LEARNING TO PARENT MATHEMATICALLY: CRITICAL FACTORS IN PARENT-CHILD MATH ENGAGEMENT

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Dramatic differences in children's math knowledge at school entry are thought to originate in the Home Math Environment (HME), where parents and caregivers are the primary provider of experiences that influence children's early math knowledge development. Little is known about what informs parent decision-making around "mathematical parenting" (i.e., parents' cognitions, motivations, and behaviors that impact and influence child math development in the HME). This study uses the RESET Framework and survey instrument to investigate parents' mathematical parenting perceptions (n = 847) across the domains of Role, Expectations, Skills, Efficacy, and Time. Parent self-reports of early childhood math knowledge and of shared math activity are also examined to shed light on the factors that influence mathematical parenting of 4-5-year-old children in the home.

Keywords: early childhood mathematics, home math environment, family engagement, early numeracy, parent involvement

Strong performance in mathematics is associated with higher performance in school and success beyond school (Ritchie & Bates, 2013; Schweinhart et al., 2005), yet standardized assessments of achievement continue to show that more than two-thirds of children struggle to demonstrate grade-level proficiency in mathematics (deBrey et al., 2019). With insufficient exposure to early mathematics knowledge prior to schooling, young children may find it difficult to learn and master key early mathematics competencies required to establish the strong numeracy foundation needed to effectively engage in later mathematics learning in elementary school and beyond (Claessens & Engel, 2013; Nguyen et al., 2016). To engage all students in learning mathematics throughout their K-12 journey and beyond, it is important to examine how learner variability at the onset of schooling can be accounted for and addressed. Learner variability prior to pre-kindergarten or kindergarten is believed to originate with differences in the Home Math Environment (HME), in which parents play a primary role in helping children to develop early math knowledge and skills (Cankaya & LeFevre, 2016; Daucort et al., 2023; Napoli & Purpura, 2018).

Parents are often their children's first teachers: they provide not only for their child's basic needs, but as more knowledgeable others, they also stimulate their child's cognitive development and lead their thinking and learning across many areas, including mathematics (Blevins-Knabe, 2016; Vygotsky, 1986). However, limited research has examined parent motivations and decision-making related to the HME, and little is known about how parents learn to do the work of "mathematical parenting" – i.e., the cognitions, utterances, behaviors, and practices of parents that influence the development of their children's math understanding, knowledge, and skills. Parents differ greatly in their mathematical parenting ability and knowledge, stemming from their differing perceptions of the role they should play in their children's mathematics development, their wide-ranging expectations for their children's math learning, their perceptions of their own math skills and efficacy in helping their children learn math, and their perceptions about the availability of time and energy to engage mathematically with their children (Betts, 2021; Betts & Son, 2022).

The purpose of present study is to examine parents' perceptions across the domains of Role, Expectations, Skills, Efficacy, and Time (i.e., the RESET Framework), and how these areas may interact with other areas of mathematical parenting, such as parent knowledge of appropriate early childhood mathematics knowledge and skills, and reports of shared parent-child math activity in the home. Better understanding of the factors that influence mathematical parenting and decision-making in the HME has the potential to not only increase our understanding of the home environment may drive early development of mathematics knowledge, but also help stakeholders better understand how partnerships between schools and communities may be built to support children's engagement in math learning.

Theoretical Framework

This study is grounded in theoretical frameworks of Vygotsky, Mowder, and Bronfenbrenner. Vygotsky's (1986) social-cultural theory of learning and the importance of the *more knowledgeable other* describe the essential role parents play in guiding and leading their child's learning beyond what the child can learn on their own. To effectively guide and lead the child's learning, parents must know what they are leading the child toward. They must have some sense of what expectations are appropriate for the child at any given developmental level, in addition to having a sense of their own role in that development, along with the knowledge, confidence, and time to engage in such guidance. Despite the importance of the parent-child learning dynamic, parents often report feeling lost when it comes to supporting their children's early math development (Betts, 2021; Blevins-Knabe, 2016; Clements & Sarama, 2014).

Mowder's (2005) parent development theory posits that individuals learn to parent as a result of one's own experiences, combined with one's personality, education, and other factors. Similarly, Bronfenbrenner's (1992) ecological systems theory of development describes the individual at the center of successively expanding layers of influence, both proximal (e.g., family and friends) and distal (e.g., society, government, etc.), which impact the formation of that individual's identities and beliefs, including mathematical parenting.

