Teaching Students What They Already Know? The (mis)alignment between mathematics instructional content and student knowledge in kindergarten

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Abstract

Kindergarten mathematics skills are important for subsequent achievement, yet mathematics is underemphasized in kindergarten classrooms. Using nationally representative data, this study explored the relationship between students' school-entry math skills, classroom content coverage, and end of kindergarten math achievement. Although the vast majority of children entered kindergarten having mastered basic counting and able to recognize simple geometric shapes, their teachers reported spending the most mathematics time – typically about 13 days per month – on this content. On average, exposure to this basic mathematics content was negatively associated with math achievement across kindergarten. Importantly, children with the lowest levels of math skills benefited from exposure to this basic mathematics content while other children benefited from exposure to more advanced content.

Keywords: early mathematics learning; kindergarten; content coverage

Recently, scholars and education advocates have focused on the importance of mathematics for young children, indicating that 3- to 6-year-olds are ready to learn varied mathematics content that establishes a solid base for future learning (National Association for the Education of Young Children, 2002; National Council of Teachers of Mathematics, 2007; National Mathematics Advisory Panel, 2008). Math skills measured at school entry are important predictors of subsequent school achievement in both reading and math (Duncan, et al., 2007), and teachers' instructional practices and content coverage have an important influence on early math skills (Bodovski & Farkas, 2007; Croninger, Rice, Rathbun, & Nishio, 2007; Crosnoe et al., 2010; Guarino, Hamilton, Lockwood, Rathbun, & Hausken, 2006; Magnuson, Ruhm, & Waldfogel, 2007; Palardy & Rumberger, 2008).

Although research highlights the importance of kindergarten mathematics for later achievement, math is underemphasized in kindergarten. Kindergarten teachers spend little time on mathematics instruction and cover very basic content, such as counting (Bargagliotti, Guarino, & Mason, 2009; Rudd, Lambert, Satterwhite, & Zaier, 2008). For example, teachers report spending approximately five hours per week on reading compared with only three hours per week on mathematics. Further, undergraduate programs in early childhood education focus little on mathematics instruction and teachers of young children are unsure about how to teach math (Ginsburg, Lee, & Boyd, 2008). Kindergarten mathematics standards and the mathematics content taught in kindergarten classrooms emphasize early number skills over more advanced mathematics skills (Reys, Chval, & Switzer, 2008).

Given the importance of early mathematics skills for later school success, understanding how math content exposure influences mathematics achievement is important for both education policy and practice. Using the Early Childhood Longitudinal Study-Kindergarten (ECLS-K) cohort, we describe how the math content on which kindergarten teachers focus aligns with students' mathematics knowledge. We explore the interaction between students' school-entry math skills, classroom content coverage, and end-of-kindergarten math achievement. We examine how exposure to specific mathematics content influences math test scores at the end of kindergarten for all children and for children with different levels of math skills at kindergarten entry.

Background

Mathematics Achievement

Children in the United States lag behind their peers in other developed countries in mathematics achievement (Ginsburg, Cooke, Leinwand, Noell, & Pollack, 2005; Mullis, Martin, & Foy, 2008; OECD, 2004). Further, low-income and minority children are at particular risk for underachievement in mathematics (Jordan, Kaplan, Ramineni & Locuniak, 2007, 2009; Siegler, 2009; Siegler & Ramani, 2008; Starkey, Klein, & Wakeley, 2004), and a large literature documents race and income gaps in school-entry math skills (e.g. Bodovski & Farkas, 2007; Fryer & Levitt, 2004; Magnuson & Duncan, 2006; Phillips, Crouse, & Ralph, 1998). Early math skills are malleable and can be influenced by a child's environment (Starkey & Klein, 2000). Recent research has shown that low-income children experience gains in mathematics skills even from brief interventions (Klein et al., 2008; Siegler & Ramani, 2008; Siegler & Ramini, 2009; Starkey et al., 2004).

The mathematics knowledge and skills that students have at school entry and acquire during kindergarten are key to later school success (Claessens & Engel, in press; Claessens, Duncan, & Engel, 2009; Duncan, et al., 2007). Thus, it is surprising that kindergarten teachers spend limited time on mathematics instruction and tend to focus most on narrow and basic mathematical content (Rudd et al., 2008). For example, in the nationally representative ECLS-K, kindergarten teachers reported spending nearly twice as much instructional time on reading compared with mathematics[2]; a pattern that continues in the average public elementary school through at least fourth grade and has been documented over two decades (Morton & Dalton, 2007). Further, nearly 20 percent of kindergarten teachers reported engaging in mathematics instruction three times per week or less (Bargagliotì et al., 2009).

Teachers and Instruction

A large literature documents both the important influence that teachers have on student learning and substantial variation in teacher effectiveness (Aaronson, Barrow, & Sander, 2007; Hanushek, Kain, O'Brian, & Rivkin, 2005; Harris & Sass, 2008; Kane, Rockoff, & Staiger, 2006; Nye, Konstonopoulos & Hedges, 2004; Rockoff, 2004), including the importance of quality teacher-child interactions (e.g. Mashburn, Painta, Hamre, Downer, et al., 2008). However, efforts to link observable teacher characteristics such as years of experience, certification, and years of education to their effectiveness have found that few teacher characteristics are associated with teacher value added. Teacher qualifications and characteristics explain little of the total variation in teacher effectiveness (Goldhaber, 2002; Rockoff, 2004).

