

Parents' Approaches to Numeracy Support: What Parents Do is Rarely What They Think is

Most Important

By

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Introduction

Early math knowledge predicts later math achievement, which in turn predicts future academic and life success (Duncan et al., 2007; Watts et al., 2014; Reyna et al., 2009; Rivera-Batiz, 1992). One learning environment important to early math knowledge development is the home math environment (HME). The HME encompasses the math-related activities and interactions children engage in at home, including the math support that parents provide their children through math talk, toys, everyday interactions, and direct instruction. Overall, parents report engaging in home math activities with their preschool children at least once a week on average (Rittle-Johnson & Zippert, 2018; Saxe et al., 1987; Skwarchuk et al., 2014; Sonnenschein et al., 2016). However, little research has examined parents' pedagogical approaches, which we define as the teaching approaches parents use and believe are important for helping their young children learn math at home. Three previous studies have examined parents' pedagogical approach beliefs, and there is some evidence that parents differ in these beliefs based on their socioeconomic status (SES). However, there is no agreed-upon measure across studies and no study has examined pedagogical approach use or how parents' pedagogical approaches relate to their math support. The current study examined parents' pedagogical approach beliefs and how they relate to their pedagogical approach use and frequency of numeracy activities.

Our theoretical framework was Situated Expectancy Value Theory (SEVT; Eccles et al., 1993; Eccles & Wigfield, 2020; Eccles et al., 1983). SEVT posits that the cultural milieu, previous achievement experiences, and parents' beliefs and behavior around the value and expectancies of academic achievement influence the academic socialization that they facilitate for their children. This academic socialization in turn influences their children's perception of

academic experiences, expectancies of success, beliefs, and values and in turn influences their children's academic achievement (Eccles et al., 1993; Eccles & Wigfield, 2020; Eccles et al., 1983).

SEVT applies well to understanding how parents influence their children's math development via the HME. Specifically, parents' beliefs are related to the frequency and complexity of their numeracy support which in turn are related to their child's math knowledge (see Douglas et al., 2021 for a review). For example, parents who believed numeracy skills were more important for their child also reported more frequent and advanced numeracy activities (Skwarchuk et al., 2014) and the same was true for parents who rated their child as having better numeracy skills than their peers (Uscianowski et al., 2020; Zippert & Ramani, 2017; Zippert & Rittle-Johnson, 2020). Additionally, numeracy support has been positively associated with children's early and later math knowledge (Daucourt et al., 2021; Mutaf-Yıldız et al., 2020; Zhang et al., 2020).

The current study focuses on a rarely studied aspect of parents' beliefs and support: pedagogical approach. Four common pedagogical approaches for supporting math learning at home have emerged from research with parents in the United States: 1) incorporating math during daily living experiences, or the "daily living" approach, 2) setting time aside to directly teach math skills, or the "direct teaching" approach, 3) providing math-related toys or activities, or the "give math toys" approach, and 4) incorporating math during activities their child enjoys, or the "during child enjoyment" approach (Cannon & Ginsburg, 2008; Deflorio & Beliakoff, 2015; Sonnenschein et al., 2016). These pedagogical approaches to home math support align with some HME literature which attempts to categorize HME activities as informal or indirect and formal or direct (Skwarchuk et al., 2014, Lefevre et al., 2009). Specifically, the "daily

living”, “give math toys”, and “during child enjoyment” approaches align with the common definition of informal or indirect activities (i.e. activities that support children’s home math learning indirectly, where numeracy is not the purpose of the activity but occurs incidentally). In contrast, the “direct teaching” approach aligns with the definition of formal or direct activities (i.e. activities that support children’s learning directly and intentionally to enhance children’s numeracy knowledge; Skwarchuk et al., 2014). Understanding how parents use and assign value to these pedagogical approaches could be an important part of HME that has been ignored.

Three previous studies have measured parents' *beliefs* about pedagogical approaches, and results about which approach parents believe is most important varied across the studies and the SES background of the parents. In a study with U.S. parents from unknown SES backgrounds, parents were most likely to describe "daily living" or "during child enjoyment" approaches when asked an open-ended question about the best way for their preschool-aged child to learn math at home (Cannon & Ginsburg, 2008). Similarly, in a study with U.S. parents from low and middle-SES backgrounds, parents from middle-SES backgrounds were most likely to choose the "daily living" approach when asked to rank a list of three approaches in order of importance (Deflorio & Beliakoff, 2015). In contrast, in the same study, parents from low-SES backgrounds were most likely to choose the "direct teaching" approach as most important. Similarly, in a study with U.S. parents from low SES backgrounds only, parents were most likely to describe the "direct teaching" approach when asked about the best way to help their child learn to do math (Sonnenschein et al., 2016). Thus, there is some evidence that parents differ in these beliefs based on their SES, with parents from low SES backgrounds believing "direct teaching" is most important and parents from middle or high SES backgrounds believing "during child enjoyment" is most important (Deflorio & Beliakoff, 2015; Sonnenschein et al., 2016). One of the studies

also reported that some beliefs varied with the child's age, with parents of four-year-olds more likely to believe "give math-related toys" was most important than parents of three-year-olds, while their beliefs about the "daily living" and "direct teaching" approaches did not differ by child age (Deflorio & Beliakoff, 2015).

