

Learning to Leverage Children’s Multiple Mathematical Knowledge Bases in Mathematics Instruction

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In this article, the authors explore prospective elementary teachers’ engagement with and reflection on activities they conducted to learn about a single child from their practicum classroom. Through these activities, prospective teachers learned about their child’s mathematical thinking and the interests, competencies, and resources she or he brought to the mathematics classroom, and then wrote reports that included instructional suggestions as to next steps to further the child’s growth in mathematics. The authors’ analyses of these reports indicate that there were a variety of ways which prospective teachers made connections to one or more of their child’s knowledge bases. In a high percentage of cases, prospective teachers attended to one of these knowledge bases, indicating that they were attending to particularities about their child and developing the dispositions to continue to do so. Implications for research and practice are discussed.

KEYWORDS: children’s funds of knowledge, children’s mathematical thinking, mathematical tasks, prospective teacher education

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Equipping prospective teachers (PSTs) with the necessary strategies and tools to meet the mathematics learning needs of today's diverse student populations is critical (Leonard, 2008; Turner et al., 2012). Research suggests, for example, that to support student learning, teachers, both prospective and practicing, need to build connections with their students, families, and communities, and to draw on these connections in their mathematics teaching (Civil, 2007; Ensign, 2005; Ewing, 2012; Gay, 2010; Lipka et al., 2005; Matthews, 2003; Meaney & Evans, 2013; Turner, Celedón-Pattichis, & Marshall, 2008; Vomvoridi-Ivanović, 2012). This building includes drawing on knowledge of children's mathematical thinking (Carpenter, Fennema, Peterson, Chang, & Loef, 1989) along with understandings about children's interests and competencies, incorporating their cultural, home and community-based knowledges and experiences (Civil, 2002; Ladson-Billings, 2009; González, Moll, & Amanti, 2005).

We refer to these multiple understandings and experiences that have the potential to shape and support students' mathematics learning as children's *multiple mathematical knowledge bases* (MMKB; Turner et al., 2012). Each of these areas (i.e., children's mathematical thinking and children's cultural and community-based knowledge and experiences) has received individual attention in research, but research in children's mathematical thinking has rarely considered the familial and cultural funds of knowledge children bring to thinking about mathematics; conversely, research in children's funds of knowledge has typically not focused in detail on children's mathematical thinking. Furthermore, research on how teacher preparation programs can support PSTs' understandings and practices related to children's MMKB is limited. This article describes how one research program,

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Teachers Empowered to Advance Change in Mathematics (TEACH MATH), engaged PSTs in mathematics learning case studies to support the PSTs in learning about and connecting to children's MMKB in their plans for mathematics instruction.

Conceptual Framework

In this section, we outline research on PSTs' orientations towards children and families from marginalized communities (e.g., immigrant communities, poor/working class communities, communities of color), and discuss PSTs' knowledge and practices related to connecting to children's MMKB in mathematics instruction.¹

PSTs' (Re)Orientations Toward Children and Families

PSTs bring limited experiences with children and families from cultural, racial, and linguistic backgrounds different from their own (Bleicher, 2011; Silverman, 2010; Taylor & Sobel, 2001). Furthermore, PSTs' limiting beliefs and assumptions about children from marginalized backgrounds can undermine student learning (Sleeter, 2001). Some PSTs hold deficit-based notions of what students from diverse cultural and linguistic groups are capable of learning and should learn (Artiles & McClafferty, 1998; Kidd, Sánchez, & Thorp, 2008) and have fears related to working with marginalized students and their families (Bleicher, 2011). PSTs also tend to be unaware of social and educational inequities associated with race, class, and ethnicity, and this lack of awareness may lead PSTs to faulty conclusions related to students' successes or struggles at school, particularly in mathematics (Ensign, 2005; Kidd et al., 2008). These orientations are widespread; they have been specifically noted about PSTs and practicing teachers working in urban contexts and are evident in teachers in a variety of teaching contexts both in the United States and internationally (Chong, 2005; Planas & Civil, 2002), and can be resistant to change (Rodriguez & Kitchen, 2005).

Scaffolded learning experiences in teacher education programs, however, can support PSTs in developing more positive, resource-based orientations toward children from marginalized communities (Aguirre, Zavala, & Katanyoutanant, 2012; Darling-Hammond & McDonald, 2000; Kidd et al., 2008; Turner et al., 2014). For example, research outside of mathematics education has found that conducting case studies of individual children can provide PSTs with opportunities to critically examine their own biases, and to "learn how to look closely at children, to see them as growing individuals, and to find ways to foster their learning" (Darling-Hammond & McDonald, 2000, p. 42). By examining a specific student's learning across

¹ A more extensive review of prior research in this area is found in Turner and Drake (2015).

home, school, and community contexts (i.e., through observations, interviews, and student work), case studies provide PSTs with opportunities to identify children's strengths, progress, and learning needs (Horowitz, Darling-Hammond, & Bransford, 2005). In our own work, we have documented how mathematics methods course activities, including interviews with individual children, helped to (re)orient PSTs toward students from marginalized groups by focusing PSTs' attention on the knowledge, skills, and competencies that these children bring to the classroom (Bartell et al., 2013). Collectively, this research suggests that teacher education programs may play an important role in supporting PSTs to explore their students' home and community experiences in order to support mathematics learning.

Connecting to Children's MMKB in Mathematics Instruction

Learning related to children's mathematical thinking. An increasingly prominent line of research in mathematics teacher education has examined teachers' understandings and practices related to children's mathematical thinking (i.e., children's problem-solving strategies, connections between strategies and problem structures, common confusions). This work, which often draws on the Cognitively Guided Instruction (CGI) research program (e.g., Carpenter et al., 1989; Fennema et al., 1996), has linked teachers' knowledge of children's mathematical thinking to productive changes in teachers' classroom practices and student learning. For instance, Fennema and colleagues (1996) found that as teachers learned about the development of children's problem-solving strategies in specific content domains, they began to use this knowledge to inform instructional decisions (e.g., lesson planning, problem selection). In turn, students demonstrated significantly higher levels of achievement on problem-solving tasks (Carpenter et al., 1989; Fennema et al., 1996).

Jacobs, Lamb, and Philipp (2010) found that prior to coursework focused on mathematics teaching and learning, PSTs have a limited capacity for attending, interpreting, and responding to children's mathematical thinking. Yet, scaffolded learning experiences such as conducting and analyzing problem-solving interviews with children have been shown to further develop PSTs' competencies (McDonough, Clarke, & Clarke, 2002; Philipp, Thanheiser, & Clement, 2002; Philipp et al., 2007; Sleep & Boerst, 2012). More specifically, Ambrose (2004) found that PSTs benefited from repeated opportunities to interview and interact with children about their reasoning, as PSTs' beliefs about children's problem-solving capacity are often resistant to change. Yet for PSTs, knowledge about children's thinking does not always transfer to instructional practices. Vacc and Bright (1999) found that although PSTs experienced significant shifts in their knowledge of children's thinking across methods courses and student teaching experiences, there was little change in how they used this knowledge for instructional planning or teaching. In a study of how PSTs adapted mathematics tasks based on knowledge of students, Nicol and Crespo (2006) found few instances where PSTs' adaptations were aimed at further exploring or connecting to children's mathe-

mathematical thinking. Research with practicing teachers has also indicated that connecting to children's mathematical thinking in instruction is a complex teaching practice that takes time to develop (Carpenter et al., 1989; Fennema et al., 1996).