The limited association between teacher characteristics and teacher effectiveness is likely because these qualities are not direct measures of instruction. Teacher qualifications, knowledge, and experience are most likely to have an indirect influence on student achievement through their correlation with teachers' instructional practices and content coverage (Goe, 2007). Studies comparing the predictive power of teacher characteristics with that of classroom practices have found that the latter, more proximal measures, better predict student test score gains (Guarino et al., 2006; Palardy & Rumberger, 2008).

For example, studies of pedagogical approaches and indicators of instructional quality, such as quality of teacher-led discussions or rigor of activities have found particular practices to be associated with student learning. Smith, Lee, and Newman (2001) found that instructional strategies coded "interactive" were associated with larger student test score gains than strategies coded "didactic." Other studies used instruments such as the Danielson Framework (Danielson, 1996) to code the quality of instructional practices, finding that teachers whose instruction included high-quality discussions, rigorous activities, and high expectations of students are more effective (Borman & Kimball, 2005; Holtzapple, 2003, Matsumura et al., 2006).

A number of studies have used the ECLS-K to examine teacher practices and their association with student achievement. In mathematics, "teaching for understanding" and "drill" both positively predicted math achievement (Milesi & Gamoran, 2006). For first graders, the use of worksheets and working on problems with a calendar were positively associated with gains in mathematics achievement, while the use of geometric manipulatives had a negative correlation (Palardy & Rumberger, 2008). Emphasis on traditional practices and computation, measurement and advanced topics, and numbers and operations were all positively associated with kindergarten math gains (Gaurino et al., 2006). Similarly, Bodovski and Farkas (2007) found that practices including both "traditional math" and "group/interactive activities", as well as instruction on content including advanced counting, practical math, and single-digit operations were all positively associated with kindergarten mathematics gains. Interestingly, Bodovski and Farkas found time spent on basic numbers and shapes to be negatively correlated with achievement.

Taken together, prior studies on instruction have found a range of pedagogical practices and instructional modalities to be associated with student achievement. Studies that included

ECLS-K teacher-reported content coverage (e.g. Guarino et al., 2006; Bodovski & Farkas, 2007) found some content to be positively associated with student achievement while other content appeared to have a negative effect. For example, students with higher levels of reading skills benefited from more advanced content and curricula in reading (Xue & Meisels, 2004). One limitation of many of the prior studies that used the ECLS-K to examine the effects of instruction is that they used measures that mixed content coverage, pedagogical practices, and instructional modalities. While all of these aspects of instruction are important, we focus on content to better understand how student exposure to specific mathematics content predicts mathematics achievement.

We posit that content exposure, in and of itself, is important for children's learning. Further, it is possible that content coverage is more amenable to change than pedagogy, instructional modalities, or the allocation of instructional time. Introducing teachers to new teaching methods and skills that they will successfully adopt is likely to be time intensive and difficult. Further, large-scale policies such as No Child Left Behind (NCLB) appear to have done little, on average, to change the allocation of instructional time (Morton & Dalton, 2007). In contrast, having teachers shift the content they cover, particularly to reallocate their focus among topics that they already teach seems quite amenable to change. Thus, while we recognize the importance of pedagogy, our study examines the effects of content coverage. We argue that content that is aligned with children's skill levels will best facilitate student learning. We expand upon the extant literature by examining the extent to which kindergarten mathematics content is aligned with school-entry math skills and how children's math skills interact with this content exposure.

Theoretical Framework

A child's predispositions, knowledge, and skills contribute to his own learning and to the environment in which he operates; in turn, the child receives feedback from others in the environment (Meisels, 1998). This complex interaction between the child and his environment affects his developmental trajectory (Bronfenbrenner & Ceci, 1994; Bronfenbrenner & Morris, 1998). Given that these interactions rely on both the individual child's skills and the environment in which he operates, we argue that school-entry skills in mathematics will interact with the mathematics content to which a child is exposed. For example, a child who enters kindergarten with high levels of math skills but is exposed to basic mathematics content might not have the opportunity to develop new mathematics skills over the kindergarten year. Similarly, a student who enters kindergarten with low levels of mathematics skills, but is exposed to advanced mathematics content might not improve in mathematics because he cannot grasp the advanced material. Exposing students to content beyond their current skills but still within their range of abilities may promote early skill development (Vygotsky, 1978). Thus, we posit that the content must be properly aligned to a child's skill level to optimize learning.

Interestingly, our investigation aligns most closely with recent theory and research in reading. Recent evidence on literacy practices has found that effective reading instruction varies by a child's skill level in language and literacy (Connor, Morrison, & Katch, 2004; Connor, Piasta, Fishman, Glasney, & Schatschneider, 2009). Termed "Child × Instruction interactions," these studies found that children benefited from instructional activities and content that was adapted to their entering skill level (Connor et al., 2004). Experimental results have provided further evidence that literacy instruction aimed at meeting a child's individual language and literacy needs does in fact produce the largest gains (Connor et al., 2009). Relatedly, theory on mathematics learning trajectories for young children posits that the mathematics children already know should be key to determining the content that they are taught (Clements & Sarama, 2009; Sarama & Clements, 2009). The current study explores the interaction between students' mathematics knowledge at kindergarten entry, the instruction that they receive in kindergarten, and their end-of-kindergarten math test scores for a nationally representative sample.