No studies have examined how parents' pedagogical approach beliefs relate to their home math support, including their *use* of general pedagogical approaches. Parents may believe certain pedagogical approaches are best for their child's development but use different approaches most often.

Current Study and Hypotheses

Figure 1 illustrates the specific factors and relations considered in the current study with U.S. parents of children ages 3-4 years. Specifically:

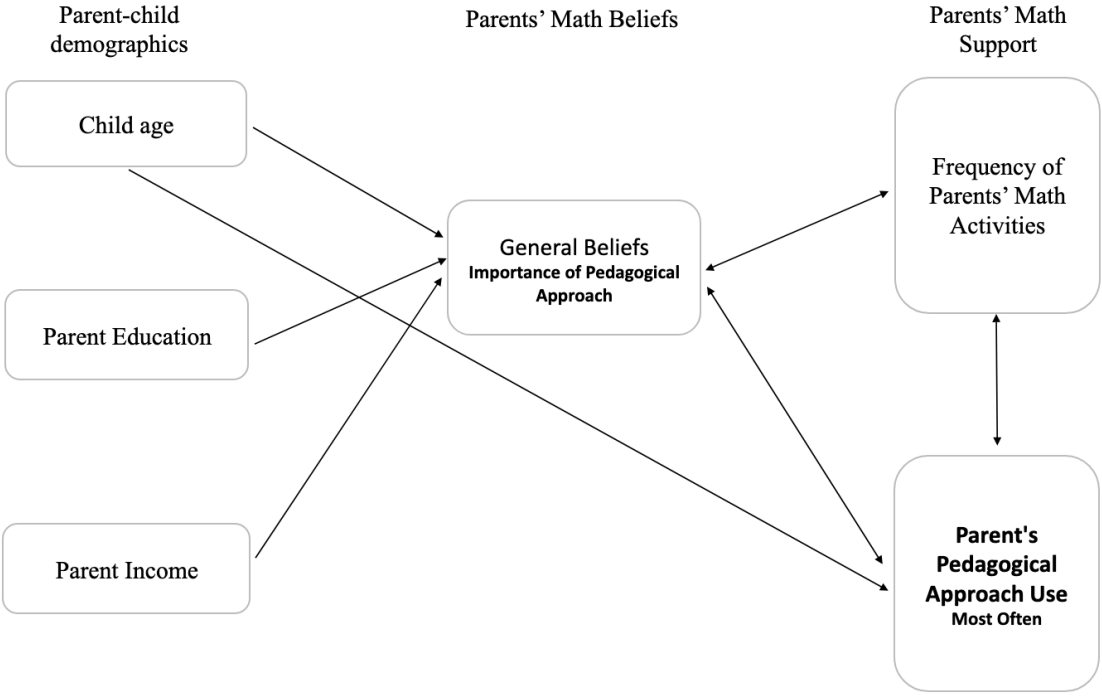
- 1. What pedagogical approach do parents report using most often to help their child learn math at home? Are there differences by child age, parent education, or income?** We hypothesized parents would use one of the more informal approaches (e.g. "daily living", "give math toys", or "during child enjoyment") most often over the more formal approach of "direct teaching" because families engage in informal math activities more often than formal activities at home (Skwarchuk et al., 2014; Susperreguy, et al., 2020, Zippert & Rittle-Johnson, 2018). We explored potential differences by child age, parent education, or income because potential differences exist for related aspects of the HME (Deflorio & Beliakoff, 2015; Thompson, et al, 2017).
- 2. What approach do parents believe is most important for helping their child learn math at home? Are there differences by child age, parent education, or income?** We hypothesized that in our sample of parents who were from predominantly middle and

upper SES backgrounds, “daily living” approaches would be reported as most important on average (Cannon & Ginsburg, 2008; Deflorio & Beliakoff, 2015). We explored potential differences by child age, parent education, or income because one study suggests these potential differences exist (Deflorio & Beliakoff, 2015).

3. Is there a difference between the pedagogical approach(es) parents use most often and believe is most important? We did not have a specific hypothesis.

4. How do parents' pedagogical approach use and beliefs relate to the frequency of numeracy activities they report? We predicted they would be related, but did not have specific hypotheses for how they would be related.

Figure 1.
Integrating Pedagogical Approach Belief and Use Into the Home Math Environment (HME)



Note. The model is a simplified model from the PEMS model (Douglas et al., 2021; Douglas et al.; in prep). Bolded text are new factors added to the model to include pedagogical approach

Method

Participants

Parents were recruited using CloudResearch, an internet-based research platform that integrates with Amazon's crowdsourcing platform Mechanical Turk (MTurk; Litman et al., 2017). Participants were paid \$10 for completing the survey. Participants were 344 U.S. parents of 3- to 4-year-olds (child mean age = 3 years and 10 months, SD = 7.8 months), with almost as many fathers as mothers responding (44% vs. 56%). More parents of boys than girls responded (61% vs. 39%). Most parents reported their race as Caucasian or White (77%). Additionally, 19% of participants identified as Hispanic or Latino. Most parents (72%) reported a household income above \$45,000 and 79% had at least a bachelor's degree as their highest educational attainment. See S1 for distribution by child age, race/ethnicity, income, and education levels.