Grounded in these theories, the RESET framework was designed to better understand the relationships between parents' perceptions about math and their mathematical parenting practices (Betts, 2021; Betts & Son, 2022). As shown in Table 1, the dimensions of the framework describe parent or caregiver perceptions of their ***Role*** in mathematical parenting, their ***Expectations*** for their child's math learning, their perception of their own math ***Skills***, their sense of self-***Efficacy***, and their perceived ***Time*** and energy available to support their child's development of math knowledge and skills.

Table 2: RESET domains as related to mathematical parenting in early childhood

RESET Framework Domain Descriptions

R (Role)	A parent's construction of their parental role is shaped by their early experiences in learning math, the ways in which they were parented, values and beliefs related to education, and other peer and societal or cultural influences. A parent's role is socially constructed and may change in response to changing social conditions, parent efforts and education (e.g., parent education or intervention programs, or even the child themselves), or the accumulation of life experiences.
E (Expectations)	The parent's expectations for the child's performance or development in mathematics is influenced by the value that the parent places on the learning of mathematics, its perceived role in the life of the parent and child, its perceived impact on the future success of the child, and the parent's knowledge and awareness of the mathematics concepts and skills appropriate for the child's age and developmental level.
S (Skills)	Parents' perceptions of their own mathematics skills and knowledge impact the ways in which they choose to interact with their children through mathematics, the types of skills and concepts they emphasize, and the expectations they have for their children's math development (e.g., if a parent feels like his or her life opportunities were limited because of weak math skills, they may conversely adopt higher expectations for their child's math learning in order to ensure the child is not limited by lack of math knowledge and skills).
E (Efficacy)	Parents' sense of self-efficacy is related to their belief in their ability to successfully support the math development of their child. It is influenced by their perceptions of math skills and knowledge, and influences their expectations for their child's math learning, as well as the ways in which they engage their child in mathematics activities.
T (Time)	Parent engagement in shared math activity is influenced by their perceptions of the time and energy available to participate. Further, parent perceptions of time and energy may be impacted by parents' perceived skills and knowledge and personal sense of self-efficacy. For example, more time and energy may be required from parents with low self-efficacy to engage meaningfully with their children through mathematics (more time to prepare in order to feel confident and comfortable, more anxiety that saps energy, etc.).

Methodology

The RESET survey instrument (see Betts, 2021 and Betts & Son, 2022) was used to gather data on the perceptions of 847 parents of 4-to-5-year-old children who had not yet started kindergarten. The research questions guiding the study are: (1) how do parents perceive themselves in terms of their Role, Expectations, Skills, Efficacy, and Time (RESET) as they relate to supporting their children's development of early math skills, (2) how do parents' perceptions across RESET domains relate to their knowledge of early childhood math skills, and (3) how do parents' perceptions across RESET domains relate to their reports of shared parent-child math engagement?

Participants

Participants from across the United States were recruited and screened by Innovate MR, a commercial panel provider, using various recruitment sources (e.g., nationwide database of volunteers for survey research, large-scale advertising networks, and mail and media advertisements, etc.). Participants were mothers (n = 626), fathers (n = 210), and non cis-identifying parents (n = 11), and represented a diverse set of ethnic (Caucasian 70%, African

American 10%, Multiracial, 9%, Latinx 7%, Asian 3%, Indigenous 1%), income (over 100K annually 19%, from 50K-100K annually 46%, less than 50K annually 35%), and educational (Undergrad/Graduate degree 34%, some college 29%, HS grad/trade/tech school 37%) backgrounds.

Instruments and procedures

The survey instrument included items related to parent perceptions along the RESET domains, parent knowledge of early childhood mathematics, and parent self-reports of the frequency with which they engage in various types of shared math activities in the home environment. Six items per domain were included in the survey, which had been tested previously and found to be reliable with alphas all above .700 (see Table 2). Parents were asked to indicate their agreement with the item (statement) using a 7-point Likert Scale ranging from *Strongly Disagree* to *Strongly Agree*. Parents were also asked to evaluate when certain common early math concepts and skills should be learned (e.g., prior to kindergarten or after, etc.), and to report on how frequently they and their child engaged in a variety of common math activities in the home (e.g., *never, monthly, weekly, daily*).