The present study

Our study provides a descriptive picture of children's early math skills and the kindergarten mathematics content to which they are exposed. We examine the influence of teacher-reported mathematics content coverage on mathematics achievement gains during kindergarten. Further, we examine how children's math knowledge at school entry interacts with the mathematics content covered in kindergarten. We hypothesize that despite the fact that most children have mastered math skills like basic counting at kindergarten entry, kindergarten teachers continue to emphasize these basic skills while underemphasizing advanced content. We also expect that children will benefit most from exposure to mathematics content that advances beyond their skills at kindergarten entry. Finally, we hypothesize that exposure to mathematics content that is at or below the level of knowledge and skills that children had at kindergarten entry will be negatively associated with mathematics learning during kindergarten.

Data

The data used in this study came from the ECLS-K. The ECLS-K followed a nationally representative sample of children who were in kindergarten in the 1998-99 school year through eighth grade. The dataset provides extensive information on children's academic skills at school entry and throughout elementary and middle school. The ECLS-K contains detailed information about children and their families, teachers, classrooms, and schools. We used data from the fall and spring of kindergarten for this analysis. When weighted, the ECLS-K is representative of all

U.S. kindergarteners from the 1998-99 school year. The ECLS-K sampling design included multiple children in most kindergarten classrooms, averaging six students per class.

Measures

Mathematics Content. In the spring of kindergarten, teachers reported on classroom activities and content. We focused on teacher reports of how often they had students engage in particular math activities. We used these items to construct math content measures designed to align with the four mathematics proficiency levels measured by the ECLS-K mathematics achievement test in the fall of kindergarten. We created content measures that align as closely as possible with the mathematics achievement test proficiency levels in order to investigate the relationship between student mathematics skills at kindergarten entry and content exposure. The four content measures we created are: *Basic Counting and Shapes; Patterns and Measurement; Place Value and Currency;* and *Addition and Subtraction*. These measures correspond to the ECLS-K mathematics Proficiency Levels 1-4 (Tourangeau, Nord, Sorongon, Najarian, & Hausken, 2009).

Table 1 shows content measure reliabilities and the teacher survey items used to construct each content measure. The far-right column provides a description of the corresponding student mathematics test proficiency level. For example, the first content measure, Basic Counting and Shapes, includes teachers' reports of how many days per month they had children count aloud, work with geometric manipulatives, practice correspondence between number and quantity, and recognize and name geometric shapes. Responses ranged from zero days to twenty days per month. The corresponding math proficiency level encompassed identifying some one-digit numerals, recognizing geometric shapes, and one-to-one counting up to ten objects. Each content measure is an average of the non-missing items in the scale. As shown in Table 1, reliabilities for the four content measures range from .58 to .78. Appendix A provides item-level detail on mathematics content and instructional practices for all items included on the spring of kindergarten teacher survey.

Given our use of secondary data, we were constrained by the available items and by the available information about the knowledge and skills encompassed in the different proficiency level measures (described below). Due to these data constraints, we created content measures that aligned as closely as possible with the mathematics achievement test proficiency levels provided by the ECLS-K and detailed below.

Student achievement. Children were given direct assessments in language and literacy (reading) and mathematics during the fall and spring of kindergarten. The assessments were designed using Item Response Theory (IRT) to allow for the examination of growth over time (Tourangeau et al., 2009). We use sample children's spring mathematics IRT scores as our dependent variable and control for children's fall mathematics IRT scores in all of our models.

The ECLS-K provides proficiency scores for nine math achievement proficiency levels as well as dichotomous variables indicating whether or not a child has mastered each of these nine levels. We use the dichotomous indicators of mastery to group children by school-entry mathematics ability for some of the analyses presented below. We use these measures to group children by their fall of kindergarten math skills, although we use children's mathematics IRT scores in all of our regression models. The ECLS-K math assessment measured children's conceptual and procedural knowledge and problem solving skills, and scores range in reliability from .89 to .94 (Tourangeau et al., 2009). The proficiency levels in math measured in kindergarten include 1) numbers, shapes, and counting to ten; 2) counting beyond ten, patterns, and relative size; 3) ordinality and sequence; and 4) addition and subtraction (see final column of

Table 1 for more detail).

Child, home, and family characteristics. We include a variety of child and family characteristics as control variables in our analyses. Many characteristics of children and their families are likely correlated with both mathematics achievement and kindergarten classrooms. Thus, we control for child race and ethnicity, age, sex, overall health, birth weight, whether the child was premature, and type of preschool care. We also include fall of kindergarten math achievement scores, reading, a general knowledge test, and teacher ratings of the child's approaches to learning (attention and task persistence). In addition to child characteristics, we control for home and family background variables including geographic region, number of preschool moves, and neighborhood safety. We also control for home environment factors such as family structure, number of siblings, home language, and parental education, occupation, and expectations for child's education. Appendix B contains a complete list of these variables.

Teacher characteristics. Teachers completed surveys about their background characteristics and qualifications in the fall and spring of kindergarten. We include a range of these variables capturing teacher background and qualifications as controls in our models including gender, age, race and ethnicity, education, and experience.