Learning related to children's home, cultural, and community-based knowledge and experiences. Research has also begun to explore teachers' (and to a lesser extent PSTs') understandings and practices related to children's home, cultural, and community-based experiences and practices, or their funds of knowledge (Civil, 2002, 2007; Gonzalez, Moll, & Amanti, 2005). This work is supported by studies which have shown that historically underrepresented groups benefit from instruction that draws on their cultural, linguistic, and community-based knowledge (Ladson-Billings, 2009; Lipka et al., 2005; Turner, Celedón-Pattichis, & Marshall, 2008). For example, Civil (2007) illustrated that practicing elementary school teachers drew on children's and family experiences with gardening to deepen students' understanding of mathematical concepts related to measurement, area, and perimeter. Turner and colleagues (2008) documented how bilingual kindergarten teachers used familiar storytelling-like conversations about family trips to the supermarket, classroom activities, or upcoming cultural celebrations to support students in successfully solving a range of basic word problems.

Taylor (2012) and Wager (2012) conducted and studied a yearlong professional development focused on supporting elementary teachers' efforts to connect school mathematics lessons to the mathematics that children used outside of school. Initially, teachers connected lessons to students' interests, or familiar out-of-school activities (e.g., finding the area of a soccer field because children play soccer), but not to the ways that children used mathematics outside of school. Taylor (2012) argues that teachers' tendency to connect first to familiar contexts, and only later (and with support) to ways that children and families use mathematics in these contexts suggests a possible trajectory in teachers' practice.

Much less is known about how PSTs learn to connect to children's out-of-school experiences in mathematics instruction (see Turner & Drake, 2015). In our prior work, we studied problem-solving-based mathematics lessons that PSTs created grounded on learning about mathematics in children's communities (Aguirre et al., 2013; Turner et al., 2014). We found that PSTs often began lessons with traditional word problems that reflected familiar names and places from children's neighborhoods, and that most PSTs found it challenging to make "consistent and substantive connections to [their students'] cultural funds of knowledge" (Turner et al., 2014, p. 45).

Also relevant when considering how PSTs might connect to children's experiences outside of school, is how PSTs conceptualize real-world connections in mathematics. This conceptualization is important as teachers' beliefs and understandings about connecting school mathematics to situations, contexts, or activities outside of school influence how and whether they choose to make such connections in their teaching (Lee, 2012; Meaney, Trinick, & Fairhill, 2013). For example, in Lee's (2012)

study of 71 K–8 PSTs, participants collected, created, and evaluated contextualized problems that they (the PSTs) believed reflected exemplary real-life connections. Lee found that while PSTs thought that real-world connections could enhance student engagement and motivation, their vision for how teachers might include such connections in their mathematics instruction was limited to posing textbook-like problems that involved calculations with money or time. In other words, Lee argued what PSTs *think* about real-life connections *and what they do* may not always coincide. One could conjecture that this gap may be even more pronounced in PSTs' attempts to pose problems that connect not just to the real world but to specific contexts in students' homes and communities.

In summary, prior research has established that PSTs (a) can increase their understanding of children's mathematical thinking by conducting problem-solving interviews with students; and (b) have an emerging capacity to learn about children's interests, families, and communities, and to (re)orient themselves, generally, to the competencies that children from marginalized groups bring to the classroom. However, there remains much to be known about how PSTs leverage and integrate their emerging understandings about children's MMKB as they plan mathematics instruction.

To address this gap in the literature, we focus here on the participation of PSTs in a purposefully designed set of experiences with a single case study child—The Mathematics Learning Case Study—aimed at introducing PSTs to the practice of connecting to children's MMKB in their mathematics teaching. In this analysis, we examine how PSTs used what they learned about their case study child's MMKB (i.e., the child's mathematical thinking, and her or his interests and home and community-based experiences) to make suggestions for future mathematics instruction. We thus address the following research question:

In what ways do PSTs draw on knowledge of children's MMKB as they make instructional suggestions for their case study child?

Methods

Participants and Context

Participants were 79 PSTs who were enrolled in a mathematics methods course as part of their teacher preparation program at one of five universities.² The five sites

² The larger TEACH MATH Project includes six university sites. Data for this study were drawn from five of those sites (Sites A, B, D, E, and F). For consistency among papers written about the project, we use those designations when referring to participants. The sixth site (Site C) is not included here because data at that site were collected at a later time.

reflected diverse geographic contexts (e.g., urban, suburban, borderland,³ and a mix of urban and suburban) and programs (e.g., variance in field placements and prior coursework). Fifty-five of the participants identified themselves as White/European descent, 10 as Hispanic/Latin@, six as Mixed Ethnicity, five as Asian American, and two as African American/Black. One participant did not identify her or his race or ethnicity.

The findings here focus centrally on work done by 59 of the PSTs who constructed contextualized problems for their case study children. Of these 59 PSTs, 56 identified as women and three as men. Forty-four of these PSTs identified as White/European descent, one as African American/Black, three as Asian American, six as Hispanic/Latin@, and four as Mixed Ethnicity. One PST provided no data about racial and ethnic background. (See Table 1 for a listing of the racial and ethnic background of PSTs by site.) PSTs that identified their racial and ethnic backgrounds as other than White/European descent were more likely to speak a language in addition to English (71%⁴: 10 of 14 spoke another language), as compared to 41% (11 of 44) of the White/European descent PSTs.

Table 1
Overview of PSTs and Children by Site

Racial and Ethnic Background	Number of PSTs				
	Site A (n = 8)	Site B (n = 17)	Site D (n = 9)	Site E (n = 13)	Site F (n = 12)
White/European Descent	4	15	3	11	11
Hispanic/Latin@	2	0	3	0	1
African American/Black	0	0	1	0	0
Asian American	1	1	1	0	0
Mixed Ethnicity	1	0	1	2	0
No Data		1			

Child Grade Level	Number of Children				
	Site A	Site B	Site D	Site E	Site F
K-1	2	8	2	5	2
2-3	2	7	4	2	4
4-5	4	2	3	2	5
6-8				4	1

³ By borderlands, we are referring to that zone in the southwestern United States that shares a border with Mexico. Students who live along that border often travel back and forth between Mexico and the United States as frequently as once a week to visit family, make purchases, and so forth. They bring particular funds of knowledge to U.S. classrooms and so we identify that area specifically. Although there are northern states that share a border with Canada and so might be thought of as borderlands, it is not as typical for students who live along that border to travel back and forth between Canada and the United States as previously described.

⁴ All percentages are rounded to the nearest whole number.

The case study children with whom these 59 PSTs worked ranged from Kindergarten to Grade 8 (Table 1 also lists children's grade levels by site). While specific demographic information about case study children is not directly available, according to written reports from the PSTs, there were 25 Hispanic/Latin@ children, 13 White/European descent children, 11 African American/Black children, seven Mixed Ethnicity children, two Asian American children, and one Native American/Indigenous child. Of these children, PSTs reported that 24 spoke English only, 21 spoke at least some Spanish, five spoke another non-English language (e.g., Hebrew, Vietnamese), and the language background was unknown for nine of the children. Overall, our participants were slightly more diverse in terms of race and ethnicity (but not gender) than national trends in the elementary school teacher population would predict (Hollins & Guzman, 2005).

Data Sources

Data sources included three written reports that PSTs completed as part of the Mathematics Learning Case Study. PSTs were asked to focus throughout the semester on one child in their practicum classroom who was different from them in one or more sociocultural aspects (e.g., race, socioeconomic status, home language, etc.). PSTs were also encouraged to choose a case study child who struggled at least somewhat with mathematics.

