How Elementary Teaching Candidates’ Learning Opportunities Are Associated With Their Knowledge, Self-Efficacy, and Beliefs

REBEKAH BERLIN  
Deans for Impact

PETER YOUNGS  
University of Virginia

JULIE COHEN  
University of Virginia

Background/Context: Many elementary teacher education programs seek to prepare candidates to enact ambitious mathematics instruction that supports students in engaging in rigorous, conceptually rich mathematics tasks. Extant literature suggests that preparedness to engage in ambitious elementary mathematics instruction is multifaceted and includes teaching candidates’ mathematical knowledge for teaching (MKT), self-efficacy with regard to teaching mathematics, and pedagogical beliefs about mathematics. Prior research has produced findings that provide discrete, and at times conflicting, information about teacher preparation.

Purpose/Objective/Research Question/Focus of Study: This study examined how elementary candidates’ learning opportunities in mathematics content courses, mathematics methods courses, and student teaching were moderated by their reports about the quality of their experiences in courses and field placements to seem to affect their MKT, self-efficacy, and beliefs.

Population/Participants/Subjects: The study participants were 220 elementary teaching candidates who were in their final year of teacher preparation at four universities in three states.

Research Design: We employed multivariate path analysis, an approach that is purposefully designed to probe heterogeneity in teaching candidates’ experiences in courses and clinical placements.
Data Collection and Analysis: We administered two surveys to each study participant: an elementary teaching candidate survey, which included measures of mathematics teaching self-efficacy and pedagogical beliefs about mathematics, and an MKT survey.

Findings/Results: The number of mathematics content courses that elementary candidates took was positively associated with their MKT and mathematics teaching self-efficacy only when they also reported having positive experiences learning mathematics. When candidates reported increased opportunities to engage with representations, decompositions, and approximations of mathematics teaching practices in mathematics methods courses, this was associated with higher MKT scores and pedagogical beliefs about mathematics. When candidates reported that their cooperating teacher was a high-quality mentor, increased opportunities to observe, attempt, and receive feedback on mathematics teaching practices during their field experience were associated with mathematics teaching self-efficacy and pedagogical beliefs about mathematics.

Conclusions/Recommendations: The findings from this multivariate path analysis, which account for both the reported quantity and the perceived quality of elementary teaching candidate experiences, may shed light on conflicting findings in prior literature. There is little agreement in extant literature about associations between facets of teacher preparation and candidate knowledge, self-efficacy, or beliefs. Explaining the positive associations in some samples and lack of associations in others may have more to do with the quality of teaching candidate experiences than with whether a candidate was exposed to a particular opportunity to learn.

Many elementary teacher education programs seek to prepare candidates to enact ambitious mathematics instruction that supports students in engaging in rigorous, conceptually rich mathematics tasks (Hiebert & Grouws, 2007; National Mathematics Advisory Panel, 2008). Extant literature suggests that preparedness to engage in ambitious elementary mathematics instruction is multifaceted and includes teaching candidates’ mathematical knowledge for teaching (MKT), self-efficacy with regard to teaching mathematics, and pedagogical beliefs about mathematics (Ball & Forzani, 2009; Drageset, 2010; Grossman et al., 2009). In most studies, researchers focus on a single component of elementary mathematics teacher preparation and its association with one or more candidate outcomes (e.g., Ronfeldt, 2012; Schmidt, Blömeke, & Tatto, 2011).

This approach has produced research findings that provide discrete, and at times conflicting, information about teacher preparation. Though there is value in concentrating on associations between experiences in and outcomes of teacher preparation, focusing on single associations of interest may obscure other important relationships. Hill et al. (2019) asserted that the field needs studies that take an expanded view and consider multiple constructs in tandem, particularly studies that explore interactive effects. In addition, Charalambous et al. (2009) provided evidence of
heterogeneity in elementary teaching candidates’ experiences in mathematics courses, with some candidates reporting positive experiences and others indicating that their experiences were not positive.

Building on Charalambous et al. (2009), the study reported here focused on how elementary candidates’ learning opportunities in mathematics content courses, mathematics methods courses, and student teaching were moderated by their reports about the quality of their experiences in courses and field placements, which seemed to affect their knowledge, self-efficacy, and beliefs. In particular, we drew on survey data from 220 elementary teaching candidates at four universities in three states and employed multivariate path analysis, an approach that is purposefully designed to probe heterogeneity in candidates’ experiences. In this study, we used multivariate path analysis to examine how differences in candidates’ perceptions of the quality of their experiences in courses and clinical placements interacted with their learning opportunities, which seemed to affect their MKT, self-efficacy with regard to teaching mathematics, and pedagogical beliefs about mathematics.

**LEARNING TO ENACT AMBITIOUS MATHEMATICS INSTRUCTION**

Ambitious mathematics instruction supports students in reaching high-level mathematics learning goals that include procedural fluency, flexible reasoning, deep conceptual understanding, and productive mathematical dispositions (Jackson & Cobb, 2010; Kazemi et al., 2009; Lampert, 2001). This type of instruction helps students engage in independent reasoning so that they can strategically choose which processes to use while solving problems (Lampert et al., 2013; Munter, 2014), and it enhances their ability to articulate complex mathematical arguments and critiques (Jackson & Cobb, 2010; Lampert et al., 2013). Scholars have asserted that ambitious mathematics instruction comprises learnable practices (Lampert & Graziani, 2009), such as eliciting students’ mathematical thinking (Kazemi et al., 2009) and adjusting in real time to what students say and do while engaged in mathematical problem solving (Fennema et al., 1993; Kazemi et al., 2009).

**PREPAREDNESS TO ENGAGE IN AMBITIOUS MATHEMATICS INSTRUCTION**

*Mathematical Knowledge for Teaching*

Mathematical knowledge for teaching (MKT) refers to the knowledge and skills necessary for planning high-quality mathematics lessons and the moment-to-moment classroom decisions embedded in instructional practice
Research indicates that MKT is an important indicator of preparedness to engage in ambitious mathematics instruction. Scholars have identified significant associations between MKT and high-quality, rigorous instructional practices (Hill et al., 2012, 2015; Kunter et al., 2013) and students’ mathematics achievement (Hill et al., 2005). In addition, researchers in Germany have demonstrated that this type of knowledge is malleable within the context of preservice preparation (Kleickmann et al., 2013).

Mathematical Teaching Self-Efficacy and Pedagogical Beliefs About Mathematics

Teachers’ mathematics teaching self-efficacy (i.e., their conceptions of themselves as learners, doers, and teachers of mathematics) has been associated with a number of key outcomes, including being more persistent with students (Nurlu, 2015) and intending to spend more instructional time on mathematics (Geist, 2015). At the same time, teachers’ having negative attitudes toward mathematics is inversely associated with their students’ attitudes toward mathematics and mathematics achievement (Beilock et al., 2010) and their own assessment of their ability to do mathematics (Geist, 2015).