Analytic Sample

Weighted descriptive statistics for the full sample and our analytic sample of 11,517 students and 2,176 teachers are provided in Tables 2 and 3 respectively. In the analytic sample, we included only those students with math, reading, and general knowledge test score data for fall of kindergarten and spring of kindergarten math test scores, as well as data on race, gender and age. As shown in Table 2, over half of the analytic student sample is White (64 percent), 15 percent is African American, and 13 percent is Hispanic. Almost one quarter of the analytic sample (21 percent) lived in single parent families in the fall of kindergarten, and 6 percent were in households where English was not the primary language spoken. Our analytic sample has fewer Hispanic children than the full sample (13 percent versus 18 percent) and are more likely to speak English at home (6 percent versus 11 percent). On the other measures, the analytic sample is similar to the full sample. In order to maximize sample size for our analytic sample, we assigned zeroes to cases with missing data on control variables and used missing data dummy variables (Cohen, Cohen, West, & Aiken, 2003). Appendix B provides information on missing data for control variables for our analytic sample. About 25 percent of the full sample was lost, because we require that children have information for all of the content measures.

Turning to Table 3, almost all kindergarten teachers in the analytic sample were women (97 percent). The average teacher was 41 years old, and most were White (85 percent). Approximately one third of teachers had at least a master's degree, and they had taught kindergarten for eight years, on average. Sample teachers had taken an average of three courses in teaching reading and a little over two and a half courses in teaching math. The majority of the sample had a teaching certificate (89 percent). Finally, teachers reported spending approximately three hours per week teaching math. There were few differences between the full and analytic samples of teachers. The analytic sample was slightly less likely to have a temporary certificate than the full sample (8 percent versus 10 percent). Like the student sample, cases of missing data on control variables for teachers were assigned zeroes and missing data dummy variables were used (Cohen et al., 2003).

Analytic Plan

First, we provide a description of the content coverage in kindergarten classrooms. Then, we examine how exposure to mathematics content influences math test scores at the end of the kindergarten year. We model the relationship as follows:

$$MATH_{iSK} = a_1 + ß_1 CONTENT_{iK} + ß_2 MATH_{iFK} + ß_3 READING_{iFK} + ß_4 GENKNOW_{iFK} + ß_5 CHILD_{iFK} + ß_6 FAM_{iFK} + ß_7 TEACHER_{iFK} + ß_8 CLASS_{iFK} + \varepsilon_i$$

Where $MATH_{iSK}$ is the IRT math achievement test score of child i measured in the spring of kindergarten (SK) and $CONTENT_{iK}$ are the set of mathematics content areas covered by child i's teacher. $MATH_{iFK,}$ $READING_{iFK}$ and $GENKNOW_{iFK}$ are IRT measures of child i's achievement in math, reading, and general knowledge assessed by tests in the fall of kindergarten to control for initial reading and math skills and cognitive ability. FAM_i and $CHILD_i$ are sets of family background and child characteristics included to control for individual differences that might influence math achievement before and after school entry. $TEACHER_{iFK}$ and $CLASS_{iFK}$ are the set of teacher characteristics such as experience and education and classroom characteristics, such as time on mathematics and type of kindergarten to control for differences in children's teacher and kindergarten classroom experiences; a_1 is a constant and e_i is a stochastic error term.

Our interest is in estimating $ß_1$, which, if correctly modeled, can be interpreted as the relationship between the kindergarten math content measures and end-of-kindergarten mathematics test scores. A key challenge in this approach lies in addressing the possibility of omitted variable bias, which occurs if teacher, classroom, family, or child characteristics are correlated both with mathematics content and mathematics achievement and are omitted from our model. Our strategy for reducing bias in our estimation of $ß_1$ is to estimate a model that includes as many prior measures of relevant teacher, classroom, child, and family characteristics as possible.

Given that theory and research suggest early mathematics skills might lead children to benefit more from particular teacher or classroom opportunities (Crosnoe et al., 2010; Gamoran, 1991), we are interested in the interaction between mathematics content exposure and school-entry math skills. To test our hypotheses regarding student mathematics skills and kindergarten mathematics content, we conducted the analysis described above for subgroups of students with different levels of math skills at the fall of kindergarten. Specifically, we conducted separate analyses for students who were not proficient on level one (5 percent of the analytic sample) as well as students whose highest levels of mastery were Proficiency Levels 1(32 percent), 2 (39 percent), 3 (19 percent) and 4 or higher (4 percent), respectively.[3] We conducted subgroup analyses rather than using formal interaction terms for ease of interpretation. As with interaction terms, the subgroup models allow for the comparison of the relationship between math content and spring of kindergarten math achievement across groups of children with differing school-entry math skills.

Results

Student knowledge at kindergarten entry

Table 4 shows that the vast majority of students – 95 percent – had mastered Proficiency Level 1 (which corresponds with Basic Counting and Shapes) by the fall of kindergarten. Nearly two-thirds of students had also mastered Proficiency Level 2 (corresponds with Patterns and Measurement), while only a quarter of the sample had mastered Proficiency Level 3 (corresponds with Place Value and Currency). Very few students, a mere 7 percent, had mastered Proficiency Level 4 (corresponds with Addition and Subtraction) in the fall of kindergarten. Mirroring these levels of mastery, at kindergarten entry, the average score on the first math proficiency probability level - identifying some one-digit numerals, recognizing geometric shapes, one to one counting of ten objects - was .94 out of 1. The average score on the second level - reading all one-digit numeral, counting beyond ten, and recognizing a sequence of patterns – was .58, and .23 for level three – reading two-digit numbers, recognizing the next number in a sequence, identifying the ordinal position of an object, and solving simple word problems. For level four – solving addition and subtraction problems – the average score was only .04.