With the goal of supporting PSTs in learning about MMKB, PSTs interacted with and observed their case study child and then wrote reports based on these experiences. More specifically, the Mathematics Learning Case Study activities included a "getting to know you/funds of knowledge" interview in which PSTs talked with their case study child about their interests, home and community activities, and their experiences in school mathematics, and problem-solving interviews with the case study child in the areas of operations with whole numbers, fractions, or base-ten concepts. PSTs produced written reports for both of these activities. PSTs also observed their case study child across multiple weeks, during mathematics lessons and at other times of the day, with the goal of learning about the child's strengths and resources. (See Appendix A or the project website <https://teachmath.info> for a more detailed overview of the Mathematics Learning Case Study components.) The Mathematics Learning Case Study culminated with a final report in which PSTs analyzed and reflected on interactions with their case study child across the semester and proposed appropriate next steps in mathematics instruction.

Data Analysis

The first two authors conducted data analyses with the assistance of the third author, a graduate research assistant. Our goal was to see the extent to which PSTs

learned about and drew on their case study child's MMKB to make instructional suggestions in the final report.

In the *first round of analysis*, we read through the datasets for the 79 participants and identified a total of 144 instructional suggestions and associated justifications. All PSTs included at least one instructional suggestion in their report, and some included multiple suggestions. Instructional suggestions included: (a) particular participation structures that might support the child's success, such as seating an English learner with another child who spoke their home language; (b) additional work in specific topics such as multiplication or measurement; (c) activities parents could engage in with their children outside of school; and (d) specific problems, both contextualized and bare number problems. Given our research question, we were particularly interested in instructional suggestions that were embedded within a context (i.e., a word problem). These contextualized tasks presented opportunities to explore how PSTs attended to children's mathematical thinking (e.g., via number choices or problem structures), as well as how they drew on children's interests and their cultural, home and community-based knowledge and experiences.⁵ Of the 144 suggestions, 96, representing the work of 59 PSTs, were contextualized tasks.

In the *second round of analysis*, we focused on the 96 contextualized tasks. Using a process of analytical induction (Bogdan & Biklen, 2003), we coded each task and associated justifications along multiple dimensions that connected to key ideas in the literature.⁶ We attended to (a) orientations towards children's strengths or learning needs (e.g., problems that built on children's competencies) (Foote et al., 2013; Kidd et al., 2008); and (b) ways that PSTs justified task contexts, problem structures, and number choices (Vacc & Bright, 1999; Land, Drake, Sweeney, Johnson, & Franke, 2015). We also coded instances when PSTs relayed *specific knowledge about the case study child* that they gathered as part of the Mathematics Learning Case Study. This included knowledge of the child's (a) mathematical thinking (problem types or number ranges with which the child had been successful or unsuccessful), (b) interests, and (c) home or community activities (e.g., family budgeting and cooking practices, afterschool activities). We also identified instances where PSTs described ideas about children in general, such as ideas about objects, places, or activities that PSTs thought would be relevant or of interest to all children, or general knowledge about mathematical concepts or skills that were ap-

⁵ Although attention to issues of language strengths and needs of some students were noted in several reports, this was not the focus of any of the instructional suggestions involving contextualized problems and thus does not figure in our analysis.

⁶ It is important to note that our analysis was limited to the written products that PSTs produced as part of the Mathematics Learning Case Study. It is probable that PSTs had additional knowledge about their case study students that was not reported in written assignments. While PSTs may have considered a range of factors in their suggestions for future instruction, our analysis is limited to the explanations and justifications for those suggestions contained in their written reports.

appropriate for children of a particular grade level. We coded these instances as *general ideas about children*, to distinguish them from the knowledge that was explicitly linked to the case study child.

We collaboratively coded a subset of the 96 contextualized tasks to establish consistency and to refine coding categories and definitions. We then each coded a small number of the tasks individually, and met to discuss discrepancies. We repeated this process, reconciling differences in coding and further refining code definitions until 85% intercoder reliability was achieved. We then each coded a third of the remaining tasks individually.

In the *third round of analysis*, we looked across coding categories for themes (Creswell, 2007), or patterns in how PSTs drew on specific knowledge about their case study child's MMKBs as they planned contextualized tasks for future instruction. The initial sections of our findings are organized according to these themes.

In the *fourth and final round of analysis* we examined disaggregated data for potential differences among sites. We compared categories of tasks posed by PSTs at each site and investigated how those differences related to other PST or child characteristics. We also disaggregated data by PST/child pairings and examined potential differences in tasks posted by White/European descent PSTs paired with White/European descent children ($n = 8$), White/European descent PSTs paired with non-White children ($n = 36$), non-White PSTs paired with White/European descent children ($n = 4$), and non-White PSTs paired with non-White children ($n = 10$). The final section of our findings reports the results of these analyses.

Findings

We begin the findings by discussing briefly how PSTs integrated knowledge of children's mathematical thinking as they developed contextualized tasks. We next discuss in more depth how PSTs integrated knowledge of their case study child's experiences, interests, and practices into these instructional suggestions. We conclude with a discussion of similarities and differences in the tasks posed across sites and among PSTs and children of different racial and ethnic backgrounds.

Integrating Knowledge of Children's Mathematical Thinking

We found that as PSTs generated contextualized tasks for their case study child, a focus on children's mathematical thinking was prominent (evident in 81 of the 96 examples: 84%). Moreover, we found that PSTs leveraged their understandings about children's mathematical thinking in ways that mirror what has been reported in prior research, with both prospective and practicing teachers (Fennema et al., 1996; Jacobs, Lamb, & Philipp, 2010; Vacc & Bright, 1999). For example, PSTs carefully selected numbers and problem structures based on the kinds of strategies and reasoning that children used during the interviews. PSTs also made deci-

sions about the kinds of tools or manipulatives they would make available to the child based on what they had learned about the child's strategies and understanding of particular number relationships. For example, one PST [B322] began with a multi-step problem from the problem-solving interview about boxes of chocolates (i.e., Sara has 3 boxes of chocolate with 4 pieces of chocolate in each box. Then she eats 5 pieces of chocolate. How many pieces of chocolate does she have left?). She then modified the problem so that it was framed in terms of her second-grade case study child (Michael) and his mother. Additionally, as the PST was interested in supporting the child's understanding of equal size groups and skip counting (something that she learned was difficult for the child during the problem-solving interview), she adjusted the problem structure so that it focused only on combining boxes of equal size. The new problem read: "Michael has 5 boxes of chocolates and each box contains 3 pieces of chocolate. Michael's mother gives him 2 more boxes of the same chocolates. How many pieces of chocolates does Michael have now?"

These findings confirm what has been noted in prior research related to how scaffolded learning interactions with individual children around mathematical tasks can support teachers' understandings and practices related to children's mathematical thinking (Jacobs et al., 2010; Sleep & Boerst, 2012). For this reason, we do not describe these findings in detail. Instead, we focus on patterns related to how PSTs integrated understandings about other aspects of children's MMKB (e.g., children's interests, home and community experiences, etc.) as they planned contextualized tasks for future instruction.

Integrating Knowledge of Children's Interests, Experiences, and Funds of Knowledge

We found that PSTs drew on knowledge related to children's interests, and their home and community-based experiences in four different ways as they generated contextualized tasks. PSTs based tasks on (a) assumptions about familiar or relevant contexts, not necessarily linked to the case study child; (b) specific knowledge of objects or activities that were familiar to the case study child; (c) mathematizations of family practices; and (d) ways that the case study child engaged in mathematics in home or community activities (see Appendix B). We discuss these patterns in the next four sub-sections.

