Reviewing the Family Math Literature

RECOMMENDATIONS FOR PRACTICE, POLICY, AND RESEARCH

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INTRODUCTION

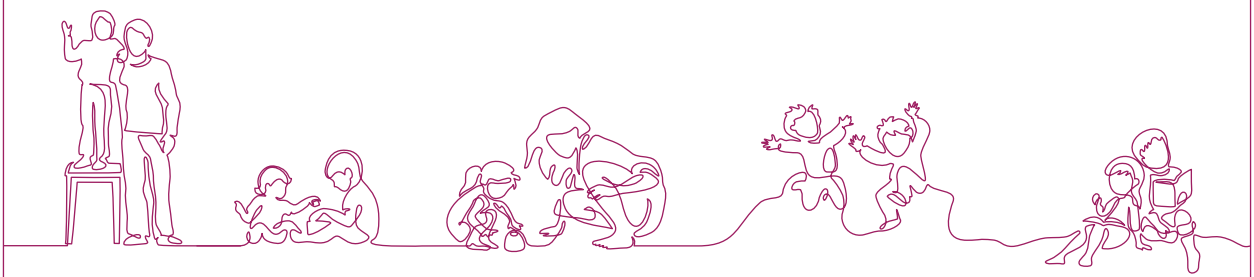
Early mathematics skills are a critical predictor of children's later academic success.

A wealth of research has shown that early math skills predict children's learning outcomes in elementary school as well as high school.[1] Concerningly, disparities in children's early math knowledge are apparent during preschool and persist as children progress in school.[2]

Since these gaps emerge even prior to formal schooling, a number of efforts are underway to support young children's math learning in both home and out-of-home settings. Stakeholders, including educators, practitioners in the community, and researchers have begun to characterize variations in early family math. Their focus is to provide families with the resources and knowledge they need to engage in positive math-related experiences that build math knowledge, math interest, and positive attitudes about math.

Typical ways families engage in math:

• talking about math • singing • book reading • playing with blocks •
• games and puzzles • everyday activities such as cooking, shopping, and cleaning up •



Efforts to support early math learning in the home environment are motivated by a number of findings. First, there is evidence that wide variations in math knowledge exist prior to kindergarten entry. Second, there is evidence that these variations are predicted by variations in math learning opportunities in the early home environment. Third, there is evidence that increasing math learning opportunities in the home increases children's math knowledge. And finally, there is evidence that math knowledge at kindergarten entry is predictive of long-term math learning trajectories.

Although the ways that families engage with math may differ depending on culture and parents' own prior experiences, all families engage with math. By building on what families are already doing, researchers and educators are developing and assessing ways to support family math engagement. These efforts involve interdisciplinary partnerships that include families in identifying ways to support children's math learning that are meaningful, feasible, and engaging.

As efforts to promote family math engagement proliferate, it is critical to examine the current state of family math engagement with a wide lens. What do we know about children's early math development and how families support this development? What approaches to increasing family math engagement are effective? What are educators and communities currently doing to support family math?

In this review, we take a two-tiered approach to examining the current state of family math engagement:

1. Research: We report the findings from a comprehensive review of the empirical literature on early math learning, birth to age eight. We begin with a broad overview of the foundational math skills children need for achievement, then discuss evidence that family math engagement and children's math achievement are linked. We also discuss interventions successful in increasing family math engagement as well as interventions outside the domain of math that could inform work in family math.

2. Practice: We report findings from a series of interviews with educators and professionals working with families in community-based settings. We conducted these interviews to provide insight into ongoing efforts to increase family math engagement.

In a third section, we integrate these findings from research and practice to examine in what ways the work from these two spheres are aligned. Importantly, we consider whether ongoing and future family math efforts can be strengthened through closer integration of research and practice. Then we summarize the key points and identify lessons learned as well as gaps in resources, services, and current knowledge. In the fourth and final section, we present recommendations for policy, practice, and future research.

DEFINING FAMILY MATH

We define "family math" as culturally-relevant math activities and interactions occurring in the informal contexts in which families engage with young children.[3] These activities and interactions provide opportunities to introduce and enhance children's math skills and knowledge, as well as to support positive attitudes towards math and learning.

Our conceptualization of "family math" considers not only the activities families engage in, but also families':

- awareness of math embedded in activities at home and in their communities;
- enthusiasm for and comfort with engaging in math and in supporting young children's math learning; and
- access to resources for supporting early math learning and knowledge about how to use these resources.

SECTION 1 REVIEW OF FAMILY MATH LITERATURE

Question 1: What skills serve as foundations for children's math achievement, and what other child characteristics are linked to differences in early math?

We reviewed research from multi-year longitudinal studies, meta-analyses, and literature reviews to identify the strongest predictors of children's mathematics achievement. These include foundational skills, as well as factors beyond family engagement that contribute to observed differences in these skills.

NUMBER KNOWLEDGE

Children begin learning about number words and numerals before the start of kindergarten, and their skills at kindergarten entry predict both their later math achievement and their rate of math learning in early elementary school.[4]

Cardinality: knowing the values associated with number words (e.g., being able to bring five forks to set the table when asked instead of three forks or ten forks); predicts later math achievement.[5]

Numeral knowledge: ability to recognize, label, and understand the values represented by written numerals; serves as a translation between informal math skills and more formal school-based math instruction.[6]

Magnitude: comparing and ordering numbers by their relative magnitudes; sets the stage for later arithmetic and algebra learning.[7]

SPATIAL REASONING AND PATTERNING

Many parents and educators focus on supporting math achievement by building early number knowledge, but data suggest that spatial reasoning and patterning are also important foundations for children's later math achievement.