In addition, there is ample evidence that teachers’ pedagogical beliefs about mathematics are relevant to their mathematics instruction (Francis et al., 2014; Swars et al., 2009). Teachers’ pedagogical beliefs about mathematics include whether they believe that children benefit more from direct transmission of discrete skills and rote memorization or from an approach that prioritizes deep conceptual understanding and connections to other mathematical ideas (Peterson et al., 1989; Staub & Stern, 2002). These divergent orientations are associated with differences in instructional decision-making, instructional practices, use of curriculum materials (Maasz & Schlöglmann, 2009; Philipp, 2007; Wilkins, 2008; Wilson & Cooney, 2002), and uptake from professional development (Philipp, 2007; Swars et al., 2009). Teachers’ belief that student mathematics learning should involve deep conceptual understanding and making connections to other mathematical ideas is often associated with increases in students’ mathematics achievement (Peterson et al., 1989; Staub & Stern, 2002).

Several studies highlight the mechanisms through which mathematics teaching self-efficacy and pedagogical beliefs about mathematics shape instruction (Francis et al., 2014). Qualitative studies have shown that two teachers with identical knowledge may teach in very different ways because of their self-efficacy or pedagogical beliefs about mathematics (Charalambous, 2015; Ernest, 1989; Pajares, 1992). This qualitative research base is complemented by quantitative studies suggesting that
beliefs mediate the relationship between teacher knowledge and instruction in elementary and middle school settings (Campbell & Malkus, 2014; Drageset, 2010; Wilkins, 2008). The associations between practicing teachers’ self-efficacy and beliefs, and multiple facets of instruction and student learning suggest that understanding teaching candidates’ self-efficacy and beliefs is an essential part of understanding their preparedness to engage in ambitious mathematics instruction.

**Interrelatedness of Knowledge, Self-Efficacy, and Beliefs**

Researchers have reported strong associations among MKT, mathematics teaching self-efficacy, and pedagogical beliefs about mathematics in samples of preservice teachers (Blömeke et al., 2014) and practicing teachers (Drageset, 2010; Francis et al., 2014; Ren & Smith, 2017; Wilson & Cooney, 2002). Other work has shown that although it is important to distinguish between a teacher’s mathematics teaching self-efficacy and pedagogical beliefs about mathematics (Wilson & Cooney, 2002), the two are closely associated (Wilkins, 2008). Despite these findings, most studies focus on knowledge, self-efficacy, or beliefs in isolation (e.g., Geist, 2015; Hill et al., 2015; Schmidt, Houang, & Cogan, 2011). This may contribute to the notion that these are separate rather than interrelated constructs.

**CONTEXTS FOR ELEMENTARY TEACHING CANDIDATE LEARNING**

The majority of the literature describing prospective teachers’ mathematical knowledge for teaching, self-efficacy, and beliefs coalesces around three major learning sites: mathematics content courses, mathematics methods courses, and field placements. Each of these contexts is reviewed individually next. However, these sites should also be considered in light of a robust body of evidence supporting the importance of alignment across two of these sites: methods and fieldwork (Boyd et al., 2009; Clift & Brady; 2005; Feiman-Nemser & Buchmann, 1985; Hammerness, 2006; Hammerness et al., 2005; Mewborn, 2000; Swars et al., 2009; Tatto, 1996; Zeichner, 2010).

**Mathematics Content Courses**

Mathematics content courses present a possible avenue to address a common challenge facing programs that aim to prepare elementary teachers for ambitious mathematics instruction: There can be wide variability in elementary teaching candidates’ mathematical knowledge (Charalambous et al., 2009). Mathematics course work can be viewed as an important opportunity for acquiring content knowledge as well as beliefs about how
mathematics should be taught (Lortie, 1975). At the same time, there is conflicting evidence on the value of mathematics content courses. Some scholars have found strong associations between the number of mathematics courses that teaching candidates take and their mathematical content knowledge (Drageset, 2010; Evans, 2011; Schmidt, Blömeke, & Tatto, 2011; Schmidt, Houang, & Cogan, 2011), their MKT (Hill et al., 2019; Schmidt, Blömeke, & Tatto, 2011; Schmidt, Houang, & Cogan, 2011), student outcomes (Boyd et al., 2009; Schmidt, Houang, & Cogan, 2011), and their pedagogical beliefs about mathematics (Ren & Smith, 2017; Smith et al., 2012; Swars et al., 2009; Wilkins, 2008). Other researchers have found disconfirming evidence of the positive influence of mathematics courses (Ball et al., 2001; Hill et al., 2019; Qian & Youngs, 2016).

Charalambous et al. (2009) documented heterogeneity in elementary teaching candidates’ experiences of mathematics content courses. Specifically, after completing content courses, some candidates reported increases in teaching self-efficacy, more positive attitudes toward mathematics, and being more likely to believe that mathematics is an evolving body of knowledge that should address human needs. For others, content courses were the site of negative experiences that led them to believe that mathematics was a static discipline made up of discrete rules and procedures. Moreover, they felt that their struggles in such courses made them question their fitness to teach elementary mathematics and increased their anxiety about mathematics (Charalambous et al., 2009). This finding may offer insight into how to interpret this conflicting evidence. In particular, through consideration of the nature of candidates’ experiences in content courses, clearer associations between such courses and teacher knowledge, self-efficacy, and beliefs might emerge.

Mathematics Methods Courses

With a few exceptions (e.g., Qian & Youngs, 2016), researchers have typically found positive associations between mathematics methods courses and important outcomes for teaching candidates in the United States. The number of mathematics methods courses taken is associated with teachers’ MKT (Hill et al., 2019; Swars et al., 2009), decreased mathematics anxiety (Swar et al., 2009), and positive attitudes toward mathematics (Gresham, 2007; Jong & Hodges, 2015; Ren & Smith, 2017). In a review of the literature, Clift and Brady (2005) documented 10 qualitative studies that identified mathematics methods courses as a site of important shifts in teaching candidates’ pedagogical beliefs about mathematics and their orientation toward reform instruction, decreases in their math anxiety, and increases in their confidence in their ability to teach mathematics.
Several researchers have examined ways in which MKT might be promoted in methods courses and uncovered promising pedagogies. For example, a growing body of work provides theoretical arguments for pedagogies of practice, which include representations, decompositions, and approximations of practice (Grossman et al., 2009). Representations of practice are examples of the work of teaching and can include video footage, written cases, and lesson plans. Decompositions of practice involve the breaking apart of representations so that individual components of a practice can be analyzed. For example, a methods instructor might decompose the process of launching a complex mathematics task into a series of four steps (Jackson et al., 2012) so that teaching candidates can analyze and rehearse them individually. Approximations of practice allow candidates to rehearse instructional practices in a highly supported environment, such as leading a mathematics routine (Boerst et al., 2011; Lampert et al., 2013; Lampert & Graziani, 2009; McDonald et al., 2013). Although these pedagogies have great conceptual promise, to date, researchers have not used large-scale data to empirically examine their association with candidates’ knowledge, self-efficacy, or beliefs. In this article, we directly investigate these associations.