Category 1: Assumptions about familiar or relevant contexts. PSTs frequently drew on assumptions about places, objects, and activities they thought would be relatable to children, including, but not necessarily specific to, their case study child. Thirty-seven of the 96 contextualized tasks (representing the work of 32 PSTs) were categorized in this way, making it the most prominent category in our analyses. These tasks often resembled textbook-like word problems (e.g., one or two sentences that provided information and a question to be solved). Frequently (in 20 of the 37 problems), PSTs began with a basic word problem structure and then replaced potentially unfamiliar or less relevant details (such as winter sports

for children in a desert context) with objects or activities that the PST thought “all children would like” or “be familiar with” such as jellybeans, swings, pennies, and classroom activities and supplies (see problem (a) in Appendix B). For example, a PST [A306] justified a problem (for a Grade 2 student) about buying gumballs with pennies by explaining, “This problem is relatable to children since they have pennies and buy things occasionally, so this is a topic that they could really imagine happening.”

Also common were instances when PSTs adapted problems from the problem-solving interviews or from the textbook used in the child's classroom (17 of the 37 problems), often with the justification that the contexts in these problems were already familiar to the child (see sample problem (b) in Appendix B). Often these adaptations were limited to changing the names of the characters in the problem. As one PST [F404] explained (about her problem for a Grade 4 student), “My problem sets would be very similar in format to those ... in the interview packet, adjusting the questions to make them more personal to her.” In one example, a PST [B313] adapted a multiplication problem (for a Grade 1 student) about placing three stickers in each of four pockets so that it included the child's name and easier numbers, moves which the PST felt would support the first grader's understanding of the problem structure. Other PSTs explicitly stated that they adapted problems they had seen in children's mathematics textbooks because these problems were not only familiar to children but also reflected what children “will continue to see, and if [case study child] is not able to master it now, he [a Grade 1 student] will continue to have trouble with math” [D404]. In summary, the most prevalent findings category contained tasks that did not necessarily reflect the experiences of the particular case study child, but instead were based on assumptions and general ideas about contexts that would be familiar or useful for all children.

Category 2: Knowledge of familiar objects or activities. In other instances, PSTs drew on specific knowledge about their case study child's interests or preferences (i.e., “favorites” such as bugs [A307], for a Kindergarten student; softballs [F404], for a Grade 4 student; or toys at the flea market [F408], for a Grade 5 student) to generate problem contexts. Thirty-one of the 96 contextualized tasks (representing the work of 25 PSTs) reflected these kinds of connections. Most often, the problems resembled textbook-like word problems, similar to those previously discussed. In these cases, however, PSTs included contexts that they “knew” were of high interest to their case study child because they believed that connecting to children's interests would enhance their engagement and motivation (e.g., “my child “lights up” every time I mention ...” [B306], for a Grade 2 student; “[this connection] helps her to focus on the problem more” [B323], for a Grade 4 student; see sample problem (c) in Appendix B). In another example, this PST generated a multiplication task for her fourth-grade case study child that involved calculating the number of boxes of macaroni and cheese in 14 containers that each held 8 boxes.

The PST explained, "The object of macaroni and cheese will help her focus since that is one of her favorite foods" [B323].

While most problems in this category reflected attempts to connect to objects or people that were of high interest to the case study child, in a few instances, PSTs posed tasks that connected to familiar activities that arguably may include mathematical activity (e.g., collecting cans to recycle [F417], for a Grade 5 student; playing video games [F414], for a Grade 3 student; shopping at the mall with friends [A300], for a Grade 2 student; and doing homework [B324], for a Grade 2 student; see sample problem (d) in Appendix B). For example, one PST [F402] knew that her first-grade child enjoyed watching and playing football, and argued: "By using football, he will better understand how to work [problems] out. ... I am activating [child]'s schema and building on his prior knowledge of football to teach him math problems that he struggles with."

In general, these tasks reflected artificial scenarios that seemed forced on a context relevant to children (e.g., How many footballs would you have left if you had 11 and lost 3?) and did not connect to the mathematics that children might engage in as part of the activity (e.g., keeping track of scores, etc.). However, PSTs justified these problems by explaining that connections to familiar activities would help students "to picture what is going on in the word problem a little better" [A300] and thereby support students' understanding. To further support their decisions, PSTs often drew on specific moments when they had witnessed increased interest and understanding from their case study child in response to these moves. This category contrasts with the instructional suggestions coded as falling into Category 1, wherein PSTs made suggestions based on assumptions they made about the relevance of problem contexts. In the case of Category 2 suggestions, PSTs began to draw on specific knowledge of the case study child they had gained through interactions with the child.

Category 3: Mathematizing family practices. In other instances, PSTs constructed problems connected to activities in which the family of the case study child engaged (e.g., eating dinner, grocery shopping, doing laundry) and then considered how people might use mathematics as part of this activity. Twenty-one of the 96 contextualized tasks (representing the work of 17 PSTs) were categorized in this way. A few tasks in this category focused on ways that parents could engage their child with mathematics as part of family activities (see sample problem (e) in Appendix B). In a more elaborated and more realistic example, a PST [E405] suggested the following multi-operation task for a fifth-grade case study child:

She shared with me that her mother is planning a Quinceañera for a family friend. ... Perhaps she could become involved in the preparations for food, figuring out how much food would be needed to feed all of the party guests. She could create a shopping list of ingredients (including quantities) and determine how much it would cost.

Although the child did not specify the kinds of mathematics that her family might use as they prepared for this event, the PST identified mathematical concepts and practices that might be involved (e.g., scaling quantities in recipes for a specific number of people, operations involving rates and decimals to calculate total cost).

In other examples, PSTs constructed tasks that teachers could implement that connected to family activities or practices (see sample problem (f) in Appendix B). In this case, knowing that her fourth-grade case study child enjoyed eating out with his family, the PST [D412] constructed a division task involving equally sharing a pizza partitioned in eighths among four family members. Although the child mentioned to the PST that he saw mathematics being used when he went out to dinner with his parents, it was unclear whether he was referring to the mathematics involved in partitioning and sharing food. That said, families may engage in this mathematical activity, and in this way this task reflects another attempt, as in the Quinceañera example, to pose problems that connect to how case study children's families might use mathematics in real-world situations.

Another PST [F415] drew on knowledge that the child's mother operated a nail salon to construct a series of problems that involved using multiple operations to calculate the cost of various salon services. According to the PST, "[the child, a fifth grader] goes occasionally to help her mother at work, and she really helped a lot for the grand opening of the salon." An example of a problem the PST thought would be familiar to the child is the following:

There are 5 girl friends who want to go to the salon to get looking all pretty for their slumber party. One pedicure is \$30, one manicure is \$20, \$5 for just paint, and massage is \$20. Two girls want to get one pedicure and manicure each. One girl wants to get a pedicure, manicure, and a massage and the other two girls want to get a pedicure and a massage each. How much money total will the salon make when these girls go?

The PST explained that this problem would encourage the case study child to use multiple strategies, including mental calculations, versus always relying on a standard algorithm. The PST noted that mental math strategies are important for working in the salon, as "[the child's mother] can't always depend on the calculator because nail salons can get pretty busy, so she should be able to tell her customers right away the final price."

In summary, in this category PSTs focused both on suggestions for how parents and families could connect to mathematics in their daily activities and on attempts to mathematize family practices outside of school for use in the classroom. Across these examples the PSTs' goal seemed to be "layering" mathematics onto known family activities. In this way, the examples in this category, as with Category 2, contrast with tasks in Categories 1 where PSTs simply inserted contexts that were assumed to be familiar or of interest.