Spatial reasoning: mental rotation, recreating three-dimensional designs, and determining locations of objects relative to others in space; predicts children's math achievement over time and training spatial reasoning leads to improvements on math achievement measures.[8] Spatial reasoning applies in many math contexts, including ordering numbers on number lines and solving missing term arithmetic problems.

Patterning: copying, extending, and identifying the core of repeating patterns; predicts later math achievement.[9] Like spatial reasoning, patterning applies to many math reasoning tasks, like understanding number sequences and solving arithmetic problems.

CHILD AND FAMILY CHARACTERISTICS

Early math skills are associated with child and family characteristics, including socioeconomic status (SES), executive functioning skills, and multilingualism, but not gender.

SES: There are consistent discrepancies between the math performance of children from low socioeconomic status households and their peers from mid- and high-SES households.[10] These gaps emerge prior to the start of kindergarten and persist through secondary school, across domains of math. For young children, the gaps appear to be driven by differences in knowledge of number words and numerals rather than non-verbal math reasoning, and can be attributed to less practice with early verbal math concepts.[11]

Executive functioning: Executive functioning skills help children concentrate, pay attention to, and learn from the mathematical information in their surroundings. Variability in these skills may relate to differences in early math performance.[12]

Language: Bilingual children perform similarly on math assessments conducted in their school language and their home language. They may also show some advantages on early math skills compared to monolingual children, but only when socioeconomic status is controlled.[13]

Gender: Although there is some evidence of gender differences in math test performance among older students and adults, there is little evidence of a gender difference in foundational early math skills.[14] The only exception is a male advantage, found in some studies, on tasks measuring the ability to mentally transform shapes.[15] Importantly, more engagement in spatial play, such as block play, among boys than girls, may contribute to this difference.

Question 2: What aspects of family math engagement are most strongly related to children's math learning, achievement, and attitudes?

To address this question we searched published articles using keywords pertaining to families (e.g., parents, home) and math (e.g., number, numeracy, spatial), and examined research studies that included children ages birth to eight years old or up to third grade. We included math-specific forms of engagement (i.e., math-related activities, parent and child talk about math, parents' school involvement related to math, parents' reported attitudes and expectations regarding math) as well as broad measures of the home learning environment (i.e., parents' guidance, cognitive stimulation, and general school involvement).

We took care to note context such as geographic regions, racial and ethnic identities, and socioeconomic characteristics of families included in research studies. We also noted developmental differences in family math engagement with children of

different ages, and differences in how this engagement was measured depending on the child's age.

Parent expectations are consistently related to child outcomes. Parents' high expectations for children's achievement are associated with stronger math skills.

Importantly, expectations about success in both the near and distant future matter. Parents' ratings of the importance of mastering certain math skills by kindergarten and expectations for their children's end-of-the-year grades are linked to stronger math skills.[16] So are parents' ratings of the highest level of education they expect their children to reach.[17] This relation is robust across participant populations; parent expectations have been linked to children's math achievement across families from diverse ethnic and socioeconomic backgrounds.

It is less clear *how* parents' expectations contribute to children's achievement, although there is some evidence that parents with higher expectations may engage in more frequent and higher quality math activities,[18] and may also transmit positive attitudes about math to their children.[19] Further, parents' home support and high expectations have been linked to lower levels of children's math anxiety.[20]

The amount of mathematics talk that children hear is a strong predictor of math outcomes. Parents' use of mathematical language with toddlers and preschoolers is associated with children's current and later math knowledge. Researchers have primarily focused on parents' use of number talk, although several studies have examined quantitative terms other than the count words (e.g., more, less, some) and spatial language.[21]

In part, parents' math talk may support children's math achievement because it helps children to develop their own use of math language, and having a strong math vocabulary may facilitate children's mathematical thinking.

The value of this input starts early. Parents' math language directed towards children ages one to three years old predicts later foundational math knowledge, specifically understanding the cardinal value of the number words.[22]

Importantly, some types of math talk contribute more than others. In particular, talk about complex, advanced math concepts and talk about larger numbers and sets of objects appear to be most predictive of children's math knowledge.[23]

While some studies of parent-child math talk have been conducted during structured play sessions with pre-selected toys,[24] several studies of naturalistic, home-based observations have also supported the connection of math talk to later math achievement, including some studies with a range of SES and diverse ethnicities of families.[25]

Frequency of math-related activities may relate to children's math outcomes, but findings are mixed based on the types of activities. Broadly, research supports associations between math-related activities

(as reported by parents) and children's math knowledge.[26] While many studies have focused on number-oriented math activities, there is also evidence for spatial activities being linked to spatial as well as numerical abilities.[27]

However, the way researchers have defined and measured math activities varies widely. Some studies combined math resources in the home and parent reports of math-related activities.[28] Others have attempted to identify types of math activities most predictive of math achievement.[29] For instance, studies have categorized activities as "formal" and "informal" (or "direct" and "indirect") to distinguish between parents' intentional, focused teaching of mathematics (e.g., workbooks, flash cards) from instances where mathematics may be embedded within an everyday or playful activity (cooking, storybook reading, board games).[30]

Formal and direct activities have been more consistently linked to math achievement than math games or everyday applications.[31] However, informal activities may tap into different math skills than the ones assessed in these research studies. It is critical to highlight that the majority of papers linking formal activities to math achievement focus on higher-SES, White families, although studies including broader SES ranges or focused on lower-SES families also have linked formal home math activities to children's math knowledge.[32]

For children in elementary school, families' school involvement is a significant predictor of children's math knowledge. Compared to studies of children in preschool and kindergarten, research on family math engagement with elementary-age children has focused more on parents' roles in school-based math learning, rather than formal and informal home math activities.

