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Preschoolers' mathematical play and colour preferences: a new window into the development of gendered beliefs about math

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ABSTRACT

In play, children often explore mathematical ideas that are vital for future learning. Children's play also reveals gender differences in both colour and toy preferences. The authors examined how gender-related colour preferences of 5-year-olds are related to preferences for math-specific games/toys and gendered beliefs about math. Spanish preschoolers ($N = 143$) completed a self-report measure of gendered beliefs about math. Children then indicated their favourite colour and were given five math-specific games/toys in that colour. Play times for each game/toy were recorded. Three findings emerged. First, girls preferred games/toys of particular colours (pink/purple) that differed from boys' preferences (blue/red). Second, play time with math games/toys did not differ between girls and boys. Third, 5-year-olds of both genders thought that girls liked math more than boys did. This is the youngest age at which these gendered beliefs about math have been shown, and suggests new theorizing about stereotypes, gender, and math.

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Early childhood education (ECE) marks an essential time in students' lives, because it helps set the foundation for behavioural expectations and academic skills that motivate children's learning and engender success in school (Welsh, Miller, Kooken, Chafouleas, & McCoach, 2016). Increasing children's participation in ECE is important for providing varied learning opportunities across topics and contexts. These opportunities are fundamental to positive long-term learning outcomes because they enable young children to engage in early learning experiences across diverse social and physical settings, which enhances learning and memory (e.g. Paz-Albo, 2015).

In Spain, the government has emphasized the importance of providing all children with the same opportunities for a high-quality ECE by implementing central government and regional education policies (Paz-Albo, 2015). These ECE programmes are intended to contribute to the physical, emotional, social, and intellectual development of both boys and girls. The preschool education curriculum in Spain emphasizes the importance of an early start to the development of logical and mathematical skills in school (Ministerio de Educación y Ciencia, 2007, 2008).

The importance of math play in ECE

The development of basic numeracy skills is one of the main goals of ECE since such development has been shown to help a child's learning at the primary school level (Watts, Duncan, Siegler, & Davis-Kean, 2014). Although play has been considered a cornerstone of learning (e.g. Bruner, 1996;

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Piaget, 1970; Vygotsky, 1978), there is much discussion and debate about the appropriate role of play in early education, including math education. Over the last two decades, the emphasis on academic accountability has led to a decline in play in and out of school, potentially influencing children's future prospects for success in school (Miller & Almon, 2009). Current pressure to teach literacy and math skills has turned ECE settings into highly structured environments in which play has been greatly diminished. Yet, play in early years is an essential part of young children's lives and a critical element of early childhood curriculum (Organisation for Economic Co-operation and Development [OECD], 2012; Marope & Kaga, 2015).

Past research in early education has focused on children's play more generally (Aydoğan, Farran, & Sağsöz, 2015; Gmitrova, Podhajecká, & Gmitrov, 2009; Linaza, 1992; Rentzou, 2014). However, it is helpful to understand why early math play, in particular, is such an important part of children's learning and development.

In play, young children often explore mathematical ideas and processes that are critical for future math learning and numeracy (Australian Association of Mathematics Teachers and Early Childhood Australia [AAMT/ECA], 2006; Perry & Dockett, 2007). Studies in the European Union show that boys and girls benefit equally when they are motivated to learn and have confidence in their own abilities to learn math (OECD, 2014). According to Clements and Sarama (2005), 'mathematical experiences for very young children should build largely upon their play' (p. 2). In a study of 2751 4-year-old children, decreased time spent in math activities at the beginning of a prekindergarten year was associated with a decrease in mathematics performance at the end of that same prekindergarten year (Chien et al., 2010). In the present study, we examine pre-K children's play with math-specific games and toys at very young ages to document the importance of early math play for the development of preschoolers' preferences and beliefs about math.

Early math play and colour/toy preferences

Gender differences exist in many aspects of children's lives, including activity preferences, cognitive interests, and behaviours (Blakemore, Berenbaum, & Liben, 2009; Goble, Martin, Hanish, & Fabes, 2012). In this paper, we focus on how children's colour preferences (which are gender-related) may be related to their preferences for games and toys that are math-specific. Exploring these cross-domain links will be informative for theories of identity development and how cultural stereotypes and expectations are assimilated by children and influence their own preferences, choices, interests, and motivations.

