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Mathematics in early childhood: Teacher educators' accounts of their work

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ABSTRACT

While early childhood practitioners have long been asked to have complex understandings of child development and provide rich, meaningful educational experiences for children, focusing on mathematics marks new terrain. Consequently, teacher educators are now tasked with figuring out how to communicate new ideas about early mathematics education to early childhood practitioners, yet we know little about their work. This paper examines what early childhood teacher educators have to say about their work. We found that there were only small differences in how they described: (1) what they teach, (2) how to teach it, (3) resources they draw from, and (4) what informs their work. When there were differences in their approaches, these often were reflective of whether the teacher educators had more of an early childhood or mathematics background. The teacher educators' descriptions show there is a need to have clear understandings of what early childhood math looks like in action and for increased collaboration between early childhood and mathematics experts.

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In light of recent evidence connecting success in school to early mathematical experiences, early childhood mathematics teaching and learning is increasingly being thrust into the policy spotlight. Kindergarten-entry mathematics skills have been found to be a particularly strong predictor of later achievement in school (Duncan et al., 2007). In fact, Duncan and his colleagues found that mathematics skills were even more predictive than early literacy, attention, and socioemotional skills—all skills that have traditionally been the trademark in early childhood education programs. In 2002 (updated in 2010), the National Association for the Education of Young Children (NAEYC) and the National Council of Teachers of Mathematics (NCTM) issued a joint position statement that advocated "high quality, challenging, and accessible mathematics education for three- to six-year old children" (p. 1) and provided research-based recommendations to guide classroom practices. Critical to this vision is the effective education of early childhood practitioners, with teacher education being a key component of this vision. While early childhood practitioners have long been asked to have complex understandings of child development and provide rich, meaningful educational experiences for children, mathematics marks new terrain (Baroody, Lai, & Mix, 2006). Consequently, teacher educators are now tasked with figuring out how to communicate new ideas about early mathematics education to early childhood practitioners.

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With this paper, we offer a window into the work of early childhood teacher educators who teach prekindergarten (preK) teachers about early mathematics teaching and learning. We employ a broad definition of early childhood teacher educators. We interviewed individuals who taught courses and/or professional development to pre- and/or in-service preK teachers. Because of the diversity of settings in which teacher educators do their work with early childhood practitioners, we intentionally sought out teacher educators from a wide range of settings, such as Head Start, universities, and district offices. In talking with these teacher educators, we addressed the question, *how do early childhood mathematics teacher educators describe their work?* We found that although the teacher educators we interviewed worked in diverse settings, they painted a fairly consistent picture of how they work with pre- and in-service preK teachers. Further, when there were differences in their approaches, these often were reflective of whether the teacher educators had more of an early childhood or mathematics background.

Educating teachers in early childhood mathematics

An emerging body of literature suggests that young children come to preschool with an astounding amount of informal mathematics knowledge (Baroody et al., 2006; Clements & Sarama, 2007; Ginsburg, Lee, & Boyd, 2008). To productively build on this knowledge, early childhood teachers must have the requisite knowledge of mathematics, as well as child development and pedagogical content knowledge as it relates to early mathematics teaching and learning. Developing deep understandings of these different strands of knowledge is key to effective teaching and learning (Bransford, Brown, & Cocking, 2000). Bransford and his colleagues (2000) noted this in a discussion about pedagogical content knowledge:

> Expert teachers know the structure of their disciplines, and this knowledge provides them with cognitive roadmaps that guide the assignments they give students, the assessments they use to gauge students' progress, and the questions they ask in the give and take of classroom life. In short, their knowledge of the discipline and their knowledge of pedagogy interact. (p. 155)

In early childhood education, both teachers and teacher educators are also tasked with figuring out how their knowledge of mathematics and the teaching of mathematics relates to their knowledge of child development.

Unfortunately, we know that many early childhood practitioners are not adequately equipped to provide math-related experiences and instruction that is reflective of new understandings about math teaching and learning (Copley, 2004). One reason for this could be that for years early childhood education has primarily focused on literacy and social-emotional development (Platas, 2008). These areas still garner the lion's share of attention in early childhood professional development (Simpson & Linder, 2014). Further, early childhood practitioners have indicated that mathematics is not a content area they would like more professional development in (Simpson & Linder, 2014). Early childhood teachers' attitudes toward mathematics may be another reason for their lack of preparation in this area. Teachers' knowledge of mathematics and mathematics teaching impacts their decisions they make about classroom instruction (Bransford et al., 2000). In early childhood, we know that practitioners are often phobic of and do not see themselves as competent in mathematics (Copley, 2004). As such, they are less likely than elementary

school teachers to provide intentional support for children's mathematical learning (Ginsburg, Pappas, & Seo, 2001).

To advance early mathematics, early childhood teacher education (both pre- and in-service training) is critical. Unfortunately, we know that mathematical content receives little attention in most preservice teacher preparation programs, almost always being integrated with other subject areas (i.e., stand-alone early childhood mathematics courses are rare) (Maxwell, Lim, & Early, 2006). Furthermore, even when preservice teachers are exposed to courses that address children's mathematical development or the content knowledge necessary for supporting it, these classes tend to be for K–3 teachers (Maxwell et al., 2006). Thus, many teachers who know they will be teaching in preK classrooms are not explicitly trained to do so. Upon entering the classroom, early childhood teachers do not necessarily have more opportunities to further their knowledge of early mathematics teaching and learning. In a study of early childhood professional development, Simpson and Linder (2014) surveyed professional development recipients and found that out of 1,127 early childhood practitioners, only 33 of them had taken mathematics-related professional development.