Measure

Pedagogical Approach Use and Belief

The questions, including the first three approaches provided, were adapted from Deflorio & Beliakoff (2015). A fourth pedagogical approach, "during child enjoyment", was included based on a common open-ended response from two other studies (Cannon & Ginsburg, 2008; Sonnenschein et al., 2016). The first question asked, "Which of the following approaches do you use at home on a regular basis to help your child develop mathematical knowledge and skills?" If a parent selected more than one approach, they automatically received a follow-up question "Which approach do you use most often?" All parents were then asked, "Rank the following approaches from least important (1) to most important (4) in your home." All questions were close-ended and parents were provided four pedagogical approaches (see Full Pedagogical

Approach column in Table 1).

Parent-child numeracy engagement at home

Parents also received a list of 15 home numeracy activities (e.g., “Add simple sums or talk about number facts”) and reported the frequency at which they engaged in each activity from 0 “never” to 5 “daily”. We calculated the average frequency of numeracy activities for each participant by averaging ratings on the items. Parents also reported on 15 patterning activities and 10 spatial activities not analyzed in this paper. The current paper focused on numeracy because numeracy is the most studied and understood component of math in the HME. See S3 for the list of numeracy activities.

Demographics

Each parent reported their race/ethnicity, gender, income, highest educational attainment, child’s age, and child’s gender at the end of the survey.

Results

Pedagogical Approach Use

The majority of parents reported using each of the pedagogical approaches and most parents (88%) reported using more than one pedagogical approach. The “daily living” approach was most frequently selected as the approach they used most often. The "during child enjoyment" approach was least frequently selected. See Table 1 for descriptive statistics for parents’ use and beliefs about the pedagogical approaches. A chi-square difference test indicated no significant difference in parents’ pedagogical approach used most often by child age, $X^2(3, 341) = 7.06, p = .07$. See S4 for descriptive statistics by child age.

Table 2 shows the pedagogical approach used most often by parents’ highest educational attainment and household income category. Chi-square difference tests showed no significant

differences for pedagogical approach use by educational attainment, $X^2(6, 338) = 11.66, p = .07$, or household income, $X^2(6, 338) = 9.72, p = .14$.

Pedagogical Approach Beliefs

As shown in Table 1, and contrary to our hypothesis, parents were most likely to select “direct teaching” as the approach they believed was most important. The other three approaches were selected as most important by a similar proportion of parents. Parents were most likely to select “daily living” as least important. There was no significant difference in pedagogical approach believed to be most important by child age, $X^2(3, 341) = 5.06, p = .17$ or by household income level $X^2(6, 338) = 6.14, p = .41$. Inspection of means in Table 2 suggests that selection of “direct teaching,” “daily living,” and “give math toys” as most important did not vary by parent education level, but that selection of “during child enjoyment” might. A chi-square difference test for pedagogical approach believed to be most important by highest educational attainment suggested there was a difference, $X^2(6, 338) = 13.31, p = .04$. Post hoc comparisons with Bonferroni correction indicated that parents with a bachelor’s degree were more likely to select the “during child enjoyment” approach as most important compared to parents with less than a bachelor’s degree or more than a bachelor’s degree.

Match in Pedagogical Approach Use and Beliefs

Most parents (83%) showed a mismatch in the approach they selected as used most often and as believed to be most important, confirmed with a Chi-Square test of independence, $X^2(9, 335) = 33.16, p < .001$. Post hoc comparisons with Bonferroni correction showed significant differences for the “daily living”, “direct teaching”, and “during child enjoyment” approaches, but no significant difference for the “give math toys” approach (see Table 1, columns 4 and 5).

Table 1*Proportions and Averages for Parents' Pedagogical Approaches Use and Belief*

Pedagogical Approach Name	Full Pedagogical Approach	Proportion Who Used	Average Importance Rank	Proportion Who Used Most Often	Proportion Who Believed Most Important	Proportion Who Believed Least Important
"Daily Living" Approach	I give my child math-related tasks or ask math-related questions during ongoing daily living experiences or routines (e.g., we talk about numbers as we use measuring cups or spoons while preparing food).	.73	2.19	0.45 ^a	0.19	.38
"Direct Teaching" Approach	I set aside time to focus on directly and intentionally teaching my child math skills (e.g., we use a math workbook or math flashcards).	.52	2.77	0.20 ^a	0.38	.21
"Give Math Toys" Approach	I enrich my child's playtime by providing math-related toys and materials that my child uses alone or with other children (e.g., my child spontaneously plays with playing cards or puzzles alone).	.67	2.46	0.19	0.21	.23
"During Child Enjoyment" Approach	I incorporate math during activities that I think my child will enjoy or play math games with my child to engage my child's math interest (e.g., we talk about math while playing board games or watching Sesame Street together).	.55	2.58	0.16 ^a	0.22	.18

Notes.

^aSignificant difference to the proportion who believed this approach was most important.