Category 4: Identifying mathematics in activities in which the child engages.

In a small number of examples (7 of the 96 tasks representing the work of 6 PSTs), PSTs selected task contexts that related to their case study child's activities and identified ways that the child engaged in mathematics as part of the activity. Although PSTs sometimes made inferences about children as they constructed these tasks (e.g., inferences about the specific ways that the child used mathematics), these tasks (more so than any others included in our analysis) reflected attempts to connect to mathematical funds of knowledge that children might bring from their experiences outside of school. For instance, in sample task (g) in Appendix B, the third-grade case study child had described to the PST [D400] that he received an allowance each week and was working to keep a record of his earnings. Although the child did not explain the specific mathematical practices he engaged in while saving, tracking, and spending his allowance, the PST knew he might bring mathematical knowledge from this practice (e.g., skills related to estimation, or organizing data) to the problem-solving situation.

In another example, a PST [D416] learned from her fifth-grade case study child that his father was a construction worker and that the child helped the father with painting and mixing cement on weekends. The PST drew on this knowledge, and the case study child's struggles with multiplication word problems during the interviews, to generate a task that involved calculating the number of gallons of paint that the case study child and his father would need to paint eight rooms if it takes two gallons of paint per room. The PST intended to connect to the child's funds of knowledge, including the mathematics that the child and father might engage in when purchasing supplies. Additionally, the task used a familiar context to help the child recognize how multiplication and rates can be used in real-world situations.

Another PST [E403] knew that her eighth-grade case study child was an avid basketball player with extensive knowledge and experience with the game. She also knew that he struggled to make sense of basic word problems and needed opportunities to explore alternate methods (beyond the standard U.S. algorithm) and to reason about the results of his calculations. The PST constructed the following problem about calculating scores to help the child generate mental strategies for operations involving equal groups: "How many shots would I have to make within the three point line [each shot would be worth 2-points] to get 27 points if I have already made 5 free throws?" The PST explained that the child would be able to draw on his experiences playing the game with siblings to solve the problem, which she felt would be particularly beneficial as the child "didn't exhibit any confidence in his math ability."

In summary, tasks in this category reflected the clearest attempts to link to ways that children used (or might use) mathematics in their out-of-school activities. Examples in this category are once again similar to those in Categories 2 and 3 in

drawing on specific knowledge of the case study child. In addition, like Category 3, Category 4 tasks focused not only on familiar contexts but also on connections to the practices and activities of children and families. What distinguished the tasks in this category is that PSTs went beyond “layering” mathematics onto family activities (i.e., Category 3) and instead connected to the mathematical practices that students already engaged in outside of school.

Patterns Across Sites, PSTs, and Children

Patterns by site. Analysis of tasks generated at each of the five research sites revealed notable patterns. At both Site B and Site F, approximately two-thirds of PSTs generated at least one Category 1 task that reflected assumptions about activities, contexts, or objects that would be relevant to case study children (65%: 11 of 17 at Site B; 67%: 8 of 12 at Site F). In fact, more than one-third of PSTs at these sites generated only Category 1 tasks (35%: 6 of 17 at Site B; 42%: 5 of 12 at Site F). However, while tasks based on assumptions (Category 1) were common among PSTs at Sites B and F, approximately 60% of PSTs also posted at least one task that drew on specific knowledge of the child's interests, activities, or practices (i.e., tasks at Categories 2, 3, or 4; 65% at site B and 58% at Site F). One notable difference was that only one PST at Site F posed a task at Category 3 or 4, while five PSTs at Site B posted Category 3 or 4 tasks. Thus while PSTs at Sites B and F posed tasks based on assumptions (Category 1) versus based on specific knowledge of the case study child (Categories 2, 3 or 4) with similar frequency, PSTs at Site B were more likely to generate Category 3 and 4 tasks. As noted in Table 1, PSTs at Sites B and F were similar demographically; at both sites approximately 90% of PSTs identified as White/European descent.

There were also similarities in the tasks posed by PSTs at Sites D and Site E. Only one-fourth to one-third of the PSTs at Sites D and E posed Category 1 tasks (33%: 3 of 9 of the PSTs at Site D; 23%: 3 of 13 at Site E), while a majority posed at least one task that drew on specific knowledge of the case study child (67%: 6 of 9 of PSTs at Site D; 100% at Site E generated tasks at Category 2 or higher). Moreover, PSTs at these two sites were more likely to generate Category 3 or 4 tasks that connected to practices of children and their families (56%: 5 of 9 of PSTs at Site D; 77%: 10 of 13 of PST at Site E). Thus unlike Sites B and F, PSTs at Sites D and E infrequently posed tasks based on assumptions about children (Category 1) and instead generated tasks that drew on knowledge of the case study child, and in particular, knowledge of family practices (Category 3 and 4). As noted in Table 1, at Site E, 85% (11 of 13) of PSTs identified as White/European descent, while PSTs at Site D reflected greater diversity in racial and ethnic background. Of the nine Site D PSTs, three identified as White/European descent, three as Hispanic/Latin@, one as Asian American, one as African American/Black and one noted Mixed Ethnicity.

At Site A, PSTs were the least likely to generate tasks that reflected specific knowledge of their case study child's experiences, activities, or interests. Only 38% (3 of 8) of Site A PSTs posed tasks at Category 2 or higher. More often, PSTs at Site A generated tasks based on assumptions about contexts that would be relatable or familiar to the children they worked with. Eight-eight percent (7 of 8) of PSTs at Site A wrote at least one Category 1 task, and 63% (5 of 8) generated only Category 1 tasks. Interestingly, PSTs at Site A reflected more racial and ethnic diversity than those at Sites B, E, and F. Half of the PSTs (4 of 8) identified as White/European descent, and the remaining PSTs identified as Hispanic/Latin@ (2), Asian American (1), or Mixed Ethnicity (1).

Other patterns by PSTs and student groups. Analysis of potential relationships between the pairing of PSTs and children with the category of tasks generated suggest that differences may be negligible. For example, we examined potential differences between White/European descent PSTs paired with White/European descent students ($n = 8$), White/European descent PSTs paired with non-White students ($n = 36$), non-White PSTs paired with White/European descent students ($n = 4$), and non-White PSTs paired with non-White students ($n = 10$). Across three of the four subgroups, approximately 40% of tasks posed by PSTs reflected assumptions about the case study child (Category 1), and approximately 60% of tasks drew on actual knowledge about the child (Categories 2–4). Similar patterns were found with tasks that connected to practices of children and families (approximately 20–30% of tasks were in Category 3 or 4, across the different subgroups). The one exception occurred with the small ($n = 4$) group of non-White PSTs who worked with White/European descent case study children, where tasks based on assumptions about the child were less evident. In short, results suggest that the specific pairing of PSTs and case study children did not substantially influence the categories in which PSTs posed tasks. Given that, by design, PSTs did not share backgrounds with their case study child, it is reasonable that none of the PST-case study child pairings produced higher instances of tasks that drew in meaningful ways on knowledge of the case study child.

