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Decreasing the SES math achievement gap: Initial math proficiency and home learning environments

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A B S T R A C T

Many children in the U.S., particularly those from low socioeconomic status (SES) backgrounds, do not develop sufficient math skills to be competitive in today's technological world. We utilized a mediation/moderation framework and the ECLS-K dataset to investigate factors that can decrease the SES-related math achievement gap in kindergarten. Starting kindergarten proficient in math and experiencing a supportive home learning environment significantly decreased SES achievement differences. Proficiency in math at the start of kindergarten accounted for the greatest decrease in the SES-math achievement gap. Findings support the importance of comprehensive and multi-contextual approaches targeted to families and schools for improving children's exposure to math-relevant experiences.

1. Introduction

Many children in the U.S., particularly those from socioeconomically disadvantaged backgrounds, do not exhibit adequate mathematical skills (National Research Council, 2009). Math disadvantages associated with various indices of low socioeconomic status (SES) are evident by kindergarten (Arnold & Doctoroff, 2003; Byrnes & Wasik, 2009; Chatterji, 2005; Duncan & Magnuson, 2005; Jordan, Kaplan, Olah, & Locuniak, 2006; Lee & Burkam, 2002; Nores & Barnett, 2014) or even earlier (Burchinal et al., 2011). Children from families with low SES, on average, score about one half standard deviation below higher SES children on standardized measures of academic achievement (e.g., Bradley & Corwyn, 2002; Duncan & Magnuson, 2005).

This study uses data from the Early Childhood Longitudinal Study-Kindergarten cohort 1998–1999 (ECLS-K) to investigate two factors that could be associated with the SES-math achievement gap: starting kindergarten with age-appropriate math skills and children's home learning environments. We examine the extent to which math proficiency at entry to kindergarten attenuates (mediates) the relation between SES and math scores at the end of kindergarten. After controlling for math proficiency at the start of kindergarten, we also consider which, if any, indicators of the home learning environment in kindergarten further attenuate (or mediate) the SES-math achievement gap.

We next examine whether SES could also be framed as a moderator between initial math proficiency, indicators of the home learning environment in kindergarten, and children's math achievement (Beauchaine, Webster-Stratton, & Reid, 2005). We examine the extent to which initial math proficiency at the start of kindergarten and the home learning environment have similar associations for children from different SES groups. By utilizing a mediation/moderation framework, we assess the chain or path of associations at the same time that we address for whom these factors are relevant (Beauchaine et al., 2005). Understanding the nature of the relation will increase our knowledge of what processes account for associations between SES and math skills, and provide a foundation for the development of possible interventions that may decrease the SES-achievement gaps.

Most studies have considered math entry skills as a continuous variable (e.g., Byrnes & Wasik, 2009; Duncan et al., 2007; Jordan, Kaplan, Ramineni, & Locuniak, 2009); we consider it as a dichotomous one to assess threshold effects (discussed further in section 1.2). We focus on math proficiency at kindergarten entry (defined as proficiency at aspects of number sense; discussed further in section 2.2.2.) because starting kindergarten with well-developed number sense is an important predictor of more advanced math skills (e.g., Anders et al., 2012; Aunola, Leskinen, Lerkkanen, & Nurmi, 2004; Duncan et al., 2007; Geary, Hoard, Nugent, & Bailey, 2013; Jordan, Glutting, Dyson, Hassinger-Das, & Irwin, 2012; Jordan, Glutting, Ramineni, & Watkins, 2010; Lago & DiPerna, 2010; Watts, Duncan, Siegler, & Davis-Kean, 2014).

Although the exact definition of what is included in number sense varies across researchers (Lago & DiPerna, 2010), most agree that it includes an understanding of whole numbers, number operations, and number relations (Jordan et al., 2010; National Research

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Council, 2009). For example, Jordan et al. (2006) included counting, number knowledge, number transformation, estimation, and number patterns as components of number sense (see also National Mathematics Advisory Panel, 2008). Similarly, the National Council of Teachers of Mathematics (1989) defined number sense as the ability to understand the meaning of numbers, define relationships among numbers, recognize the relative size of numbers, and use referents for measuring objects. For example, children in preschool through second grade are expected to be able to connect number words and numerals with the quantities they represent, using various physical models and representations (National Council of Teachers of Mathematics, 1989; http://www.nctm.org/Standards-and-Positions/Principles-and-Standards/Principles,-Standards,-and-Expectations/). By third grade, children are expected to recognize equivalent representations for the same number and generate them by decomposing and composing numbers. Number sense has also been called informal or everyday math, suggesting that its roots generally lie in informal or daily experiences (Ginsburg, Lee, & Boyd, 2008) rather than the types of formal instruction experienced in elementary school.

1.1. Socioeconomic status and young children's math skills

There has been extensive research investigating the impact of SES on children's development (e.g., Bradley, Corwyn, McAdoo, & Garcia Coll, 2001; Byrnes & Wasik, 2009; Crosnoe & Cooper, 2010; Duncan & Magnuson, 2005; Gershoff, Aber, Raver, & Lennon, 2007; Guo & Harris, 2000; McLoyd, 1998). Children from low SES families are more likely to start school with lower academic skills; these differences between low SES children and their higher SES peers continue or expand as children proceed through school (Bradley & Corwyn, 2002; Caro, McDonald, & Willms, 2009; Sirin, 2005).

Consistent with findings of children's general academic skills, there are differences related to SES in children's acquisition of math skills (Jordan et al., 2006: National Research Council, 2009). Children from low SES backgrounds generally enter kindergarten with more limited math skills than their middle income peers (see Klein, Starkey, Clements, Sarama, & Iyer, 2008 for a review). For example, Jordan et al. (2006), among others, found that children from low income backgrounds generally began kindergarten with less well-developed number sense than their more affluent peers. Others have noted that most children develop basic counting skills by the start of kindergarten; however, SES related group-based differences emerge in the more advanced number sense skills (e.g., numerical magnitude estimation), and then in subsequent math skills (Claessens & Engel, 2013; National Research Council, 2009).

1.2. Children's math proficiency at kindergarten entry

Regardless of SES, young children acquire informal mathematical knowledge through their involvement in home activities before the start of formal schooling; such knowledge serves as the basis for development of math skills once they enter school (Ginsburg et al., 2008; National Research Council, 2009; Ramani & Siegler, 2014; Starkey, Klein, & Wakely, 2004). Children who start school with more limited number sense continue to have difficulties as they proceed through elementary school (Jordan, Kaplan, Locuniak, & Ramineni, 2007).

It is possible that children may need to display a certain level or threshold of math skills to achieve maximum benefit from teachers' instruction (e.g., Connor, Morrison, & Katch, 2004 for reading instruction). Research on children's math development shows the importance of achieving certain math skills as the threshold for future math development. For example, Siegler et al. (2012), using children in the U.S. and Great Britain, found that children's knowledge of fractions and division at the end of elementary school predicted their knowledge of algebra in high school, even after controlling for other math knowledge, SES, parents' education, intellectual abilities. In another study, Siegler and colleagues showed that number line estimation and calculation fluency in third grade were the major predictors of knowledge of fractions at the end of fifth grade (Bailey, Siegler, & Geary, 2014; see also Jordan et al., 2013). Most pertinent for this study, Claessens and Engel (2013), using the ECLS-K data set, found that what we are calling math proficiency at the start of kindergarten (attainment of proficiency level 2) was the strongest predictor of children's math skills in eighth grade. Proficiency level 2 included reading all single-digit numerals, counting beyond 10, recognizing a sequence of patterns, and using nonstandard units of length to compare objects. We do not yet know, however, whether starting kindergarten with a certain level of math skills attenuates the negative impact of SES on math achievement.

1.3. Home learning environments

The home environment is an important context or microsystem for young children's development (Bronfenbrenner, 1979). Growing up in a cognitively stimulating home predicts children's immediate and longer-term academic development (e.g., Crosnoe & Cooper, 2010; Crosnoe et al., 2010). A cognitively stimulating home learning environment typically has been defined as including a broad array of possible activities and interactions with others (e.g., Caldwell & Bradley, 1984; Crosnoe & Cooper, 2010).