Field Placements

Research on field experiences in teacher education emphasizes the importance of field placement characteristics for future teacher practice (Boyd et al., 2009; Ronfeldt, 2012). For example, Boyd et al. (2009) reported that beginning teacher effectiveness was associated with preparation program oversight regarding the selection of cooperating teachers, requirements for cooperating teacher experience, having a minimum number of required supervisory observations, explicit links between coursework and field experience, and having a number of courses that require field experiences. In addition, Ronfeldt (2012) found that teaching candidates placed in better functioning urban schools, with lower levels of teacher turnover, tended to stay in teaching longer than peers who learned to teach in poorly functioning ones.

In addition to the characteristics of the schools where teaching candidates are placed and program policies regarding cooperating teachers, research has focused on the role and quality of the cooperating teaching and university supervisor. For example, Ronfeldt and Reininger (2012) reported that candidates’ perceptions of the quality of their cooperating teachers and of other aspects of their student teaching placements were strongly associated with their self-efficacy, perceptions of preparedness, and career plans. At the same time, there is wide variability in the quality
of feedback that candidates receive from their cooperating teachers and university supervisors (Borko & Mayfield, 1995; Frykholm, 1998; Solomon et al., 2017).

Variability is also substantial in the types of instructional practice that candidates observe (Jong & Hodges, 2015). Some hypothesize that this is due to resource constraints. For example, many preparation programs lack a sufficient number of cooperating teachers who can model for candidates the types of instruction valued in the program (Borko & Mayfield, 1995). Similarly, university supervisors are often assigned to support elementary candidates in subjects in which the supervisor has no training (Borko & Mayfield, 1995; Zeichner, 2010). Research has also emphasized the importance of candidates’ perceptions of and trust in their cooperating teacher and university supervisor (Mewborn, 2000) in their acquisition of stable beliefs.

This article addressed gaps in the literature regarding how elementary teaching candidates’ experiences in mathematics content courses, mathematics methods courses, and student teaching are associated with their MKT, self-efficacy with regard to teaching mathematics, and pedagogical beliefs about mathematics. In particular, we focused on how candidates’ perceptions of the nature and quality of their experiences in courses and student teaching moderated associations between opportunities to learn (OTLs) and knowledge, self-efficacy, and beliefs. Our study drew on survey data from 220 elementary teaching candidates at four universities in three states to address three research questions:

1. In what ways are the number of mathematics content courses taken by elementary teaching candidates and the types of experiences that they report in those courses associated with different facets of their preparedness to teach mathematics?

2. In what ways are elementary teaching candidates’ reports of opportunities to learn about mathematics instruction through practice-based teacher education pedagogies in methods courses associated with different facets of candidate preparedness to teach mathematics?

3. In what ways are elementary teaching candidates’ reports of opportunities to learn about mathematics instruction through practice-based teacher education pedagogies in student teaching placements and perceptions of support from cooperating teachers associated with different facets of candidate preparedness to teach mathematics?
CONCEPTUAL FRAMEWORK AND HYPOTHESES

In many quantitative studies of teacher preparation, researchers have used descriptive techniques to highlight the magnitude and significance of associations between specific variables of interest after controlling for other teaching candidate or program characteristics (e.g., Drageset, 2010; Ren & Smith, 2017; Ronfeldt, 2012; Schmidt, Blömeke, & Tatto, 2011; Schmidt, Houang, & Cogan, 2011). Although there is benefit to investigating such associations between teacher preparation experiences and candidate or beginning teacher outcomes, this approach can sometimes lead to inconsistent findings or fail to uncover other important associations. Hill et al. (2019) recommended that scholars adopt a broader perspective and examine constructs in combination, including interaction effects. They also suggested that although in isolation, certain variables may appear significant, they may not remain significant when other variables are included. Though Hill and colleagues (2019) were referring to research on practicing teachers, their message is relevant for research on teacher preparation.

The framework that we employed in this study draws on scholarship on (a) OTL in teacher preparation and (b) heterogeneity in teaching candidates’ experiences in courses and field placements to investigate multiple constructs together and to consider possible interaction effects. Schmidt, Blömeke, and Tatto (2011) defined OTL as “the content to which future teachers are exposed as a part of their teacher preparation programs” (p. 140). Following their approach, in this study, we focused on three main categories of content in mathematics teacher preparation: mathematics, mathematics pedagogy, and field experiences. As noted earlier, Charalambous et al. (2009) documented variation in elementary candidates’ experiences in mathematics courses, with some reporting more positive experiences than others. Our study used their work as a starting point for examining how elementary candidates’ OTL in mathematics content courses, mathematics methods courses, and student teaching were moderated by their reports about the quality of their experiences in these settings to potentially affect their knowledge, self-efficacy, and beliefs.

In particular, in this study, we drew on survey data from 220 elementary candidates at four universities to test three hypotheses. The first hypothesis addressed OTL in mathematics content courses. As noted, several studies reported positive associations between the number of mathematics content courses taken by teaching candidates and their knowledge and beliefs, while a small number of researchers have found no association between these variables. As a result, we were interested in exploring whether having a positive experience learning mathematics moderated OTL in
such courses in ways that were systematically associated with candidate outcomes. This led to the following hypothesis:

Hypothesis 1: When an elementary teaching candidate reports having positive experiences in mathematics content courses, the number of mathematics content courses taken by that candidate is positively associated with their MKT, mathematics teaching self-efficacy (math TSE), and pedagogical beliefs about mathematics. When they do not report having positive experiences in math content courses, there is no association between the number of mathematics content courses taken and their MKT, math TSE, or pedagogical beliefs about mathematics.

The second hypothesis addressed OTL in mathematics methods courses and student teaching. As noted, researchers have made conceptual arguments and conducted qualitative studies about the importance for teaching candidates of experiencing representations, decompositions, and approximations of mathematics instructional practices in coursework and field experiences (e.g., Boerst et al., 2011; Grossman et al., 2009), but there have been few large-scale studies of how such experiences are associated with candidate knowledge, self-efficacy, or beliefs. Thus, in this study, we wanted to test a hypothesis about such experiences. This led to the following hypothesis:

Hypothesis 2: The extent to which an elementary teaching candidate reports engaging with representations, decompositions, and approximations of mathematics instructional practices (i.e., practice-based teacher education pedagogies) in mathematics methods courses is positively associated with their MKT, math TSE, and pedagogical beliefs about mathematics.