In thinking about how to advance early mathematics teacher education, considering how teacher educators approach their work is key. Two areas of importance are their pedagogical methods and what influences their teaching. In addition to being well-versed in what they are teaching, teacher educators also need to be thoughtful about the teaching methods they employ. For example, current supported professional development practices call for teacher educators to move away from one-shot professional development sessions (Desimone & Garet, 2015), to provide explicit examples of what the content/practices they are promoting look like in early childhood classrooms, and to provide sustained support for implementation of these ideas and practices, often through coaching and mentoring (Winton, Synder, and Goffin 2016). These trends in teacher education practices reflect sociocultural beliefs about learning by creating opportunities for groups of people to jointly interact with potential new mathematical practices and ideas (Lave & Wenger, 1991).

Considering what influences teacher educators' work draws attention to the roles of policy and work context. In recent years, educational policies increasingly target teaching and learning inside classrooms (Spillane, 1999). Knowing which policies teacher educators attend to is important, as it has implications for what the learning opportunities look like and what teachers bring back to their classrooms. For example, the Common Core State Standards in mathematics (CCSS-M) aim to repair an American curriculum that is a "mile wide and an inch deep" (Schmidt, Houang, & Cogan, 2002) by stressing conceptual understanding of a smaller number of key ideas. Thus, if teacher educators consider the CCSS-M in the planning of their course or professional development, the content and pedagogical strategies they cover most likely reflect CCSS-M. We also know that teachers and those who educate them do not make sense of policy or work in a vacuum. Sociological theories of sensemaking (Vaughan, 1996; Weick, 1995) recognize that as individuals make sense of new information, these beliefs are situated in and shaped by organizational context. With mathematics being a relatively new focus for early childhood teacher educators, it makes sense to consider how their work contexts influence their work with preK teachers.

It appears that even with structures in place to ensure that early childhood teachers are receiving appropriate training in mathematics content and pedagogy, the field of early childhood mathematics, in general, is not yet in a place to provide research-based guidance on what to teach and how to teach it. Parks and Wager (2015) spoke to this issue in a literature review that examined how the literature conceptualizes both what and how early mathematics should be taught to both early childhood teachers and children. They found an emphasis on elementary rather than early childhood mathematics and a lack of practice-oriented research for teacher educators. In turn, they called for research that informs the work of early mathematics professional development designers and facilitators, stating that there is a need for

> the field to capitalize on this time of increased attention to early childhood mathematics to seek to differentiate this context from that of elementary and to put a spotlight on the needs of practitioners at all levels who seek to meet the mathematical needs of young children. (p. 137)

All this suggests that researchers need to be intentional about shifting the current, elementary-focused discourse if, as a field, we want to deepen our knowledge of early mathematics teacher education practices.

In such a dynamic time for the field—from shifts in standards, to new demands on teachers' practices, to changing expectations for teacher educators—we agree with Parks and Wager (2015) that there is a need to spotlight the needs of "practitioners at all levels." We believe that one underutilized source of information are the teacher educators themselves—those on the front lines, teaching pre- and in-service teachers. We know that teacher educators are key actors who mediate information from research to practice (Stein, Smith, & Silver 1999). Rarely, however, do we take a close look at their perspectives. Consequently, with this paper we investigate how early mathematics teacher educators describe the kinds of early mathematics they teach, how they teach it, and what informs their teaching.

Methods

The data used in this analysis was collected as part of a needs assessment for a larger project that developed resources for teacher educators who work with both pre- and in-service teachers in early childhood mathematics.[1] Before the designers could work on creating those resources, it was important to have a sense of the teacher educators' current work and the supports and barriers that they experience. The intent was to create resources reflecting teacher educators' needs instead of researchers' interpretations of or assumptions about their needs. Here, we draw on this information to analyze the mathematical domains teacher educators addressed, the pedagogies they promoted, the teaching methods they employed in their professional development offerings, the resources they drew from, and the policies informing their work.

Participants

We collected qualitative interview data from 45 teacher educators who all taught future or current preK teachers. They taught in a number of different sectors, ranging from 4-year

universities to district offices (see Table 1). They were located in 17 different states. All 17 states had some version of early learning standards, and all but three states had adopted the Common Core State Standards in Mathematics.

We began recruiting participants using a snowball sampling method (Patton, 2002). First, we identified participants by asking colleagues working in early childhood mathematics for recommendations. We specified that we wanted to speak with people who teach and/or provide professional development in early childhood mathematics. We also stressed that we wanted to speak with teacher educators who worked in varied settings, ensuring we talked to people from different sectors, multiple states, and people who worked with both pre- and in-service educators. During all interviews, we asked our participants to recommend other people we should speak with. While this snowballing method of recruitment was mostly successful, it did not connect us with teacher educators from Head Start or county/regional offices. Consequently, after we exhausted our initial snowball sample, we e-mailed one or two individuals from these sectors in each state to address this lack of representation and then continued with the snowball sampling method.