Results

Parent perceptions on RESET

Table 2 shows simple descriptive statistics that describe how parents perceived themselves across the five RESET domains. Parent responses on domain Likert items were combined to create mean scores for each domain (e.g., Role Mean of 5.67, etc.). These domain means acted as proxies for the degree to which parents experienced higher or lower perceptions of themselves across the five RESET domains, with higher means indicating more positive perceptions, and lower means indicating more negative perceptions. In general, parents expressed higher perceptions of Role (M = 5.66, SD = .87) and Expectations (M = 5.76, SD = .84), and lower perceptions of Skills (M = 4.58, SD = 1.41), Efficacy (M = 5.09, SD = .99), and Time (M = 4.76, SD = 1.06).

Table 3: Descriptive statistics for parent perceptions on RESET (N = 847)

	Role (α = .72)	Expectations (α = .78)	Skills (α = .85)	Efficacy (α = .74)	Time (α = .73)
Mean	5.66	5.76	4.58	5.10	4.67
Median	5.67	5.83	4.67	5.00	4.50
Mode	6.00	6.00	5.00	4.67	4.00
Std. Deviation	.87	.84	1.41	.99	1.06
Variance	.75	.71	2.00	.98	1.13

Separate multiple linear regression analyses were performed to determine relationships between parent Gender, Income, Education level, Ethnicity (independent variables), and parent perceptions along the RESET domain means (dependent variables). Parents of differently identifying gender roles (i.e., mothers, fathers, etc.) demonstrated some differences across the RESET domains, with Mothers expressing significantly higher perceptions of their Role in their children’s math learning (β = 0.07, p = 0.03). When compared to Mothers, Fathers expressed significantly higher perceptions of their personal math Skills (β = 0.11, p = 0.001).

Tukey's HSD Test for multiple comparisons revealed a significant difference between Mothers and Fathers in their perceptions of Role ($p = 0.012$, 95% CI = [0.03, 0.36]), with Mothers having higher perceptions of their Role in their children's math learning. Conversely, Fathers demonstrated significantly higher perceptions of their math Skills ($p < 0.001$, 95% CI = [0.36, 0.88]), and self-Efficacy ($p = 0.0$, 95% CI = [-0.01, 0.36]) than Mothers when engaging in mathematical parenting. Non-cisgender identifying parents, while too small a group to perform statistical analysis ($n = 11$) trended more with self-identifying mothers than fathers.

Multiple linear regression analyses showed that Income was a significant predictor of positive parent perceptions along three RESET domains: Expectations ($\beta = 0.09$, $p = 0.03$), Skills ($\beta = 0.12$, $p = 0.001$), and Efficacy ($\beta = 0.08$, $p = 0.05$). However, Income was a significant predictor of *negative* parent perceptions of Role ($\beta = -0.09$, $p = 0.03$). In other words, parents with higher incomes had lower perceptions of their Role. Additionally, Parents' Education level was a significant predictor of positive parent perceptions in Expectations ($\beta = 0.14$, $p < 0.001$), Skills ($\beta = 0.14$, $p < 0.001$), and Efficacy ($\beta = 0.11$, $p = 0.003$) domains. Parents with more education tended to have higher expectations for their child's learning and more positive perceptions of their own math skills and self-efficacy. No significant differences were observed on the RESET domains across Ethnicity; parents did not differ significantly along the Time domain.

RESET and Parent ECE Math Knowledge

Parent understanding of early math skills may have important implications for their math parenting, since poor understanding of early math learning and how to support it may lead to insufficient support or expectations. To better understand parent knowledge of early math skills, parents were presented with 10 early math skills and asked to indicate when they believed the target skill should be learned (see Table 3). The 10 early math skills presented to parents on the RESET survey all appear in various preschool skills frameworks including those from New Jersey, New York, and California and were considered appropriate for children to learn before beginning kindergarten. During data analysis, parent responses were categorized as (1) before beginning preschool, (2) in preschool/pre-k, (3) in kindergarten or beyond. Additionally, the skills presented were categorized as either Simple Number Skills or as Advanced Number Skills, since early mastery of Advanced Number Skills is more closely associated with later mathematics achievement in school and beyond (Nguyen et al., 2016).