Gender differences in colour and toy preferences

Examining gender differences in young children's toy play is important for at least two reasons (Weisgram, Fulcher, & Dinella, 2014). First, toy play is a central aspect of young children's daily experience (Cherney, Kelly-Vance, Glover, Ruane, & Ryalls, 2003). Second, the type of toy play in which children engage may shape their later cognitive and social development (Martin, Eisenbud, & Rose, 1995).

Preferences for gender-typical toys (e.g. 'trucks are for boys' and 'dolls are for girls') are among the largest of early behavioural gender differences (Hines, 2010; Hyde, 2005). Such gender differences appear by age 2 (Alexander, Wilcox, & Woods, 2009; Snow, Jacklin, & Maccoby, 1983; Zosuls et al., 2009) and increase across childhood (Golombok, Rust, Zervoulis, Golding, & Hines, 2012).

Colour is a feature that children use to indicate whether a certain toy is 'for their gender' or not. In Europe and in the U.S.A., blues and primary colours have been associated with boys, and pink and purples (as well as pastel variants of many colours) have been associated with girls since the 1940s (Paoletti, 2012). Gender differences in colour preferences seem to emerge later in childhood than gender differences in toy preferences (Jadva, Hines, & Golombok, 2010; LoBue & DeLoache, 2011). (The generalizations about colour made in this article are not argued to be culturally universal and fixed, but rather are stated in reference to empirical work in contemporary Western culture.)

Colour preferences and early toy and math play

Colour has been demonstrated to have significant effects on children's toy choices and stereotypes (Henshaw, Kelly, & Gratton, 1992; Picariello, Greenberg, & Pillemer, 1990). Past research has shown that pink coloured toys may give girls implicit permission to play with these toys (Weisgram et al., 2014). However, little is known about the impact of colour on preferences for games/toys that are math-specific. The present study examines whether children's preference for colours that are stereotype-consistent (pink and purple colours for girls and blue and other primary colours for boys) are related to gender differences in preferences for math-specific games/toys.

Gender stereotypes in education

Across many Western cultures, including Spain, there is a wide-spread stereotype among adults linking mathematics with males (Dweck, 2007; Guiso, Monte, Sapienza, & Zingales, 2008; Nosek et al., 2009). Research has also revealed that elementary school children are knowledgeable about gender stereotypes about math (Cvencek, Kapur, & Meltzoff, 2015; Cvencek, Meltzoff, & Greenwald, 2011; Steffens, Jelenec, & Noack, 2010). However, there is a gap in the literature about the earliest emergence of such gendered beliefs about math before the start of formal schooling.

There is a reason to think that preschool children may not yet have assimilated the pervasive cultural stereotype about math = boys, and indeed that, unlike adults, preschoolers may hold a 'girls like math' belief. Starting from preschool and continuing through elementary school, girls already believe that they are academically superior to boys (Hartley & Sutton, 2013). To our knowledge, no research has systematically examined gender differences in beliefs about 'who likes math more' in the prekindergarten period, at 5 years of age or younger. The available research has focused on school-aged children, showing that, starting at 6 years of age, children display either gender-neutral stereotypes about math or an in-group bias about their own gender (boys report that boys are better in math than girls, and girls report that girls are better in math than boys) (Galdi, Cadinu, & Tomasetto, 2014; Master, Cheryan, Moscatelli, & Meltzoff, 2017). The nature of early beliefs about gender and math, before they enter school, is currently unknown. Also, further research is needed to identify how children's preferences for other gender stereotyped domains, such as colours and math-specific games/toys, may be related to beliefs about 'who does math.'

Purpose of the study

The present study examines whether or not 5-year-old girls and boys differ in their colour preferences, and as part of this study, special attention is paid to preschoolers' preferences for math-specific game/toys of different colours that we systematically varied through experimental control. We also examined whether girls and boys differed in their gendered beliefs about math (i.e. stereotypes). We hypothesised that girls and boys would differ in their colour preferences, but not in their preferences for math-specific games/toys. We had no firm predictions about gender differences in preschoolers' stereotypes about who does math, because prior research has not been done at this young age within the Spanish culture. To our knowledge, this is a first study to examine how colour and toy play preferences with math-specific games relate to children's belief about math and gender before they enter formal schooling.