Parents' engagement with children's school-based math learning, particularly helping with homework, has been one area of research on school involvement. Helping with homework tends to be negatively associated with achievement, although this finding might stem from parents getting more involved when children are struggling.[33] Additionally, parents' math attitudes may mediate the relation between homework help and math achievement: the more high math anxious parents report helping their first grade children with homework, the lower their children's math learning over the school year, controlling for beginning-of-the-year math achievement levels.[34]

In contrast to math homework help, parents' broader (not math-specific) school involvement is generally a positive predictor of child achievement in school, including math achievement.[35] However, there is some variation in the strength and direction of the relation—as well as what forms of school involvement are related to children's academic achievement (e.g., parent-teacher communication, parent participation in school events)—when examining families' ethnicities, socioeconomic status, or immigration status.[36] This variation may be in part attributed to socioeconomic differences in how schools engage with families.[37]

The overall quality of the home learning environment is associated with math achievement. The home learning environment has been found to predict children's math achievement.[38] Measures of the home learning environment vary but often include aspects pertaining to literacy, such as the number of books in the home, and quality ratings of parents' general engagement with children. In some instances, math-specific aspects such as presence of math games or puzzles have also been included. Having a rich learning environment overall and responsive family members may facilitate opportunities for math engagement. Further, rich learning environments are likely important for helping children develop the domain-general cognitive skills that support mathematical thinking.

FOR FURTHER RESEARCH

This research into the factors that contribute to early math learning leaves several gaps in our understanding.

- To what extent are there cultural differences in families' routine activities? How do families effectively support children's math learning in their own contexts?
- Beyond supporting formal education, how do families with elementary-aged students engage in math together? The majority of studies have focused on math engagement in preschool and kindergarten, with little attention to families' math activities beyond kindergarten.
- In addition to family math centered around numeracy, how are families engaging in spatial skills and patterning, which are also linked to math achievement?[39] This work will give us a fuller picture of the types of family math engagement most strongly related to children's math learning, achievement, and positive attitudes.

Question 3: What do we know about how families are engaging in children's early math learning as part of their day-to-day lives?

We addressed this question in the same literature search as Question 2. We examined descriptive data about family math engagement as measured by parents' reports and by observations of parent-child exchanges and joint activities. We also looked at data on parents' reported attitudes about math and their expectations for their child's math achievement, and how these attitudes and expectations relate to family math engagement.

There is substantial variation in the frequency and types of math-related activities families engage in, and in the quality of family math engagement. One of the most consistent and critical findings across research on family math engagement is that there is great variation in how much families engage in math. This variation appears both in studies asking parents to report on their activities[40] and in direct observations of parent-child interactions.[41] There are also differences in the complexity of parent-child talk about math,[42] and whether parents report engaging in formal math teaching activities or supporting math learning in informal activity contexts.[43]

Math often takes a backseat to reading. While parents often express a belief that early math learning is important, they also express that they feel less knowledgeable about how to support math learning compared to supporting learning to read.[44] Not surprisingly, then, parents often report less frequent math engagement than language and literacy engagement through activities such as shared book reading.[45]

Cultural context plays a role in how families engage with young children, both in general and in math. Much of the work examining how family characteristics such as race, ethnicity, and language relate to family engagement in children's learning has included broad, non-math-specific measures such as the general home learning environment (HLE) and parents' school involvement. Studies comparing across race/ethnicity have observed higher HLE ratings and more school involvement among White families (and sometimes Asian families) and English-speaking families compared to Black and Latino families and families who are English language learners or bilingual.[46] Importantly, culture not only has been linked to how much families engage in children's learning, but also relates to qualitative differences in family engagement.[47] For instance, there may be cultural differences in the extent to which families directly involve children in math as opposed to modeling math in situations where children are observers.[48]

Parents' attitudes, education, and income relate to family math engagement. Not surprisingly, parents' own enjoyment of and positive attitudes towards math are associated with higher frequencies of parent-reported math activities.[49] Similarly, parents

with higher expectations for children's early math have reported higher frequencies of direct teaching.[50] In contrast, there is some evidence that parents with higher math anxiety may engage in fewer math activities,[51] although other studies have not found a relation between math anxiety and math engagement.[52]

Education and income also have been linked to math engagement. Parents' education has been positively related to the complexity of the math they do with young children.[53] Findings related to income are more varied, with some studies finding that low-income parents engaged in more formal math activities than higher-income parents,[54] while other studies have found that parents in disadvantaged neighborhoods report fewer education-related practices.[55] It is important to note that there is diversity in the complexity of math parents talk about with their children within low-income samples.[56]

FOR FURTHER RESEARCH

While evidence indicates that parent education, income, and attitudes about math predict the frequency and quality of math activities, there are still gaps in our knowledge.