When participants were asked to rank the approaches they ranked them from Least Important = 1 to Most Important = 4

*** p < .001 ** p < .01 * p < .05

Table 2*Proportion of Parents who selected Pedagogical Approach Most Often and Most Important by Education and Income Level*

	Most Often ^a					X ²	Most Important			
	N	Pedagogical Approach Proportion					Pedagogical Approach Proportion			
		Daily Living	Direct Teaching	Give Math Toys	During Child Enjoyment		Daily Living	Direct Teaching	Give Math Toys	During Child Enjoyment
Highest Education	-	-	-	-	-	11.66	-	-	-	-
< bachelor's degree	73	0.40	0.13	0.21	0.26		0.21	0.40	0.25	0.15
bachelor's degree	189	0.44	0.24	0.19	0.13		0.15	0.38	0.17	0.29 ^a
> bachelor's degree	82	0.52	0.17	0.20	0.11		0.24	0.38	0.24	0.13
Household Income	-	-	-	-	-	9.72	-	-	-	-
< \$45,000	95	0.44	0.24	0.16	0.16		0.22	0.35	0.22	0.21
\$45,000 to \$89,999	140	0.51	0.13	0.19	0.17		0.14	0.45	0.18	0.23
> \$90,000	109	0.38	0.26	0.23	0.13		0.21	0.33	0.23	0.23

Note. ^aBoth parents with less than a bachelor's degree and with more than a bachelor's degree were significantly different from parents with a bachelor's degree, $p < .05$.

*** $p < .001$ ** $p < .01$ * $p < .05$

Relations to Frequency of Numeracy Activities

Parents who reported using “direct teaching” most often reported the highest frequency of numeracy activities. In contrast, parents who reported believing that "during child enjoyment" was most important reported the highest frequency of numeracy activities. See Table 3 for the average frequency of numeracy activities based on the pedagogical approach parents selected as used most often and as most important.

Table 3

Average Frequency of HME Numeracy Activities by Pedagogical Approach Most Often and Most Important

	Most Often	Most Important
	Mean (SD)	Mean(SD)
Daily Living	4.32 (.91) ^a	4.40 (.92)
Direct Teaching	4.70 (.83)	4.25 (.91)
Give math-related toys	4.57 (.90)	4.32 (.88)
During child enjoyment	4.18 (.84) ^a	4.68 (.96) ^a

Notes. Frequency rating scale: 0 = never, 1 = once a month or less, 2 = few times a month, 3 = about once a week, 4 = a few times a week, 5 = daily

^apost hoc test significant difference from direct teaching with Bonferroni correction

We conducted two one-way ANOVAs to test the relation between parents’ pedagogical approach and the frequency of their numeracy support, with pedagogical approach parents used most often or parents believed was most important as the factor and average frequency of home numeracy activities as the dependent variable. There was a significant effect of the pedagogical approach that parents reported using most often on the frequency of numeracy activities, $F(3, 331) = 4.82, p < .01$. A post hoc Bonferroni test confirmed that parents who reported *using* “direct teaching” most often reported engaging in numeracy activities more frequently than

parents who reported the “daily living” or "during child enjoyment" approaches, with no differences between the three informal approaches.

Additionally, there was a significant effect of the pedagogical approach that parents reported as most important on the frequency of their numeracy activities, $F(3,340) = 3.69$, $p = .01$. Specifically, a post hoc Bonferroni test confirmed that parents who believed "during child enjoyment" was most important reported engaging in numeracy activities more frequently than parents who selected “direct teaching” as most important, with no significant differences between the three informal approaches. Overall, use and beliefs about direct instruction had opposite relations with the reported frequency of home numeracy activities.

Discussion

To the best of our knowledge, this was the first study to separately examine parents’ use and beliefs about how to best support their children’s math development at home. We were also the first to analyze how these factors relate to parents’ frequency of HME activities.

Additionally, the current study made an important contribution to research on the HME by surveying both mothers and fathers. The previous three studies on pedagogical approach beliefs were almost exclusively with mothers.

The Disconnect between Pedagogical Approach Use and Beliefs

Contrary to our hypothesis and findings in Deflorio and Beliakoff (2015), parents in the current study, who were predominantly from middle- and high-SES backgrounds, most often selected a “direct teaching” approach as most important to their children’s math learning at home compared to three other, informal approaches. This was more similar to prior findings with low-SES parents (Cannon & Ginsburg 2008; Deflorio & Beliakoff, 2015). We also did not find differences by parents' education level or income in the frequency of selecting “direct teaching”

as most important, contrary to findings in Deflorio & Beliakoff (2015) that parents who were eligible for subsidized preschool were more likely to choose “direct teaching”. At the same time, the combined frequency of selecting any of the three informal pedagogical approaches as most important indicated that parents were more likely to believe an informal approach was more important than a formal, direct teaching approach.

Turning to pedagogical approach use, parents in the current study tended to select the “daily living” approach as the approach they used most often. This finding provides support that pedagogical use is separate from belief. Indeed, parents’ pedagogical approach beliefs did not align with what pedagogical approach they used most often. This mismatch held for individual parents - over 80% of parents did not believe the approach they used most often was most important to their child’s math development at home. This disconnect may have important implications for how to support successful math learning at home. If parents believe a particular approach is most important for their child’s success but are not engaging their child with that approach as often as with other approaches, updating their beliefs about the importance or usefulness of an approach may not change behavior.