Method

Participants

A total of 143 Spanish 5-year-old children (72 boys and 71 girls) participated in the study. All children were recruited through five public preschools in Madrid, Spain. Parents were told about the study and

given consent forms to sign, and completed forms were collected by the teachers. The mean age for children participating in the study was 5.89 years ($SD = 0.29$). According to available school data, children were predominantly from middle-class families.

Procedure

Children were tested individually in a quiet room outside of his or her classroom while seated at a desk facing a 38.1-cm touchscreen laptop. Each child first completed a self-report measure of gender stereotypes about math, and then played with five math-specific games/toys (abacus, number tiles, worksheet, geometric shapes, and dominoes) in order to get practice with early math concepts such as number recognition, counting, and addition. The amount of playtime ranged from 5 to 21 minutes.

Instruments

The instruments used for this study were designed by the primary investigators as part of an educational programme to foster mathematical skills in Madrid schools.

Self-report measure of gender stereotypes about math

Children first completed a self-report measure of gender stereotypes about math. This measure was administered as one Likert-scale question based on Harter and Pike's (1984) Pictorial Scale of Perceived Competence and Acceptance for Young Children. Children were shown pictures of two child characters and responded by reporting: (a) which of the two characters (boy or girl) they believed liked math to a greater degree, and (b) whether the character liked math 'a little' or 'a lot.' This was done by pointing to two different-sized circles (1.1 cm and 2.3 cm in diameter, respectively) to indicate less versus more liking. Asking this question comparatively, rather than requiring children to evaluate girls and boys separately, helps highlight any contrasts between the genders (Cvencek et al., 2011; Heyman & Legare, 2004; Kurtz-Costes, Copping, Rowley, & Kinlaw, 2014). We avoided offering children a neutral option to assure that they would not default to the neutral response option without fully considering their answer, which may lead to less reliable responses (Borgers, Hox, & Sikkel, 2004). The self-report measure was scored so that it had the computational lower and upper bounds of −2 and +2.

Colour and game/toy preferences

Next, children selected their favourite colours, and were then given five different math-specific games/toys to play with. Children were told that they could play with as many or as few math-specific games/toys as they wanted. If the child did not finish playing earlier, the experimenter stopped the play after 25 minutes.

Colour preferences

Children were asked to choose their favourite colour. This was done using two questions. First, children were presented with seven differently-coloured shapes in a row and then asked to touch the shape (on the touchscreen) to indicate their favourite colour. The seven colours were: red, orange, yellow, green, blue, purple, and pink. The shapes for any given child were all the same, but the shape each child saw was randomized (squares, circles, triangles, diamonds, ovals, or rectangles). Second, each child's response was verified by the experimenter by verbally asking the child, 'What is your favorite color?' The child responded to this question verbally. This verification was done to confirm that the child picked the colour that actually represented his/her favourite. If the child picked the same colour in both items, then that colour was the one in which the math-specific games/toys were given. If a child gave a different verbal answer than the shape he/she picked (e.g. if a girl picked the purple square, but then said red was her favourite colour), the experimenter

asked the child to say what his/her favourite really was. Whichever colour the child chose at that time was the colour in which the math-specific games/toys were given.

Math-specific game/toy preferences

Children were given five different math-specific games/toys to play with: abacus, dominoes, number tiles, geometric shape sorter, and worksheet (see Figure 1). All of these toys can be found in Spanish preschool classrooms, and children in this study would have likely had some prior experience with most of these toys. The abacus consisted of 10 rows of 10 beads, mounted on wire rods inside of a wooden frame; the dominoes consisted of 27 wooden tiles, each measuring 7.5 cm × 3.7 cm × 0.9 cm; the number tiles game consisted of a set of 65 wooden tiles, each measuring 2 cm × 1.8 cm × 0.4 cm, with 5 of each displaying a number from 0 to 9, addition, subtraction, and equals signs; the wooden shape sorter included nine slots for three basic geometric shapes (three each of circles, triangles, and squares); and the worksheet consisted of sequencing and counting games.