Mathematics content in kindergarten

Table 4 also shows descriptive statistics for the mathematics content measures. On average, teachers reported teaching Basic Counting and Shapes nearly 13 days per month, Patterns and Measurement approximately eight days per month, Place Value and Currency nearly nine days per month, and Addition and Subtraction just over four days per month. Teachers spent considerably more time on Basic Counting and Shapes, content that corresponds with math proficiency level one, which 95 percent of sample students had already mastered when they entered kindergarten, than they did on any of the other content measures. Teachers spent the least amount of time on the fourth content measure, Addition and Subtraction. Because nearly half of the sample (45 percent) attended part-day kindergarten, we examined these content measures separately for full- and half-day kindergarten classrooms (results not shown). Full-day kindergarten teachers reported spending approximately half a day per month, on average, more on each content measure. Table 5 shows moderate, positive correlations among the content measures. The correlation between Basic Counting and Shapes and Patterns and Measurement was the strongest, .6, ranging down to .3 for Basic Counting and Shapes with Addition and

Subtraction.

Mathematics content and mathematics achievement

Table 6 presents results from multiple regression models predicting spring of kindergarten mathematics achievement test scores using the teacher-reported measures of mathematics content covered during kindergarten. For each of our four mathematics content measures, we show four different models. The first column for each measure shows results from a model that included only the fall of kindergarten mathematics test score, an indicator for full-day kindergarten, minutes of mathematics per week, and that content measure. The next column adds teacher, student, and family characteristics to the previous model. We estimated models for each content measure separately and then included all four content measures in a single model with and without additional controls (columns [9] and [10]). All variables shown, as well as the outcome, were standardized to a mean of zero and standard deviation of one and all models were weighted. Standard errors were clustered by school to adjust for non-independence.

As shown in Table 6, columns (1) and (2), devoting additional days per month to Basic Counting and Shapes was negatively associated with end-of-kindergarten mathematics test scores. These results suggest that an additional four days per month (a standard deviation of the content measure) of instruction on Basic Counting and Shapes was associated with math test scores that were about .02 standard deviation units lower, controlling for prior achievement as well as a host of child, family, and teacher characteristics. Time on Patterns and Measurement was not statistically significantly associated with end-of-kindergarten mathematics achievement, and the coefficient was near zero (columns [3] and [4]). Teaching Place Value and Currency an additional five days per month was associated with increased mathematics test scores at the end of kindergarten (columns [5] and [6]) of about .03 standard deviations. The last mathematics content measure we examined, Addition and Subtraction, was positively associated with mathematics test scores, columns (7) and (8). In the fully controlled model (column [8]), an additional four days per month of Addition and Subtraction was associated with an increase in math test scores of about .04 standard deviations.

The results described thus far have shown the relationship between individual mathematics content measures and children's math achievement at the end of kindergarten. In order to examine the relationship between each content measure and mathematics achievement net of the other measures, columns (9) and (10) show results for a model including all four of the mathematics content measures. When all four mathematics content measures were included in the model, Basic Counting and Shapes remained negatively associated with mathematics achievement, growing slightly in magnitude to -.03. Patterns and Measurement remained statistically insignificant and near zero. Place Value and Currency and Addition and Subtraction continued to be positively and statistically significantly associated with spring of kindergarten mathematics test scores. The magnitudes of the coefficients for these two content measures in the full models were similar to those shown in the previous models. Finally, although not the primary focus of our analysis, across all the models shown in Table 6, time spent on mathematics was positively and statistically significantly associated with math achievement at the end of kindergarten.

Mathematics content and achievement by student mathematics skills

We hypothesized that children may benefit differentially from exposure to particular mathematics content during the kindergarten year depending on their kindergarten-entry mathematics skills. Thus, we examined the relationship between our four mathematics content measures and children's math achievement for subgroups of children with different levels of kindergarten-entry mathematics skills. Table 7 presents results from models that are equivalent to those shown in columns (9) and (10) of Table 6 for five subgroups of children determined by their highest level of math proficiency at kindergarten entry. These groups are children who have not mastered Proficiency Level 1 and those who have mastered Proficiency Levels 1, 2, 3, or 4 or higher, respectively. The first column for each subgroup in Table 7 presents the results from models without teacher, child, and family control variables and the second column includes these controls.

Fully controlled results for the group of children with the lowest level of kindergarten-entry math skills (Table 7, column [2]) showed that additional exposure to Basic Counting and Shapes was positively associated with end-of-kindergarten mathematics test scores for this group. Exposure to content including Place Value and Currency and Addition and Subtraction was not associated with end-of-kindergarten math skills; however, more time on Patterns and Measurement was negatively associated with spring of kindergarten math achievement for these children.

