics department.

When applying a pedagogical model (teacher mentoring) to a new audience (from primary and secondary preservice teachers to mathematics GSIs), it is critical to justify the framework through empirical research (e.g., Speer King, & Howell, 2015) to make sure one does not overgeneralize. Empirical research in GSI teaching practices is also needed due to the limited research of undergraduate mathematics education (Speer, Smith, & Horvath, 2010). Therefore, we look to teacher mentoring research to justify our framework and study design.

Peer-Mentoring for GSIs Drawing from Teacher Education Research

Emerging trends in K-12 mentoring indicates that workshops, classroom visits, and meetings are vital to provide improvement and develop sustainability in leadership where novices eventually become mentors (Ganser, 2005). Overlapping these results with Boyle and Boice's (1998) empirical research on university teacher mentoring, further emphasizes the importance of systematic meetings among mentors and novices. Therefore, the mentoring structure used in our project includes these identified key components for teacher mentoring: systematic small group meetings, observations, and post-observation discussions (Ganser, 2005; Rogers & Yee, 2017).

We focus specifically on peer-mentoring (instead of faculty-mentoring) because faculty's relationships with doctoral GSIs can become ethically complicated since the faculty member can also take on different positions of power; i.e., advisors, qualifying exam evaluators, and course instructors (Johnson & Nelson, 1999). Furthermore, when a mentor is a peer, they are more likely to be genuinely aware of the individualized pedagogical decisions and needs associated

with a novice's current experiences (Yee & Rogers, 2017). In this study, experienced GSIs who apply to be mentors are selected and serve as guides and resources for novice GSIs. Prior to mentoring, we provided a research- and practice-based PD seminar for mentors, where mentors met with the mentor facilitators (authors) for 1hr/wk for 15 weeks to learn the roles and expectations of mentors (Portner, 2005; Yee & Rogers, 2017).

Following Speer et al.'s (2010) call for increased research in undergraduate teaching practices, this peer-mentorship program provided a unique and credible lens for examining GSIs' pedagogical needs. As Speer et al. point out, undergraduate teaching practices for GSIs are still in their infancy and also lack significant empirical research about how and what to teach GSIs in PD courses. In our research study, mentor small-group meetings had topics chosen by the mentors and novices as critical and time-sensitive to their current work as new instructors of record. Thus, mentor and novice GSI topics of discussion could offer the field important insight into what teaching topics are critical for GSI development from their point of view.

Method

Peer-Mentoring Program Participants

Experienced GSIs at two universities applied and were selected to be mentors by the researchers based on their teaching experiences (aptitude for implementing student-centered techniques), their pedagogical accolades (teaching awards and student evaluations), and most importantly their desire to help novices to improve teaching at their university (essay responses were required). A total of nine mentors, who were mathematics and statistics doctoral candidates, were involved in this study across the two universities.

The number of participants was determined by the average size of each university's mathematics GSI program. Novices who were teaching an undergraduate mathematics course for the first time were required to have a peer mentor as an aspect of the mandatory PD seminar for new GSIs in both universities' mathematics departments. Novices who were teaching these courses for the second time or who already took the PD seminar but did not previously have a teaching assignment were invited to participate. The peer-mentoring program continues over an entire academic year, but we focus on the 32 novices who participated during a single semester because of the timing of when we collected survey data about their experiences.

Pedagogical Topics Data Collection and Analysis

On a written survey that listed all topics discussed in small groups during the semester for each of the nine mentors, 23 novices. Novices to provided feedback on how valuable they found topics that were discussed in their peer-mentoring, small-group meetings in two ways:

a. From the list of topics from meetings this semester, they found their mentor's name and rated the topics listed on a scale from 1-10 (1=not valued, 10=highly valued).
b. They looked at the topics listed under the other mentors' names and circled those that they believed could have been valuable to discuss in small-group meetings.

To address RQ1, we analyzed the survey responses by considering frequencies of ratings novices provided for part (a) about how valuable they considered the topics they personally discussed with their mentor and small group. Using clustering analysis (Willig & Stainton-Rogers, 2007), we categorized the specific topics small groups discussed by grouping them by themes of participatory structure and educational context (Table 1). Additionally, since different mentors discussed different topics, we analyzed novices' responses to part (b) on the survey by tallying the number of topics circled and determined frequencies for each topic.