Children from different SES levels do not have equal access to comparable home learning environments. Bradley et al. (2001), using the National Longitudinal Study of Youth data set, found that low income children had less access to learning tools at home than middle income children. Similarly, low income families spend less time than middle income ones in cognitively enriching environments outside the home (Phillips, 2011). Children from low income backgrounds are also less likely to engage in cognitively enriching verbal (Hart & Risley, 1995) or reading interactions (Guo & Harris, 2000; Serpell, Baker, & Sonnenschein, 2005). The differences in the language low and middle income children hear at home can result in differences in their readiness for or understanding of instruction at school (Hindman, Skibbe, Miller, & Zimmerman, 2010).

Parents' expectations for their children's development and achievement, and their involvement in their children's general educational development, particularly at school, are associated with children's academic achievement (Fan & Chen, 2001; Galindo & Sheldon, 2012; Hill & Taylor, 2004; Jeynes, 2005; Sonnenschein, Stapleton, & Metzger, 2014; Yamamato & Holloway, 2010). Dearing, Kreider, Simpkins, and Weiss (2006) found that the SES-related reading gap was eliminated when parents were involved at their children's schools. However, low income parents generally are less involved than middle-income parents (Grolnick, Benjet, Kurowski, & Apostoleris, 1997; Lee & Bowen, 2006; Reynolds, 1992). Based on the results of a meta-analysis with 25 studies, Fan and Chen (2001) found that parents' expectations for their children's future educational attainment accounted for more variance in children's academic achievement than other aspects of parent involvement. Most research has focused on parents' expectations for their children's future educational attainment; however, recent research shows the need to focus as well on expectations for what skills children need to have in kindergarten because of their predictive value for achievement (Sonnenschein & Galindo, 2015).

Children's early math skills can be acquired through their experiences at home and/or preschool (Ginsburg et al., 2008). However, our knowledge of what specific aspects of the home environment foster children's math skills is still fairly limited. Research has shown links between literacy-related activities, other components of the home learning environment and children's math skills. For example, reading at home and parents' expectations for their children's future educational achievement are associated with children's math achievement (Byrnes & Wasik, 2009; Chatterji, 2005; Davis-Kean, 2005; Sonnenschein & Galindo, 2015; Yan & Lin, 2005).

LeFevre and colleagues (LeFevre, Polyzoi, Skwarchuk, Fast, & Sowinski, 2010; LeFevre et al., 2009) found that the frequency with which young children engaged in playing board games, card games, cooking, and shopping predicted their math knowledge and fluency (see also Anders et al., 2012; Kleemans, Peeters, Segers, & Verhoeven, 2012; Ramani & Siegler, 2008; Saxe, Guberman, & Gearhart, 1987). Involvement in these activities is important for math learning as it provides children with problem-solving and different concepts presented in daily-living contexts (see Civil & Andrade, 2002; LeFevre et al., 2009). Cooking for example, could help children learn key mathematical concepts by making abstract concepts such as counting, addition, measurement or fractions, concrete. Ramani and Siegler (2008) also found that playing a board game similar to Chutes and Ladders facilitated the development of numerical magnitude skills because the game provided cues about the magnitude and order of the numbers.

Skwarchuk, Sowinski, and LeFevre (2014) found that parents of kindergarten children engaged in both formal (systematic instruction in math) and informal math activities (playing games) with their children. These two forms of math-related interactions were associated with different types of math knowledge when children were in first grade. Formal math activities predicted symbolic number knowledge (knowledge of arithmetic symbols including numbers and knowledge of numerical concepts such as rounding; Polk, Reed, Keenan, Hogarth, & Anderson, 2001) whereas informal activities predicted what they called non-symbolic math knowledge (the ability to understand and manipulate numerical magnitudes that do not involve actual numerals; Kolkman, Kroesbergen, & Leseman, 2013).

Most studies have considered a composite score of home learning environment, only looked at a few indicators, or created a latent home learning variable instead of exploring the impact of individual variables (Cheadle, 2008; Yeung, Linver, & Brooks-Gunn, 2002). Given that there may be differences in which aspect of the home learning environment best promotes math development, it is important to consider the effects of individual variables and include a broad set of variables (Byrnes & Wasik, 2009). Therefore, this study includes an array of home indicators –availability of learning tools, participation in home learning activities, parents' involvement at school and expectations for their children's current and future learning – found to be relevant not only for math but for different dimensions of academic development.

1.4. Mediation/moderation processes

We do not yet know whether starting kindergarten with a certain level or threshold of math skills attenuates the negative association of SES and math achievement. If so, it reinforces the need to focus more on home-based interventions prior to kindergarten (Burchinal, Vandergrift, Pianta, & Mashburn, 2010; Wang, Shen, & Byrnes, 2013). It is also possible that SES can moderate the relation between math proficiency and children's math skills. Determining whether SES is a moderator will determine which groups, if any, should be differentially treated as targets for interventions or whether resources need to be differentially devoted to improving children's math skills (Edwards & Lambert, 2007; Judd, Kenny, & McClelland, 2001).

Most studies have considered the association between SES and children's achievement as one in which the home learning environment mediates the association between the two variables (e.g., Cheadle, 2008; Davis-Kean, 2005; Linver, Brooks-Gunn, & Kohen, 2002; Yeung et al., 2002). Consistent with such an approach, the family investment model has been used to discuss how SES, particularly income, affects parents' ability to provide appropriate physical and material environments for their children (Evans, 2004). Bradley et al. (2001) noted that there were significantly fewer books and other cultural artifacts in the homes of low income than middle income families (see also Guo & Harris, 2000). A related way to conceptualize income-related differences comes from the work of Lareau (2003), who noted that *concerted cultivation*, or deliberately fostering children's cognitive skills, occurred less frequently in low income than middle income families. Components of concerted cultivation include children's participation in adult-orchestrated leisure activities, parents' investments in educational materials at home, and parents' involvement with their children's school. Using data from the ECLS-K, Cheadle (2008) found that concerted cultivation partially mediated the relation between income and children's academic achievement.

Although most researchers have viewed SES as a predictor of children's development, a few have shown that the relation between aspects of the home environment and aspects of children's development are moderated by SES. Hill (2001) found that income moderated the relation between parenting behaviors (warmth, acceptance) and kindergartners' early reading scores: the relation was much stronger for lower than higher income families. Magnuson, Sexton, Davis-Kean, and Huston (2007) found an interaction between mothers' educational levels, an aspect of SES, and the quality of the home environment (assessed with the Home Observation for Measurement of the Environment [HOME], Caldwell & Bradley, 1984) on the academic achievement of children ages 6 through 12. Changes in maternal education had a positive effect only if the mother's initial educational level was low (see also Bakermans-Kranenburg, van Ijzendoorn, & Bradley, 2005; Geoffrey et al., 2007). Based on previous research, we expect to find a stronger influence of math proficiency at kindergarten entry and the home learning environment for those students coming from the most economically disadvantaged background.

1.5. The present study

This study investigates three questions about the association between SES and math achievement gaps. One, to what extent does children's math proficiency at entry to kindergarten attenuate (mediate) the relation between SES and math scores at the end of kindergarten? Two, after accounting for the effects of math proficiency, do indicators of the home learning environment in kindergarten further attenuate the relation between SES and children's math achievement at the end of kindergarten? Three, to what extent does SES moderate the relation between math proficiency at the start of kindergarten and indicators of the home learning environment and children's math achievement?

Only recently have scholars begun to emphasize the importance of examining mediation and moderation aspects of the relations among variables (Donaldson, 2001; Judd et al., 2001). Consistent with recommendations by Beauchaine et al. (2005) and Preacher, Rucker, and Hayes (2007), we consider both approaches within the current study to document the processes through which SES affects children's math skills, *and* whether these processes operate in the same manner for children from different SES backgrounds (see also Jones et al., 2009; Rieppi et al., 2002 who examine demographic characteristics as moderators).