For children who had mastered only mathematics Proficiency Level 1 at kindergarten entry (columns [3] and [4]), time on Basic Counting and Shapes was negatively associated with end-of-kindergarten mathematics achievement, and the negative effect of exposure to this basic content is statistically significantly different from the positive effect of exposure to Basic Counting and Shapes among children who had not yet mastered Proficiency Level 1. Neither Patterns and Measurement nor Addition and Subtraction were related to children's math achievement among this group of students. However, additional time on Place Value and Currency was positively associated with math achievement. For the subgroup of students who had mastered Proficiency Level 2 at the start of kindergarten (columns [5] and [6]), Basic

Counting and Shapes was also negatively associated with end-of-kindergarten mathematics achievement test scores, and additional time on Place Value and Currency and Addition and Subtraction was related to increases in math achievement at the end of kindergarten.

We see a similar relationship between the content areas and math achievement for children who have mastered level 3 at kindergarten entry (columns [7] and [8]). For these students, time on Patterns and Measurement was negatively associated with math skills at the end of kindergarten. As with the previous results, these children appeared to benefit from more exposure to Place Value and Currency and Addition and Subtraction. For those children who were high math achievers at kindergarten entry, having mastered Proficiency Level 4 or above, none of the mathematics content measures statistically significantly predicted end-of-kindergarten math achievement. It is important to note that the differences we find across groups are not statically significant (p<.05) in all cases. The differences are statistically significant for the effect of exposure to Basic Counting and Shapes on children who have not mastered Proficiency Level 1 at kindergarten entry compared with children who have mastered Proficiency Levels 1, 2, or 3.[4] We also examined differences across full- or part-day kindergarten by estimating the models shown in Table 7 separately by full- and part-day kindergarten. The results (not shown) indicated no differences between content and math achievement outcomes by kindergarten type.

One potential explanation of our finding that children benefit differentially from exposure to the most basic content (Basic Counting and Shapes) depending on their knowledge at kindergarten entry is that teachers might adjust their content based on student knowledge. As such, we explored the extent to which teacher-reported content coverage varies by student mathematics achievement at the fall of kindergarten. Figure 1 shows teacher-reported content coverage by sample students' fall of kindergarten mathematics achievement. While content exposure does vary somewhat by student knowledge at kindergarten entry, sample children are exposed to similar amounts of both basic and advanced content, regardless of school-entry knowledge. For example, children who enter kindergarten not yet having mastered Proficiency Level 1 are exposed to Basic Counting and Shapes, on average, 13.1 days per month and are exposed to Addition and Subtraction 3.8 days per month, on average. Children at the opposite end of the mathematics knowledge distribution at kindergarten entry, those who have mastered the four most basic proficiency levels, experience an average of 12.1 days of instruction on Basic Counting and Shapes and 4.9 days of instruction on Addition and Subtraction. These differences suggest that teachers might adjust mathematics content coverage in response to children's entering skill levels. However, the figure also reveals that all kindergarten students are exposed to a large amount of Basic Counting and Shapes even though the vast majority have already mastered this content.

Taken together, Table 7 and Figure 1 show that both the small group (5 percent of the sample) of children who benefit from exposure to Basic Counting and Shapes and the large group who do not are exposed to nearly the same amount of that content. Results also show that all children are exposed to less content related to Place Value and Currency and little content related to Addition and Subtraction – content that the vast majority of students benefit from and for which we find no evidence of negative effects.

Discussion

Using a nationally representative sample of kindergartners, this study examined the relationship between kindergarten classroom mathematics content coverage and children's math achievement test scores at the end of kindergarten. Our results reveal several important relationships. First, the vast majority of kindergarten students (95 percent) entered school having mastered basic counting and are able to recognize geometric shapes. Second, among the mathematics content covered in kindergarten, teachers reported spending the most time – about 13 days per month– on Basic Counting and Shapes. This suggests that children are exposed to mathematics content that they have already mastered for much of the already limited time they spend learning mathematics during kindergarten. Indeed, regression-adjusted results showed that for the majority of children, the teacher-reported content measure Basic Counting and Shapes was negatively associated with math achievement across the kindergarten year and that children benefited most from exposure to more advanced mathematics content such as Place Value and Currency and Addition and Subtraction. We also examined this relationship by subgroups of children based on their kindergarten-entry math skills. As anticipated, we found that children who had not mastered basic counting at kindergarten entry benefited from this content coverage but that those children who already had these skills actually gained less in mathematics if their teachers reported spending more time on this content.

The fact that most children have mastered certain basic math skills at kindergarten entry and that their teachers reported a substantial focus on these skills points to a mismatch between the skills that many students have and the mathematics content that they are typically exposed to in kindergarten. This misalignment between student skills and content coverage is potentially problematic and may result from several different factors. First, teachers are unsure about teaching mathematics and spend less time on mathematics than reading, particularly in the first years of school (Bargagliotti et al., 2009; Ginsburg et al., 2008; Rudd et al., 2008). Thus, teachers may focus on the most basic skills because of a discomfort with teaching math or because of a lack of math pedagogical knowledge beyond the most basic skills. In addition, teachers may not be aware of children's mathematics skill levels at kindergarten entry. For example, teachers in schools without early assessments in mathematics may have relatively little information about the skills their students have in mathematics, and thus, spend more time on the basics. Finally, it is possible that kindergarten teachers may, in fact, have a sense of what math skills children have and be equipped to teach more advanced content. These teachers may be following state or district mathematics standards for kindergarten classrooms that emphasize early number skills over more advanced mathematics skills (Reys et al, 2008).