The experimenter recorded the length of time the children played with each toy. Two types of overall play times were calculated: First, the play times for each math-specific game/toy were used to quantify which was most popular across children (i.e. the one children played with the longest), which was the second most popular (i.e. the one children played with the second longest), etc. Second, the play times for all five math-specific games/toys were summed to arrive at the overall playtime for each child. We were interested in examining whether: (a) most popular math-specific games/toys would differ for girls versus boys, and whether (b) one gender would spend more time playing with math-specific games/toys than the other gender overall.

Results

The results are organized in four sections: (a) analyses of preschoolers' colour preferences, (b) analyses of preschoolers' preferences for math-specific games/toys, (c) analyses examining preschoolers' gendered beliefs (i.e. stereotypes) about who likes math, and (d) analyses providing an initial test of how such stereotypes about math are related to children's preferences for math-specific games/toys.

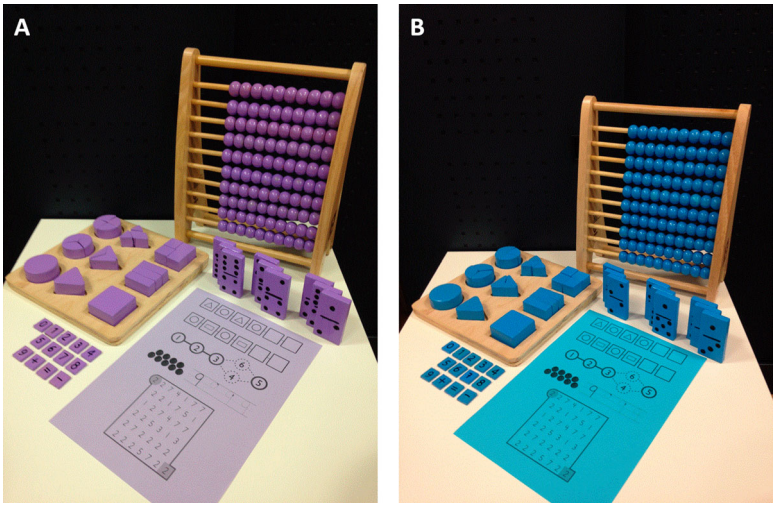

Figure 1. Sample sets of math-specific games/toys. The items in A are identical to those in B except that the ones in A are a purple colour and B are a blue colour. Starting at the bottom left corner and moving clockwise, the five math-specific games/toys displayed are: (i) number tiles, (ii) geometric shape sorter, (iii) abacus, (iv) dominoes, and (v) worksheet.

Colour preferences

As shown in Table 1, boys' colour preferences were significantly different from those of girls. A 2 (Gender: Boy and Girl) × 7 (Colour: Red, Orange, Yellow, Green, Blue, Purple, and Pink) Chi-square test revealed significant differences in 5-year-olds' colour choices, χ^2 (1, $n = 135$) = 68.05, $p < .0001$. The majority of girls chose either purple or pink (67.7%) and the majority of boys chose either blue or red (62.9%).

Math-specific game/toy preferences

We examined children's game/toy preferences in four ways. First, we conducted a 2 (Gender: Boy and Girl) × 5 (Math Game/Toy: Abacus, Dominoes, Number Tiles, Geometric Shape Sorter, and Worksheet) Chi-square test to compare whether girls and boys differed in their game/toy choices. This test revealed no significant differences, $p > .75$. Second, an independent samples *t*-test was used to compare the overall, average play times of girls to the average play times of boys. This test also revealed no significant differences between girls and boys, $p > .38$. Third, we compared the total number of games girls played to the total number of games boys played. No gender differences were revealed, $p > .40$. Finally, we compared the individual play times of girls to those of boys separately for each of the five math-specific games/toys. None of the *t*-tests revealed any significant gender differences, all $ps > .26$. Taken together, these results show that that neither (a) the game/toy preferences nor (b) the actual play times differed between girls and boys.

Self-reported gendered beliefs about who likes math

On the self-report measure of gendered beliefs about who likes math, both boys and girls were more likely to pick the girl character, instead of the boy, as 'liking to do math more,' $t(134) = 5.34$, $p < .00001$. This occurred both for girls ($M = 1.16$; $SD = 1.59$), $t(64) = 5.87$, $p < .00001$, and boys ($M = .48$; $SD = 1.83$), $t(69) = 2.17$, $p = .033$ (see Figure 2), although girls were more likely to pick the girl character as 'liking to do math more' than were boys, $t(133) = 2.30$, $p = .023$. Clearly, these young children had not yet adopted the prevalent cultural stereotype that math = boys more than girls.