Finally, we compared the tasks posed for case study children of different racial and ethnic backgrounds. As noted in Table 1, 13 case study children were White/European descent, and 46 students were identified as non-White, including African American/Black (11), Hispanic/Latin@ (25), Asian American (2), Native American/Indigenous (1) or Mixed Ethnicity (7).⁷ We found that children identified

⁷ While we recognize the substantial diversity of students within any given racial and ethnic group, and acknowledge that it can be problematic to sort students according to specific demographic features, for the purposes of this analysis we use these labels to examine possible differences between tasks posed for students of different backgrounds. We consider patterns in tasks posed for White versus non-White students, as well as patterns in tasks posed for students from each racial and ethnic group.

as non-White were more likely to receive at least one task based on assumptions (59%: 27 of 46 of non-White children received Category 1 tasks as compared to 38%: 5 of 13 of White/European descent). This difference was particularly pronounced for Hispanic/Latin@ children, 68% (17 of 25) of whom received Category 1 tasks. Similar trends were noted for Category 2–4 tasks. For instance, non-White children were slightly less likely to receive Category 2 tasks that drew on specific knowledge of their interests and experiences (65% as compared to 77% of White/European descent children), or Category 3 or 4 tasks based on practices that they or their families engaged in (35% of non-White children received Category 3 or 4 tasks, as compared to 46% of White/European descent). Once again, these trends were particularly prevalent for Hispanic/Latin@ children, only 28% (7 of 25) of whom received Category 3 or 4 tasks.

These moderately higher level of tasks received by the 13 White/European descent case study children is not explained by the pairing of PSTs and child (as previously discussed) or by the racial and ethnic background of PSTs (as White/European descent children worked with PSTs from various backgrounds). What seemed more salient were general differences among sites. White/European descent children at Site F received Category 1 and 2 tasks from White/European descent PSTs, which follows the overall trends at that site. In contrast, White/European descent children at site B, all of whom worked with White/European descent PSTs, received a similar, but slightly broader range of tasks (Categories 1, 2, and 3), which again follows the overall trends among sites. White/European descent children at Site D received many Category 3 and 4 tasks, similar to other students at this site. Also, there were no White/European descent students at Site A, where PSTs were most likely to generate lower-level tasks. These findings suggest that White/European descent children were underrepresented at sites that produced higher percentages of Category 1 and 2 tasks (Site A in particular) and over represented at sites that produced higher-level problems (Site D in particular, where almost half of the case study children were White/European descent).

The slightly lower level of tasks received by the 25 Hispanic/Latin@ children also seems related to general differences across sites. For instance, Hispanic/Latin@ children were overrepresented at Sites A and F, where PSTs were more likely to pose tasks at Categories 1 and 2. Whereas 34% (20 of 59) of all case study children worked with PSTs at Sites A and F, 44% (11 of 25) of Hispanic/Latin@ children were from these two sites. When considering Hispanic/Latin@ children that received Category 1 tasks in particular, the differences are even more pronounced. As previously noted, while 68% (17 of 25) of all Hispanic/Latin@ children received at least one task based on assumptions (Category 1), 91% (10 of 11) of the Hispanic/Latin@ children at Sites A and F received tasks this level. In con-

trast, at Sites D and E, where PSTs were most likely to generate tasks at higher levels, only 38% of Hispanic/Latin@ children received Category 1 tasks.

In summary, the differences in the category of tasks received by children from different racial and ethnic backgrounds seem less related to the pairing of PSTs and children, or the racial and ethnic background of the PST, and more related to the overall differences between sites. We conjecture potential reasons for differences among sites in the next section.

Discussion and Implications

Categorization of Tasks

As previously noted, in 81 of the 96 contextualized tasks (84%) analyzed in this study, PSTs drew on children's mathematical thinking. Furthermore in 59 of the contextualized tasks (61%), PSTs drew on specific knowledge about the case study child's interests, activities, or practices. These 59 tasks were discussed in findings Categories 2, 3, and 4. Additionally, in 47 of those 59 tasks (80%), PSTs were able to draw on both knowledge of children's mathematical thinking and specific knowledge about the case study child's interests, activities, or practices. We find this result notable because it suggests that connecting to children's MMKB in plans for future instruction, a practice that can be challenging even for experienced teachers (Taylor, 2012; Wager, 2012), is accessible to PSTs, at least in an emerging form. This result may reflect the affordances of the Mathematics Learning Case Study, specifically the scaffolded learning opportunities to focus closely on a particular child, and to learn about the child's MMKB through multiple interactions, over time. We suspect that the high incidence of connections to children's mathematical thinking may have been an artifact of the structure of Mathematics Learning Case Study assignments. The problem-solving interviews, coupled with requests to generate specific follow-up problems for the child to solve, may have made it easier for PSTs to draw directly on knowledge gained about children's mathematical thinking, as compared to other types of knowledge about the child as they developed tasks for future instruction.

Category 1 and 2 tasks. In terms of the different ways that PSTs made connections to children's interests, experiences, or funds of knowledge, the most prevalent single category in our findings were tasks based on assumptions about objects or activities that would be familiar to all children (Category 1, approximately 40%). Yet, if we look at the tasks that drew on the specific knowledge about the case study child (Categories 2, 3, and 4), we see that this occurred in approximately 61% of the tasks. But tasks in Categories 1 and 2 both reflected only slight adaptations, such as inserting an object or setting that was known to be of interest, to what otherwise would be standard textbook-like word problems. Considering that PSTs

conducted “getting to know you/funds of knowledge interviews,” had numerous informal interactions with their case study child, and were encouraged to draw on what they learned about children’s activities and family practices when generating instructional suggestions, these results underscore the documented difficulty that even practicing teachers have had in connecting deeply to children’s experiences in mathematics tasks (Hedges, Cullen, & Jordan, 2011; Taylor, 2012; Wager, 2012). Part of the challenge may be related to Vacc and Bright’s (1999) finding that, although PSTs demonstrate gains in their knowledge about children as a result of activities in methods courses, they tend not to use this knowledge in planning instruction or in teaching. Lee’s (2012) study offers another possible interpretation, suggesting that the low incidence of tasks that went beyond superficial connections to children’s experiences may be related to the gap between PSTs’ vision for making connections in mathematics teaching, and their ability to enact this vision in instructional plans and practice. Differences in the prevalence of Category 1 and 2 tasks across sites suggest other possible explanations; we elaborate on these points later in the discussion.

Despite the superficial nature of the tasks in these two categories, we nonetheless argue that they constitute emerging and potentially useful attempts to connect mathematics instruction to children’s interests and experiences. PSTs explained that including relevant and familiar contexts enhanced student engagement, referencing instances when children participated more actively in problem solving when high-interest objects, activities, or people were used in tasks. This interpretation that the use of relatable, high-interest contexts contributed to student success may have motivated PSTs to emulate this practice in their plans for future instruction. Furthermore, some recent research offers support for PSTs’ interpretations, suggesting that connections to children’s interests in mathematics word problems can help children make sense of tasks and can enhance achievement, particularly for lower-achieving children and for challenging tasks (Renninger, Ewen, & Lasher, 2002; Walkington, Petrosino, & Sherman, 2013). Additionally, Hedges and colleagues (2011) argue that connections to children’s interests can serve as entry points to children’s funds of knowledge because “children’s interests are stimulated by the experiences that they engage in with their families, communities and cultures” (p. 187). In this way, connections to children’s interests can be productive, particularly if teachers also attend to the mathematical knowledge and practices that children may bring related to those interests (Civil, 2002, 2007; Gonzalez, Moll, & Amanti, 2005). In fact, it may be useful to conceptualize the tasks in Category 1 and 2 tasks as an initial and potentially productive step along a path toward more meaningful connections.

Category 3 and 4 tasks. The tasks in Category 3 (20%) reflected PSTs’ attempts to connect to understandings about family practices. Yet lacking specific knowledge about how families use (or do not use) mathematics as part of their practices, PSTs imagined the mathematics that might be involved, or how one could

layer mathematics onto the activity. Wager (2012) identified a similar category of connections in her work with practicing teachers. She explains, “the activity was identified [by teachers] first and then a school mathematical practice was matched to that activity” (p. 15).