Parents’ pedagogical approaches align somewhat with the broader literature on pedagogy in teaching. The “daily living” and "during child enjoyment" approaches share similarities with guided play and guided participation, the “direct teaching” approach shares similarities with direct instruction, and the "give math related-toys" approach shares similarities with play-based and child-initiated play. In this way, pedagogical approaches can be compared and discussed with findings in the teaching literature. In fact, similar to the current study, there is a disconnect between teachers believing children can learn from play but still mostly using direct instruction (e.g., Kim, 2004; Pui-Wah & Stimpson, 2004, Pyle et al., 2018). These parallel pedagogical

disconnects suggest our finding has implications for pedagogical approach beliefs and uses, for, not parents alone but, perhaps all adults who interact with learners. Future research should examine explanations for common threads between these disconnects (e.g. messages schools and society send about direct instruction and perhaps preparation for formal schooling which emphasizes direct teaching, social desirability, and the impact of experience and routine). For example, previous research highlights the impact of additional variables like parent-educator communication on parents' math support (Lin et al., 2019).

Additionally, we did not find a relationship between child age and pedagogical approach use or belief. Although previous literature has examined child age as a factor influencing the HME, Deflorio & Beliakoff (2015) is the only other study so far to examine pedagogical beliefs by child age. They found parents of four-year-olds were more likely to believe “give math-related toys” was most important” than parents of three-year-olds, but beliefs about the “daily living” and “direct teaching” approaches did not differ by child age. Combined with the current study, most pedagogical beliefs do not seem to differ for 3- vs. 4-year-old children.

Overall, the current study found little evidence for SES differences in pedagogical approach use or belief by parent income or education level in the current study. We found parents who believed the "during child enjoyment" was most important were significantly different by educational attainment compared to other parents, but there were no significant differences by education or income for any other belief approaches or pedagogical approach use. Notably, our sample was largely well-educated and middle to high-income which limited our ability to consider SES differences.

Pedagogical Approach and Frequency of Numeracy Activities

The pedagogical approach parents believed was most important related to their frequency

of numeracy activities. Other studies have found parents' frequency of home math activities was related to other parents' beliefs about the value of math, their child's interests, and their own math ability (see Douglas et al. 2021 for a review). Specifically, a few studies found parents' beliefs about the importance of certain numeracy skills were positively related to their frequency of numeracy activities with their child (Musun-Miller & Blevins-Knabe, 1998; Skwarchuk et al., 2014). This finding would suggest parents' pedagogical beliefs, which are about general importance, might also relate to their frequency of numeracy activities, and the results of the current study support this hypothesis.

Although we found an overall relationship between pedagogical approach beliefs and the frequency of numeracy activities, most groups did not differ in the frequency of activities. The only significant difference was that parents who believed the "during child enjoyment" approach was most important reported engaging in more frequent numeracy activities overall than parents who believed in the "direct teaching" approach. For pedagogical approach use, parents who used "direct teaching" most often engaged in *more* numeracy activities than parents who used "during child enjoyment" or parents who used "daily living" most often. Perhaps these opposite effects are further evidence for the disconnect between the use and belief found in our other analyses. If the parents' own approaches they use and believe are not aligning, an opposite effect is not surprising. For direct teaching, specifically, perhaps parents who use direct teaching most often are doing more activities overall. Perhaps, direct instruction by nature takes time which is only possible if you already have extended time to do a large number of activities. On the other hand, direct teaching was the most frequently chosen as most important (38%) so maybe it is the most socially desirable approach. However, it might not be the most realistic approach to engage in every day for some parents (e.g. parents with less time) and so those parents might not be able to

act on their belief about its importance.

Implications

Our results have implications for parental perceptions about the quality of their math support at home. Parents who know their actions to be inconsistent with their beliefs about what is most beneficial may develop self-doubt about the quality of support they are providing to their preschool children. Their beliefs and use of early math support may be shaped by messaging that they receive from media, parent-teacher communication, and other sources around approaches and activities that help their child learn math at home. Our findings also suggest a relationship between approaches and the frequency of activities. Notably, parents' numeracy support differed by both their pedagogical use and beliefs. Current research often relies on the frequency of specific activities to measure the HME. Further research is needed to explore how pedagogical approaches relate to the HME. Specifically, more work is needed on how the four pedagogical approaches align with different types of numeracy activities.

Furthermore, parents' belief that direct instruction was most important to their children's learning at home does not align with beliefs among psychologists that play-based learning is best for preschool-age children (e.g., Hirsch-Pasek et al., 2009; Skene et al., 2022; Weisberg, Hirsh-Pasek; Golinkoff, 2013). Perhaps parents' beliefs are shaped by educational or other resources about formal school readiness where direct instruction is emphasized. At the same time, most parents are using the informal, play-based approaches that psychologists suggest are best for preschool-age children. However, parents' other beliefs are uniquely predictive of the frequency and complexity of the math support parents provide their children at home (e.g., Douglas, 2022). Interventions geared at changing parents' beliefs about the importance of a pedagogical approach may not be enough; parents may not adopt approaches even if they are

convinced that the approach is the most beneficial.