2. Method

2.1. Sample

The data came from the Early Childhood Longitudinal Study (ECLS-K) Kindergarten Class of 1998–99 which included a nationally representative sample of about 21 000 kindergarteners in over 1000 schools (see National Center for Education Statistics, 2001 for additional details). We used the kindergarten sample from

Table 1
Weighted descriptive statistics for the ECLS-K sample.

	Mean or %	*SD*	% of Missing	Range
Key analytical variables				
Math IRT	27.63	8.86	0	07.32–59.34
SES Q1 (lowest; %)	19.0		0	0–100
SES Q2	19.3			
SES Q3	18.9			
SES Q4	19.1			
SES Q5 (highest)	19.3			
Proficiency at entry	43.7		9.66	0–100
Learning tools	0.01	0.77	4.21	−1.14–3.44
General learning activities	0.00	0.42	4.21	−1.86–3.90
Reading learning activities	3.24	0.65	4.23	1–4
Parental involvement in school	0.54	0.24	7.78	0–1
Future educational expectations	4.10	1.11	14.19	1–6
Current educational expectations	4.00	0.50	13.70	1–5
Child and Family Control variables				
Race/ethnicity (%)				
White	55.9		0.17	0–100
Black	14.8			
Latino	18.5			
Asian	5.5			
Other	5.3			
Female (%)	48.8		0.01	0–100
English home (%)	87.0		4.77	0–100
Children's approaches to learning	3.11	0.68	3.17	1–4
Age at kindergarten entry (months)	65.48	4.42	13.76	33–84
Retained in kindergarten (%)	4.5	0.21	13.75	0–100
Family type (%)				
Two-biological parents	66.8		13.62	0–100
Two-parents, one biological	7.9			
Single-parent family	21.6			
Other parental arrangements	3.7			
Number of siblings	1.44	1.15	13.62	0–11
Maternal depression	1.46	0.46	9.55	1–4
Child care arrangement (%)				
Center-based care	43.7		14.84	0–100
Home-based care	23.8			
Head Start care	9.29			
Other care	5.02			
No formal care	18.19			
Teacher and Classroom Control variables				
Amount of math instruction	1.85	0.73	13.16	1–4
Instructional practices				
Numbers & geometry	4.48	0.71	10.66	1–6
Advanced number & operations	3.48	1.34	11.09	1–6
Traditional practices & computation	3.20	0.98	10.61	1–6
Measurement & advanced topics	2.72	0.83	10.64	1–6
Teacher-highest education degree	2.12	0.90	20.28	1–5
Certification (%)				
Highest	64.23		13.33	0–100
Regular	20.94			
Alternative	14.82			
Elementary Certification (%)	84.9		13.02	0–100
Class SES composition	−0.099	0.601	4.85	−4.47–2.48

Note: Percentages of missing data were calculated based on 19 280 children students or 3530 classroom/teachers. All descriptive statistics were computed using the database before conducting multiple imputation utilizing survey commands with similar stratification and sampling units. Population weights differed depending upon whether we estimated descriptive statistics for child ("*c2cw0*") or teacher/classroom ("*b2tw0*") level variables.

1998–1999 and limited our analytical sample to children with available math test scores in the spring of kindergarten (19 650 children) and whose teachers responded to the survey (19 280 children). The sample sizes were rounded to the nearest 10 because of restricted license requirements. To deal with missing data, we applied the Imputation by Chained Equations (ICE) algorithm in STATA. ICE handles complex data structures by fitting a sequence of chain equations to impute variables in order of increasing "missingness," that is, the variable with the least missing values is imputed first and so on (Royston, 2005). Following Downey, Von Hippel, and Broh (2004), we separately imputed student—and classroom—level information. To the best of our knowledge, a procedure to impute missing values with nested data has yet to be developed. The imputation procedure resulted in 15 plausible data sets that were analyzed with the MI command. The analytical sample in this study included 19 280 children from 3530 classrooms in 1085 schools.

Table 1 shows the percentage of missing cases, means or percentages, and standard deviations for all variables before applying multiple imputation procedures.

2.2. Measures

2.2.1. Math achievement

Math achievement was measured using individually administered two-stage adaptive math tests, with content areas and domains based on the National Assessment for Educational Progress (NAEP) framework (National Center for Education Statistics, 2001). These measured number sense, properties and operations;

measurement; geometry and spatial sense; data analysis, statistics, and probabilities; and patterns, algebra, and functions. We used item response theory (IRT) scale scores from spring of kindergarten to measure math achievement (variable name = c2rmscal). The IRT math scale scores are criterion-referenced measures of achievement that place children's performance within a common and continuous 64-point scale. We used spring of kindergarten math achievement scores as the dependent variable. Internal item-level reliability of the ECLS-K math test overall scores in the spring of kindergarten was .81 (Rock & Pollack, 2002). Test validity was evaluated by judgments of technical and substantive experts, by patterns of correlations across rounds of data collection and subjects, and by patterns of results with other national tests, including NAEP (Pollack, Atkins-Burnett, Najarian, & Rock, 2005). For additional details on the ECLS-K assessments, see Rock and Pollack (2002), and for a few examples of items utilized in the math test scores, see http://www.myeclsk2011.com/samples.html.

2.2.2. Math proficiency at kindergarten entry

Math proficiency level scores at kindergarten entry were used to categorize children as displaying proficient or limited proficient math skills (variable name = c1mprob2; Claessens & Engel, 2013). Consistent with ECLS-K guidelines, children were considered to display math proficiency if they obtained a proficient probability of 0.75 or higher on the proficiency level 2 which included reading all single-digit numerals, counting beyond 10, recognizing a sequence of patterns, and using nonstandard units of length to compare objects (National Center for Education Statistics, 2001). As noted by Claessens and Engel (2013), attainment of proficiency level 2 (but not the other levels) was highly predictive of future math skills through eighth grade. Most of the tasks comprising proficiency level 2 are considered components of number sense (Lago & DiPerna, 2010; National Council of Teacher of Mathematics Standards). It is important to note that proficiency level 1 also included aspects of number sense (identifying some one-digit numerals, recognizing geometric shapes, and one-to-one counting of up to 10 objects) but almost all children showed proficiency in acquisition of these skills by the start of kindergarten (Claessens & Engel, 2013). About 43% of children began kindergarten with proficient mathematical skills.

2.2.3. Socioeconomic status

We used the composite SES variable, constructed by ECLS-K specialists, based on mothers' and fathers' education, mothers' and fathers' occupational prestige, and household income. This composite is the average of the five measures that were previously standardized with a mean of 0 and standard deviation of 1 (National Center for Education Statistics, 2001). For analytical purposes, this measure was divided into quintiles; the highest quintile is the reference group.

2.2.4. Home learning environment

This was measured using access to learning tools, general learning and reading learning activities, parents' involvement in school, and parents' future and current educational expectations. These variables were created utilizing items in the ECLS-K home environment section from the fall and spring of kindergarten, adapted from the commonly used HOME Inventory developed by Caldwell and Bradley (1984). Similar scales from the ECLS-K have been used in many published articles (see Cheadle, 2008; Crosnoe & Cooper, 2010; Galindo & Sheldon, 2012).

2.2.4.1. Learning tools. This index consisted of number of books and CDs, records and tapes in the home, and whether the child had a computer. The first two questions were open-ended; the third question was dichotomous (0 = no, 1 = yes). Therefore, parents' responses to the items were standardized and then averaged to create a composite measure. The Cronbach's alpha for this index is .58, somewhat lower than optimal. These alphas are consistent with what others have found using the same or similar indices (e.g., Crosnoe & Cooper, 2010). Note that we do not necessarily expect different components of this index, or others discussed below, to be highly interrelated. That is, parents may provide their children one but not all of the experiences/tools within a category. Our interest with this category is whether children have access to learning tools rather than the specific tools they can access. In addition, although the reliability indicators are less than optimal, utilizing scales with heterogeneous items is important for the construct validity of a measure (Eisinga, Grotenhuis, & Pelzer, 2013). The same reasoning applies to the other constructs noted below.