The third hypothesis addressed OTL in student teaching placements. Prior research has documented the effects of student teaching placements on teacher commitment, retention, and effectiveness. As noted, Ronfeldt and Reininger (2012) provided empirical evidence that teaching candidates’ perceptions of the quality of their student teaching experience, including the quality of their cooperating teachers, were strongly associated with candidates’ self-efficacy and other outcomes. We built on this study to examine how elementary candidates’ perceptions of the quality of the mentoring that they received from their cooperating teacher interacted with opportunities to observe, try out, and receive feedback on mathematics instructional practices to potentially affect their knowledge, self-efficacy, and beliefs. This led to the following hypothesis:

Hypothesis 3: When an elementary teaching candidate reports having a high-quality mentoring experience with their cooperating teacher
during student teaching, the number of opportunities that that candidate reports having to observe, attempt, and receive feedback on mathematics teaching practices during student teaching is positively associated with their MKT, math TSE, and pedagogical beliefs about mathematics. When they do not report having positive experiences with their cooperating teacher, there is no association between their reported number of opportunities to observe, attempt, and receive feedback on mathematics teaching practices during student teaching and their MKT, math TSE, or pedagogical beliefs about mathematics.

In summary, this study is among the first to examine how elementary teaching candidates’ OTLs in courses and field placements are moderated by their perceptions about the positive or negative nature or quality of their learning experiences in these settings. Rather than focus on individual facets of preparedness to engage in ambitious mathematics instruction, such as an exclusive examination of candidate knowledge, self-efficacy, or beliefs, we explored them in tandem. Likewise, instead of investigating associations between specific features of teacher preparation, such as methods courses, and outcomes, we looked across coursework and field experiences. By shifting the unit of analysis away from program characteristics to preparation as experienced by the teaching candidate, we surface potentially important information about the nature of the experiences that support candidate preparedness.

METHOD

TEACHER EDUCATION PROGRAM SAMPLE

The data presented here are drawn from a larger longitudinal study of elementary teacher preparation. The four elementary teacher education programs in our sample collectively prepared approximately 500 elementary teaching candidates in 2015–2016 (the year in which we collected data from elementary candidates in these programs for this analysis). The four programs were at Cardinal University, Meadowlark University, Oriole University, and Robin University. We selected these programs because each incorporated research-based practices in elementary mathematics methods courses and carefully structured student teaching to support candidates in learning about and enacting ambitious instruction in mathematics. Research-based practices are instructional strategies in mathematics that foster students’ deep, conceptual understanding of academic content and are associated with student learning (Hiebert & Grouws, 2007; National Mathematics Advisory Panel, 2008).
The four programs varied in several ways; among these were characteristics of the universities (e.g., location, focus, selectivity) and the programs, including length of student teaching, and structure and sequence of methods courses and field experiences. Table 1 shows descriptive information about features of these programs and how they varied across the sample. Three of the programs required 12–15 weeks of student teaching, and Meadowlark mandated that candidates complete 30 weeks of student teaching. Two of the programs required two mathematics methods courses, whereas Cardinal and Oriole candidates completed one each. Three of the programs had a required course sequence, and one allowed flexibility in the course-taking sequence.

Table 1. Descriptive Information for Elementary Teacher Education Programs in Study

<table>
<thead>
<tr>
<th></th>
<th>Cardinal</th>
<th>Meadowlark</th>
<th>Oriole</th>
<th>Robin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of Program</td>
<td>5-year BS/MA program</td>
<td>5-year BA program plus MA credits</td>
<td>5-year BS/MA program</td>
<td>4-year BA program</td>
</tr>
<tr>
<td>Approximate Annual Number of Elementary Graduates</td>
<td>40</td>
<td>200</td>
<td>60</td>
<td>200</td>
</tr>
<tr>
<td>Required Course Sequence</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Required Math Methods Courses</td>
<td>1 math methods</td>
<td>2 math methods</td>
<td>1 math methods</td>
<td>1 math methods</td>
</tr>
<tr>
<td>Pre–Student Teaching Field Experience</td>
<td>6 hours/week for 3 semesters</td>
<td>4 hours/week for 2 semesters</td>
<td>1 day/week for 1 semester</td>
<td>6 hours/week for 1 semester</td>
</tr>
<tr>
<td>Length of Student Teaching</td>
<td>12 weeks</td>
<td>30 weeks</td>
<td>15 weeks</td>
<td>15 weeks</td>
</tr>
<tr>
<td>Length of Lead Responsibility for Teaching</td>
<td>5 weeks</td>
<td>10 weeks</td>
<td>8 weeks</td>
<td>8 weeks</td>
</tr>
<tr>
<td>Timing of Student Teaching</td>
<td>Spring of 4th year</td>
<td>Fall and spring of 5th year</td>
<td>Fall of 5th year</td>
<td>Spring of 4th year</td>
</tr>
</tbody>
</table>

TEACHING CANDIDATE SAMPLE

Participants in this study were 220 preservice elementary teaching candidates from the four universities listed earlier: 26 from Cardinal, 67 from Meadowlark, 50 from Oriole, and 77 from Robin. As is typical of most teacher education programs in the United States, most candidates identified as White (87%) and female (95%; Sleeter, 2001).
MEASURES

Scales were drawn from two measures. The first, the Elementary Teaching Candidate (ETC) survey, included multiple scales that probed elementary candidates’ backgrounds and experiences during teacher preparation. The second measure was the elementary number and operations MKT measure (Hill et al., 2008). Both were administered online and through paper surveys (via the U.S. mail) to candidates near the end of, or immediately following graduation from, their preparation programs. Candidates were paid $25 for each measure they completed.

Mathematics Teaching Self-Efficacy

We drew on prior research on mathematics teaching self-efficacy (Charalambous et al., 2009; Enochs et al., 2000) to create five items in the ETC survey that probed elementary candidates’ self-efficacy related to teaching mathematics. Respondents were asked to respond on a 4-point Likert scale indicating the extent to which they agreed with each item. These items were: “Even if I work hard, I will not teach math as well as I will most subjects,” “I understand math concepts well enough to effective in teaching math,” “I’m not the type to do well in mathematics,” “If I work hard, I am confident in my ability to learn new math strategies,” and “I understand math concepts well enough to be effective in teaching math.”

We chose these five items because they are all relevant for enacting ambitious mathematics instruction that helps students acquire strong conceptual knowledge and engage in disciplinary practices. For example, when candidates respond agree or strongly agree to the first and third items, this would likely serve as a barrier to their implementation of ambitious mathematics practices. Conversely, responding agree or strongly agree to the second, fourth, and fifth items would likely facilitate their enactment of ambitious practices. After negative items were reverse coded, the five items were averaged to create a scale score (M = 3.30, SD = 0.45). The Cronbach’s alpha reliability coefficient for the mathematics teaching self-efficacy items was α = .75.