Limitations

One limitation of the current study is it only provides correlational evidence. Another limitation of the current study is that our sample was largely well-educated and middle-income, and only a few parents were on the ends of the economic spectrum, reducing the study's ability to detect income or education-related differences. It is beyond the scope of this project to determine which approaches are optimal, but, if some approaches are actually more beneficial than others, our work has important implications for how to encourage parental use of an optimal approach. More research is needed to understand what frictions prevent parents from acting on their beliefs about what is most beneficial and parents' understanding of and feelings toward this misalignment.

Conclusion

HME research focuses on parents' beliefs and support, but little research has focused on the approaches parents take to supporting their children's math learning at home and our study was the first to examine pedagogical approach use and belief together. We identified a disconnect between parents' pedagogical approach use and beliefs suggesting that the ideas that parents have about what they should do differ from what they are doing. Some pedagogical beliefs and use were related to the frequency of home numeracy activities, specifically finding an opposite relation for use and belief with the frequency of numeracy activities for direct teaching. Overall, there is still much to learn about parents' beliefs about the HME and how researchers can best influence the adoption of beneficial approaches to support children's math development at home.

References

- Cannon, J., & Ginsburg, H. P. (2008). “Doing the Math”: Maternal Beliefs About Early Mathematics Versus Language Learning. *Early Education & Development, 19*(2), 238–260. <https://doi.org/10.1080/10409280801963913>
- Daucourt, M. C., Napoli, A. R., Quinn, J. M., Wood, S. G., & Hart, S. A. (2021). The Home Math Environment and Math Achievement: A Meta-Analysis. *Psychological Bulletin, 147*(6), 565–596. <https://doi.org/10.1037/bul0000330>
- DeFlorio, L., & Beliakoff, A. (2015). Socioeconomic Status and Preschoolers’ Mathematical Knowledge: The Contribution of Home Activities and Parent Beliefs. *Early Education and Development, 26*(3), 319–341. <https://doi.org/10.1080/10409289.2015.968239>
- Douglas, A.-A. L. (2022). *Parental Early Math Support: The Role of Parental Knowledge About Early Math Development* [Thesis]. <https://ir.vanderbilt.edu/handle/1803/17531>
- Douglas, A.-A., Zippert, E. L., & Rittle-Johnson, B. (2021). Chapter Nine - Parents’ numeracy beliefs and their early numeracy support: A synthesis of the literature. In J. J. Lockman (Ed.), *Advances in Child Development and Behavior* (Vol. 61, pp. 279–316). JAI. <https://doi.org/10.1016/bs.acdb.2021.05.003>
- Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., Pagani, L. S., Feinstein, L., Engel, M., Brooks-Gunn, J., Sexton, H., Duckworth, K., & Japel, C. (2007). School readiness and later achievement. *Developmental Psychology, 43*, 1428–1446. <https://doi.org/10.1037/0012-1649.43.6.1428>
- Eccles, J. S., Midgley, C., Wigfield, A., Buchanan, C. M., Reuman, D., Flanagan, C., & Mac Iver, D. (1993). Development during adolescence: The impact of stage-environment fit

- on young adolescents' experiences in schools and in families. *American Psychologist*, 48, 90–101. <https://doi.org/10.1037/0003-066X.48.2.90>
- Eccles, J. S., & Wigfield, A. (2020). From expectancy-value theory to situated expectancy-value theory: A developmental, social cognitive, and sociocultural perspective on motivation. *Contemporary Educational Psychology*, 61, 101859. <https://doi.org/10.1016/j.cedpsych.2020.101859>
- Eccles, J. S., Adler T. F., Goff, S. B., Kaczala, C. M., Meece, J. L., & Midgley, C. (1983). Expectancies, values, and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motivation* (pp. 75–146). W. H. Freeman.
- Hirsh-Pasek, K., Golinkoff, R. M., Berk, L. E., & Singer, D. (2009). *A Mandate for Playful Learning in Preschool: Applying the Scientific Evidence*. Oxford University Press, USA.
- Kim, M. (2004). Teachers' Philosophical Orientation and Practices: A Study of Novice Preschool Teachers in South Korea. *Contemporary Issues in Early Childhood*, 5(3), 276–292.
- LeFevre, J.-A., Skwarchuk, S.-L., Smith-Chant, B. L., Fast, L., Kamawar, D., & Bisanz, J. (2009). Home numeracy experiences and children's math performance in the early school years. *Canadian Journal of Behavioural Science/Revue Canadienne Des Sciences Du Comportement*, 41(2), 55–66. <https://doi.org/10.1037/a0014532>
- Lin, J., Litkowski, E., Schmerold, K., Elicker, J., Schmitt, S. A., & Purpura, D. J. (2019). Parent–Educator Communication Linked to More Frequent Home Learning Activities for Preschoolers. *Child & Youth Care Forum*, 48(5), 757–772. <https://doi.org/10.1007/s10566-019-09505-9>