The small number of tasks in Category 4 (approximately 7%) reflected attempts to connect to the mathematical knowledge and practices that children brought from experiences outside of school. We conjecture that the low incidence of tasks that evidenced these connections may reflect a tension that arises when teachers attempt to connect to out-of-school practices (e.g., cooking, gardening, shopping) in school mathematics lessons (Taylor, 2012; Wager, 2012). When teachers try to make the mathematics in these activities more explicit, the connections to what actually happens outside of school can be lost so that the problem generated for classroom use no longer resembles the out-of-school practice (González, Andrade, Civil, & Moll, 2001; Masingila, Davidenko, & Prus-Wisniowska, 1996). We see glimpses of this tension in each of the examples in Categories 3 and 4. In the case of the basketball task for example, it was reasonable for the PST [E403] to assume that the child would be knowledgeable about scoring and might even have strategies for quickly calculating scores that he could draw on to solve the problem posed. Yet, while some basketball players may calculate how many shots would be needed to score a given number of points, for others these types of calculations may not be an authentic part of their play. A related tension in constructing problems is attention to the appropriateness of concepts and number choice considering both the grade level and the mathematical competencies of the child. In this case, although the numbers may seem inappropriate for an eighth grader, the PST appears to be responding to specific needs (understanding basic word problems, exploring alternative calculation methods) she had identified for the child.

While it is important to acknowledge these tensions, we argue that it is productive for PSTs to analyze and attempt to connect to mathematical practices in out-of-school activities. Posing these kinds of problems, even if they do not always mirror the specific ways that children and families engage in mathematical reasoning outside of school, opens a space for children to talk about their out-of-school mathematics practices. Teachers can use these tasks to position student's home and family activities as mathematical, validating children's funds of knowledge. We see this effort as a critically important part of challenging deficit-based narratives about children and youth from marginalized communities. Also important is that children may learn mathematics more deeply when problem contexts are familiar and build on children's knowledge. Walkington and colleagues (2013) found this to be true when working with older children. We conjecture that for younger children as well, when tasks connect to familiar contexts, children need to expend less effort under-

standing the context, making available more resources for understanding the mathematics.

There may be additional reasons why it is difficult for PSTs to generate tasks that connect to the ways children and families engage in mathematics outside of school. In comparison to practicing teachers, PSTs are just entering the profession and have not had the same experiences with elementary school mathematics and mathematics classroom practices or curricula. It may also be that the activities within the Mathematics Learning Case Study did not always provide the range and depth of opportunities required for PSTs to learn about how children and families used mathematics in everyday activity. Prior research has documented that it takes time for teachers to build relationships with children and families and to move beyond serendipitous or piecemeal connections to children's funds of knowledge (Hedges et al., 2011). While the Mathematics Learning Case Study was designed to support PSTs in attending closely to children's knowledge, experiences, and resources, PSTs may need additional opportunities to learn about children in different contexts and over time. Differences in the prevalence of Category 3 and 4 tasks across sites support this conjecture, as we elaborate below.

Differences Across Sites

As outlined in our findings, analysis across sites revealed notable contrasts between the categories of tasks posed by each group of PSTs. In this section we conjecture and discuss possible explanations for these differences. To begin, the differences in tasks posed cannot be attributed to the racial and ethnic background of the PSTs. At some sites, White/European descent PSTs wrote many Category 3 and 4 tasks that connected to practices of children and families (Site E), while other sites with mostly White/European descent PSTs evidenced a higher proportion of Category 1 and 2 tasks, including tasks based mainly on assumptions, rather than specific knowledge about case study children (Sites B and F). Conversely, in one instance a group of PSTs from diverse racial and ethnic backgrounds proposed numerous Category 3 and 4 tasks (Site D), while at another site where PSTs reflected racial and ethnic diversity, all tasks were in Category 1 or 2 (Site A).

A more viable explanation for the notable contrasts between sites is differences in how the Mathematics Learning Case Study Module was implemented. For example, at Site A, where PSTs were most likely to write Category 1 tasks, the case study assignment was completed during a 4-week period at the beginning of the semester-long course. For 3 weeks, PSTs conducted weekly interviews and observations of their case study children, and then during the fourth week, wrote the final report. In contrast, at several other sites where PSTs produced a greater range of tasks and where a majority of tasks drew on specific knowledge of the case study child, PSTs worked on the case study assignment across a significant portion of the course (Site D, E, and F). For example, at Site D, PSTs met their child at the begin-

ning of the semester, conducted initial getting to know you interviews in week 4, and problem-solving interviews in weeks 5 and 6 and then continued to observe and interact with the case study child several times a week for the balance of the semester. Final case study reports were not submitted until the last week of the semester. Sites E and F followed a similar schedule. At Site B, where tasks generated resembled those produced by PSTs at Site F, PSTs completed the case study assignment during an intensive weeklong immersion in the field. During this week, PSTs focused intently on learning about the case study child through multiple interviews, observations, and interactions. These differences in how the case study assignment was implemented suggest that PSTs may benefit from prolonged or intensive interactions with their case study child that allow extended opportunities (beyond those included in the structured interviews) to learn about their child's experiences, interests, competencies, and practices.

Another possible explanation for the differences across sites includes the age and prior life experiences of PSTs. For instance, at Site E, where PSTs were most likely to pose Category 3 and 4 tasks that drew on specific knowledge of children's and families' practices, PSTs were graduate students completing a combined master's degree and teaching certification program. While some of these PSTs entered the graduate program immediately following their undergraduate degree, others returned to school after working in other fields. Similarly, at Site D where PSTs also generated many Category 3 and 4 tasks, PSTs reflected greater diversity in age and prior life experience than those at other sites. PSTs at Site D were all undergraduate students, yet some were parents, and others immigrated to the United States as children and thus had experiences with different cultures, languages, and school systems. At the other three sites (Site A, B, and F), PSTs were almost all traditional undergraduate students who entered college immediately following high school. While the numbers of PSTs at each site are small and do not support broad generalizations, the differences noted across sites suggest that both extended opportunities to interact with case study children coupled with a broader range of life experiences (due to age, work experience, and family background) may support PSTs in learning about children's experiences and connecting to this knowledge in their mathematics teaching. These findings related to how different factors (i.e., PST and child background, PST-child pairings, site implementation) seemed to influence the tasks that PSTs posed are an important contribution to the literature, and one that outlines promising direction for future research.

Conclusion

Despite the challenges, we see a hopeful story emerging. As noted earlier, nearly half of the 96 contextualized tasks (46%) attended to both children's mathematical thinking and specific knowledge of the case study child's out-of-school in-

terests and activities, and all but three of the 96 tasks (97%) connected to either the child's mathematical reasoning or the child's interests and activities. The fact that almost every PST focused on some specific knowledge about their case study child indicates that PSTs were attending to particularities about children, and potentially developing the disposition to continue to do so (Leonard, 2008). Our findings also suggest that PSTs were learning to (re)orient to children from diverse cultural, linguistic, and racial backgrounds in ways that reflected a resource-based (rather than deficit-based) perspective. Through their scaffolded learning assignments in the Mathematics Learning Case Study, PSTs learned specific things about children's knowledge and experiences and positioned that knowledge as a resource to support school mathematics learning. In this way, our study demonstrates the value of case study experiences for learning to orient children as mathematical learners in ways that recognize their families, communities, and out-of-school interests and activities as resources that can support mathematics learning. Finally, this study challenges the notion that teaching that connects deeply to children's MMKB is out of the reach of PSTs and thus should not be a focus in teacher preparation programs. Our findings suggest that with specific kinds of support, such as extended or intensive opportunities to interact with children both in and out of the classroom, PSTs can begin to leverage knowledge about children's and families' out-of-school activities in their plans for instruction.