Since we interviewed teacher educators from a variety of settings, their audiences and delivery methods varied. Twenty-eight of the teacher educators we talked with provided professional development to in-service teachers, 6 worked with preservice teachers, and 11 worked with both pre- and in-service teachers. They taught traditional university courses to preservice teachers and/or conducted professional development for in-service teachers. The university courses ranged from entire courses on early childhood mathematics teaching and learning to mathematics courses for elementary teachers with a designated time for early childhood topics or early childhood curriculum courses with a designated amount of time for mathematics. The professional development structures varied as well. As with undergraduate courses, the setting impacted the amount of time spent on early mathematics. For instance, one teacher educator, a university professor who taught professional development, worked with the same teachers for 2 years, meeting with them once a week during the school year. Others, often those who worked in regional offices or for school districts, taught one-shot early mathematics professional development sessions during mandatory professional development days or during after-school hours when teachers could elect to come.

Table 1. Teacher Educators' Work Setting

Sector	n
Four-year university	11
Head Start	6
County office of education/regional service center	6
Community college	5
District office	5
Other[1]	12
Total	45

[1]Included in the "Other" sector were those teacher educators who work at university-based centers (n = 3), nonprofits (n = 2), an early childhood education institute (n = 2), and state department offices (n = 2). We also collected data from one teacher (who provided professional development to her colleagues), one city administration official, and one independent consultant.

Considering that teachers' ideas about mathematics impact what they teach and how they teach it (Bransford et al., 2000), we anticipated that teacher educators would have different perspectives if they had an early childhood background, a mathematics background, or a combination of the two. To help us see any potential patterns based on their backgrounds, we identified where the participants' expertise lay. To do this we looked at:

(1) The ways in which the teacher educators self-identified.
(2) Their research focus and home departments if they worked at a college or university.
(3) Their job titles and descriptions of their roles.
(4) The primary purpose of the course or professional development they typically taught.

Of the 45 teacher educators in our sample, 26 had more of an early childhood background, 11 had more of a mathematics background, 7 had expertise in both fields, and one person we spoke with had neither, as she supported teacher learning in general.

Data collection and analysis

We conducted interviews with each participant by phone. They lasted for approximately 45 minutes. The interviews were primarily semistructured, but also included three forced choice questions (Patton, 2002) (see Appendix). All interviews were audio-recorded, transcribed, and uploaded into NVivo for analysis. We created pseudonyms to ensure confidentiality.

To begin analysis, we generated a set of descriptive codes that allowed us to more clearly see the nature of the teacher educators' work (Patton, 2002; Saldaña, 2009). We then divided the four authors into two coding teams and each coding team, consisting of two authors each, read all of the interviews. The coding team with more of a teacher education background used codes related to early childhood and mathematics teaching and learning. The other team had more policy experience and used codes related to what was shaping the teacher educators' practices. We held biweekly research team meetings where we discussed emerging codes and themes. We also kept ongoing analytic memos (Saldaña, 2009) in a shared space so we could see and comment on the development of our colleagues' ideas. When pertinent, we triangulated our assertions by having each researcher look across data sources to ensure that findings about a particular group (e.g., Head Start teacher educators, teacher educators with early childhood expertise) were representative of that group (Mathison, 1988). Throughout these processes, we began to see that there were a number of commonalities across our sample, with some small differences in how early childhood versus mathematics teacher educators approached their work.

Findings

Across the wide variety of people we spoke with, teacher educators with different professional backgrounds and working in different settings across the United States, we found that there were only small differences in how they described their work. These differences

related to whether they had early childhood or mathematics expertise. Overall, however, we found that they offered a compatible vision of their work. Here we describe the mathematical domains the teacher educators focused on, the kinds of pedagogical practices they recommended, how they approached their own teaching, the policies they drew from, and how the contexts in which they worked influenced their teaching. We then examine the small differences we found between those who worked in different sectors and those who had early childhood or mathematics backgrounds.

Mathematical domains: a focus on number

Thirty-two of the 45 teacher educators spoke about the importance of number. Other mathematical domains like operations (n = 16), geometry (n = 17), measurement and data (n = 16), and early forms of algebraic thinking (n = 18) did come up, but less frequently and in a slightly different manner. That is, with number they explicitly identified skills that are important in the teaching and learning of number sense, such as counting, one-to-one correspondence, cardinality, and subitizing. With the less frequently mentioned domains referred to above, they tended to name the overarching domains or talk about them briefly, with less detail.

Albeit much less frequently, teacher educators also stressed wanting their pre- and in-service teachers to work on developing deeper, conceptual understandings (n = 13) of mathematics in their students. Ten spoke about mathematical process skills such as having children engage in activities that teach problem solving, reasoning and proof, communication, connections, and representation skills (NCTM, 2000). Although teacher educators sometimes talked about developing these types of mathematical understandings in general, absent of particular content, when they did talk about particular mathematical content in this manner, number was the domain they discussed most often, buttressing our finding that number was particularly salient in the teacher educators' professional development offerings. For example, Dana, who works at a district office, said:

> Teachers have a tendency to jump through things too quickly and focus on surface level and rote skills without getting at concepts. I see the professional development being more about developing deep conceptual understanding of things and getting people to understand that we're only going to work with the numbers one through five for, like, three months, because we want kids to totally understand just the numbers one through five. Versus, like, "Oh, they can count to five! I'm going to have them count to 10, and then 20, and we're going to put things together." It's understanding—building understanding, a solid understanding of math ideas versus rote skills. It's understanding versus skills and procedure.