Table 1. Topic Categories Discussed During Peer-Mentoring Small Group Meetings

Categories	Examples	No. of Mentors
(A) Facilitating Collaborative Learning	Strategies to enhance student interaction (e.g., pro and cons of group work, anonymizing questions, and giving students a voice and a choice)	5
(B) Facilitating Student Engagement	Encouraging student participation; Motivating students; Teaching students with varying levels of background knowledge	3
(C) Facilitating Reflection	Reflecting on the semester thus far; Things to try next time you teach; Video reflection	5
(D) Facilitating Constructive Criticism About Teaching	Mock lessons; Discussing strengths the mentor observed in novice's lessons	6
(E) Creating & Using Formative Assessment During Class	Using formative assessments (e.g., minute papers, polling); Incorporating assessments during class time; How to monitor student learning in class	5
(F) Creating & Using Effective Summative Assessments	Writing exams, quizzes, or homework assignments	5
(G) Grading Assessments	How to grade (incl., consistency, remaining objective, & group grading)	6
(H) Managing Students in Class	Addressing aggressive/overbearing students; Helping with submissive/quiet students; Addressing mathphobia	3
(I) Managing Students Outside Class	Communicating with students (via emails or in office hours). Communicating about grades	5
(J) Negotiating GSI Small Group Meeting Behavior	Determining expectations for small group meetings	6
(K) Managing Time Outside Class	Work-life-school balance	2
(L) Creating & Modifying Lesson Plans	Ways to save time lesson planning; Creating emergency lesson plans; Modifying lesson plans	3
(M) Brainstorming Course-Specific Advice	Advice about teaching MATH X; Difficulties about teaching MATH X in the first Y weeks	2

To investigate RQ2, we solicited input from mentors after they completed their first year mentoring. We asked mentors to provide a likely timeline for the topics from Table 1 that they would most likely use in small group meetings if they mentored again. Since small-group meetings were typically bi-weekly, we broke a fifteen-week semester out into two-week blocks and listed the 15th week alone. Mentors specified at most two categories from Table 1 for each 2-week span. They could add additional topics or exclude any of the thirteen categories from their timeline, as they saw fit. Seven of the nine mentors suggested timelines in this way. From these data, we determined the frequencies and timing for each topic, focusing on topics that were suggested by multiple mentors for a similar time period of the semester.

Results

We first present results relevant to RQ1, focused on what small-group meeting topics novices valued. Based on the mean across all topics by all novices was a 7.85 out of 10 with a standard deviation of 1.46, providing a viable striation of the data into thirds with the partitions of 1-5, 6-8, and 9-10. Thus, when recording responses to part (a) in the survey, we considered their perceived value of a given topic to be reported as: *High* with a 9 or 10 rating, *Medium* with a 6-8 rating, or *Low* with a 1-5 rating. Frequencies for how valuable novices rated each topic are displayed in Figure 1. Since novices only attended small-group meetings with their peer-mentor, they had the opportunity to rate how valuable they would find topics that other small groups discussed. The frequencies of circled topics are displayed in Figure 2, where the percentages are out of the total number of circled items.

We can see there are some topics, that were reported as highly valued (Figure 1) that were also rarely circled (Figure 2). For instance, *grading* (Topic G) was discussed in six mentor's small group meetings, and it was ranked highly valued, but it was only circled 1% of the time.

We interpret this to mean that for topics such as these, novices tended to perceive them as initially helpful, but they did not consider them as necessary to discuss multiple times or in a subsequent semester of peer-mentoring with the same group of novices.

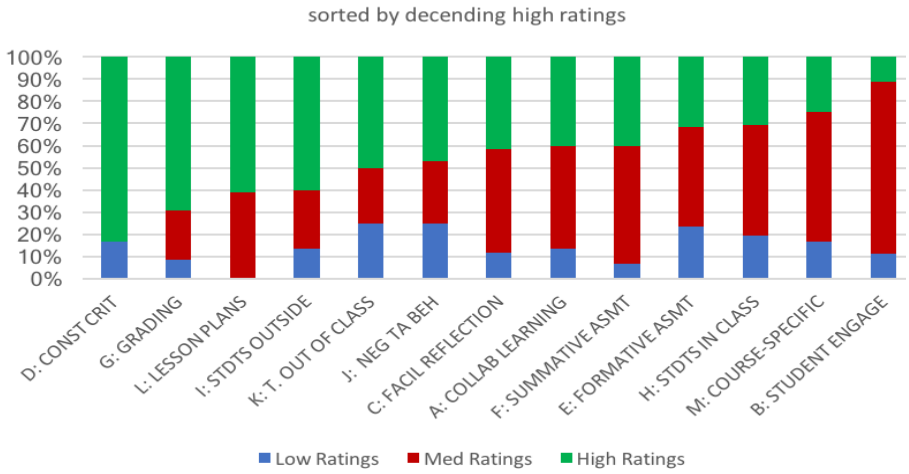

Figure 1. Small-group meeting topics, sorted by novices' ratings for how they valued that topic.