2.2.4.2. General home learning activities. This was the average of parents' responses to two questions. Parents reported how often (1 = never to 4 = everyday) they or other family members participated in the following activities with their child: tell stories, sing songs, do arts, do chores, play games or do puzzles, talk about nature or do science projects, play sports and build things together or play with construction toys. Parents also reported whether (0 = no, 1 = yes) the child participated in dance lessons, athletic events, organized clubs, music lessons, drama classes, art lessons, organized performing, craft classes, and non-English language instruction outside of school hours. Responses to items within each question were standardized and then averaged. Cronbach's alpha was .62.

2.2.4.3. Reading home learning activities. We averaged parents' responses to three questions, the frequency (1 = never to 4 = everyday) with which children looked at picture books, and read books by themselves or with others. Cronbach's alpha was .63.

2.2.4.4. Parents' involvement in school. Parents reported whether they attended/participated (0 = no, 1 = yes) in various school-related events: open house or back-to-school nights; meetings of PTA, PTO, or parent–teacher–student organization; meetings of the parent advisory group or policy council; regularly-scheduled parent–teacher conferences or meeting with teachers; school or class events; volunteering at the school or serving on a committee; and fundraising for the school. An index was created by averaging responses to questions. Cronbach's alpha was .58.

2.2.4.5. Parents' future educational expectations. Parents were asked what level of educational attainment they believed their child would achieve. Response options ranged from 1 = receive less than a high school diploma to 6 = get a PhD, MD, or other higher degree.

2.2.4.6. Parents' current educational expectations. Parents were asked to rate how important (1 = not important to 5 = essential) it was for their child to have certain competencies to be ready for kindergarten: knowing how to count to 20 or more, sharing and taking turns, using pencils and paint brushes, knowing alphabet letters, communicating well, and sitting still and paying attention. We averaged responses to these questions to create this index. Cronbach's alpha was .77.

The strength of associations among the various indicators of the home learning environment ranged from small to moderate. Thus, multicollinearity among the indicators was not an issue. Learning tools was moderately correlated with parents' involvement in school ($r = .39$), general home learning ($r = .36$) and reading home learning ($r = .25$). General home learning was moderately correlated with parents' involvement in school and reading home learning ($r = .32$, respectively). Correlations with parents' future educational expectations were small ($r = .15$ for general and reading learning activities; $r = .12$ for learning tools and parents' involvement in school; and

$r = .10$ for current educational expectations). Correlations with parents' current educational expectations were .02 for learning tools, .00 for parents' involvement in school, .06 for general learning activities, and .08 for reading learning activities.

2.2.5. Control variables

As several scholars have noted, SES is often correlated with other demographic variables such as race/ethnicity (Dearing, McCartney, & Taylor, 2001; Yeung & Conley, 2008). We therefore controlled for race/ethnicity and other potentially pertinent factors. Child-level control variables were assessment date, children's approaches to learning, gender, race/ethnicity, age at kindergarten entry, whether the child repeated kindergarten, and type of non-parental child care. Family level controls were family type (child living with two biological parents, reference group; two parents, one biological; one biological parent; or other including guardian or adoptive parents), primary home language, and number of siblings at home. Classroom and school factors are also associated with SES (Crosnoe & Cooper, 2010). Accordingly, we controlled the socioeconomic composition of the student body, teachers' educational attainment (1 = high school degree, associate degree or BA, 2 = one year beyond BA, 3 = Masters, 4 = educational specialists or professional diploma, or 5 = doctorate) and certification type (elementary and highest, regular, or alternative). We also added indicators of instructional practices (frequency of instruction focusing on numbers and geometry, advanced numbers and operations, traditional practices and computation, measurement and advanced topics; 1 = never to 6 = daily) and amount of math instruction (1 = 1 to 30 minutes, 2 = 31–60 minutes, 3 = 61–90 minutes, or 4 = more than 90 minutes) as its contribution has been identified in other studies (Sonnenschein & Galindo, 2015). These control variables have been commonly used in studies of academic achievement utilizing the ECLS-K (e.g., Cooper, 2010; Gershoff et al., 2007).

2.3. Analytic plan

All descriptive and inferential statistical analyses were estimated using Stata 13 survey commands specifying stratification levels, sampling units, and population weights (c2tcwstr, c2tcwpsu, c2cw0) to take into account the complex cluster sample design and nested structure of the ECLS-K data. Thus, these commands addressed potential concerns about the nesting of the data (students within classrooms within schools). Tables report unstandardized coefficients; standardized coefficients are included in the text. Because Stata does not provide standardized beta coefficients when utilizing survey commands, all standardized coefficients were calculated manually by multiplying the standard coefficient by the ratio of the standard deviation of the independent variable to the standard deviation of the dependent variable. These standard deviations were calculated from the initial database prior to multiple imputation.

Two analytical strategies were taken. First, we tested four models utilizing OLS regression to examine the association between math proficiency at kindergarten entry, the home learning environment, and math achievement with spring of kindergarten math scores as the dependent variable. Model 1 included only SES quintiles; model 2 included SES quintiles and control variables. We then added math proficiency at kindergarten entry to examine the extent to which this variable mediated the relation between math achievement and SES (model 3). In model 4 we added indicators of the home learning environment.

We tested mediation using the KHB-method, based on the Sobel test (Sobel, 1982). This method examines the associations of multiple mediators simultaneously when control variables are also included in the model. This method corrects for the fact that when comparing models with different variables, error distribution and variance of the dependent variables differ across models (Karlson & Holm, 2011). Although this method was originally developed to be used within logit and probit frameworks, its application has been expanded into linear models (Breen, Karlson, & Holm, 2013). Because we were interested in testing the mediating associations of seven variables (math proficiency and six indicators of home learning environment), we explored potential mediation paths by utilizing a block approach: testing the mediation of each of these two groups of variables (math proficiency, home learning environment) separately and then in combination. Because the KHB-method in Stata command does not support estimation procedures with more than one data set (recall that the imputation resulted in 15 data sets), we tested for mediation by randomly selecting one of the fifteen datasets.

The second analytic strategy estimated the moderating associations of SES using seven models, within the OLS regression framework, with spring kindergarten math score as the dependent variable. Following Jose (2013), these models included math proficiency and all indicators of home learning environment as main effects to avoid model misspecification but examined interaction effects separately. For example, model 5 included math proficiency and all indicators of the home environment but only the interaction terms for math proficiency and SES. All continuous variables (but not dichotomous ones) were centered to facilitate the interpretation of the interaction coefficients and to avoid potential problems of multicollinearity. In Table 4, we report only main effects and interaction terms' coefficients, although all models included similar control variables as in previous analyses.

3. Results

3.1. Math proficiency at kindergarten entry, home learning environment, and math achievement at the end of kindergarten

Consistent with other research (Crosnoe & Cooper, 2010; Duncan & Murnane, 2011), there were significant achievement gaps at the end of kindergarten by SES quintiles (Table 2). The unadjusted differences (with no controls) in math achievement for students in the lowest two quintiles (quintiles 1 and 2) were 0.48 and 0.32 standard deviations (SD) lower than that of students in the highest SES quintile (quintile 5, $p < 0.05$). Statistically significant differences ($p < 0.05$) were also observed for students in the third and fourth quintiles, although these differences were smaller in magnitude (0.25 and 0.14 SDs, respectively). As model 2 shows, after controlling for key child, family and classroom covariates, the SES achievement gaps decreased substantially, although they remained statistically significant (Table 2). The SES achievement gaps were 0.18 and 0.13 SDs for students in the two lowest quintiles (1 and 2) and 0.11 and 0.06 SDs for students in the third and fourth quintiles relative to students in the highest quintile (5).