Teacher educators, like Dana, were pushing for their pre- and in-service teachers to think about what it means to cultivate deep mathematical thinking in young children, moving beyond a focus on isolated mathematical skills.

Pedagogical practices: Promoting a child-centered approach

The teacher educators also spoke about the pedagogical approaches they promoted. They primarily did so in two ways—using popular early childhood terms and detailing the kinds of practices they did not approve of. Most of the teacher educators, 35 out of 45, talked about child-centered approaches to teaching, often emphasizing play-based and

developmentally appropriate practices. While these terms can be reflective of a child-centered approach in early childhood education, at times they did not help create a clear picture of practice due to their ubiquitous nature. As one teacher educator said with a laugh, "A lot of these words are so loaded" (Elizabeth, university-based center). Two other teacher educators joked in a similar manner, referring to terms such as inquiry-based and developmentally appropriate as "jargon" and "buzzwords."

When participants described what they meant by terms like play and developmentally appropriate, their descriptions varied. When talking about play, for instance, some described playful, teacher-created activities that at times equated play with hands-on activities, while others described infusing math into typical classroom practices. Still others talked about teachers actively playing with children during choice- or play-time and engaging them in mathematically rich conversations. The following quotes illustrate these contrasts:

> It's mostly done through games, through play, where the teacher might introduce a game to a group of children. It's put over in the math center or in the block area or the science center, even the literacy center, depending on what it is, and then the children will play with it on their own. (Emma, county office of education)

> If I'm working with a child during free play and they happen to pick up something where I can do some counting with them, then that's what I do. But there's not necessarily a systematic approach. (Elaine, Head Start)

> And some of it, and the hardest part, which folks have been writing about forever, is mathematizing play. How do you looking at kids doing things in play, identify the math, so you have to know the math pretty well, and then think about what you would do next? Either what questions you might ask right then or maybe not, because maybe you shouldn't interrupt that play at the time, or what you might ask later, what you might do later to extend that learning and help them connect those ideas to math. (Betty, 4-year university)

Emma's quote speaks to a playful approach in which a teacher-created or commercial activity, such as a board game, is considered play. Elaine describes a familiar scene in an early childhood classroom, in which children are playing and the teacher, while sitting nearby or sometimes playing with them, asks the children to count the objects they are playing with. The counting, in such scenarios, is not necessarily a part of the child's play; rather the child is playing and the teacher sees an opening for counting—*Look at how tall your tower is, how many blocks did you use?* Betty also describes how mathematics can be a part of children's play, but she does so differently than Elaine. Her take on play suggests a responsive approach in which the teacher uses her mathematical knowledge to build on children's play in a way that is relevant to both what children are doing in terms of math and the play they are currently involved in. Each of these different takes on play impact the kinds of teaching and learning experiences children have access to in their classrooms.

Explanations of "developmentally appropriate" also differed. When talking about the importance of being developmentally appropriate, Vivian, who works at a community college, described the term by first referencing NAEYC's Developmentally Appropriate Practice book and then she said, "It's being kept current in the latest research and incorporating that into—using that to base your experiences that you provide children with." Lisa, who works at a 4-year university, focused on children's cognitive capabilities by saying that to her developmentally appropriate meant "that children have the cognitive process in place to be able to engage in the math the way the teacher's asking them to, but

also that learning is a social process as well." Others defined developmentally appropriate by what it was not, making statements such as, "Get rid of the dittos [worksheets]. It needs to be really concrete, hands-on. It has to be developmentally appropriate" (Emma, county office of education). Although teacher educators described child-centered practices such as play and developmentally appropriate practices in different ways, there was a common thread to their descriptions—teachers should connect their knowledge of mathematics with their knowledge of child development in playful interactions with children about things children are interested in.

While teacher educators spoke passionately about the kinds of mathematics teaching they promoted, they often included ideas about what they did not approve of, which again reflected a preference for child-centered approaches. For example, didactic teaching was most commonly mentioned as an approach teacher educators did not promote (n = 25). Educators cited their disdain for instructional techniques like teaching isolated skills through the use of worksheets, rote memorization, or "drill & kill." Fifteen teacher educators stated that whole-group activities could be used *at times*, but that often this was an inappropriate instructional method. For example, Linda, who works at a community college, described whole-group instruction as an inappropriate practice: "I don't think you should do math in a large group with preschoolers." On the other hand, Marilyn, who works at a school district, approached whole-group mathematics instruction more cautiously: "Are there times when they teach whole-group? Yeah. That's a very small part of the day. For the most part we do teach the small-group math. But the younger the children are, the less effective a whole-group setting is." A few teacher educators also said they were wary of scripted curricula (n = 4) and formal assessments (n = 3). Although most of the teacher educators promoted integrating mathematics throughout the day, four had concerns about only using integration because, "Everybody's trying to integrate math with everything else under the sun and they end up not really teaching it" (Tara, 4-year university.)