Stereotypes in relation to game/toy preferences

Given the gender differences in self-reported gendered beliefs about math, we conducted follow-up analyses to examine whether these gender differences were stronger or weaker among those children who chose particular math-specific games/toys as their favourites. Five tests of the gender differences in children's self-reported gendered beliefs about math were conducted for subsamples of girls and boys who spent most time playing with each of the five math-specific games/toys. All *t*-tests were conducted using Bonferroni adjusted alpha levels of .01 per test. Among those children who played with the geometric shape sorter the longest ($n = 23$ girls; $n = 26$ boys), girls had significantly stronger 'girls like math more' beliefs than boys did, $t(47) = 2.72$, $p = .009$. None of the other gender differences were statistically significant, all $ps > .36$ (however, the

Table 1. Preferred colours and math games/toys of Spanish 5-year-old girls and boys, as indicated by percentages of children who (a) picked the colour as being their favourite colour and (b) the math game/toy they spent most time playing with.

	Girls ($n = 65$)		Boys ($n = 70$)	
Rank	Colour (% favourite)	Game/toy (% played most)	Colour (% favourite)	Game/toy (% played most)
1	Purple (38.5%)	Geometric shapes (35.4 %)	Red (34.3%)	Geometric shapes (37.1%)
2	Pink (29.2%)	Number tiles (21.5%)	Blue (28.6%)	Dominoes (21.4%)
3	Blue (16.9%)	Abacus (18.5%)	Orange (14.3%)	Number tiles (18.6%)
4	Red (12.3%)	Dominoes (13.8%)	Yellow (11.4%)	Abacus (15.7%)
5	Green (1.5%)	Worksheet (10.8%)	Green (8.6%)	Worksheet (7.1%)

Note: Statistically significant gender differences were found for children's colour preferences, χ^2 (1, $n = 135$) = 68.49, $p < .0001$, but not for children's math-specific game/toy preferences ($p > .75$).

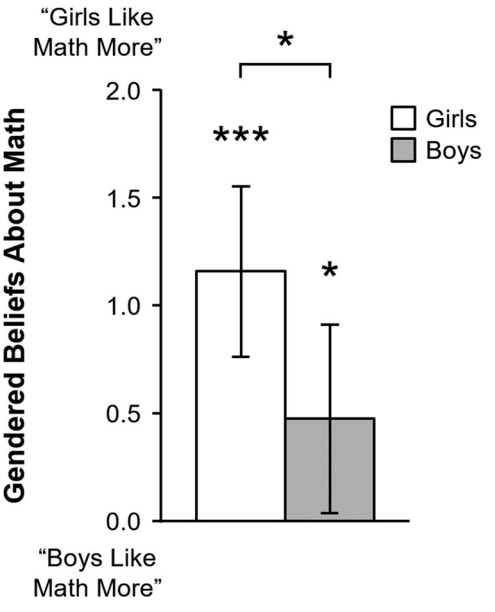

Figure 2. Gender differences in self-reported gendered beliefs about math in Spanish preschool boys and girls. Asterisks above each bar indicate difference from the neutral value of zero. The asterisk on the line above the bar graph indicates gender difference between boys and girls. ***$p < .001$, *$p < .05$. Error bars = *SE*s.

comparison between girls and boys who spent most time playing with number tiles approached significance, $p = .02$).

Discussion

The present study provides a first test of Spanish prekindergarten children's colour/toy preferences and their gendered beliefs about math with a large sample of preschoolers. It thus addresses an important gap in the literature and has interesting implications for early education. The results showed that girls and boys significantly differed in their colour preferences, but not in their preferences for math-specific games/toys. Interestingly, in this preschool sample, which is younger than has been used before, children as a whole reported the belief that 'girls like math more,' and girls did so more strongly than boys did. These results provide developmental evidence that children at 5 years of age, although capable of holding gender-linked preferences about colour that conform to adult stereotypes (girls = pink and boys = blue) still do not hold strong traditional gender stereotypes about math ('math is for boys').