Math proficiency at kindergarten entry and indicators of the home learning environment were associated with math achievement at the end of kindergarten (see models 3 and 4). After controlling for SES, and other covariates, children who began kindergarten proficient in math obtained math scores that were 0.43 SDs higher than those for children who began kindergarten non-proficient in math (model 3). After controlling for SES, math proficiency and key child, family, and classroom covariates, all indicators of the home learning environment in kindergarten, except for general learning activities, were significantly associated with math achievement. Other things being equal, children with greater access to learning tools (0.05 SD), reading activities (0.03 SD), and whose parents reported higher levels of parental involvement in school (0.02 SDs) and higher current/future educational expectations (0.03 SD, respectively) obtained higher math scores in the spring of kindergarten (model 4). To have a better sense of the relative importance of these indicators, we estimated the standardized coefficient for parents'

Table 2
Kindergarten math achievement by income quartiles, math proficiency at kindergarten entry, and home learning environment indicators.

	Model 1	Model 2	Model 3	Model 4
SES Q1 (lowest)	–10.803*** (0.262)	–4.006*** (0.246)	–2.631*** (0.216)	–1.928*** (0.230)
SES Q2	–7.135*** (0.275)	–2.848*** (0.233)	–1.698*** (0.192)	–1.229*** (0.203)
SES Q3	–5.610*** (0.258)	–2.549*** (0.207)	–1.622*** (0.178)	–1.330*** (0.183)
SES Q4	–3.140*** (0.244)	–1.384*** (0.199)	–0.969*** (0.174)	–0.810*** (0.175)
SES Q5 (highest)	–	–	–	–
Math proficiency at entry			7.731*** (0.132)	7.577*** (0.131)
Learning tools				0.559*** (0.085)
General learning activities				0.118 (0.144)
Reading learning activities				0.369*** (0.092)
Parental involvement in school				0.770** (0.284)
Future educational expectations				0.212*** (0.050)
Current educational expectation				0.486*** (0.107)
Control Variables				
Black		–2.492*** (0.222)	–2.067*** (0.192)	–2.002*** (0.190)
Latino		–1.920*** (0.209)	–1.247*** (0.179)	–1.248*** (0.180)
Asian		0.751* (0.373)	0.875** (0.311)	0.979** (0.311)
Other		–1.700*** (0.272)	–1.277*** (0.230)	–1.186*** (0.231)
Female		–1.263*** (0.116)	–1.063*** (0.104)	–1.178*** (0.104)
English home		1.456*** (0.228)	1.004*** (0.204)	0.852*** (0.205)
Approaches to learning		4.650*** (0.094)	3.224*** (0.092)	3.113*** (0.091)
Age at kindergarten entry		0.323*** (0.015)	0.188*** (0.013)	0.194*** (0.013)
Retained in kindergarten		2.998*** (0.279)	1.388*** (0.233)	1.554*** (0.229)
Two-parents, one biological		–0.497* (0.221)	–0.512** (0.194)	–0.426* (0.194)
Single-parent family		–0.314* (0.152)	–0.272+ (0.140)	–0.194 (0.142)
Other parental arrangements		–1.127*** (0.338)	–1.172*** (0.282)	–1.087*** (0.280)
Number of siblings		–0.290*** (0.050)	–0.206*** (0.045)	–0.194*** (0.045)
Maternal depression		–0.310* (0.128)	–0.264* (0.114)	–0.203+ (0.115)
Home-based care		–1.010*** (0.155)	–0.476*** (0.139)	–0.402** (0.138)
Head Start care		–1.239*** (0.215)	0.785*** (0.237)	0.860*** (0.233)
Other care		–0.511+ (0.271)	–0.171 (0.240)	–0.129 (0.237)
No care		–1.448*** (0.175)	–0.709*** (0.155)	–0.672*** (0.155)
Amount of math instruction		0.276* (0.113)	0.306** (0.102)	0.308** (0.100)
Numbers & geometry		–0.782*** (0.149)	–0.729*** (0.123)	–0.731*** (0.121)
Advanced number & operations		0.319*** (0.067)	0.233*** (0.057)	0.229*** (0.057)
Traditional practices & computation		0.928*** (0.094)	0.886*** (0.084)	0.878*** (0.084)
Measurement & advanced topics		0.268* (0.129)	0.203+ (0.109)	0.194+ (0.109)
Teacher education		–0.083 (0.094)	–0.070 (0.081)	–0.067 (0.080)
Certification-highest		0.072 (0.188)	–0.033 (0.166)	–0.054 (0.165)
Certification-alternative		0.308 (0.267)	0.192 (0.244)	0.183 (0.243)
Certification-elementary		0.284 (0.242)	0.111 (0.210)	0.106 (0.209)
Class SES composition		2.215*** (0.171)	1.486*** (0.163)	1.315*** (0.162)
R^2	0.17	0.41	0.53	0.54
F-statistic	$F(4, 997) = 486.13$	$F(33, 968) = 265.11$	$F(34, 967) = 402.29$	$F(40, 961) = 351.83$

Note: Math achievement is represented by unstandardized coefficients in the table; standardized coefficients are reported in the text. Robust standard errors are in parentheses. p-Values are based on estimations with robust standard errors. Reference group was children in the highest quintile (SES Q5). All models were estimated utilizing survey commands with similar stratification and sampling units. Reported R^2 and F-value are the average values across 15 datasets.
+ $p \leq 0.10$; * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$.

education (0.09SD), which is a key predictor of children's achievement outcomes (e.g. Davis-Kean, 2005; Hill & Taylor, 2004; Lareau, 2003). Although the absolute values of the home indicators are small, they are moderately important in relative terms, compared with the association of parents' education and achievement.

3.2. Mediation of math proficiency at kindergarten entry and home learning environment

Table 3 shows mediational associations of math proficiency and home indicators by reporting the decomposition of the total association between SES and math achievement into direct and indirect associations The mediation analysis of math proficiency (column 1) corresponds to model 3 reported in Table 2. The mediation analysis of indicators of the home learning environment (column 2) corresponds to model 4. In this analysis, math proficiency is a control variable because we intended to examine the mediating role of indicators of the home learning environment in kindergarten after controlling for the association of math proficiency at kindergarten entry. General learning activities was also included as a control variable in this mediation analysis because it was not significantly associated with math achievement in the spring of kindergarten. The simultaneous mediation analysis of math proficiency and indicators of home learning environment (column 3) corresponds to model 4 and includes the same control variables as the mediation reported in column 2.

Overall, math proficiency at kindergarten entry partially attenuated (mediated) the relation between SES and math achievement. Results of the KHB-method tests in Column 1 indicated that the adjusted association between math achievement and SES was partially but significantly mediated by math proficiency at kindergarten entry for all SES quintiles (quintile 1, $z' = -7.04$, $p < 0.001$; quintile 2, $z' = -6.30$, $p < 0.001$; quintile 3, $z' = -4.71$, $p < 0.001$; quintile 4, $z' = -2.50$, $p < 0.05$; recall quintile 5 is the reference group). Math proficiency at kindergarten entry, after controlling for all covariates in the model, accounted for about one-third of the total association of SES, across SES quintiles, on math achievement in the spring of kindergarten.

Results of the KHB-method tests in Column 2 indicated that the adjusted association between math achievement and SES was also partially mediated by indicators of the home learning environment in kindergarten for all SES quintiles, even after controlling for

Table 3
Decomposition of total effect of SES on math achievement into direct and indirect effects via math proficiency and home learning environment indicators.