Pedagogical Beliefs About Mathematics

In the ETC survey, we measured elementary candidates’ pedagogical beliefs about mathematics using five items from the mathematics teaching candidate survey used in the Teacher Education and Development Study in Mathematics (TEDS-M study; Schmidt, Houang, & Cogan, 2011). Respondents were asked to respond on a 4-point Likert scale indicating the extent to which they agreed with each item. These items were:
“Mathematics is a subject in which natural ability matters a lot more than effort,” “If students are underachieving in mathematics, it is most likely due to ineffective mathematics instruction,” “In addition to getting a right answer in mathematics, it is important to understand why the answer is correct,” “It is helpful for pupils to discuss different ways to solve particular problems,” and “Nonstandard procedures in mathematics should be discouraged because they can interfere with the correct learning procedure.”

We chose these items because they address teachers’ beliefs about how mathematics should be taught; thus, we refer to them as pedagogical beliefs about mathematics. For example, when candidates respond *agree* or *strongly agree* to the first and fifth items, this would likely serve as a barrier to their promoting student conceptual understanding and engagement in rigorous tasks. On the other hand, responding *agree* or *strongly agree* to the second, third, and fourth items would likely facilitate their enactment of ambitious practices ($M = 3.41$, $SD = 0.31$). The Cronbach’s alpha reliability coefficient for the mathematics beliefs items was $\alpha = .45$.

**Opportunity to Learn**

In the ETC survey, items about OTL in teacher preparation were modified from the New York City Pathways study (Boyd et al., 2009) and the TEDS-M study (Schmidt, Houang, & Cogan, 2011). Participants were asked to indicate whether or not they had had the opportunity to learn about or attempt 12 mathematics instructional practices: “Design high cognitive demand mathematics tasks for students,” “Teaching strategies for learning mathematics content,” “Differentiate instruction in mathematics,” “Connect mathematics to students’ prior mathematical knowledge,” “Connect mathematics to students’ personal/cultural experience,” “Use representations to develop students’ mathematical understanding,” “Facilitate students’ use of manipulatives in doing mathematics,” “Facilitate students’ use of technology in doing mathematics,” “Identify and respond to common patterns of student thinking in mathematics (e.g., strategies, misconceptions),” “Facilitate classroom discussion in mathematics,” “Manage time and student behavior during mathematics instruction,” and “Provide students feedback in learning mathematics.”

Previous literature suggests that mathematics content cannot be divorced from mathematics pedagogy in teacher education (Ghousseini & Herbst, 2016). Therefore, for each of the 12 mathematics instructional practices, candidates were also asked to indicate whether they had engaged with this practice through particular pedagogies of practice (Grossman et al., 2009; Lampert et al., 2013). In particular, they indicated whether they had engaged with representations and decompositions of the 12
specific mathematics practices through written and video cases. They also reported whether they had the opportunity to approximate, or rehearse with peers, each of the 12 practices. Each of the 12 practices that candidates engaged through a practice-based pedagogy was assigned 1 point. Items were summed to create a total score for OTL in methods courses ($M = 10.73, SD = 4.86$).

Candidates also indicated whether they had exposure to the same practices in their field placements. They reported whether they had “observed a teacher use this practice with students” and whether they had “received feedback on their attempts to use this practice with students.” Each of these reported OTLs was assigned 1 point and summed to create a total score for OTL in field placements ($M = 12.40, SD = 5.40$).

Teaching Candidates’ Perceptions of Quality

In the ETC survey, teaching candidates were asked to rate on a 4-point Likert scale the extent to which they agreed with several statements regarding their cooperating teacher and university supervisor. Scores of 1 or 2 indicated disagreement; scores of 3 or 4 indicated agreement. Negative items were reverse coded. Items were first averaged to create scale scores and then dichotomized to indicate whether or not the candidate perceived this individual to be a high-quality mentor. Average scores over 2.5 were assigned a value of 1 to indicate that, on average, the candidate perceived this individual to be a high-quality mentor. Average scores below 2.5 were assigned a value of 0 to indicate that, on average, the candidate did not perceive this individual to be a high-quality mentor.

The seven-item Perceptions of Support From Cooperating Teacher scale ($M = 3.38, SD = 0.43, \alpha = .72$) explored candidates’ perceptions of support from their cooperating teacher and the extent to which this support aligned with other components of the preparation program. These items were: “My cooperating teacher is an excellent teacher and a worthy role model,” “My cooperating teacher gave me useful feedback,” “My cooperating teacher was usually in the room when I taught a lesson,” “My cooperating teacher was knowledgeable about my teacher education program,” “My cooperating teacher taught in ways that were quite different from the methods I was learning in my university courses,” “I had useful meetings with my cooperating teacher to discuss my teaching,” and “My cooperating teacher allowed me to try out the strategies and techniques I was learning in my teacher education courses.” A total of 206 out of 220 candidates indicated that their cooperating teacher was a high-quality mentor; only 14 indicated that their cooperating teacher was not a high-quality mentor.
The five-item Perceptions of Support From University Supervisors scale ($M = 3.57$, $SD = 0.51$, $\alpha = .85$) also probed candidates' perceptions of support and alignment. The scale consisted of the following statements: “My supervisor was available to talk with me when I had questions or concerns about teaching,” “My supervisor observed me on a regular basis,” “My supervisor gave me useful feedback on my teaching,” “My supervisor provided feedback that was aligned with the theories and methods advocated in my methods courses,” and “My supervisor and cooperating teacher held similar ideas about teaching and learning.” A total of 210 out of 220 candidates indicated that they perceived their supervisor to be a high-quality mentor; only 10 indicated that they perceived their supervisor as not being a high-quality mentor.

**Teaching Candidates’ Mathematics Content Courses**

In the ETC survey, respondents indicated the number of courses they took in each of the following subject areas in high school, college, and graduate school: algebra I, algebra II, geometry, statistics (probability), precalculus/calculus, and trigonometry. These were summed to create a total count of mathematics coursework for each participant. Responses ranged from one to 11 mathematics courses ($M = 6.38$, $SD = 2.10$). In addition, candidates indicated whether they agreed with the statement, “I have had mostly positive experiences learning mathematics.”

Participants also self-reported their high school grade point average (GPA) and the scale their district used to compute GPAs. We divided GPA by the GPA scale to create a scaled GPA for each respondent ($M = 0.93$, $SD = 0.08$).