- Litman, L., Robinson, J., & Abberbock, T. (2017). TurkPrime.com: A versatile crowdsourcing data acquisition platform for the behavioral sciences. *Behavior Research Methods*, 49(2), 433–442. <https://doi.org/10.3758/s13428-016-0727-z>
- Musun-Miller, L., & Blevins-Knabe, B. (1998). Adults' beliefs about children and mathematics: How important is it and how do children learn about it? *Early Development and Parenting*, 7(4), 191–202
[https://doi.org/10.1002/\(SICI\)1099-0917\(199812\)7:4<191::AID-EDP181>3.0.CO;2-I](https://doi.org/10.1002/(SICI)1099-0917(199812)7:4<191::AID-EDP181>3.0.CO;2-I)
- Mutaf-Yıldız, B., Sasanguie, D., De Smedt, B., & Reynvoet, B. (2020). Probing the Relationship Between Home Numeracy and Children's Mathematical Skills: A Systematic Review. *Frontiers in Psychology*, 11, 2074. <https://doi.org/10.3389/fpsyg.2020.02074>
- Pui-Wah, D. C., & Stimpson, P. (2004). Articulating contrasts in kindergarten teachers' implicit knowledge on play-based learning. *International Journal of Educational Research*, 41(4), 339–352. <https://doi.org/10.1016/j.ijer.2005.08.005>
- Pyle, A., DeLuca, C., & Danniels, E. (2017). A scoping review of research on play-based pedagogies in kindergarten education. *Review of Education*, 5(3), 311–351.
<https://doi.org/10.1002/rev3.3097>
- Reyna, V. F., Nelson, W. L., Han, P. K., & Dieckmann, N. F. (2009). How numeracy influences risk comprehension and medical decision making. *Psychological Bulletin*, 135(6), 943–973. <https://doi.org/10.1037/a0017327>
- Rittle-Johnson, Bethany & Zippert, Erica L. (2018). The home math environment: More than numeracy. *Early Childhood Research Quarterly*.

- Rivera-Batiz, F. L. (1992). Quantitative Literacy and the Likelihood of Employment among Young Adults in the United States. *The Journal of Human Resources*, 27(2), 313–328. <https://doi.org/10.2307/145737>
- Saxe, G. B., Guberman, S. R., Gearhart, M., Gelman, R., Massey, C. M., & Rogoff, B. (1987). Social Processes in Early Number Development. *Monographs of the Society for Research in Child Development*, 52(2), i. <https://doi.org/10.2307/1166071>
- Skene, K., O’Farrelly, C. M., Byrne, E. M., Kirby, N., Stevens, E. C., & Ramchandani, P. G. (2022). Can guidance during play enhance children’s learning and development in educational contexts? A systematic review and meta-analysis. *Child Development*, 93(4), 1162–1180. <https://doi.org/10.1111/cdev.13730>
- Skwarchuk, S.-L., Sowinski, C., & LeFevre, J.-A. (2014). Formal and informal home learning activities in relation to children’s early numeracy and literacy skills: The development of a home numeracy model. *Journal of Experimental Child Psychology*, 121, 63–84. <https://doi.org/10.1016/j.jecp.2013.11.006>
- Sonnenschein, S., Metzger, S. R., & Thompson, J. A. (2016). Low-Income Parents’ Socialization of Their Preschoolers’ Early Reading and Math Skills. *Research in Human Development*, 13(3), 207–224. <https://doi.org/10.1080/15427609.2016.1194707>
- Susperreguy, M. I., Douglas, H., Xu, C., Molina-Rojas, N., & LeFevre, J.-A. (2020). Expanding the Home Numeracy Model to Chilean children: Relations among parental expectations, attitudes, activities, and children’s mathematical outcomes. *Early Childhood Research Quarterly*, 50, 16–28. <https://doi.org/10.1016/j.ecresq.2018.06.010>

- Thompson, R. J., Napoli, A. R., & Purpura, D. J. (2017). Age-related differences in the relation between the home numeracy environment and numeracy skills. *Infant and Child Development, 26*(5), e2019. <https://doi.org/10.1002/icd.2019>
- Uscianowski, C., Almeda, Ma. V., & Ginsburg, H. P. (2020). Differences in the complexity of math and literacy questions parents pose during storybook reading. *Early Childhood Research Quarterly, 50*, 40–50. <https://doi.org/10.1016/j.ecresq.2018.07.003>
- Watts, T. W., Duncan, G. J., Siegler, R. S., & Davis-Kean, P. E. (2014). What’s past is prologue: Relations between early mathematics knowledge and high school achievement. *Educational Researcher, 43*, 352–360. <https://doi.org/10.3102/0013189X14553660>
- Weisberg, D. S., Hirsh-Pasek, K., & Golinkoff, R. M. (2013). Guided Play: Where Curricular Goals Meet a Playful Pedagogy. *Mind, Brain, and Education, 7*(2), 104–112. <https://doi.org/10.1111/mbe.12015>
- Zhang, Xiao, Hu, Bi Ying, Zou, Xinzhuo, & Ren, Lixin. (2020). Parent-Child Number Application Activities Predict Children’s Math Trajectories From Preschool to Primary School. *Journal of Educational Psychology*. <https://doi.org/10.1037/edu0000457>
- Zippert, E. L., & Ramani, G. B. (2017). Parents’ Estimations of Preschoolers’ Number Skills Relate to at-Home Number-Related Activity Engagement: Parents’ Estimates of Child’s Number Skills. *Infant and Child Development, 26*(2), e1968. <https://doi.org/10.1002/icd.1968>
- Zippert, E. L., & Rittle-Johnson, B. (2020). The home math environment: More than numeracy. *Early Childhood Research Quarterly, 50*, 4–15. <https://doi.org/10.1016/j.ecresq.2018.07.0>