Approach to professional development: Sociocultural teacher education practices

The teacher educators also described the ways in which they teach in their courses and professional development. In addition to describing more traditional practices like reading, projects, lecturing, Power Point presentations, and class discussions, three primary approaches emerged: modeling, coaching or mentoring, and engaging teachers in mathematics activities. These teaching methods were not necessarily used in isolation, as they often described using a combination of modeling and coaching or modeling and engaging teachers in activities. Moreover, their description of each method highlighted an emphasis on active participation in authentic and inherently social learning experiences, thus reflecting sociocultural beliefs about how people learn (Lave & Wenger, 1991; Vygotsky, 1978).

Modeling was mentioned the most by the teacher educators that we interviewed (n = 27). By modeling we mean an instructional strategy in which the teacher educator demonstrates a new concept and the pre- and in-service teachers learn through observation. To model, teacher educators both acted out practices, sometimes pulling activities from a particular curriculum, and used video. Katherine, who works at a community college, said:

> I think my students really do well when they observe something and have an opportunity to discuss it—video kinds of things and seeing what it looks like in action helps. "This is what math looks like with young children." Because they still have this idea that what math looks like is worksheets. It helps for them to see.

Betty, who works at a 4-year university, discussed the kinds of questioning techniques she employs along with video modeling by describing how she asks teachers, "OK, what do you see? What do you notice kids are doing? What does it mean they understand? What could you do next?" Similar to Katherine and Betty, many of the teacher educators indicated that video was particularly useful for demonstrating teaching strategies because readings and group discussions about math practices are not always enough. This again reflected the teacher educators' belief in the power of practice-based learning as opposed to readings and discussions that they often saw as disconnected from what teachers would be doing in their classrooms.

Coaching or mentoring was the next most prominent instructional approach used (n = 20). Coaching/mentoring included coplanning lessons, coteaching lessons, providing feedback on lessons, helping teachers create tools and activities and ways to use them in the classroom, and helping teachers work with student data. The teacher educators believed that coaching/mentoring is a very important piece of the professional development puzzle because it gives teachers the space to try out the strategies they learned in the course or professional development in classrooms. It also allows them to get feedback on their teaching and gives them the time to reflect on their practice. For example, Carrie, who works at a university-based center, said,

> My experience of coaching is not just with this project, but I think coaching embodies that kind of reminder to transfer what you've learned... because otherwise teachers get back in the classroom and they're overwhelmed with other demands and it's hard to try new things, because they don't always work so great the first time.

Head Start teacher educators were particularly adamant about the importance of coaching. Five of the six Head Start teacher educators talked about the importance of coaching, and one of them said that as an organization, "Head Start is telling programs: 'You have to coach. That's the only type of professional development that works really, really well, and you have to do it'" (Dina, Head Start).

> Finally, teacher educators said that they engaged teachers in mathematical activities during their course or professional development. Most (n = 15) said that they engaged the teachers in the same activities that teachers could then do in their classrooms. However, a few (n = 4) said that activities should be *similar* to activities children could do, but be more complex and reflective of where adults are with their mathematical thinking. Here, instead of the purpose being to reproduce the mathematics activity in their classrooms, the purpose was to "surface the important ideas that the adults need to be grappling with as they design activities for young kids" (Karen, early childhood education institute.)

Attention to policy

While we were primarily interested in what early childhood teacher educators currently do in order to design appropriate tools, it was important to recognize that policy is one factor that played a role in shaping teacher educators' practice. All teacher educators, regardless of whom or where they were teaching, noted that they considered at least one policy when

Table 2. Policies Considered by Teacher Educators

Policy	Number of Teacher Educators
State-specific PreK early learning standards	26
Common Core State Standards	24
Student assessments and testing	7
Teacher licensing or accreditation requirements	6
NAEYC standards	5
NCTM standards	4
Teacher evaluation standards	3
Head Start Performance Standards	4
Teacher preparation program requirements	1

constructing their courses or professional development. Table 2 displays the policies that teacher educators considered. As we see in Table 2, these policies either targeted students, such as student assessments and testing, or targeted teachers, such as teacher licensing or accreditation requirements. However, standards targeting students were more commonly considered. For example, the majority of the teacher educators considered their state's preK early learning standards. Many also reported considering the Common Core State Standards, although these standards do not include preK. Consideration of the policies in Table 2 impacted teacher educators' practice in varied ways. Two teacher educators discussed restructuring their professional development or courses based on changes in the standards. Teacher educators noted that policies shaped the nature of their work by determining how funds were distributed or by creating what they viewed as time-consuming, unnecessary work for them. They also spoke about the ways they incorporated standards into their professional development or courses. For example, 10 teacher educators reported explicitly aligning their training activities to standards, using standards to guide what they cover, and aligning their materials with the standards. Dana, who works at a district office, emphasized how purposeful she was both in aligning the professional development content to the standards and in telling her teachers that they ought to do the same.

> We would refer to them [the standards]. Part of the session would most definitely talk about, 'Here's the content we're focused on. Here's the standard that it aligns to. Here's the content we're focused on. Here is a chunk of standards that you should be focused on in your instruction.' So explicit connections are definitely made.