**Mathematical Knowledge for Teaching**

The Mathematical Knowledge for Teaching (MKT) measure addressed the common mathematical knowledge that is held by a well-educated adult (e.g., the ability to calculate correctly), and the specialized mathematical knowledge that is unique to teachers (e.g., the ability to identify the mathematical misconceptions that cause common student errors or whether a nontraditional student solution strategy generalizes). In this study, we administered the elementary number and operations MKT survey. This domain was chosen because it is the largest curriculum focus in the United States (National Mathematics Advisory Panel, 2008). Responses were scored using the 2-parameter logistic item response theory (IRT) method, and elementary candidates’ IRT scores were used as the outcome in the subsequent analyses. IRT scores ranged from -2.75 to 2.41 ($M = 0.30$, $SD = 0.83$). Hill et al. (2005) reported that this measure’s
teacher-level reliability was in the .80s. With regard to the measure’s latent structure, Hill et al. (2004) carried out factor analysis that indicated the presence of a strong general factor in the MKT items.

**ANALYTIC STRATEGIES**

In this study, multivariate path analysis allowed for simultaneous exploration of the association between elementary candidates’ background experiences, their OTL in courses and student teaching in teacher preparation, their perceptions of their cooperating teachers and university supervisors, and multiple aspects of preparedness to teach elementary mathematics (see Figure 1 for the path analysis that we used in this study). We chose a multivariate approach (i.e., an analytic design that includes multiple theoretically-associated outcome variables), given the depth of literature on the interrelatedness of candidate knowledge, self-efficacy, and beliefs.

![Figure 1. Hypothesized framework for multivariate path analysis](chart)

Our multivariate path analysis has three outcomes: (a) elementary teaching candidate MKT; (b) candidate mathematics teaching self-efficacy; and (c) candidate pedagogical beliefs about mathematics. We also correlated the residuals for each of these three endogenous variables, assuming that some of the variance not accounted for by our predictors was likely related
between the outcomes. For this model, we included candidate background experiences and candidate reports of OTL in courses and field placements.

As noted, we attended not only to elementary candidates’ experiences in mathematics content courses and student teaching, but also to candidates’ perceptions of those experiences. This allowed us to capture not just numbers of courses taken or OTLs mathematics instructional practices, but also whether candidates’ perceived quality of these experiences moderated the association between the number of experiences they were exposed to and each outcome. The first moderation effect we tested was whether associations between the number of mathematics courses that a candidate reported taking and their knowledge, self-efficacy, and beliefs were moderated by whether they reported having “mostly positive experiences learning mathematics.” We used this to investigate whether the differential impact of positive and negative experiences in mathematics courses documented qualitatively by Charalambous and colleagues (2009) held at a larger scale.

A substantial body of literature suggests significant heterogeneity in elementary candidates’ experiences in their field placements (Borko & Mayfield, 1995; Solomon et al., 2017; Zeichner et al., 2015). We wanted to examine whether certain types of experiences during fieldwork were differentially associated with candidates’ knowledge, self-efficacy, and beliefs. For example, we expected that additional OTL during fieldwork might not be associated with greater preparedness if the candidate reported a lack of support in the field or little alignment between fieldwork and methods. To examine this, we tested two moderation effects to see if associations between the numbers of candidate-reported OTLs in their field placements and their knowledge, self-efficacy, and beliefs were moderated by their perceptions of whether their cooperating teacher and university supervisor were high-quality mentors.

Even though elementary candidates in this study were nested into four different teacher education programs, we did not account for this in our analysis for two reasons. First, four clusters is below the recommended level 2 sample size for multilevel modeling (Maas & Hox, 2005). Second, after calculating intraclass correlation coefficients (ICCs) from unconditional two-level models for each outcome variable, we found that very little of the variance was accounted for at the program level; that is, the ICCs were all < 0.05 (Raudenbush & Bryk, 2002).³

To evaluate model fit, we examined the comparative fit index (CFI), the root mean square error of approximation (RMSEA), the standardized root mean squared residual (SRMR), and the Tucker-Lewis index (TLI). CFI and TLI values were > 0.90, and SRMR and RMSEA were < 0.08, which indicated acceptable fit (Hu & Bentler, 1999; Kline, 2005). All the models were estimated using the maximum likelihood option in Stata 14.
RESULTS

MODEL FIT

Several factors point to good model fit with the data. First, the chi-square value was not significant, $\chi^2(2) = 1.44$, $p = .49$. Second, the fit indices suggested strong model fit ($CFI = 1.00$, $TLI = 1.05$, $RMSEA = 0.00$, $SRMR = 0.01$). In addition, the $R^2$ values indicated that the model helps to explain variation in the endogenous variables; in particular, the model explained 18% of the variance in elementary candidate MKT scores; 35% of the variance in mathematics teaching self-efficacy; 15% of the variance in their pedagogical beliefs about mathematics; and 52% of the variance in the model overall.

ESTIMATES

Overview

Standardized parameter estimates are presented in Table 2. In addition to the estimates in Table 2, the correlation between the residuals of the measures of (a) mathematics teaching self-efficacy (MTSE) and (b) pedagogical beliefs about mathematics (Beliefs) was significant ($\beta = .37$; $p < .001$). The correlations between the error terms of the other endogenous variables were not significant. In addition, neither the main effect for the perceived quality of university supervisor nor the interaction terms were significant. For this reason, we dropped all of these in favor of a more parsimonious model. Likelihood ratio tests indicated that the reduced model did not differ significantly from the original model ($p > .10$).

Table 2. Standardized Parameter Estimates and Standard Errors

<table>
<thead>
<tr>
<th></th>
<th>MKT</th>
<th>MTSE</th>
<th>Beliefs</th>
</tr>
</thead>
<tbody>
<tr>
<td>HS GPA</td>
<td>0.15**</td>
<td>-0.01</td>
<td>-0.04</td>
</tr>
<tr>
<td>(0.06)</td>
<td></td>
<td>(0.06)</td>
<td>(0.07)</td>
</tr>
<tr>
<td>Number of Mathematics Courses</td>
<td>-0.09</td>
<td>-0.32**</td>
<td>-0.03</td>
</tr>
<tr>
<td>(0.13)</td>
<td></td>
<td>(0.11)</td>
<td>(0.13)</td>
</tr>
<tr>
<td>Mathematics Courses × Positive Experiences Learning Mathematics</td>
<td>0.39**</td>
<td>0.76***</td>
<td>0.19</td>
</tr>
<tr>
<td>(0.16)</td>
<td></td>
<td>(0.14)</td>
<td>(0.17)</td>
</tr>
<tr>
<td>OTL Method</td>
<td>0.17**</td>
<td>0.12*</td>
<td>0.20**</td>
</tr>
<tr>
<td>(0.07)</td>
<td></td>
<td>(0.06)</td>
<td>(0.07)</td>
</tr>
<tr>
<td>OTL Field</td>
<td>0.11</td>
<td>-0.74**</td>
<td>-0.65**</td>
</tr>
<tr>
<td>(0.28)</td>
<td></td>
<td>(0.25)</td>
<td>(0.29)</td>
</tr>
<tr>
<td>OTL Field × Perception of CT Quality</td>
<td>-0.20</td>
<td>0.94**</td>
<td>0.91**</td>
</tr>
<tr>
<td>(0.33)</td>
<td></td>
<td>(0.28)</td>
<td>(0.33)</td>
</tr>
</tbody>
</table>

Note. MKT = mathematical knowledge for teaching; MTSE = mathematics teaching self-efficacy; OTL = opportunity to learn; CT = cooperating teacher.