Beyond the descriptive pattern of children's entering math skills and the content teachers cover, this study examined how teacher-reported mathematics content coverage was related to children's mathematics achievement scores at the end of kindergarten. We found that for most children exposure to basic content was negatively associated with children's math achievement measured at the end of kindergarten. Time spent on Basic Counting and Shapes was associated with lower mathematics achievement at the end of kindergarten for all but the lowest achieving students. We also found that exposure to more advanced mathematics content in kindergarten was associated with increased math achievement. Thus, while exposure to basic skills may be detrimental for the majority of students, exposure to advanced content appears to benefit most students with no evidence of deleterious effects.

The fact that the vast majority of children have mastered basic numbers and geometric shapes may explain why we find exposure to these skills over the course of kindergarten to be detrimental to students' math achievement. To test this hypothesis, we examined whether the relationship between kindergarten mathematics content coverage and children's mathematics achievement varied by children's school-entry mathematics skills. We found that a child's entering skill level determined the relationship between exposure to basic mathematics content and subsequent math achievement. Among children who had not mastered basic math skills at kindergarten entry, more time on basic mathematics content during kindergarten was positively associated with spring of kindergarten mathematics achievement. However, for students who had already mastered these skills at kindergarten entry -- over 95 percent of kindergarteners -- more time on basic mathematics content was negatively associated with math achievement at the end of kindergarten. For this group of students, exposure to more advanced content was positively associated with end-of-kindergarten mathematics achievement.

These results support the idea that the effect of mathematics content exposure on a child's achievement in kindergarten depends upon that child's mathematics skills at kindergarten entry. Recent research on language and literacy has highlighted the importance of the interaction between child and instruction (Connor et al., 2009; 2004). In an experimental intervention, literacy instruction aimed at meeting children's individual language and literacy needs resulted in the largest learning gains (Connor et al., 2009). Consistent with the results of these literacy studies and with theory about early mathematics learning (Clements & Sarama, 2009; Sarama & Clements, 2009), the present study provides suggestive evidence that children benefited most from instruction that best matched their individual skill levels in mathematics. Further research on the interaction between mathematics content coverage and children's skill levels is needed, but the results found here suggest a possible role of "Child x Instruction" interactions for improving mathematics achievement.

The findings presented here have shown that a large portion of the mathematics content taught during kindergarten may not meet the needs of many kindergarteners and that closer attention to children's knowledge and skills at school entry may be warranted. However, the effect sizes found in this study are small. Typically around .03 or .04 of a standard deviation, these effect sizes suggest that a relatively modest shift in classroom content coverage would lead to small gains in mathematics achievement. In this case, an effect of .03 is associated with a teacher report of spending approximately four more days per month on a particular mathematics content area, such as Addition and Subtraction. It is important to note that an effect size of .03 is larger in magnitude than the estimated relationship between many other classroom and teacher inputs and student achievement. For example, teacher qualifications and education were unrelated to children's achievement gains in the present study and are consistently found to have small to null relationships with student achievement (Nye et al., 2004; Rockoff, 2004). More time in school, as indicated by full-day kindergarten attendance, was related to increased math achievement with an effect size of about a tenth of a standard deviation. Given the costs likely involved in shifting classroom mathematics content to cover more advanced skills versus the costs associated with extending the school day, it seems that small changes to content coverage may be a potentially lower-cost avenue for improving student learning in mathematics.

Based on our findings that the vast majority of kindergarten students are exposed to large amounts of content that they do not benefit from in kindergarten as well as prior research finding that kindergarten teachers spend less time on and are unsure about teaching mathematics (e.g. Ginsburg et al., 2008), future research should examine the potential for professional development aimed at supporting teachers as they shift content coverage and continue to develop their pedagogical content knowledge for teaching mathematics in the early years of school.

Limitations

The present study is not without limitations. The data used here are non-experimental. Thus, concerns about selection and omitted variable bias persist. We controlled for a wide range of teacher, child, and family characteristics, but we cannot be certain that we have accounted for all potential omitted variables. However, the fact that we found a differential effect of exposure to particular mathematics content for children with different math skills provides evidence that both supports our hypotheses and reduces the threat from omitted variable bias.

We are also constrained to using the math achievement tests and mathematics content information available in the ECLS-K. While these variables appear to cover a broad range of content and the measures we created were both reasonably reliable and correlated with student achievement in logical ways, more nuanced measures of classroom content coverage might better capture what children are exposed to over the course of kindergarten. Future research should replicate our analyses using more detailed measures of both content and student knowledge. For example, the usefulness of classroom observations using measures such as the CLASS (e.g. Mashburn et al., 2008) or even of instructional logs completed by teachers (Rowan, Jacob, & Correnti, 2009) for measuring instruction is well documented. However, if classical measurement error is the primary problem with these measures, our estimated coefficients are likely biased toward zero.

Finally, the ECLS-K cohort was in kindergarten during the 1998-99 school year, prior to the implementation of influential reforms such as NCLB. Although these data are now over a decade old, recent evidence suggests that time on math in first through fourth grades did not change substantially following NCLB (Morton & Dalton, 2007) and also indicates that the kindergarten mathematics standards of many states do emphasize very basic mathematics content (Reys et al., 2008).