Standards, student testing requirements, and teacher credentialing are traditionally referred to when thinking about education policies. Yet, curriculum has been increasingly recognized as a powerful policy tool (Remillard, 2000; Stein, Remillard, & Smith, 2007). The teacher educators we interviewed referred to a wide array of curricula and curricular-support materials that they drew from to inform their teaching. The Creative Curriculum was mentioned most frequently. While there were too many to report here, Table 3 shows the most frequently mentioned curricula (≥5). When describing why they used these particular curricular resources, teacher educators emphasized that the materials were researched-based, focused on how young children learn math, and relevant to the teachers they taught. They also talked about how they used these resources in ways that were reflective of the pedagogies they were promoting. For example, the way Vivian, who works at a community college, described her use of the Creative Curriculum was connected to the instructional goals she had for her teachers, "We look for things that are open-ended

Table 3. Most Frequently Referenced Curricula and Curricular Support Materials

Curricular Resources and the Number of Teacher Educators Using Them			
The Creative Curriculum	10	Kathy Richardson's books and videos	7
Doug Clements' work	9	NAEYC resources	6
High Scope curriculum	8	NCTM resources	5
Everyday Math curriculum	7	Cognitively Guided Instruction books	5
Juanita Copley's books	7	Cathy Fosnot's books and videos	5
John Van de Walle's books	7	*Teaching Young Children Mathematics* by Sydney Schwartz	5

and accessible for teachers to use quickly but promote higher order of thinking skills. That's what I was saying, as opposed to paper-and-pencil, we look for thought-producing types of activities." Also, the teacher educators did not necessarily use the whole of any given book, curriculum, or body of work. Instead, they picked particular items that they found useful, such as Clements' Mathematical Learning Trajectories, or particular activities from Everyday Math.

Influential work contexts

In addition to policy, we found that the teacher educators' contexts and recognition of their teachers' contexts also influenced their work. Nine teacher educators spoke about the importance of being responsive to their pre- and in-service teachers gathering information about what was already happening in classrooms. For example, Megan, who works for Head Start, noted that she wanted to be sure teachers were being trained in a way that had relevance to their practice in their classrooms. She reported, "We want what they [teachers] do to be relevant to their classroom the next day. We don't want them to feel like they're coming to their training and it doesn't have any relevance to what they do." In order to achieve this relevance, Megan stated that they ask teachers, "What are the hard parts of your day? What are the places you're struggling? Where are your child's outcomes not what would you like them to be?" Through these discussions with teachers, Megan emphasized that they were able to provide services that were more practical for participating teachers' classrooms. Similarly, Sue (state department of education) discussed the importance of aligning professional development activities with classroom activities. She reported asking teachers about their goals and existing resources in order to purposefully plan her professional development for each group of teachers. She stated,

> Even before I plan this [professional development], I sit down with the district and we have a long conversation about, 'Tell me what's happening in your classrooms… What are your goals for them?' I work to find out my audience first. And then I'll use the resources that I know that they already have.

Teacher educators' own work context was also influential, both enabling and constraining what they do. They generally felt supported by their organizations when their philosophies and the organization's philosophies were aligned, when they had the freedom to design the course that they wanted, when they considered their colleagues supportive, and when they had the ability to create their own resources. At the same time, lack of time to focus on mathematics during courses or professional development emerged as the most common workplace constraint, with eight of the teacher educators noting this challenge.

Katherine, who works at a community college, highlighted this point. She discussed the misalignment between what she feels her students need in terms of instruction on mathematics teaching and the constraints of degree requirements.

> What would be better for my students is if we had a whole class dedicated to math. But the way our curriculum is laid out and the constraints of what we have to get in within the degree, that's just not a possibility. I wouldn't blame that on anything, I think it's the nature of higher ed. that there's never enough time.

Teacher educators also brought up the issue of time in describing how academic standards and assessments got in the way of their work. They reported that complying with a range of standards such as professional teaching standards and early learning standards made it difficult to cover all the content that they wanted to teach.

The relative focus on elementary education in relation to preK posed additional forms of workplace constraints for a few of the teacher educators. For example, two teacher educators who worked in district offices noted that preK was underemphasized in the district. Katherine, who works at a community college, also specified how this lack of emphasis carried over to the capacity of faculty.

> I think a lot of the teachers, even the faculty, are not that good at it [early childhood math]. The level that would be required to be successful to really get the vast majority of early childhood practitioners doing math in a really good, strong way would require an enormous amount of training for faculty and time commitment and interest as well. I don't know how many people are that interested in teaching it.

Katherine's statement embodies several of the constraints other teacher educators pointed out. She noted that deep training in mathematics instruction takes commitment and time. She also raised the idea that it is not just early childhood practitioners who lack an interest in teaching mathematics, remarking that early childhood faculty are not necessarily interested in, nor do they have expertise in, mathematics.

Differences by sector and background

Overall, when looking across the different sectors that the teacher educators worked in, we rarely found differences in how they talked about their work. The few that we did find are highlighted in this section. One of these by-sector differences concerned teacher educators' impressions about the time they had available to address early mathematics. Eight teacher educators spoke about time constraints, six of whom worked in higher education—either at community colleges or 4-year-universities. Another, albeit obvious, by-sector difference concerned the policies they referenced as being influential to their work. Only Head Start teacher educators referenced the Head Start Performance Standards.