* $p < .10$. ** $p < .05$. *** $p < .001$. ns = nonsignificant.
Mathematics Content Courses

These analyses indicated that the impact of taking more mathematics content courses is highly divergent, depending on the quality of the experience. For example, an increase in the number of mathematics content courses that an elementary teaching candidate reported taking was negatively associated with their mathematics teaching self-efficacy when the candidate reported that they had not had “mostly positive experiences learning mathematics” ($\beta = 0.32; p = 0.005$). However, an increase in the number of mathematics content courses that a candidate reported taking when they also reported having had positive experiences learning mathematics was positively correlated with their math teaching self-efficacy ($\beta = 0.76; p < 0.001$) and their MKT score ($\beta = 0.39; p = 0.016$).

Put plainly, there were different associations between the number of mathematics content courses that a candidate reported taking and their knowledge and self-efficacy, depending on whether they reported positive or negative experiences learning mathematics. There was no association between mathematics content course taking and candidates’ pedagogical beliefs about mathematics, regardless of whether they had positive or negative experiences learning mathematics. In addition, candidates who reported higher high school GPAs also had significantly higher MKT scores ($\beta = 0.15; p = 0.02$). GPAs were not associated with either self-efficacy or beliefs.

OTL in Methods Courses

These analyses showed that when elementary candidates reported increased opportunities to engage with representations, decompositions, and approximations of mathematics teaching practices in mathematics methods courses, this was associated with higher MKT scores ($\beta = 0.17; p = 0.01$) as well as pedagogical beliefs about mathematics ($\beta = 0.20; p = 0.004$). Increased exposure to pedagogies of practice was also positively correlated with candidates’ math teaching self-efficacy, though this relationship was not significant ($\beta = 0.12; p = 0.06$).

OTL in Field Placements

In this sample, when an elementary candidate reported that their cooperating teacher was a high-quality mentor, increased opportunities to observe, attempt, and receive feedback on mathematics teaching practices during their field experience were associated with mathematics teaching self-efficacy ($\beta = 0.94; p = 0.001$) and pedagogical beliefs about mathematics ($\beta = 0.91; p = 0.005$).
For candidates who did not report having a high-quality mentor, increased opportunities to observe, attempt, and get feedback on mathematics teaching practices were correlated with lower likelihood of reporting higher levels of math teaching self-efficacy ($\beta = -0.74$, $p = .03$) or pedagogical beliefs about mathematics ($\beta = -0.65$, $p = .02$). OTL in the field was not associated with MKT, regardless of whether candidates reported that they received high-quality mentoring from their cooperating teacher.

DISCUSSION

The goal of this study was to examine how interactions between (a) elementary teaching candidates’ experiences in courses and field experiences and (b) their perceptions of the quality of these experiences were associated with their mathematical knowledge for teaching, their mathematics teaching self-efficacy, and their pedagogical beliefs about mathematics. Results from our multivariate path analysis demonstrate how candidate-reported experiences in mathematics content courses, mathematics methods courses, and student teaching work in complementary ways to support candidate preparedness. Results also highlight the extent to which associations between (a) reported experience in courses and field placements and (b) candidates’ knowledge, self-efficacy, and beliefs vary by other reported characteristics of those experiences.

MATHEMATICS CONTENT COURSES

In this study, the number of mathematics content courses that an elementary candidate took was positively associated with their preparedness to engage in ambitious mathematics instruction only when they also reported having positive experiences learning mathematics; this is consistent with Hypothesis 1. In addition, we also found that additional mathematics content courses were negatively correlated with candidates’ mathematics teaching self-efficacy when the candidate reported that they had not had positive experiences learning mathematics. This confirms across a sample of 220 candidates what Charalambous et al. (2009) documented qualitatively in a smaller sample: Negative experiences learning mathematics are associated with lower levels of self-efficacy with regard to teaching mathematics. In addition, the association between candidates’ mathematics content course taking through high school and college and their preparedness to teach elementary mathematics ambitiously suggests that preparation begins long before candidates officially enroll in a teacher education program and provides evidence of the need to examine effects of preparation at the
individual candidate level. That is, the process of socialization that elementary candidates go through as they develop identities as mathematics teachers includes their experiences in mathematics content courses at the high school and college levels.

PEDAGOGIES OF PRACTICE IN MATHEMATICS METHODS COURSES

A major finding from this study was that the use of practice-based pedagogies in mathematics methods courses was positively associated with multiple facets of elementary candidates’ preparedness to engage in ambitious elementary mathematics instruction; this is consistent with Hypothesis 2. Prior literature has theorized that practice-based pedagogies may be critical to solving the problem of enactment in teacher preparation; that is, the gap between educational theory, which is often the focus of methods courses, and the actual knowledge, self-efficacy, and beliefs that constitute preparedness to support student growth in real classrooms (Ball & Forzani, 2009; Grossman et al., 2009; Kennedy, 1999; Lampert et al., 2013). Our study is among the first to provide empirical evidence in support of this claim and to show that this theory holds at a large scale in the context of elementary mathematics teacher education.

The strong association between exposure to practice-based pedagogies in mathematics methods courses and candidates’ preparedness to teach elementary mathematics suggests that the pedagogies of practice framework could be a powerful lens through which teacher educators could reflect on and improve the quality of the OTL they provide to candidates. Ghousseini and Herbst (2016) created a model of how individual mathematics teacher educators can engage in this type of analysis of their teaching to determine whether and how the pedagogies they employ contribute to various facets of candidate growth. In particular, this type of self-inquiry affords the opportunity for teacher educators to transform the tools they use to support candidates so that these tools become better aligned to their goal: candidates’ preparedness to teach mathematics ambitiously. In doing so, teacher educators can support elementary candidates’ socialization into mathematics teaching and the development of their identities as mathematics teachers.

HIGH-QUALITY COOPERATING TEACHERS

These analyses also suggest that the influence of a field placement depends on both the perceived quality of the mentoring from the cooperating teacher and the types of OTL that an elementary candidate experiences while student teaching; this is consistent with Hypothesis 3. Elementary candidates who report weaker mentoring from cooperating teachers—or
a misalignment between lessons learned in student teaching and methods coursework—may have fallen prey to what Feiman-Nemser and Buchmann (1985) famously termed “the two worlds pitfall.” Researchers suggest that candidates left to independently make sense of the disconnect between their methods courses and field experiences are less likely to apply what they learn in either setting, do not learn as much as better supported peers, and often report feeling confused, frustrated, and doubtful of their ability to become a teacher (Hammerness et al., 2005). This helps explain the negative association between increased OTL in student teaching and both (a) mathematics teaching self-efficacy and (b) pedagogical beliefs about mathematics when candidates reported that their cooperating teacher did not teach, provide feedback, or allow them to attempt practices in ways that were aligned with what they were learning in other parts of their program.