- What accounts for the different amounts and types of math families engage in, and what other parent or family characteristics influence the quality of family math exchanges?
- How are families engaging in math beyond child-centered activities (i.e., formal math teaching and play)? In many cultural contexts, activities are not directed around children. Instead, children are on the periphery of community-centered activities and are observers of these activities.[57]

Question 4: What do we know about how community settings such as early child care can support family math engagement?

To address this question we conducted a review of published research articles using keywords related to early childhood care (e.g., preschool, daycare) and math, again limiting to studies that included children birth to age eight. We also referred to the National Center for Education Statistics for descriptive information about the rates of attendance in non-home care settings among young children in the U.S.

Non-parental child care can be a key support for family math engagement. Seventy-five percent of children ages three to five not yet in kindergarten receive some type of routine non-parental care, including relative care (26%), non-relative home-based care (12%), and center-based care (61%).[58] Consequently, the math experiences available to children in non-parental care, and how this can support family math engagement, are critical to consider.

There are frequent opportunities for math learning across non-parental care settings. Observational studies of preschool classrooms estimate that only 2 to 8 percent of the day is spent on math instruction.[59] However, math learning opportunities also arise in free-play contexts. Observational studies of home-based care settings suggest 13 percent of children's total words in free-play activities were math related.[60] Many informal math activities recommended to families can similarly be incorporated into non-parental care settings to complement existing instruction, such as reading math-related story books[61] or counting out snacks at snack time.

There are opportunities for educators and childcare providers to facilitate family math. Family involvement in children's education is an important support for early learning. For instance, parent involvement in kindergarten buffers the relation between children's socioeconomic status and math performance.[62] Childcare providers and educators can facilitate parent involvement through enhanced communication and offering structured family math activities. Parents who receive frequent communication from their childcare providers regarding what children are learning, what to expect from their child at each stage, their child's performance in school, and how to help their child learn report that they more frequently engage with their children in math activities at home.[63] Providing developmentally appropriate math homework or math game

packets to complete at home with a family member is an effective way to increase family math involvement.[64]

Children's math experiences in non-parental child care may vary substantially based on the quality and context of care. Enrollment in care settings varies based on family demographics, with parents with higher educational attainment, higher earnings, and longer working hours more likely to choose center-based care.[65] Latinx and non-English speaking parents are more likely to enroll their child in home-based care settings.[66] Children who attend center-based care have higher math performance on average than children who attend home-based care.[67] Although there is a strong relation between children's socioeconomic status and their math performance, attending high-quality early childcare programs can buffer the negative relation of lower socioeconomic status and children's later math performance.[68]

FOR FURTHER RESEARCH

While research is promising about early math opportunities outside the home, several questions remain.

- Are math opportunities in non-family care settings similar to or different from children's family math opportunities? How does this (mis)alignment affect learning?
- We need more descriptive research on how early childhood educators and families communicate about math in the home. Is it more or less frequent than other types of school-to-home communication? Does it vary by school setting or population served? Are there effective methods of improving communication and alignment of math learning goals across settings?
- Another area for additional research involves broadening to include community settings beyond school and childcare. Families interact together in a wide range of settings in their communities, and there is emerging work examining family math engagement in places such as museums and grocery stores.[69] How do modifications or enhancements to existing settings like playgrounds, bus stops, and libraries affect learning and enjoyment, and how might these stakeholders implement more permanent change?

Question 5: What is the evidence on interventions aimed at improving family math engagement? What evidence from broader family engagement efforts can help to inform future work for promoting family math?

We again searched published articles using the same series of keywords pertaining to families and math, while also including a series of keywords pertaining to engagement (e.g., involvement, interaction) and intervention. For the second question, we replaced math terms with other education terms (e.g., read, literacy, education). Again, we limited our examination to research studies that included children ages birth to eight or up to third grade.

Evidence for the efficacy of math engagement interventions is limited, but promising. Much of the focus to date has been on describing the home numeracy environment and its relation to children's math knowledge, with moderate success in designing various interventions to shift parent behavior. There has been much more work done to develop interventions that address other goals such as literacy, nutrition, and childhood obesity, as well as general parenting skills. These interventions provide many insights.

In-lab (or one-time exposure) interventions have successfully promoted family engagement in math, leading to changes in the way caregivers incorporate math into everyday activities. Small tweaks to materials provided to parents and/or prompts in parent-child environments can lead to subtle shifts in family math engagement.[70] Posting signs at museums, grocery stores, or playgrounds reminding parents to ask questions or provide additional instructions can lead to positive changes in parent-child interactions.[71] One important caveat: the positive effects have been measured immediately after the intervention, making it unclear whether there are long-term impacts of these interventions or whether they yield long-term changes in attitudes and behavior. Furthermore, there is little to no evidence directly linking these small changes to differences in achievement outcomes for children.

Interventions focused on the home environment have primarily relied on teachers working with parents to deliver the interventions. Interventions designed to increase parent-child math engagement through parent contact with either researchers or teachers and schools have been moderately successful.[72] Providing parent education and tools so parents can engage in the lessons their children are learning leads to improvements in student performance. Preliminary evidence also shows that less intensive interventions, such as simple prompts from an app, can be

beneficial, specifically by improving parental expectations parents for children's math performance.[73]

Evidence from family engagement interventions in other educational contexts provides promising future directions for family math engagement. Successful interventions in early childhood literacy have shown that using multiple strategies to change family engagement behaviors, as well as including both parents and teachers in the interventions, are important for changing child learning outcomes.[74] Indeed, strong parent-teacher relationships correlate with parent participation in interventions,[75] suggesting the importance of delivering interventions via practitioners already well-known and trusted by parents.