	Column 1 Math Proficiency	Column2 Home Environment	Column 3 Proficiency & Home Environment
SES Q1, lowest			
Coefficients and (standard errors)			
Total effect	−4.046*** (0.198)	−2.591*** (0.199)	−3.829*** (0.198)
Direct effect	−2.734*** (0.198)	−1.986*** (0.206)	−1.986*** (0.206)
Indirect effect	−1.312*** (0.186)	−0.606*** (0.063)	−1.843*** (0.198)
Mediation %	32.43	23.38	48.14
Via math proficiency	100		65.62
Via learning tools		47.91	16.45
Via parental involvement		21.23	7.20
Via general learning activities		–	–
Via reading activities		10.22	3.65
Via future educational expectations		20.64	7.09
Via current educational expectations		NA	NA
SES Q2			
Coefficients and (standard errors)			
Total effect	−3.129*** (0.170)	−1.835*** (0.171)	−2.944*** (0.170)
Direct effect	−1.956*** (0.170)	−1.450*** (0.174)	−1.450*** (0.174)
Indirect effect	−1.173*** (0.186)	−0.384*** (0.050)	−1.494*** (0.194)
Mediation %	37.50	20.94	50.74
Via math proficiency	100		71.95
Via learning tools		48.76	13.65
Via parental involvement		18.84	5.20
Via general learning activities		–	–
Via reading activities		10.42	3.07
Via future educational expectations		21.98	6.14
Via current educational expectations		NA	NA
SES Q3			
Coefficients and (standard errors)			
Total effect	−2.510*** (0.158)	−1.539*** (0.158)	−2.366*** (0.158)
Direct effect	−1.633*** (0.158)	−1.311*** (0.160)	−1.311*** (0.160)
Indirect effect	−0.876*** (0.186)	−0.228*** (0.042)	−1.055*** (0.192)
Mediation %	34.92	14.80	44.58
Via math proficiency	100		74.89
Via learning tools		46.63	11.69
Via parental involvement		13.69	3.39
Via general learning activities		–	–
Via reading activities		14.91	3.85
Via future educational expectations		24.77	6.17
Via current educational expectations		NA	NA
SES Q4			
Coefficients and (standard errors)			
Total effect	−1.600*** (0.147)	−1.084*** (0.146)	−1.521*** (0.146)
Direct effect	−1.136*** (0.147)	−0.967*** (0.147)	−0.967*** (0.147)
Indirect effect	−0.465* (0.186)	−0.117** (0.037)	−0.554** (0.190)
Mediation %	29.05	10.76	36.44
Via math proficiency	100		75.03
Via learning tools		39.18	9.84
Via parental involvement		11.99	2.97
Via general learning activities		–	–
Via reading activities		19.32	4.89
Via future educational expectations		29.51	7.28
Via current educational expectations		NA	NA

Note: Reference group was children in the highest quintile (SES Q5). NA = no mediating effect was observed. The variables measuring "general learning activities" was not included in the mediation analyses because it was not significant in the regression models reported in Table 2.
+$p \leq 0.10$; *$p \leq 0.05$; **$p \leq 0.01$; *** $p \leq 0.001$.

math proficiency at kindergarten (quintile 1, $z' = -9.66$, $p < 0.001$; quintile 2, $z' = -7.73$, $p < 0.001$; quintile 3, $z' = -5.39$, $p < 0.001$; quintile 4, $z' = -3.11$, $p < 0.01$). After controlling for covariates and math proficiency at kindergarten entry, the full set of home learning environment indicators in kindergarten accounted for between 23% and 11% of the total association of SES, across SES quintiles, on math achievement in the spring of kindergarten.

Also, after examining the contribution of each home indicator as a mediator, we found that all indicators, except for current educational expectations, had a mediating association for all group comparisons (quintile 1, $z' = 0.75$, $p < 0.45$; quintile 2, $z' = 1.81$, $p < 0.071$; quintile 3, $z' = 2.41$, $p < 0.016$; quintile 4, $z' = 1.60$, $p < 0.11$). Furthermore, the greatest proportion of the mediating association of the home learning environment was accounted for by access to learning tools. For example, 48% of the total mediating association was accounted for by learning tools when the lowest and highest SES quintiles were compared. Twenty percent of the mediating association was accounted by future educational expectations and parental involvement between these two quintiles. The patterns with the indicators of the home learning environment in kindergarten were consistent across the other SES quintile comparisons.

Results from the combined mediation analysis indicated that both math proficiency and indicators of the home learning environment in kindergarten partially mediated the relation between SES and math achievement when both sets of variables were included in the model (quintile 1, lowest, $z' = -9.32$, $p < 0.001$; quintile 2, $z' = -7.71$, $p < 0.001$; quintile 3, $z' = -5.50$, $p < 0.001$; quintile 4, $z' = -2.91$, $p < 0.01$). Math proficiency at kindergarten entry combined with indicators of the home learning environment in kindergarten accounted for between 48% and 36% of the total SES association, across SES quintiles, on math achievement in the spring of kindergarten. Math proficiency at kindergarten entry accounted for around two-thirds of the total mediating associations across SES groups. The relative importance of this variable as a mediator increased when the higher SES groups were compared. For example, math proficiency at kindergarten entry accounted for 75% of the total mediating association of SES, when students in the fourth and fifth quintiles were examined, whereas this variable only accounted for 65% when comparing the lowest and highest quintiles. Indicators of the home learning environment in kindergarten also contributed to the mediation associations, although their relative contribution was lower. After taking into account the mediating role of math proficiency at kindergarten entry, access to learning tools accounted for 16% of the total mediating association when comparing the lowest and highest quintiles.

3.3. *Moderation of SES on the relations between math proficiency at kindergarten entry, home learning environment and math achievement*

Most of the moderation analyses were non-significant and patterns of moderation were not consistent across key independent variables and comparison groups. As model 5 (Table 4) indicates, SES only moderated the association between math proficiency at kindergarten entry and math achievement for children in the two highest quintiles ($b = -0.86$, $p < 0.05$). The association between math proficiency at kindergarten entry and math achievement differs depending on whether students were in the 4th or 5th quintile. In other words, this association was stronger for children in the highest quintile (5) than for children in the 4th quintile.

SES did not moderate most of the associations between home learning environment indicators in kindergarten and math achievement in kindergarten; the only two exceptions were general and reading learning activities. SES moderated the relationship between general and reading learning activities and math achievement for children in the second and highest quintiles ($b = -1.34$, $p < 0.01$ and $b = -0.70$, $p < 0.01$). General learning activities also moderated the SES achievement gaps for children in the third and highest quintiles ($b = -0.95$, $p < 0.05$). The advantages associated with these two types of involvement were stronger for those students in the highest SES quintiles than for those in the 4th quintile. These findings suggest that, in the few cases where there was moderation, children from the 5th SES quintiles benefitted more from math proficiency at kindergarten entry and general and reading activities. Thus, these key variables were not factors that could provide stronger opportunities for those economically disadvantaged students.

4. Discussion

Eliminating the SES achievement gap in early childhood is a major social concern given its lasting consequences for children's academic and subsequent economic well-being (Alexander, Entwisle, & Olson, 2007; Duncan & Murnane, 2011). This study examined SES-math achievement gaps in kindergarten and the potential mediating/moderating associations of key predictors using a nationally representative dataset. We addressed three questions: One, to what extent does children's math proficiency at the start of kindergarten attenuate the relation between SES and math scores at the end of kindergarten? Two, after accounting for the associations of math proficiency, do indicators of the home learning environment in kindergarten further attenuate the relation between SES and children's math achievement at the end of kindergarten? Three, to what extent does SES moderate the association between math proficiency at the

Table 4
Examining the moderating effects of socio-economic status.