Table 4: Simple and Advanced Number Skills

Level of Rigor	Early Childhood Math Items used on the survey
Simple Number Skills (SNS)	• *Say the number names in order from 1 to 10* • *Recognize written numbers 1 to 10* • *Say the names of numbers in order when counting a group of up to 10 things (like when counting toys, 1...2...3...4... etc.)* • *Recognize or make simple patterns (e.g., red, yellow, red, yellow)* • *Tell how many there are "in all" when counting a group of up to 10 items*
Advanced Number Skills (ANS)	• *Recognize / create more advanced patterns (e.g., blue, blue, green, blue, blue, green)* • *Say the number names in order from 10 to 20* • *Count two different groups of things and say how many there are all together ("this group has 3, and this group has 5, that's 8 all together")*

- *Correctly say the number names backwards from 10 to 1*
- *Start counting forward from a number that isn't the number one. For example, start at 6... then 7...8....9...10 etc.*

Separate multiple linear regression analyses were performed to identify relationships between parent perceptions along the RESET domains (dependent variables) and parent knowledge of early childhood math skills (independent variables). Both Expectations ($\beta = 0.31$, $p < 0.001$) and Time ($\beta = 0.28$, $p < 0.001$) domains were significant predictors of parent knowledge of Simple Number Skills (SNS) as appropriately learned before kindergarten. In other words, parents with higher perceptions of Expectations and more Time available seemed to have more accurate knowledge of SNS as appropriate for children to engage in prior to kindergarten. Regarding parent knowledge of the more Advanced Number Skills (ANS), parent perceptions of Role ($\beta = 0.14$, $p = 0.003$), higher Expectations ($\beta = 0.15$, $p < 0.001$), and higher perceptions of Time ($\beta = 0.104$, $p < 0.03$) available significantly predicted parent knowledge of ANS as appropriately learned prior to kindergarten.

RESET and Shared Math Activity

For math activity in the home, parents were presented with 12 different items describing common parent-child shared math activities. Parents were asked to indicate the frequency with which they engaged in the presented activities. Responses were categorized as: (1) never, (2) monthly, (3) weekly, or (4) daily. During data analysis, activities were further categorized as Formal/Informal, Explicit/Implicit, or Simple/Advanced (see Table 4).

Table 5: Types of activity categories based on items presented on the survey

Category	Description	Sample Survey Item
Formal	Activities consistent with traditional learning approaches found in school such as workbooks, worksheets, flashcards, etc.	*"We do flashcards together to help my child learn the names of numbers."*
Informal	Spontaneous or impromptu activities involving authentic integration of number concepts and skills within natural life activities.	*"We use our everyday activities to do addition problems (example: I have 4 toys and you have 2... how many do we have all together?)."*
Explicit	Activities whose specific purpose is to teach, practice, or reinforce math concepts or skills.	*"I help my child practice math skills using digital learning apps on our smart phone or tablet."*
Implicit	Activities whose specific purpose is something other than to teach, practice or reinforce math concepts or skills and involve math concepts and skills as part of the activity.	*"We play board games and count out the spaces one by one when moving the game piece."*
Simple	Activities focused on the simple number skills of count sequence, cardinality to ten, and numeral recognition to ten.	*"We use our everyday activities to practice counting up to 10 things together (like fingers, toys, snacks, or other things)."*

Advanced	Activities focused on more advanced number knowledge (e.g., 1:1 correspondence and cardinality beyond ten, concepts of addition and/or subtraction, comparing quantities, and patterns).	*"I help my child notice when one group of things has more (or less) than another group of things (for example, there are 5 trucks and 2 cars - there are more trucks than cars)."*

Once again, separate multiple linear regression analyses were conducted to examine relationships between RESET domain means (dependent variables) and parent self-reports of shared math activity in the home (independent variables). Both the Expectations ($\beta = 0.33$, $p < 0.001$) and Time ($\beta = 0.29$, $p < 0.001$) domains were significantly related to overall math activity frequency. Parents with higher perceptions of Expectations for their child's math learning and Time available to spend on shared math activity reported more frequent overall math activity engagement. Parent perceptions of Expectations and Time were significantly positively related to all activities ($p < 0.001$), regardless of their categorization (e.g., formal vs. informal, explicit vs. implicit, simple vs. advanced). One unexpected result was that parent perceptions in the Role domain were significantly negatively correlated with reports of Formal activity frequency ($\beta = -0.13$, $p = 0.003$), meaning that parents with higher perceptions of Role in their child's math learning were more likely to report *less* frequent Formal math activity engagement (e.g., workbooks, flashcards, or digital math apps).

Additionally, regression analyses exploring relationships between parent demographics and activity frequency showed that the only significant relationships existed between Parent Gender, Education Level, and Explicit activities: Fathers engaged in less frequent Explicit activity than Mothers ($\beta = - 0.07$, $p = 0.03$), while parents with higher Education levels ($\beta = 0.076$, $p = 0.05$) reported engaging in more frequent Explicit activities.