FOR FURTHER RESEARCH

While findings from research on family math engagement interventions are promising, there are limitations that make these findings difficult to generalize. Examples of limitations include interventions with small (and homogeneous) samples, high reliance on parental self-report, and limited (or no) long-term follow-up. Additionally, often the intervention approaches used in research have required substantial investments of time and/or money. Consequently, moving forward, intervention work needs to address two questions:

- How effective are interventions when implemented at a large scale with high-need families?
- What types of long-term outcomes stem from family engagement interventions?

SECTION 2

INTERVIEWS WITH EDUCATORS AND COMMUNITY-BASED PRACTITIONERS WORKING WITH FAMILIES

In addition to our review of the family math literature, we partnered with individuals engaged in supporting family math through school programs and community-based venues. We reached out to early childhood educators, administrators and site directors, and professionals working with families outside of school settings (e.g., leaders of non-profit, community-based family organizations; media development professionals focused on programming for children and families). We intentionally recruited partners who serve families from varying backgrounds and SES and interviewed them about their perspectives and approaches to family math. While our partners work with families in varying capacities, there were many areas of agreement among those we interviewed. In this section, we present a summary of what practitioners are currently doing to support family math and where they see areas for growth.

Family Math Efforts

We asked practitioners about their experiences working with families, specifically: What have you been doing to support family math engagement? What approaches and strategies have you found effective?

Math needs to be incorporated into what families are already doing. Practitioners expressed a common theme that families are busy and need help to see math opportunities in everyday activities, or to recognize the math they are already doing. For example, one practitioner suggested parents could talk about the numbers on their cell phones and help their children match them to numbers they see in their environment.

School-based events are a common approach. Many practitioners—even some not working in a school—identified schools as an opportune setting to promote family math. They described different approaches, including sending home activities tied to classroom math content and sending home "math kits" with manipulatives and other materials accompanied by suggested family activities. Additional approaches include parent engagement events or family math nights with either educational sessions for caregivers or guided activities for families. As noted in the Places for Growth section below, however, turnout is sometimes limited, and families who do attend may be those most likely to engage in math without extra prompting.

We need to take advantage of opportunities to meet with families where they already are beyond school. Several practitioners noted that there are opportunities to reach families outside of school and that these efforts have proven effective. One described a Saturday morning math club for parents and children. Others described connecting with families where they are—community basketball programs, pediatricians' offices,

community-based resource centers, laundromats—and building on existing relationships to help families enhance math in their lives. Such settings provide an opportunity to deliver math resources to families. For instance, some libraries have offered math kits for families to take home. There are also opportunities to bring math into these settings, such as setting up interactive math installations in restaurants or playgrounds.

Taking time to talk with families is critical. Practitioners discussed the value of developing trusting relationships with families, in particular through face-to-face interactions. Doing so provides opportunities to have ongoing conversations about family math. Practitioners are able to learn what families are already doing, hear what particular concerns parents have, and identify the barriers to family math engagement, such as parents' math anxiety or a need to broaden conceptualizations of what early math is.

Families and communities need to be engaged as partners in the process. Practitioners talked about the importance of incorporating parent voices into efforts and decisions surrounding family math. As an example, one practitioner described how they recruited older children and parents to co-construct installations for families with younger children. Engaging the community helps ensure that resources are placed in areas that families actually frequent and in contexts that are meaningful. Similarly, another practitioner discussed the importance of teachers building partnerships with parents and creating an environment that is welcoming for families.

Places for Growth in Family Math Engagement Efforts

We also asked practitioners what they saw as the main areas for growth in family math engagement.

Finding the best ways to connect with families, especially the families who can most benefit from support. Practitioners report encountering obstacles to their goal of ongoing, in-person communication with parents. For example, logistical challenges such as children traveling to and from school by bus, or pick-up/drop-off policies that gather children in a central location can limit practitioners' opportunities for face-to-face contact with parents. Practitioners observed that the parents attending family engagement events are the ones already doing a lot of math at home. Parents with more demands and fewer resources likely need more support yet often have less flexibility to attend school-based events.

Helping promote positive math attitudes among families. Practitioners commented that in some cases attitudes towards math impede family math engagement. First, practitioners noted that negative math experiences and math anxiety might make parents less inclined to engage in math. Second, practitioners expressed that not all parents recognize the value of supporting math learning before elementary school. Third, practitioners described a narrow conceptualization of early math and lack of

understanding of how families can support math development. They want to help families understand that foundational math skills go beyond counting, while also helping them understand what is developmentally appropriate for young children. Some parents have an expectation that math needs to be completed through homework and worksheets. Practitioners found it challenging to help parents identify opportunities for informal math and motivate them to engage in family math when there is not a formal homework assignment.

Supporting equity and social justice. Multiple practitioners expressed concerns that family math strategies need to be inclusive and that in order to achieve this, the field needs to understand what family math looks like in different cultural contexts. Practitioners noted a tendency to dismiss activities as math because they are in a different language or involve an unfamiliar cultural practice, and that broadening educators' perspectives of family math would be advantageous. Exploring how math is talked about in different languages and used in different cultures could provide new classroom strategies and approaches that help children connect. Additionally, one practitioner noted that some of the best resources and community events are costly and might not be accessible to all families, especially the families who could most benefit.