	Model 5 Math Proficiency	Model 6 Learning tools	Model 7 Involvement in school	Model 8 General learning activities	Model 9 Reading learning activities	Model 10 Future educational expectations	Model 11 Current educational expectations
Main SES Effects							
SES Q1 (lowest)	−1.786*** (0.278)	−1.721*** (0.256)	−1.769*** (0.247)	−1.770*** (0.233)	−1.816*** (0.231)	−1.880*** (0.232)	−1.923*** (0.230)
SES Q2	−1.003*** (0.250)	−1.183*** (0.217)	−1.184*** (0.211)	−1.154*** (0.202)	−1.201*** (0.204)	−1.196*** (0.208)	−1.224*** (0.203)
SES Q3	−0.999*** (0.268)	−1.242*** (0.198)	−1.276*** (0.201)	−1.201*** (0.188)	−1.278*** (0.185)	−1.228*** (0.190)	−1.307*** (0.183)
SES Q4	−0.330 (0.256)	−0.730*** (0.203)	−0.753*** (0.193)	−0.677*** (0.180)	−0.750*** (0.179)	−0.769*** (0.182)	−0.810*** (0.175)
Main indicator effect	7.965*** (0.287)	0.726*** (0.189)	1.081 (0.709)	0.774** (0.279)	0.674*** (0.204)	0.365* (0.157)	0.433* (0.216)
Interaction effects							
SES Q1 × Indicator	0.270 (0.419)	0.036 (0.274)	0.346 (0.819)	−0.511 (0.379)	0.042 (0.254)	−0.134 (0.177)	0.158 (0.315)
SES Q2 × Indicator	−0.343 (0.380)	−0.340 (0.236)	−0.375 (0.872)	−1.340*** (0.389)	−0.698** (0.263)	−0.213 (0.179)	0.088 (0.339)
SES Q3 × Indicator	−0.629+ (0.362)	−0.275 (0.242)	−1.016 (0.867)	−0.952* (0.389)	−0.475+ (0.275)	−0.254 (0.189)	−0.329 (0.320)
SES Q4 × Indicator	−0.857* (0.352)	−0.145 (0.254)	−0.592 (0.859)	−0.628 (0.415)	−0.411 (0.271)	−0.065 (0.193)	0.332 (0.311)

Note: Math achievement is represented by unstandardized coefficients in the table; standardized coefficients are reported in the text. Robust standard errors are in parentheses. *p*-Values are based on estimations with robust standard errors. Reference group was children in the highest quintile (SES Q5). All models were estimated utilizing survey commands with similar stratification and sampling units. All models included similar statistical controls which are not reported in the table. Reported R^2 and *F*-value are the average values across 15 datasets.
+ $p \leq 0.10$; * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$.

start of kindergarten, indicators of the home learning environment in kindergarten, and children's math achievement?

Consistent with other research (Arnold & Doctoroff, 2003; Byrnes & Wasik, 2009; Jordan et al., 2006), we found a significant association between SES and children's math scores at the end of kindergarten. The magnitudes of the unadjusted gaps were between one-third and half standard deviations across SES-groups, with the largest gap between children in the highest and lowest quintiles. As noted by Duncan and Murnane (2011; see also Yeung & Conley, 2008), children from families of low SES generally have less access to educational resources, live in low SES neighborhoods and are more likely to attend schools with children with limited academic achievement. Thus, it is imperative to identify factors that can promote the academic success of children from low SES backgrounds.

4.1. Math proficiency as a mediator of SES-math achievement gaps

A major contribution of this study was to show the associations of math proficiency at the start of kindergarten with children's subsequent math skills. Although prior research shows the importance of early math skills for children's long-term development (Anders et al., 2012; Bodovski & Farkas, 2007; Duncan et al., 2007; Geary et al., 2013), those studies treated math skills as a continuous variable. In contrast, this study showed the importance of starting kindergarten with a certain level or threshold of math skills.

Starting kindergarten proficient in math is important for subsequent learning for two reasons. One, children who start kindergarten proficient in math have the required math foundation to capitalize on classroom instruction. As Kaplan and Walpole (2005) argued about early reading skills, certain forms of knowledge acquisition is sequential: One first needs to master one level before being able to advance to the next level. Two, math instruction in the average kindergarten classroom may better match the skills of children who start kindergarten with what we call proficient math skills. These explanations are based on research on reading (Connor et al., 2004; Morrison & Connor, 2002); future research should investigate similar aspects of math learning and instruction.

Our results not only indicated that math proficiency at the start of kindergarten had a significant association with math achievement, but also that being proficient substantially attenuated, although did not fully eliminate, the association between SES and math skills at the end of the kindergarten. On average, math proficiency decreased the SES-math achievement gap by one third. However, it is important to note that more children from higher SES started kindergarten proficient in math: The percentage of children who started kindergarten proficient in math ranged from 14.11 and 29.45 in the 1st and 2nd SES quintile, respectively, to 37.43 in the 3rd quintile, and 50.59 and 63.85 in the 4th and 5th quintiles, respectively.

4.2. Home learning environment as a mediator of SES-math achievement gaps

As discussed in section 1.3, there is a large body of research showing that growing up in a stimulating home environment predicts children's academic development (Crosnoe & Cooper, 2010; Crosnoe et al, 2010; Serpell et al., 2005). Consistent with the family investment model (Evans, 2004), research shows SES differences, favoring those from higher SES, in the nature and amount of home academic stimulation (Bradley et al., 2001; Phillips, 2011). In fact, Haskins, Garfinkel, and McLanahan (2014) attribute much of the SES gap in early learning to children's home environments. However, research addressing what specific indicators of the home learning environment predict children's math development, and more specifically, attenuate SES-math achievement gaps, is far more limited.

Consistent with previous research, the findings from this study identify four particularly important indicators of the home learning environment: learning tools, reading with children, parents' expectations and involvement at school. These findings are over and above the contribution of math proficiency. These home learning indicators not only represent the overall academic orientation of families by measuring parents' beliefs expressed through expectations, and access to learning tools, but also parents' behaviors that may facilitate learning. As Davis-Kean (2005) argued, parents' educational expectations for their children influenced the provision of relevant learning experiences to their children and their flexibility to modify their home environment to respond to their children's needs. Similarly, access to books and technology at home could be important contexts for facilitating the learning of mathematical concepts and procedures embedded in non-specific math activities (see Anderson, Anderson, & Shapiro, 2005 for an examination of math learning through story telling).

Surprisingly, the association between general learning activities and math achievement was not significant when including all home learning environment indicators. This finding may be related to the nature of learning activities collected by the ECLS-K study, which include activities such as talk about nature, do science projects, sing songs, do arts, or play sports, which do not necessarily focus on math content. Nevertheless, knowing what indicators of the home learning environment foster math skills in kindergarten can serve as a springboard for teachers to discuss with parents what they can do at home with their children to foster their math development.

Of particular interest are the mediation associations of access to learning tools, reading at home, parental involvement in school, and parents' future educational expectations, on the association between SES and math achievement. Consistent with the family involvement model and concerted cultivation (Cheadle, 2008; Evans, 2004; Lareau, 2003), learning tools and reading practices are less present in the homes of children from low SES backgrounds (Bradley et al., 2001), and these parents experience greater barriers for involvement in school (Cooper, 2010). Nevertheless, there is ample evidence showing that comprehensive and systematic family–school partnerships positively influence family practices (Galindo & Pucino, 2012; Galindo & Sheldon, 2012; Sanders, 2003).

4.3. SES as moderating the relationship between math proficiency and home learning environment and math achievement

A potential way to decrease or eliminate the SES achievement gap is to observe a stronger association of key factors for those students in the lowest SES quintiles than in the highest.

Unfortunately, the findings in this study did not support such a pattern. There was no overall evidence of moderation contrary to our expectations. In the few analyses where there were significant associations for moderation, contrary to our expectations, the moderators provided stronger benefits for children in the highest SES quintile. That said, there are still relevant implications from the moderation analyses.

SES only moderated the relationships between two indicators of the home learning environment in kindergarten (general and reading learning activities) and math achievement at the end of kindergarten (when examining students in the 2nd or 3rd vs. 5th quintiles). In these cases, the advantages were stronger for children in the highest quintile. These results suggest that children from the upper SES quintiles were able to draw upon other family strengths or learning opportunities to capitalize even further on the advantages associated with their high SES. It is also possible that the nature of the interactions children have when engaging in general and reading learning activities may differ for children from low and higher SES families, and therefore be more beneficial for the latter group (Serpell et al., 2005).