Implications for Research and Practice

In addition to the importance of extended interactions with children discussed here, PSTs may benefit from additional support as they learn to connect to children's varied knowledge bases in their planning. We found that PSTs often learned far more about their case study child's interests, experiences, and strengths than they incorporated in their instructional suggestions. This finding suggests that additional scaffolds are needed to help PSTs utilize that knowledge as they plan for instruction. More attention, for example, could be focused on adapting problem contexts to align with the information about their case study child accessed in the "getting to know you/funds of knowledge" interviews, or in informal conversations and observations. PSTs also participated in a community mathematics walk during the methods course in which they learned about the mathematical resources in the community surrounding the elementary school. Yet, we saw little attention to the knowledge gained during this activity in the PSTs' instructional suggestions. Linking this experience more explicitly to the Mathematics Learning Case Study may provide PSTs with additional entry points into making connections to children's MMKB. PSTs may also benefit from examples of how experienced teachers draw on children's MMKB in their teaching. Methods course instructors might invite mentor teachers (teachers who work with PSTs in the field) to share this aspect of

their practice, and/or help mentor teachers to explicitly mark these teaching moves when PSTs are in their classrooms.

Additionally, our findings draw attention to a type of knowledge that PSTs should develop to be effective teachers of mathematics that has not been given significant attention in mathematics teacher preparation. In order for teachers to support the learning of all students, particularly those from under-represented populations, it is important that mathematics teacher educators support PSTs in delving deeply into the knowledge and experiences that children bring to school so that they can be leveraged in the service of their mathematical learning. The Mathematics Learning Case Study shows promise in moving teachers toward making these connections; particularly in contexts where extended time during the semester is devoted to interactions with and observations of the child.

Research on the effectiveness of this project and other attempts to support PSTs' ability to connect to children's experiences and funds of knowledge would be a fruitful direction for future research. At a minimum, these results point to the need for more coordinated, multi-site research in teacher education to better understand how differences in implementation and program context impact PST learning and practice. Whether it is possible to improve results through additional activities or scaffolds in methods courses warrants further research.

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APPENDIX A

Overview: Mathematics Learning Case Study Module

This module focuses on the mathematics learning and dispositions of a case study child. Prospective teachers (PSTs) work with a case study child over the course of a semester, and consider how to use what they learn in mathematics instruction. The activities within this module include (a) conducting a mathematics “getting to know you/funds of knowledge” interview, (b) conducting one or more problem-solving interview assessments, (c) conducting informal observations of the child during mathematics lessons and other times of the day, and (d) engaging in written analysis and reflection.

Activity 1: Mathematics “Getting to Know You/Funds of Knowledge” Interview

PSTs conduct an interview with one child in their practicum classroom in an effort to become more familiar with the child’s activities and interests, the child’s home and community knowledge base, and home and community resources. Activity goals are:

- To find out more about the child including her or his interests, activities she or he engages in outside of school with family and friends, and what she or he identifies as activities at which she or he excels (i.e., does she play soccer at a local park, does he go to a community center, where does she or he shop, etc.).
- To identify places, locations, and activities in the community that are familiar to the child, and to find out what the child knows about potential mathematical activity in those settings. These could include locations in the neighborhood immediately surrounding the school, locations/settings in the neighborhood in which the child lives, as well as locations/settings in the broader community with which the child is familiar.
- To find out more about the child’s dispositions towards mathematics.

Activity 2: Problem Solving Interviews

PSTs conduct one or more problem-solving interviews with their case study child. These interviews provide an opportunity to practice eliciting, interpreting, and assessing children’s thinking about mathematics, with a particular focus on their understanding of number concepts. PSTs are provided with a set of sample problem-solving tasks, but are also encouraged to adapt questions as needed for their case study child. PSTs take detailed notes during the interview and collect all student work. Whole number interview protocols and guidelines were adapted from the work of Tom Carpenter and the Cognitively Guided Instruction (CGI) Group (Carpenter, Fennema, Franke, Levi, & Empson, 1999), as well as work of Susan Empson and colleagues (Empson, Turner, & Junk, 2006). The fraction interview protocol was adapted from work done with Edd Taylor.

Activity 3: Synthesizing and Connecting Across Activities

This assignment is designed to cut across the previous activities in this module. In this written report completed outside of class, the PST reflects across the multiple interviews and observations that she or he completed with her or his case study child, and considers how to use this knowledge in mathematics instruction.

APPENDIX B

Example Tasks Posed by PSTs

Findings Category	Sub-Category	Examples
<p>Category 1: Generating Tasks Based on Assumptions about Familiar or Relevant Contexts</p> <p>37 of 96 tasks (representing 32 PSTs)</p> <p>Tasks based on assumptions about objects and activities that would be relatable to children.</p>	<p>Tasks resembled typical textbook-like word problems (e.g., information followed by a question to be solved)</p> <p>Tasks adapted from the problem-solving interviews or from the curriculum used in the case study child's classroom</p>	<p>(a) Amanda went to the store and bought 6 stickers. She already had 18 stickers. How many stickers does Amanda have in all?</p> <p>(b) There are 9 birds flying in the air, some of them landed on a tree. Now there are only 4 birds left flying in the air. How many of the birds landed on tree?</p>
<p>Category 2: Generating Tasks Based on Knowledge of Objects or Activities Familiar to Case Study Child</p> <p>31 of 96 tasks (representing 25 PSTs)</p> <p>Tasks based on specific knowledge about the case study child's interests or preferences.</p>	<p>Tasks resembled textbook-like word problems but included objects and people known to be of high-interest to the case study child</p> <p>Tasks connected to activities known to be of high interest to the case study child, in this case football. However, tasks did not connect to the math that children might do as part of that activity.</p>	<p>(c) Mary has some frogs. Kevin gave Mary 3 more frogs. Mary now has 8 frogs. How many frogs did Mary have at the beginning?</p> <p>(d) Jason has 9 footballs. He loses 5 of them. How many footballs does Jason have now?</p>
<p>Category 3: Generating Tasks by Mathematizing Case Child's Family Practices</p> <p>21 of 96 tasks (representing 17 PSTs)</p> <p>Tasks based on an activity or practice in which the family of the case study child engaged. PSTs considered how people might use mathematics as part of this activity.</p>	<p>Tasks focused on home activities in which parents could engage the case study child in mathematics.</p> <p>Tasks focused on connections teachers would make in classroom mathematics lessons to home or family activities.</p>	<p>(e) The next time you [the parent] go to the grocery store with [child's name], you might ask him to count how many items were in your cart as you check out.</p> <p>(f) John goes out to eat with his parents on Friday night. His mom orders a large pie for herself, John, John's sister, and John's dad. This large pizza comes with eight slices. If each person in John's family wants to eat the same amount of slices, how many slices will each person get?</p>

Category 4: Generating Tasks by Identifying Mathematics in Activities in which the Case Study Child Engages	Note: No sub-categories within Category 4.	(g) If you receive 5 dollars a week for allowance, how much would you have after a month? If after one month, you spent 13 dollars on a new soccer ball, how much money do you have left?
7 of 96 tasks (representing 6 PSTs)		
Task that related to activities in which PSTs knew their case study child participated, and also identified mathematics that the child engaged in as part of the activity		