The colour preferences expressed by the children seem to reflect the pattern of colour stereotypes held in the adult culture. The majority of girls chose either pink or purple and the majority of boys chose either blue or red, which is consistent with previous research (Paoletti, 2012). The gender difference in preference for colours was quite strong, providing evidence that children's gender-typed colour preferences probably develop well before the mean age tested in the present study – 5-years-old. The developmental time course and sources of these strong gender-linked colour preferences would be interesting to trace.

In contrast to boys and girls differing in their colour preferences, no significant differences were observed in children's actual play times with math-specific games/toys. In the present study, this might be due to the fact that math-specific games/toys were painted in each child's favourite colour (by design). In further research, we would like to systematically vary the colour of the math games/toys to evaluate whether preschool children's choices about math-specific games/toys might be influenced by their own colour beliefs. A math-specific toy that is painted in 'my favorite

color' may have functioned as 'my toy' (for related work, see Cvencek, Greenwald, & Meltzoff, 2016). Consequently, in this study, children's own colour preferences may have driven their preferences for math games/toys more than any potential gendered beliefs about math.

The pattern of results found here point to several potential practical implications. The colour of math games and toys could be used to motivate play with these objects or even to influence children's beliefs about who (which gender) is supposed to play with them. At 5 years of age, children's gendered beliefs about math do not (yet) reflect the prevalent adult gender stereotypes linking math with boys. Intervention programmes aimed at preventing girls from developing these stereotypical notions about gender and math might profitably be directed during these early years. In fact, developmental studies have shown the malleability of young children's beliefs about math during kindergarten, and have demonstrated that social-based interventions can improve kindergarteners' identification with math, feelings of self-efficacy about math, and even their persistence on engaging with math puzzles (Master, Cheryan, & Meltzoff, 2017).

The present study shows that at 5 years of age, Spanish girls and boys both verbally report that girls like math more than boys do. Why would both 5-year-old girls and boys hold this belief, which deviates from the pervasive adult stereotype? One tentative hypothesis is that during the preschool years, children hold beliefs that girls are more advanced on academic subjects such reading and math (Hartley & Sutton, 2013; Jones & Myhill, 2004). This suggests a three-step developmental pathway in children's stereotypes. First, there may be a more general belief about who likes academic subjects, and children's early stereotypes may be that *girls = academic topics* (more than boys do). Second, as children move through kindergarten and very early elementary school, children generally tend to choose their own-gender group as being better at various activities and academic subjects, which may be due to their in-group biases (Heyman & Legare, 2004; Master, Cheryan, Moscatelli, et al., 2017; Passolunghi, Rueda Ferreira, & Tomasetto, 2014). Third, as children transition further through elementary school, these beliefs change to reflect the more pervasive, adult gender stereotypes linking math with boys (Cvencek et al., 2011; Cvencek, Meltzoff, & Kapur, 2014).

Our findings are compatible with this working hypothesis about developmental change, insofar as both girls and boys held the belief that 'girls like math more.' Future studies will profit from a targeted focus on the preschool to early elementary school time period to chart the precise developmental timetable for the emergence of math–gender stereotypes and the mechanisms by which children 'catch' these biases and beliefs from their cultural surround (e.g. Skinner, Meltzoff, & Olson, 2017).

The early demonstration of the gendered belief that girls like math more than boys is also potentially informative in light of the finding that such beliefs were stronger in girls than in boys among those children who played with the Geometric Shape Sorter the longest. If children's beliefs develop partly as a consequence of their own experience with math-specific games/toys, then providing young girls with desirable games/toys involving three-dimensional geometric shapes may be a useful tool for fostering positive beliefs about math at the early stages of their educational careers. (Of course, we recognize that the direction and nature of the cause–effect may be complex and bidirectional; see also Levine, Ratliff, Huttenlocher, & Cannon, 2012; Uttal & Cohen, 2012.).

Conclusions

This is the first study examining how colour preferences in pre-kindergartener children relate to their: (a) preferences for mathematic games/toys and (b) gendered beliefs about an academic subject such as math. The results show that 5-year-old children who have already developed preferences that are in line with adult stereotypes about gender and colour (girls = pink and boys = blue) still do not differ in their preferences for math toys, nor do they hold strong the pervasive adult gender stereotypes about math (math = boys). Based on these and other findings, we suggested future research on the emergence and internalization of cultural stereotypes about gender and math. We also proposed interventions that may be helpful in motivating early STEM learning in children to enhance ECE.

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