This pattern of findings showing that math proficiency and indicators of the home learning environment were more beneficial to higher SES children is not uncommon. Ceci and Papierno (2005), in discussing possible effects of interventions, noted that sometimes interventions intended to close SES-achievement gaps actually increase such gaps. One approach to avoid such a pattern is to target interventions, if possible, to the focal group (in this case, lower SES children). Given these findings, interventions can build upon math proficiency at kindergarten entry and indicators of the home learning environment (e.g., learning tools, reading, parent expectations and involvement at school) identified in the mediational analyses, to target low income SES children and their families. Recommendations for such are presented in section 4.5.

4.4. Limitations

Although this study increases our knowledge of how early proficiency in math and the home learning environment significantly narrow SES-related math achievement gaps in kindergarten, there are limitations to the study. One, the alphas for the home indices were sometimes fairly low, although similar scales with comparable alphas have been consistently used in several publications (Crosnoe et al, 2010; Galindo & Sheldon, 2012). Two, the information from the parents were self-reports and may not be a veridical representation of actual practices. Three, our selection of indicators of the home learning environment obviously is constrained by what was available in the dataset. For example, it did not include factors such as parents' warmth and nurturance, factors known to be relevant for children's academic growth (Brooks-Gunn & Markman, 2005; Duncan & Magnuson, 2005) or questions that focused on specific math activities. Four, we focused on children's home learning environment in kindergarten. However, the home learning environment in kindergarten is probably highly correlated with the environment before kindergarten and related to children's math skills at the start of kindergarten. Unfortunately, that is a naturally occurring confound experienced by other researchers investigating these types of issues (e.g., Crosnoe & Cooper, 2010; Crosnoe et al, 2010). Five, although the ECLS-K study followed systematic procedures to design, construct, and study the psychometric characteristics of the cognitive assessments (see Rock & Pollack, 2002), standardized assessments are not necessarily free of cultural and racial/ethnic biases (Jencks, 1998; see also Steele, 1997). This is particularly relevant in a study that focuses on SES-related achievement given the overrepresentation of racial/ethnic minority students among those in the lowest SES groups. It is important to note that the ECLS-K study conducted differential items functioning (DIF) to investigate *statistically* potential racial biases of items (for additional information, see Rock & Pollack, 2002). Six, the ECLS-K tested kindergartners in 1998, with test development probably occurring a few years earlier. Thus, it is important to consider whether the math items assessed are still pertinent for today's kindergartners. ECLS-K in kindergarten emphasized number and shape (proficiency level 1), relative size (proficiency level 2, see National Center for Education Statistics, 2001), and ordinality, sequence (proficiency level 3). The Common Core State Standards (CCSS-M) for math in kindergarten include knowledge of counting and cardinality, operations and algebraic thinking, number and operations in based ten, measurement and data and geometry (www.nctm.org). A comparison of the elements making up the actual math domains in both the ECLS-K and the CCSS-M reveals considerable overlap. Thus, the findings appear relevant for understanding how today's kindergarteners fare in math. Knowing with which skills children start kindergarten, and which skills these children or groups of children still need to develop, has implications for what instructional programs in preschool or kindergarten should target (see further discussion in section 4.5 of effective interventions). Research on reading by Connor and colleagues (Connor et al., 2004; Morrison & Connor, 2002) confirms the importance of a match between children's skills and instruction.

Despite the limitations, discussed above, the data from this study show how aspects of the home learning environment attenuate the SES math achievement gap. This has important implications for how to improve all children's math skills.

4.5. Policy and educational implications

These findings, showing that starting kindergarten proficient in math significantly attenuated the association between SES and children's math achievement and that the home learning environment in kindergarten further reduced the gap, have significant implications for policy makers and educators. Several studies have shown that school-based intervention programs focused on improving children's early math skills can be effective. Jordan et al. (2012) successfully taught kindergarten children number sense; effects were still evident eight weeks later when children were tested at posttest. Their population consisted of mainly low income children. Clarke et al. (2011) also developed an effective curriculum for use with kindergartners. The curriculum included number operations, geometry, measurement, and vocabulary. About 56% of the kindergartners were from low income backgrounds as indexed by free and reduced lunch status. Children showed significant growth over the school year compared to a control group who did not receive the focal curriculum.

The prior two studies focused on kindergartners; others have addressed math skill development in preschool. Klein and Starkey have conducted several studies using trained classroom teachers as interventionists and found significant positive effects of the training with low income preschoolers (Klein, Starkey, DeFlorio, & Brown, 2012; Klein et al., 2008; see also Clements & Sarama, 2007, 2008). Both Klein et al. (2012) and Sarama and Clements (2004) have developed empirically validated education curricula for use in preschools.

Early formal education (e.g., center-based child care, preschool, Head Start) can be an important arena for fostering children's early math skills (Nores & Barnett, 2014; Wang et al., 2013). However, a significant proportion of children, particularly from low SES families, do not participate in any type of early formal education before kindergarten (Bassok, 2010; Loeb, Bridges, Bassok, Fuller, & Rumberger, 2007), attend programs that are less adequate than those attended by children from higher SES (Nores & Barnett, 2014), or have teachers who do little or no direct math instruction (Hindman, 2013). Ginsburg et al. (2008) note, for example, that many teachers of preschoolers report not knowing what to do to promote children's math skills. Teachers need to improve their knowledge of how to teach math to this age group. Such instruction should include direct math instruction (Klein et al., 2008) but also can include more indirect instruction, such as math-related talk during circle time (Klibanoff, Levine, Huttenlocher, Vasilyeva, & Hedges, 2006).

Following Bronfenbrenner's (1979) ecological theory, and recognizing that development is highly influenced by the interrelationships among contexts, we argue that a comprehensive multi-contextual approach be taken to improve the educational opportunities of children from low SES backgrounds. Such an approach should focus on the home (Burchinal et al., 2010) *and* school contexts (including preschool; Ginsburg et al., 2008; Yoshikawa et al., 2013).

Many parents, including those from middle SES backgrounds, report not knowing what to do to foster their children's math skills (Cannon & Ginsburg, 2008), and view math as less important than reading (Musun-Miller & Blevins-Knabe, 1998; Starkey et al., 2004).

Furthermore, low income children reportedly experience fewer math-related activities at home than middle income children (Ramani & Siegler, 2008; Saxe et al., 1987) and there is substantial variability in the amount of math-related talk and experiences children have at home (Levine, Suriyakham, Rowe, Huttenlocher, & Gunderson, 2010), even when one controls for SES. Taken together, these findings show that there is a need to increase parents' awareness of the importance of math and ways to foster their children's math skills (Sonnenschein et al., 2012).

Through developing strong family and school partnerships and building upon the strengths of the families, schools can help parents increase their awareness of what home learning activities foster children's math development and utilization of math learning opportunities at home (Epstein & Sanders, 2000; Klein et al., 2008; Sheldon, Epstein, & Galindo, 2010). For example, Klein et al.'s (2008) school-based training study with low income preschoolers included a component where teachers sent home relevant math activities for parents to do. Parents reported liking and doing the activities (Starkey et al., 2004). An added advantage of such partnerships is that it would inform teachers about what parents are doing at home to foster their children's educational development, something teachers often do not know (Serpell et al., 2005; Sonnenschein & Schmidt, 2000).

5. Conclusion

Much of the research on SES-math achievement gaps has focused on mediational processes (Cheadle, 2008; Davis-Kean, 2005; Linver et al., 2002). Our study was one of the first, we believe, to compare mediational and moderation approaches in the same study. Such a comparison is important because it allows us to identify factors or processes that decrease the gap and determine whether associations vary with SES (Edwards & Lambert, 2007; Judd et al., 2001).

The findings from this study identify important processes that may reduce the SES-math achievement gap. Starting kindergarten proficient in math significantly attenuated that gap. Aspects of the home learning environment in kindergarten including access to home learning tools, reading with children, parents' expectations and involvement at school further reduced the gap. The next step for educators and policy makers is to translate these potential pathways into actualities for children from low SES backgrounds.

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