Other topics, however, were highly valued (Figure 1) and highly requested for future small-group meetings (Figure 2), even though they were addressed by many of the mentors. For instance, the most highly rated and most frequently circled topic *facilitating constructive criticism about teaching* (Topic D) was also discussed by six of the nine mentors (Table 1).

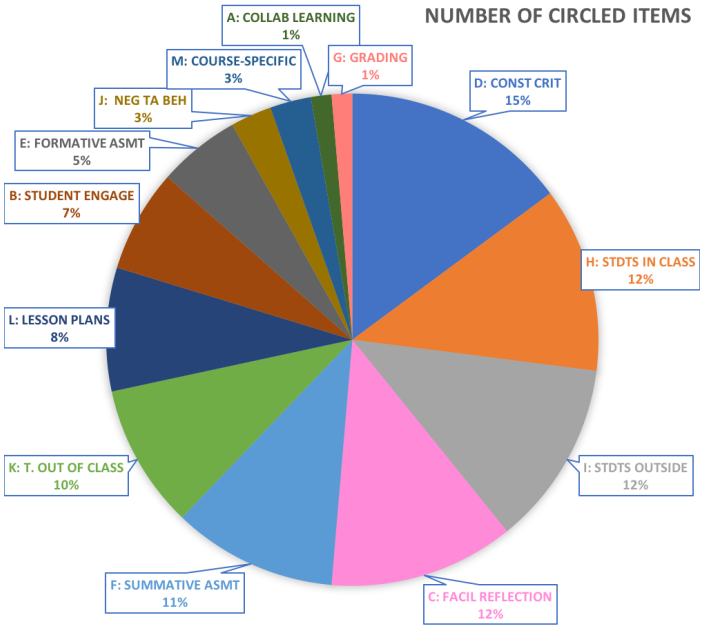

Figure 2. Frequencies of topics novices circled in answering part (b) of the survey

This topic often included opportunities for novices to participate in *mock lessons* during the small group meeting. This strategy was suggested when mentors were meeting with the peer-mentoring program facilitator (one author) and brainstorming ways to address one another's concerns. Specifically, one mentor was trying to figure out how to help a novice develop the

ability to respond to students' questions with confidence and precise mathematical language during class. Another mentor suggested having the novice present a portion of a prepared lesson to the small group so the rest of the group, and the mentor, could pretend to be undergraduate students and then provide feedback and suggestions for the novice to improve. The rest of the mentors were excited about this strategy and decided to call it a "mock lesson." There was concern, however, that a novice might feel singled out if asked to present a mock lesson, so the mentors further brainstormed about ways to mitigate that possibility (e.g., having the mentor present a mock lesson first or soliciting volunteers from the small group initially then asking the remaining novices to select a week to do the same). This strategy was so well received at the university where it was first discussed that mentors at the other university involved on this project implemented this strategy a few weeks later. The survey results suggest, therefore, that there are topics that are popular among novices despite being addressed by many of the mentors, and should therefore continue to be incorporated into novices' small group meetings.