We also found minor differences in teacher educators' responses when considering whether they had more early childhood or mathematics expertise. Due to the diverse nature of both the settings in which preK is offered and the programs through which preK teachers pursue licensure, preK teacher preparation and professional development experiences can be led by teacher educators whose background experiences are in either early childhood or mathematics education. One notable difference in how early childhood and mathematics teacher educators talked about their work arose when they spoke about what pedagogical practices they did *not* promote. Many (n = 25) teacher educators described

Table 4. Patterns amongst Curricular Resources

		Teacher Educator Expertise		
Resources	Total	Early Childhood	Mathematics	Both
Cognitively Guided Instruction books	5	0	4	1
The Creative Curriculum	10	8	1	1
High Scope	8	8	0	0
John Van de Walle books	7	1	4	2
NAEYC resources	6	5	0	1
Teaching Young Children Mathematics by Sydney Schwartz	5	1	4	0

didactic approaches to mathematics instruction as inappropriate. Only four of these teacher educators were mathematics-leaning in their expertise, indicating that more teacher educators with training and experience in early childhood (versus mathematics) felt strongly about not using didactic teaching methods with young children. There was also a small difference in regards to their opinions about integrating mathematics throughout the day. Although most teacher educators spoke positively about integration, four cautioned that integrating mathematics could lead to children not having consistent opportunities to engage in mathematics activities. Only one of the teacher educators who held these concerns had an early childhood background.

Concerning the curricula that teacher educators drew from, we saw that educators with particular backgrounds tended to prefer certain curricula (see Table 4). Those with a mathematics background were more likely to use CGI, Van de Walle's books, and Sydney Schwartz's *Teaching Young Children Mathematics*. Those with an early childhood background were more likely to refer to The Creative Curriculum, High Scope curricular materials, and NAEYC's resources.

Again, it is noteworthy that across the range of teacher educators we spoke with, there were not many differences in how they spoke about their work in early childhood mathematics. From the mathematical domains they addressed in their courses and professional development, to the early childhood pedagogies they promoted, the teaching methods they employed, the policies they considered, and the constraints they faced in their workplaces—they often offered a surprisingly cohesive vision of their work. In the following section, we discuss some reasons that this might be the case, along with key implications these findings have for early childhood teacher education practice and research.

Discussion and conclusion

In light of recent evidence (Duncan et al., 2007), we know that young children need access to high-quality early mathematics experiences. Knowing that early childhood pre- and in-service teachers are not consistently well-prepared to teach young children mathematics (Maxwell et al., 2006; Simpson & Linder, 2014), for this to happen, we have to consider the opportunities early childhood practitioners have to think deeply about early mathematics teaching and learning. Key to this process are teacher educators. These individuals are on the front lines providing learning opportunities to early childhood practitioners, yet we rarely hear directly from them. With this paper, we offered a glimpse into their work. In particular, we learned about the mathematical content they taught and pedagogical

approaches they promoted, how they conducted their courses or professional development sessions, and the ways in which policy and workplace context impacted their work.

Regarding mathematical content and pedagogical approaches, our findings reflect typical early childhood mathematics practices. We found that the early childhood teacher educators focused primarily on number, although they did also address other domains such as algebraic thinking, geometry, and measurement. While our data did not allow us to flesh out the reasons for this, the more detailed focus on number is not surprising given that developing number sense is often considered a foundational component of early mathematics (National Research Council, 2009). We also found that the teacher educators asked their pre- and in-service teachers to teach these domains primarily via child-centered approaches, reflecting common recommendations for approaches that are developmentally appropriate in early childhood (Copple & Bredekamp, 2009).

Mathematical process skills were mentioned much less frequently, which led us to think more about the relationships between these kinds of mathematical skills and core early childhood tenets. In NAEYC and NCTM's (2010) joint position statement on early mathematics, one of their recommendations is to "Use curriculum and teaching practices that strengthen children's problem-solving and reasoning processes as well as representing, communicating, and connecting mathematical ideas" (p. 5). The skills present in this recommendation are reflective of both NAEYC's Developmentally Appropriate Practices (Copple & Bredekamp, 2009) and NCTM's mathematical process standards (2000). They are also skills that are key components of the Common Core State Standards for Mathematical Practice and the teacher educators did report using the Common Core. Although the Common Core does not address preK, these kinds of skills are ones that early childhood educators have long cared about. Growing children's capacity to problem solve, collect information about their world and make conclusions based on their observations, communicate their ideas and discuss them with their peers, and make models of their thinking are all tenets that are reflected in popular early childhood education approaches (i.e., The Project Approach, Reggio Emilia, High Scope). Thus, we wondered if focusing on mathematical process skills could be an avenue for deepening connections between the fields of mathematics and early childhood.

We also found minor differences in how teacher educators with backgrounds in early childhood versus mathematics talked about the pedagogical practices they promoted and the curricular resources they drew from. Although it is not surprising that early childhood education and mathematics education experts would approach their work differently, we do think these differences, put into conversation with the lack of clear descriptions of some of the pedagogical practices (e.g., "play" and "developmentally appropriate practice"), speak to Parks and Wager's (2015) call for a need to be more explicit about what good early childhood mathematics looks like in action. In fact, the teacher educators we spoke with seemed to recognize the importance of this, using videos to provide concrete examples of teachers and young children engaged in mathematical activities.