Appendices

A1

Demographic Statistics

Variable	Proportion	Variable	Proportion
Child Age		Household Income	
3 year old	.52	Less than \$27,000	.07
4 year old	.48	\$27,000 to \$44,999	.20
Race/Ethnicity		\$45,000 to \$89,999	.41
White	.77	\$90,000 to \$134,999	.25
Black	.08	\$135,000 or more	.06
Asian or Pacific Islander	.05	Highest Educational Attainment	
Biracial or Mixed Race	.04	High School Diploma or GED	.05
American Indian or Native	.03	Some college or 2-year degree	.15
Other Race/ethnicity	.02	Bachelors degree	.55
I am unsure or I prefer not to say	.01	Some Graduate work	.03
Identify as Hispanic/Latino	.19	Masters professional or doctoral degree	.21

To have more equal SES groups for data analysis, we collapsed the responses for both SES variables into three more equally-sized groups: less than a bachelor's degree, a bachelor's degree, and more than a bachelor's degree, and less than \$45,000, \$45,000 to \$89,999, and more than \$90,000

A2

Our Pedagogical Approach Measure Compared to Deflorio & Beliakoff (2015)

Questions	Deflorio & Beliakoff (2015)	Our measure
Use Question	“Which of the following approaches do you use at home on a regular basis to help your child develop mathematical knowledge and skills?”	“Which of the following approaches do you use at home on a regular basis to help your child develop mathematical knowledge and skills?”
Most Often Question	NA	If select more than one approach for use question, then ask: “Which approach do you use most often?”
Belief Question	if select more than one approach for use question, then ask: “Rank the approaches you use from most important (1), to less important (2), to least important (3) in your home”	Ask everyone: “Rank the following approaches from least important (1) to most important (4) in your home.”
First Approach	I give my child math-related tasks or ask math-related questions during ongoing domestic routines (e.g., we use measuring cups or spoons while preparing food)	I give my child math-related tasks or ask math-related questions during ongoing daily living experiences or routines (e.g., we talk about numbers as we use measuring cups or spoons while preparing food).
Second Approach	I set aside time to be with my child on a regular basis to help him/her develop cognitive skills (e.g., we look at a number book, play a board game, or use math software together)	I set aside time to focus on directly and intentionally teaching my child math skills (e.g., we use a math workbook or math flashcards).
Third Approach	I enrich my child’s playtime (alone or with other children) by providing math-related toys and materials (e.g., my child spontaneously plays with cards or shape puzzles or watches Sesame Street alone)	I enrich my child’s playtime by providing math-related toys and materials that my child uses alone or with other children (e.g., my child spontaneously plays with playing cards or puzzles alone).
Fourth Approach	N/A	I incorporate math during activities that I think my child will enjoy or play math games with my child to engage my child’s math interest (e.g., we talk about math while playing board games or watching Sesame Street together).

A3

Home Numeracy Activities

Activity	Activity Type
Count Items	Formal
Count out loud without objects	Formal
Talk about written numbers (for example, "That's a 7")	Formal
Add simple sums or talk about number facts (for example, $2+2=4$)	Formal
Practice subtracting items (for example, when playing with 2 toy cars, asking "How many cars will you have if I take away one of your cars?")	Informal
Compare quantities (for example, when playing card games or serving food for dinner or sharing toys)	Informal
Compare written numbers (for example, "5 is bigger than 4")	Formal
Compare the cost of items when shopping (for example, "This milk costs less because it costs \$3 and the other milk costs \$4.")	Informal
Read books that show and talk about numbers (for example, "One Fish, Two Fish", "The Very Hungry Caterpillar")	Informal
Watch TV shows or videos that show and talk about numbers (for example, "Peg + Cat", "Monster Math Squad")	Informal
Play computer games or use apps or interactive websites that include number games (for example, "Elmo Loves 123s", "PBS Kids math games")	Informal
Play board games that involve numbers (for example, "Chutes & Ladders", "Drafts/Checkers", "Ludi/ Ludo", "Dominos")	Informal
Play card games that involve numbers	Informal
Play hand or movement games that involve numbers (for example, "Slide/Back Front", "Down by the River", "Hide and Seek", "Chinese Skip/Chinese Jump Rope")	Informal
Create art that involves numbers	Informal

A4***Proportion of Parent Pedagogical Approach Use and Belief by Child Age***

	Pedagogical Approach Use		Pedagogical Approach Belief	
	3 year old	4 year old	3 year old	4 year old
Daily Living	.45	.45	.15	.23
Direct Teaching	.17	.24	.42	.34
Give math-related toys	.18	.21	.20	.21
During their activities child enjoys	.20	.11	.23	.22
N	174	161	179	165