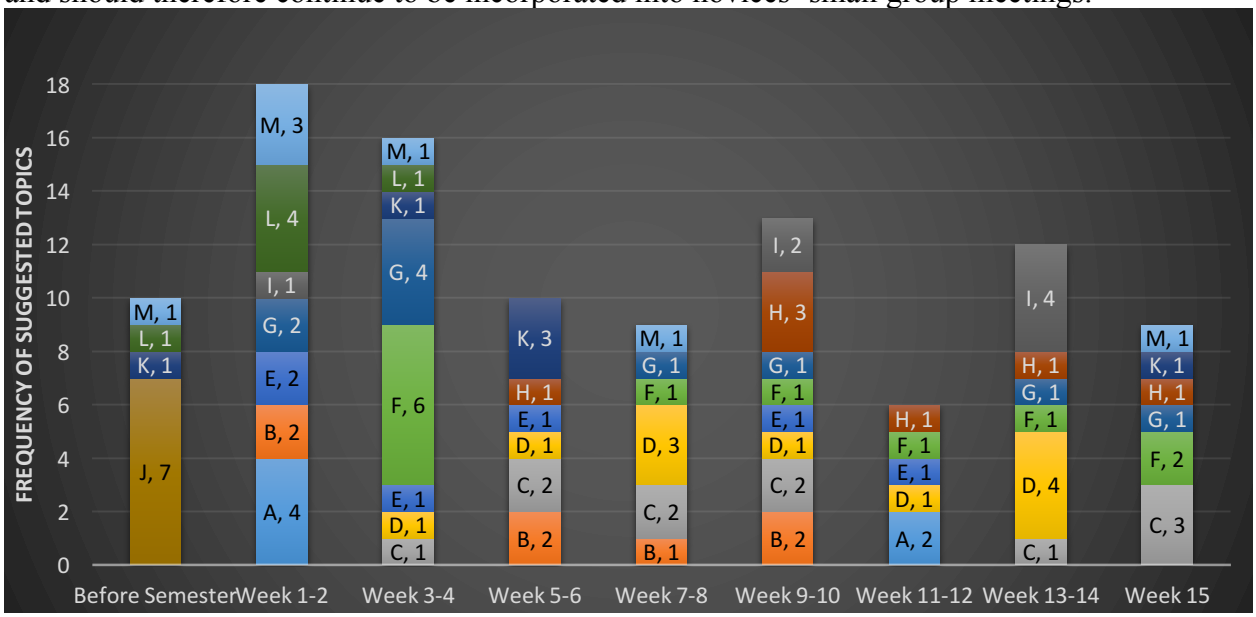

Figure 3. Mentors suggested timeline of pedagogical topics relative to weeks of a 15-week semester

Results relevant to RQ2 stem from seven suggested timelines that mentors created after mentoring for two semesters. The frequencies and timing for each topic, focusing on topics that were suggested by multiple mentors for a similar time period of the semester, are presented in Figure 3. The total number of suggested topics on the vertical axis could indicate that there were certain weeks of the semester that mentors considered more critical for sharing issues than others. That is, Weeks 1-2 (18) and Weeks 3-4 (16) had the greatest frequency of topic suggestions, which could suggest mentors saw these as crucial times to work with novices. Later in the semester, however, Weeks 11-12 received the fewest suggested topics.

Figure 3 also shows that before the semester began, all the mentors (7) preferred to discuss small-group meeting behavior (Topic J) rather than letting it unfold throughout the semester. During the first two weeks of the semester, mentors frequently suggested that collaborative learning (Topic A, 4), lesson plans (L, 4), and course-specific advice (M, 3) should be discussed while a majority of mentors suggested summative assessments (F, 6) and grading (G, 4) during Weeks 3-4. Moreover, nearing the end of the semester, mentors frequently suggested different topics: mock lessons (D, 4) and outside of class interactions (I, 4) during weeks 13-14 and reflection (C, 3) during the final week of the semester. By tallying each topic's frequency across

the semester, we see that Topics C (11 total), D (11 total), F (12 total), and G (10 total) were the most popular throughout the entire semester with certain weeks where some topics may have been more frequently suggested (Figure 3). If we take the most frequented topic from each two-week timeframe, we see one possible timeline for the small-group meetings to be J, A & L, F & G, K, D, H, A, D & I, and C.

Discussion

This study investigated what pedagogical topics novice GSIs perceived as valuable when participating in small group meetings during their first or second semester teaching collegiate mathematics and how experienced mentor GSIs suggested (re-)ordering these topics in a semester timeline. For RQ1, we found there were four meeting topics highly valued by at least 50% of novice: mock lessons, grading, interactions outside class, time management, and lesson plans (D, G, I, K, & L, Figure 1). Cross referencing these results with topic preferences novices circled (Figure 2) suggests that novices desired additional future group meetings to be centered around four of these five highly-valued topics (D, I, K and L). These results, coupled with the fact that the number of mentors who addressed these topics varied (6 mentors vs. 2 or 3 mentors; Table 1), suggests novices valued and desired more discussion of these critical topics. Considering the low-ratings (Figure 1), we note that time management (K) and small group behavior (J) had very similar ratings overall, but only two mentors discussed K while a majority discussed J. Cross referencing these results with Figure 2 suggests these topics are ones that novices would like to discuss further, but mentors may need additional, explicit support to facilitate effective discussions about them.

For RQ2, certain pedagogical topics were suggested at certain times with higher frequency than other topics (Figure 3). The most frequented topics throughout a semester were reflection, mock lessons, summative assessments, and grading (C, D, F, & G). Overlapping these results from RQ1, we see that only topic D, facilitating constructive criticism about teaching especially using mock lessons, is pervasive throughout the timeline for the mentors and a highly valued topic of the novices. This suggests that both the novices and mentors valued this topic for peer mentorship. This also supports the need for peer observations (see Yee & Rogers, 2017), another aspect of this peer-mentorship program, because themes from these observations contributed to mentors' use of mock lessons and these observations were designed to provide constructive criticism of novices' teaching.