Discussion & Implications

The RESET framework and its corresponding survey instrument provided effective means for examining parent perceptions around mathematical parenting, and specifically their role in the Home Math Environment. Findings related to Gender Roles pose some interesting considerations for stakeholders, and for teachers and schools who have primarily focused their efforts on working with mothers. Findings suggest that while mothers generally view themselves as having an important Role to play in the early math development of their children, fathers exhibit higher perceptions across the domains of Expectations, Skills, Efficacy, and Time. A potential implication here is that fathers see less of a Role for themselves in the early math learning than mothers do, even though they rate themselves more highly across the other domains. This raises the question of whether educators and schools are conducting adequate outreach to fathers to leverage their high expectations, skills, efficacy, and time available to help when it comes to supporting their children's early math learning (e.g., "Daddy and Me" programs, etc.). There may be opportunities to help fathers see a role for themselves in their children's early math learning and to help them better understand what that role might entail.

More complex questions arise around mothers and their significantly lower self-perceptions of their math skills, efficacy, and time. These results are consistent with prior research on math and gender that show lower perceptions of math skills and efficacy among girls and young women, even though measures of mathematics achievement show no significant gender differences (Else-Quest et al., 2010: Huang, 2013; Perez-Felkner, Nix, & Thomas, 2017). Increasing mothers' self-efficacy presents an enormous challenge that may not be easily met. However, examining ways to better guide the math parenting time and energy of mothers may present a more attainable pathway. Given mothers' perceptions of limited amount of time to engage in active math parenting (e.g., shared math activity), parent engagement programs can do much to ensure that invitations for involvement include accessible activities that parents can easily implement, or that can be conveniently integrated within family routines (Betts, 2021).

The relationships between parents' Income and Education levels on their perceptions along RESET were mostly expected. Research has consistently shown relationships between higher income and education and higher achievement in mathematics (Ritchie & Bates, 2013). Parents of higher income and education that demonstrated significantly higher perceptions of Expectations, Skills, and Efficacy is consistent with that research. However, the somewhat unexpected result that higher parental Income was associated with decreased perceptions of parental Role may suggest that higher income parents—while still maintaining high expectations for their children's early math development—may not view themselves as having a *direct* Role to play in that development (which is how the items are presented). Rather, these parents may use their resources to ensure that their child's math learning needs are met (e.g., through preschool, private daycare, etc.), even if they are not directly or personally meeting them.

The relationship between the domain of Expectations on the RESET framework and parent engagement in math activities is also consistent with prior research (e.g., Missall et al., 2015). Parents' high expectations are associated with their increased involvement in their children's learning (Walker et al., 2005). Additionally, the significant relationships between parents' perceptions of Time available to spend with their child is also not unexpected, as individuals tend to make time for those things they value or for which they have high expectations (Marjoribanks, 1976).

An unexpected finding is the result that parents with higher perceptions of their Role in the math development of their children are less likely to engage in Formal activities such as workbook or flashcard activities. This result, combined with the finding that higher perceptions of Role were also associated with better knowledge of appropriate early childhood math knowledge and skills, and also more strongly associated with parent knowledge of Advanced Number Skills specifically, may indicate that "high Role" parents may be more likely or able to recognize opportunities for informally exploring a variety of math experiences in their everyday activities rather than relying on formal math resources such as workbooks or flashcards. Parents who have less knowledge of which early math skills are appropriate for their child—but recognize that they should be supporting their child's math development in some way—may be more likely to use more formal (i.e., vetted, or trusted) resources to help them.

Limitations and Areas for Future Study

One of the study limitations is that the sample was limited to only English-speaking/reading parents with access to the Internet. Participants were also limited to those within the communications reach of the commercial panel provider. Furthermore, this study relies solely on parent self-reports of their perceptions along RESET, early math knowledge, and shared math activity in the home, which subject them to bias. Future studies should include different groups of parents *and* children and incorporate observations and measures of child math knowledge, allowing for more concrete connections to be made between factors that influence mathematical parenting and the impact of that parenting on child learning and achievement.

Conclusion and Contributions

Though this study reports on early work with the RESET Framework and survey instrument, it represents a significant contribution to the study of the Home Math Environment – a field that has been limited by too few standardized, validated tools and methods. As better tools and methods are developed to study and increase our understanding of the Home Math Environment, so too increases the potential for better parent, family, and community engagement programs that will support children's early development of math knowledge and understanding in the home.

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