Identifying approaches that help schools and childcare centers implement family math. Parallel to parents and families feeling they have too much on their plates, teachers and administrators often expressed having many commitments. This busyness can be a barrier to schools participating in family engagement programs or events aimed at increasing family math. Practitioners expressed a need to identify new approaches to creating events that work for both schools and families.

Recognizing that supporting family math does not have a one-size-fits-all solution. Practitioners discussed the importance of considering individual families' needs and contexts. Not all families have the same strengths or challenges, and supports need to be adaptable to address diverse needs. Similarly, one practitioner pointed out that different settings (e.g., school vs. center-based care vs. home-based care) may need to take different approaches to supporting family math.

SECTION 3 SUMMARY OF FINDINGS

In this section we identify commonalities and disparities between research findings and perspectives expressed by practitioners in the fields of education and family engagement. Together, these commonalities and differences highlight areas of strength in the field of family math, as well as critical areas for future focus.

There is a consensus that family math needs to go beyond counting and number. In line with research highlighting the importance of supporting broad mathematical skills including spatial reasoning and patterning, practitioners also recognized the need to support young children's math beyond basic numerical skills. Despite this shared recognition, research on family math engagement has primarily focused on numeracy. Practitioners note a similar need to help families broaden their conceptualization of early math.

Both research and practice highlight the need to address families' attitudes and beliefs about math. Parents' attitudes and expectations about math are some of the strongest and most consistent family-related predictors of children's math achievement. Critically, practitioners conveyed that parents' attitudes, particularly their own negative experiences and anxiety about math, are often barriers to family math engagement. To date, interventions reported in research studies, as well as programs and strategies described by practitioners, have often emphasized increasing the frequency of family math engagement with less of a focus on addressing families' attitudes.

Families who could most benefit from support are often underserved. Research suggests that parents' math attitudes and expectations, limited time and resources, and language are linked to lower child achievement. Consequently, family math engagement efforts may be most beneficial for families with lower levels of income and education, high levels of math anxiety, and those who are English-language learners. Yet, as noted by practitioners, these characteristics may also contribute to families being harder to reach. For instance, families with high levels of math anxiety may be more resistant to participating in math events. Limited resources or language barriers may also interfere with families' school or community involvement.

Research and practice reflect the importance of recognizing sociocultural differences in how families engage in math. Studies have revealed differences in the contexts and manners in which families from diverse sociocultural backgrounds engage in math. Educators and community-based practitioners also noted the value in respecting and building on how different cultures engage in math. Practitioners also emphasized that diverse contexts and challenges mean that there is likely not a single approach to supporting family math that can be easily applied in all situations.

Research examining interventions, however, has not always incorporated contextual considerations.

Research-based support for structured math activities and practitioners' recommendation for embedding math into everyday life can be reconciled. Research indicates that parent reports of formal math teaching activities, where children's math learning is the central focus, are more consistently associated with math achievement than reports of informal, embedded math activities. Practitioners, on the other hand, emphasize the importance of helping families recognize opportunities to incorporate math into their everyday life. The rationale for promoting informal math is that families are overwhelmed and need to be able to build math into their existing routines. It is possible, however, that practitioners could help parents include elements of structured math activities in informal activities.

Research on family math interventions is in its infancy and has yet to address some challenges practitioners describe. The field of family math intervention so far has focused on examining different approaches among relatively accessible groups of families. The work is only beginning to consider practical challenges such as how to reach families who can benefit most from these interventions. Further, intervention studies have yet to fully explore sustainability or scalability of the interventions. Many successful educational interventions in family engagement rely on researchers and teachers providing extensive time and support to parents throughout the process, which may not be feasible on a large scale or long-term. Additionally, parents are frequently asked to commit to engaging in the intervention for specified periods of time (e.g. 10-15 minutes, 4 times a week over the course of 7 weeks), but it is unclear how parents can sustain these commitments in the long term.

SECTION 4 RECOMMENDATIONS

In this section we build on the existing knowledge and successes in the field of family math to present recommendations focused on concrete areas for improvement and change. We organized the recommendations by policy, practice, and research. However, implementation efforts will be most effective through interdisciplinary collaborations among stakeholders involved in family math.

POLICY

- Expand non-school-based efforts; provide funding to integrate math into community spaces (like museums, libraries, and grocery stores) and connect families with community resources. Engage and partner with individuals already involved in community and connected to families.
- Incorporate family math into early math curricula to support early educators in promoting family engagement by 1) emphasizing early math skills that predict later achievement; and 2) ensuring alignment between the math concepts learned in school and at home.
- Ensure that work is implemented at the local level to reflect family and community context. What are the shared cultural practices or community settings that can be utilized to promote family math? What are the unique needs to consider, such as languages spoken, or types of resources that are limited? How can supports or resources be adapted to fit the cultural contexts and values of families in the area?
- Develop avenues such as online platforms, workshops, or conferences for those involved in family math to share ideas.
- Create initiatives for new resources to be accessible for diverse families. Situate no- or low-cost family math events or installations in underserved communities. Consider opportunities to enlist the support of local organizations or businesses.
- Include family engagement in professional development to help practitioners view parents as partners in education, in order to engage and empower families.