Findings from this study provide empirical data that can inform undergraduate mathematics education. Our research design allowed us to capture some information about novices' perspectives of pedagogical topics discussed and mentors preferred timeline of those topics while novices were developing as instructors. Together, this data answered our research questions and provided empirical results, desperately needed by the field (Speer et al., 2015), on which pedagogical topics are specifically valued by novice and experienced GSIs of undergraduate mathematics education. Moreover, our work build's on Portner's (2005) work by expanding the field's understanding of teacher mentoring to GSIs of undergraduate mathematics courses.

The valued topics, and their suggested order, directly informed the next iteration of the peer-mentoring program; specifically, before the next mentoring cycle began mentors generated a draft of meeting topics informed by these results. More broadly, these findings can also provide structure for other universities designing teaching seminars, pedagogical courses, and teacher development. For example, an undergraduate teacher educator or course coordinator could use the results from Figure 3 to determine an ordering of certain course material relative to the timeline of struggles relevant to novice undergraduate instructors.

References

Belnap, J. K., & Allred, K. (2009). Mathematics teaching assistants: Their instructional involvement and preparation opportunities. In L. L. B. Border (Ed.), *Studies in Graduate and Professional Student Development* (pp. 11–38). Stillwater, OK: New Forums Press, Inc.

Bressoud, D., Mesa, V., & Rasmussen, C. (Eds.). (2015). *Insights and recommendations from the MAA national study of college calculus*. MAA Press.

Ellis, J. F., Deshler, J. M., & Speer, N. M. (2016a). Pass rates and student evaluations: Evaluating professional development of graduate teaching assistants. In *40th International Group for the Psychology of Mathematics Education Annual Conference*. Szeged, Hungary.

Ellis, J. F., Deshler, J. M., & Speer, N. M. (2016b). Supporting institutional change: A two-pronged approach related to graduate teaching assistant professional development. In *19th Annual conference on Research in Undergraduate Mathematics Education*. Pittsburgh, PA.

Gasner, T. (2005). Learning from the past-building for the future. In *Teacher mentoring and induction: The state of the art and beyond* (pp. 3-20). Corwin Press.

Hill, H. C., Ball, D. L., & Schilling, S. G. (2008). Unpacking pedagogical content knowledge: Conceptualizing and measuring teachers' topic-specific knowledge of students. *Journal for Research in Mathematics Education*, 372-400.

Johnson, W. B., & Nelson, N. (1999). Mentoring relationships in graduate training: Some ethical concerns. *Ethics and Behavior*, 9, 189–210.

Lortie, D. C. (1975). *Schoolteacher: A sociological study*. Chicago, IL: University of Chicago Press.

Portner, H. (2005). *Teacher mentoring and induction: The state of the art and beyond*. Corwin Press.

Rogers, K. C., & Steele, M. D. (2016). Graduate teaching assistants' enactment of reasoning-and-proving tasks in a content course for elementary teachers. *Journal for Research in Mathematics Education, 47*, 372–419.

Rogers, K. C. & Yee, S.P. (2017, November). Experienced and novice graduate students navigating mathematics instruction together. Proceedings from *39th Conference of the North American Chapter of the Psychology of Mathematics Education* (PME-NA), Indianapolis, IN.

Smith, M. S., & Stein, M. K. (2011). *5 Practices for Orchestrating Productive Mathematics Discussions*. Reston, VA: National Council for Teachers of Mathematics

Speer, N. M., King, K. D., & Howell, H. (2015). Definitions of mathematical knowledge for teaching: Using these constructs in research on secondary and college mathematics teachers. *Journal of Mathematics Teacher Education*, *18*(2), 105-122.

Speer, N. M., & Murphy, T. J. (2009). Research on graduate students as teachers of undergraduate mathematics. In L. L. B. Border (Ed.), *Studies in Graduate and Professional Student Development* (pp. xiii–xvi). Stillwater, OK: New Forums Press, Inc.

Speer, N. M., Smith, J. P., & Horvath, A. (2010). Collegiate mathematics teaching: An unexamined practice. *The Journal of Mathematical Behavior*, *29*(2), 99-114.

Willig, C., & Stainton-Rogers, W. (Eds.). (2007). *The SAGE handbook of qualitative research in psychology*. Los Angeles, Sage Publications.

Yee, S.P. & Rogers, K. C. (2017, February). Mentor professional development for mathematics graduate student instructors. Proceedings from *20th Conference of the Research in Undergraduate Mathematics Education* (RUME), San Diego, CA.