Perhaps not surprising in this age of accountability and testing, we found that a number of policies impacted teacher educators' work. State-specific preK early learning standards and the Common Core State Standards were the two policies that teacher educators most frequently cited as shaping what they taught in their courses and professional development. Considering that the Common Core State Standards do not include standards for preK, we found it surprising that a majority of the teacher educators that we spoke with said that these

standards shape their work. Although we recognize that not all of the teacher educators worked exclusively with preK teachers, we believe this could suggest that teacher educators are responding to the pressures early childhood practitioners feel to prepare young children for the heightened academic expectations in kindergarten (Bassok, Latham, & Rorem, 2016). Another interpretation could suggest that teacher educators working with preK practitioners are interested in aligning their work with kindergarten and thus are familiarizing themselves with kindergarten expectations. Likely, both of these viewpoints are at play.

We also found that the teacher educators used particular instructional methods, often modeling desired practices, coaching or mentoring, and engaging their pre- and in-service teachers in mathematical activities. When coaching or mentoring was done in combination with modeling or engaging teachers in mathematical activities, these teacher education practices were well-aligned with current recommendations for professional development practices in which teachers should have access to explicit examples of desired practices and continuous support with implementing them in their classrooms (Winton et al., 2016). It is also important to recall that some of the teacher educators lamented the lack of time they felt they had available to dedicate to mathematics. Moreover, some spoke about mostly teaching one-shot professional development sessions, and others who taught early childhood courses spoke about only having a few class sessions they could dedicate to mathematics. Unfortunately, this is not reflective of recent reports about the movement away from one-shot professional development sessions (Desimone & Garet, 2015). It does, however, reinforce current understandings about the lack of time given to mathematics in early childhood courses (Maxwell et al., 2006).

While we learned a great deal about what is happening in early mathematics teacher education, there were also some limitations to our method. The primary limitation of this study was our sampling method. Snowball sampling, rather than providing us with a more representative sample, led to an overrepresentation of people who worked at 4-year universities. We also could have benefitted from systematically collecting data on the exact frequency and amount of time that teacher educators spent on early mathematics in their courses and professional development. They did describe the basic structures of the courses, but more detailed information could paint a different picture of some of their teaching methods because we know that the amount of time people spend together impacts the quality of learning experiences (Desimone & Garet, 2015). Finally, although it is outside of the scope of this particular study, pairing the interviews with observations could enhance the data because we could see the teacher educators in action.

Despite these limitations, this study contains important implications for the field of early childhood mathematics teacher education. As the push for public preK increases and our knowledge of what young children can do in mathematics expands, determining the best approach for preparing preK teachers to teach mathematics will be a key issue. In order to do this, teacher educators from various settings need to think deeply about what quality early mathematics practices look like in action. We recommend that teacher educators consider the role mathematical process skills already do and could play in early mathematics teaching. We also recommend being more explicit about what common early childhood pedagogical practices can offer mathematics teaching and learning. Here we do not necessarily mean there should be a consensus about what something like play should look like, but that clearer explanations of how play can be used in different ways could be helpful for more intentional use in

mathematics instruction. We believe such efforts could help those who have traditionally been mathematics educators and those who have been early childhood educators collaborate, working together to see how their fields can learn from each other. For research, we recommend developing more in-depth understandings of how early childhood and mathematics and/or early childhood and elementary teacher educators approach teaching mathematics courses and professional development differently. Beyond these ideas for future consideration, our hope is that providing information about the current state of early childhood mathematics teacher education will support other scholars in generating new ideas for the field.

Note

1. This study comes from the Development and Research in Early Math Education (DREME) Network . The DREME Network conducts research and creates tools to support early math teaching and learning, with a focus on the preschool years. Within the DREME Network, the Early Math Resources for Teacher Educators project supports the training of prospective and practicing early childhood teacher educators.

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Appendix : Forced choice questions

(1) Which of the following video resources would be most helpful to you for preparing people in early childhood mathematics? Least helpful? Why?
   (i) Videos of young children doing mathematics?
   (ii) Videos of teachers working with a small group of students on mathematics?
   (iii) Videos of teachers leading a whole class mathematics lesson?
   (iv) Videos of teachers interacting with children mathematically during choice time?

(2) Which of the following instructional resources would be most helpful to you for preparing people in early childhood mathematics? Least helpful? Why?
   (i) Student assessment methods for the teachers to use with their students and ways to use them?
   (ii) (Teacher education) curricular materials?
   (iii) Sample syllabi from an early math education course?
   (iv) Learning activities that your students can use to teach mathematics?
   (v) Exercises to promote your students' interpretations of children's mathematics thinking?

(3) Which of the following supports would be most helpful to you for preparing people in early childhood mathematics? Least helpful? Why?
   (i) In-depth explanations of early childhood mathematics concepts?
   (ii) Tools for showing how one mathematics concept can be used or taught productively with other content in the classroom?
   (iii) Relevant readings on children's mathematics thinking?
   (iv) Interviews with children about how they think about mathematics?