EXPAND
non-school-based efforts

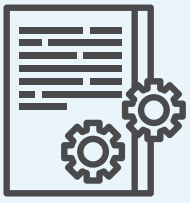
INCORPORATE
family math into early math curricula

IMPLEMENT
local efforts tailored to communities

PROMOTE
pathways to share ideas

ENSURE
resources are accessible

INCORPORATE
family engagement into professional development

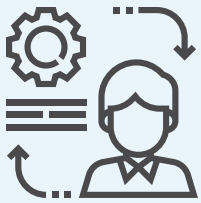


PRACTICE

- Help families recognize that math is more than counting. Provide guided activities on other aspects of math and help parents see why they are important. Help parents understand how to engage young children in developmentally-appropriate ways.
- Build on parents' high expectations and beliefs about the importance of math: make connections between early math experiences and children's later school success.
- When emphasizing math engagement in everyday, routine activities, provide examples of how to do so for children of all ages. Encourage families to find the math in what they are already doing.
- Point out math opportunities in play and book reading that parents engage in with children. Identify apps and web-based resources that can give parents ideas for how to talk about math, such as Bedtime Math, and how to select high-quality media.

EMPHASIZE
math is more than counting

BUILD
on high expectations



ENCOURAGE
math in families' everyday routines

POINT OUT
math in play and book reading

MAKE
adult-only events engaging and low-pressure

SUPPORT
parent-to-parent family math outreach

- Develop adult-only events that provide engaging opportunities to try out math activities in a low-pressure, distraction-free setting. Ensure that parents are able to attend by providing separate, simultaneous activities for children.
- Connect with other community-based partners to maximize the reach of family math events, drawing on the distinct resources of schools and community settings, such as community centers hosting and promoting events organized by schools.
- Implement strategies for parent peer-to-peer outreach, such as parent ambassadors, to broaden school-to-home communication strategies and reach more families. Collaborate with parents and family members to develop culturally-responsive and relevant events and resources.

RESEARCH

- Include more heterogeneous families in both exploratory studies and intervention studies to expand knowledge beyond highly-educated, middle class White families. This will provide critical information about how to support family math engagement across a wide range of life circumstances and cultural differences.
- Utilize open-ended methodologies to examine children's opportunities to participate in family- or community-centered math activities in addition to child-centered activities. Consider work focusing on particular communities or cultural contexts to focus on developing asset-based models of family engagement and ensure that comparative studies do not frame differences as deficits.
- Build on research indicating that culture and SES have qualitative impacts on parents' school involvement. Consider how context may impact the best ways to reach and connect with families, including examining potential pathways for reaching families outside of school.

ENSURE
research samples are representative and inclusive

DEVELOP
asset-based family engagement models

EVALUATE
approaches to reach families beyond school

ADDRESS
attitudes as part of intervention work

EXAMINE
sustainability and generalizability of interventions

EXPLORE
aspects of math that are most critical and feasible to target

- Since expectations and attitudes are some of the most robust predictors of math achievement, research should examine the impact of interventions on these aspects of family math. Approaches should attempt to address math attitudes and beliefs directly, or indirectly through interventions aimed at increasing the quantity or quality of family math engagement.
- Conduct studies that evaluate the long-term outcomes and sustainability of family math interventions, as well as the feasibility of implementing programs on a large scale. Examine how to design interventions that are flexible in building on the strengths of diverse families.
- Continue to examine the characteristics of family math engagement that are most predictive of children's math learning, and whether these vary across sociocultural contexts. Research has often linked formal math activities—where children's math learning is the focal point of the activity—to math achievement. In order to identify general principles across diverse family contexts, it is critical to examine what features of these activities or family practices during these activities most effectively support children's learning.

CLOSING COMMENTS

The field of family math has seen notable growth in recent years, and research has identified key elements of early math learning and family engagement that show promise for promoting later math achievement. Further, research shows that family math engagement has the potential to be enhanced, with supports such as books, games, and apps increasing families' conversations about math and learning. Family math is also receiving more attention in practice; schools and communities are increasingly working to promote early family engagement through resources and events for parents and families. In particular, practitioners show increased awareness of the need to use a strength-based approach and be responsive to families' diverse cultural and socioeconomic backgrounds when working with families in supporting young children's math learning. Two other areas of need are addressing families' math attitudes, which are strongly linked to children's early math, and increasing the reach of family math supports to underserved families. By expanding consideration of cultural context and accessibility as part of research and community efforts, and by enlisting families to provide input early and often, we can advance our understanding of best practices for empowering families to engage in early math in ways that are meaningful, enjoyable, and promote equity in math achievement.