In contrast, other elementary candidates in this study reported having high-quality cooperating teachers who were knowledgeable about their preparation program, taught in ways that were aligned with mathematics methods courses, and allowed candidates to try out practices learned in methods courses. Being placed with this type of cooperating teacher may have meant that the burden of boundary crossing between the university and school placement did not fall solely on the candidate. In addition, candidates who reported that their cooperating teacher was a high-quality mentor also indicated that their cooperating teacher was supportive; that is, they provided helpful feedback, they were in the room when the candidate taught, and they regularly held useful meetings to discuss teaching. In this way, such cooperating teachers supported their socialization into mathematics teaching and the development of their identities as mathematics teachers.

Studies that are not specific to the preparation of mathematics teachers, discussing teacher preparation in general, have noted that increased support and coherence of this type can lead to candidates being more likely to adopt important teaching practices; in other words, candidates are not left to simply sink or swim in student teaching (Hammerness et al., 2005; Zeichner, 2010). Our results add to this body of literature by showing across 220 candidates the importance of this type of coherence and support from a cooperating teacher in the specific context of elementary mathematics teacher preparation.
LIMITATIONS

This analysis has some limitations. First, the data in this study all relied on elementary teaching candidate self-reports, not observations of actual experiences. It is possible that a candidate’s exposure to various OTLs about mathematics teaching during teacher preparation were different from what they reported. It is also possible that they misremembered or misreported their prior course taking or high school GPA. Further, grading scales and course rigor vary across districts, so high school GPAs are themselves a limited measure of prior achievement. Second, our measure of pedagogical beliefs about mathematics had a low Cronbach’s alpha reliability coefficient ($\alpha = .45$); this was partly because we included survey items on both beliefs about mathematics and beliefs about mathematics pedagogy in creating this measure. In future research, it will be important to include measures of teachers’ beliefs that are well-grounded in prior research (Francis et al., 2014) and that have stronger evidence of internal consistency.

Third, in this study we were able to identify associations between learning opportunities in courses and field placements, and MKT, mathematics teaching self-efficacy, and pedagogical beliefs about mathematics; we also considered how candidate perceptions of the quality of their experiences in courses and student teaching moderate these associations. However, we were not able to explore how MKT, mathematics teaching self-efficacy, and pedagogical beliefs about mathematics developed over time. Despite these limitations, this analysis provides a foundation for multiple lines of future research.

Researchers could build on this analysis to delve further into the quality of teaching candidates’ experiences. Just as teaching quality has proved to be essential to understanding student learning in K–12 classrooms, it is likely that instructional quality in mathematics content courses and mathematics methods courses plays an equally important role in the context of teacher preparation. Additionally, in this analysis, candidates’ perceptions proved to be important in understanding associations between their experiences during fieldwork and their preparedness. It is probable that their perceptions of their experiences during methods courses are equally important. Data in this study were limited to reports of the quantity of particular experiences in methods courses; there were no data on candidate perceptions of the quality of those experiences. It is possible that there was substantial heterogeneity in candidates’ experiences in methods courses that mutes the average effect presented here.

Taken together, the findings from this multivariate path analysis, which account for both the reported quantity and the perceived quality of elementary teaching candidate experiences, may shed light on the conflicting findings in prior literature. There is little agreement in extant literature
about associations between facets of teacher preparation and candidate knowledge, self-efficacy, or beliefs. Explaining the positive associations in some samples and lack of associations in others may have more to do with the quality of teaching candidate experiences than with whether a candidate was exposed to a particular OTL.

These results also reinforce the need to take a more expansive view when studying teacher preparation. The associations reported here could not have been uncovered if data on teaching candidate backgrounds, experiences, perceptions of those experiences, knowledge, self-efficacy, and beliefs had not been collected and analyzed simultaneously. Although path analysis methodology is rarely used in teacher preparation research, it has the potential, as shown in the present study, to highlight the highly contextualized and interdependent nature of candidates’ experiences in teacher preparation. Our study is among the first to use multivariate path analysis as a means to intentionally highlight the variability inherent in teacher preparation. As such, it marks a turn toward a broader use of a range of quantitative methodologies, better suited to reflect at a large scale the complexity of preparing teachers, which has been documented by qualitative researchers for decades.

ACKNOWLEDGEMENT

This material is based on work supported by the Spencer Foundation under Grant No. 201600103 and the National Science Foundation under Grant No. DGE 1535024. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the funders.

NOTES

1. Whereas some of these studies do not clarify whether the term “mathematics content courses” (a) describes courses that are specifically designed for teachers or (b) refers to traditional college mathematics courses (Boyd et al., 2009; Hill, 2010; Hill et al., 2018; Schmidt, Houang, & Cogan, 2011), others are more explicit. Some studies focus on mathematics content courses for teachers (Drageset, 2010; Smith et al., 2012; Swars et al., 2009), and others concentrate on college mathematics courses (Drageset, 2010; Evans, 2011; Qian & Youngs, 2016; Ren & Smith, 2017; Wilkins, 2008).

2. Pseudonyms were used for the teacher education programs in this study.

3. As a sensitivity analysis, after initial estimation, we reran our model with program fixed effects. Parameter estimates were robust to inclusion of program fixed effects. This is consistent with prior literature suggesting that there are more similarities than differences between teacher preparation programs (e.g., Boyd et al., 2009).
REFERENCES


REBEKAH BERLIN is the program director for the Deans for Impact Learning by Scientific Design Network. She previously taught elementary mathematics in Memphis, Tennessee, and worked as a research assistant and teacher educator at the University of Virginia. Her research and professional interests focus on teacher education and teacher quality. A recent publication has appeared in *AERA Open*.

PETER YOUNGS is a professor in the Department of Curriculum, Instruction, and Special Education at the University of Virginia. His research interests focus on teacher development and the social context of schooling. Recent publications have appeared in *Elementary School Journal, Journal of Teacher Education*, and *Teaching and Teacher Education*. He is currently serving as coeditor of *American Educational Research Journal* (2019 through 2022).

JULIE COHEN is an associate professor in the Department of Curriculum, Instruction, and Special Education at the University of Virginia. Her research interests focus on the role of simulation in teacher preparation and strategies for promoting teacher quality at scale. Recent publications have appeared in *AERA Open, Educational Evaluation and Policy Analysis*, and *Journal of Teacher Education*. She received a National Academy of Education/Spencer Foundation postdoctoral fellowship.