Endnotes

1 Duncan et al., 2007; Watts, Duncan, Siegler, & Davis-Kean, 2014
2 Duncan et al., 2007
3 Our group developed this definition based on wording originally proposed by the Family Math Roadmap Project, a collaborative effort to advance family engagement in math: https://education-first.com/familymath/
4 Duncan et al., 2007; Watts, Duncan, Siegler, & Davis-Kean, 2014
5 Geary & vanMarle, 2018; Geary et al., 2018
6 Clarke & Shinn, 2004; Purpura, Baroody, & Lonigan, 2013
7 Schneider et al., 2017, 2018; Siegler, 2016; Spaepen et al., 2018
8 Cheng & Mix, 2014; Lachance & Mazzocco, 2006; Verdine, Irwin, Golinkoff, & Hirsh-Pasek, 2014
9 Rittle-Johnson, Fyfe, Hofer, & Farran, 2017; Rittle-Johnson, Zippert, & Boice, 2018
10 Jordan & Levine, 2009; Larson, Russ, Nelson, Olson, & Halfon, 2015
11 Clements & Sarama, 2007; Dyson, Jordan, & Glutting, 2013; Jordan, Huttenlocher, & Levine, 1992; Scalise, Daubert & Ramani, 2017; Siegler, 2009
12 Bull & Lee, 2014; Clark, Pritchard, & Woodward, 2010
13 Daubert & Ramani, 2019; Sarnecka, Negen, & Goldman, 2018
14 Hutchison, Lyons, & Ansari, 2019; Hyde, 2005; Lachance & Mazzocco, 2006
15 Levine, Foley, Lourenco, Erlich, & Ratliff, 2016
16 e.g., Aunola et al., 2003; Kleemans et al., 2012
17 e.g., Entwistle & Alexander, 1996; Galindo & Sonnenschein, 2015; Tan et al., 2017
18 e.g., del Rio et al., 2017; Skwarchuk et al., 2014
19 e.g., Aunola et al., 2013; Lee & Kim, 2016
20 Vukovic et al., 2013
21 e.g., Lombardi et al., 2017; Pruden et al., 2011
22 Levine et al., 2010
23 Elliott et al., 2017; Gunderson & Levine, 2011; Ramani et al., 2015
24 Casey et al., 2016; Leyva et al., 2017; Mutaf Yildiz et al., 2018b
25 Levine et al., 2010; Susperreguy & Davis-Kean, 2016
26 e.g., Harris et al, 2014; Napoli & Purpura, 2018; Segers et al., 2015
27 e.g., Casey et al., 2014; Jirout & Newcombe, 2015; Levine et al., 2012
28 e.g., Anders et al., 2012
29 e.g., Dearing et al., 2012; Niklas & Schneider, 2013
30 Huang et al., 2017; Mutaf-Yildez et al., 2018a
31 e.g., Huntsinger et al., 2016; LeFevre et al., 2010; Ramani et al., 2015; Skwarchuk et al. 2014; Thompson et al., 2017
32 e.g., Ramani et al., 2015; Sonnenschein et al., 2016; Thompson et al., 2017
33 e.g., McDonnall et al., 2012; Silinskas et al., 2015
34 Maloney et al., 2015
35 e.g., Bryce et al., 2018; Greenman et al., 2011; Park & Holloway, 2017
36 e.g., Chang et al., 2015; Cooper et al., 2010; Hill & Craft, 2003
37 e.g., Gonzalez & Jackson, 2013
38 e.g., Assel et al., 2003; Cabrera et al., 2017; Crosnoe et al., 2010; Galindo & Sonnenschein, 2015; Melhuish, Phan et al., 2008; Melhuish, Sylva et al., 2008.
39 e.g., Cheng & Mix, 2014; Levine et al. 2012; Rittle-Johnson, Fyfe, Hofer, & Farran, 2016
40 e.g., Skwarchuk et al., 2014
41 e.g., Daubert et al., 2018; Eason & Ramani, 2020; Levine et al., 2010; Leyva et al., 2017
42 Gunderson & Levine, 2011; Ramani et al., 2015
43 e.g., LeFevre et al., 2009
44 Cannon & Ginsberg
45 e.g., Drummond & Stipek, 2004
46 e.g., Chang et al., 2015; Cheadle, 2008; Sonnenschein & Galindo, 2015
47 e.g., Gibbs et al., 2016; Gonzalez & Jackson, 2013; Sonnenschein & Galindo, 2015
48 e.g., Galindo et al., 2019
49 e.g., LeFevre et al., 2010; Sonnenschein et al., 2016
50 e.g., del Rio et al., 2017; Skwarchuk et al., 2014
51 del Rio et al., 2017; Berkowitz, Gibson & Levine, under review
52 Hart et al., 2016
53 e.g., Saxe et al., 1987
54 del Rio et al., 2017; Silinskas et al., 2010
55 Greenman et al., 2011
56 e.g., Ramani et al., 2015
57 Lave & Wenger, 1991
58 U.S. Department of Education. Institute of Education Sciences, National Center for Education Statistics (2018).
59 Early et al., 2010; Piasta et al., 2014
60 Hendershot et al., 2016
61 Gibson et al., 2015; Purpura et al., 2019; Purpura et al., 2017
62 Cooper et al., 2010
63 Lin et al., 2019
64 Sheldon & Epstein, 2005
65 Hirshberg et al., 2005
66 Hirshberg et al., 2005
67 Broberg et al., 1997; Claessens, 2012; Samiei et al., 2016
68 Dearing et al., 2009
69 Braham et al., 2018; Cooper, 2011; Hanner et al., 2019; Marcus et al., 2017; Vandermaas-Peeler et al., 2016
70 e.g., Boriello & Liben, 2018
71 Braham et al., 2018; Haden et al., 2014; Polinsky et al., 2017
72 e.g., Dulay et al., 2019; Kritzer & Pagliaro, 2013; Niklas et al., 2016
73 Berkowitz et al., 2015; Schaeffer et al., 2018
74 Hendrie et al., 2012; Kupzyk & Daly, 2017
75 Mendez, 2010

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Reviewing the Family Math Literature

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