Conclusion

The present study expands our understanding of children's math achievement, the mathematics content taught in kindergarten, and the relationship between content exposure, children's math skills, and learning. Using a nationally representative sample of children, we found that most children have mastered basic math skills at school entry, that most kindergarten teachers spend substantial time teaching these same basic skills, and that this is detrimental for most children's mathematics achievement. Future research should explore the driving forces behind this misalignment. Finally, this study is one of the first to demonstrate, using nationally representative data, that children's mathematics skills are important determinants of the mathematics content exposure that will optimize their learning.

Notes

[1]Authors' calculation using ECLS-K.

[2]Three percent of the analysis sample (n=337) of students are missing data for the variable indicating highest level of math proficiency despite the fact that they do have math test scores. We include these students in our main analyses, but, by definition they are excluded from the subgroup analyses.

[3] As shown in Table 7, differences are also statistically significant for the effect of exposure to Patterns and Measurement between children who had not mastered Proficiency Level 1 and those who had mastered Proficiency Level 2, and for the effect of exposure to Place Value and Currency for children who had mastered Proficiency Level 1 and those who had mastered Proficiency Level 3.

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Table 1. Reliabilities and items for teacher-reported content measures and corresponding information for student proficiency levels

Content measures	α	Individual items from teacher survey	Item Mean (days per month)	Student math proficiency levels[1]
1. Basic Counting and Shapes	0.58			Proficiency level 1
		Count out loud	18.00	Identify some one-digit numerals, recognize geometric shapes, 1:1 counting, up to ten objects.
		Work with geometric manipulatives	9.80	
		Correspondence between number and quantity	14.31	
		Recognizing and naming geometric shapes	8.70	
2. Patterns and Measurement	0.78			Proficiency level 2
		Work with rulers and other measuring instruments	3.80	Reading all one-digit numerals, counting beyond ten, recognizing a sequence of patterns, and using nonstandard units of length to compare objects.
		Identifying relative quantity	10.06	
		Sorting objects according to a rule	7.65	
		Ordering objects by size or other property	6.88	
		Making, copying, or extending patterns	10.00	
3. Place Value and Currency	0.60			Proficiency level 3
		Recognizing the value of coins and currency	6.11	Reading two-digit numerals, recognizing the next number in a sequence, identifying the ordinal position of an object, solving simple word problems.
		Place value	6.92	
		Reading two-digit numbers	12.95	
		Ordinal numbers	8.46	
4. Addition and Subtraction	0.71			Proficiency level 4
		Adding single-digit numbers	8.74	Solving simple addition and subtraction problems.
		Subtracting single-digit numbers	6.82	
		Adding two-digit numbers	1.25	
		Subtracting two-digit numbers, without regrouping	0.69	

[1]Tourangeau et al., 2009

Table 2. Child background characteristics measured in fall of kindergarten

	Analytic Sample n = 11,517		Full Sample n = 15,259	
	Mean	S.D.	Mean	S.D.
Full day kindergarten	0.55		0.56	
Test Scores				
Math	26.71	9.12	26.13	9.04
Reading	35.38	9.94	35.32	9.97
General Knowledge	22.72	7.40	22.62	7.40
Child characteristics				
White	0.64		0.59	
African American	0.15		0.15	
Hispanic	0.13		0.18	
Asian	0.02		0.03	
Other	0.05		0.05	
Female	0.49		0.49	
Age (in months at fall assessment)	68.55	4.26	68.46	4.28
Selected home and family characteristics				
Maternal education (high school or less)	0.41	0.49	0.44	0.50
Single parent	0.21		0.21	
Number of siblings	1.41	1.09	1.45	1.13
English not primary home language	0.06		0.11	

Note. Sample size varies for full sample due to missing data for individual variables. For means and standard deviations on the full set of child and family background characteristics for the analytic sample see Appendix B. Weighted using student weights.

Table 3. Descriptive statistics for kindergarten teacher characteristics

	Analysis Sample n = 2,176		Full Sample n = 3,243	
Teacher Characteristics	Mean	S.D.	Mean	S.D.
Demographic characteristics				
Female	0.97		0.96	
Hispanic	0.04		0.06	
White	0.85		0.82	
African American	0.05		0.06	
Asian	0.02		0.02	
Other	0.01		0.01	
Age	41.35	9.88	40.99	10.03
Education and experience				
Masters degree or higher	0.35	0.48	0.34	0.47
Years teaching kindergarten	8.45	7.33	8.07	7.40
College course in:				
Early childhood education	4.26	2.14	4.16	2.18
Methods of teaching reading	3.21	1.85	3.14	1.86
Methods of teaching math	2.61	1.72	2.51	1.73
Certification				
Not certified	0.03		0.03	
Temporary or probational certification	0.08		0.10	
Lessons or projects on math (minutes per week)	188	107	186	108

Note. Sample size varies for full sample due to missing data for individual variables.
Weighted using student weights.

Table 4. Mastery rates and proficiency probability scores for analytic sample and corresponding descriptive statistics for teacher-reported content measures

Student Math Proficiency Levels	Fall Kindergarten: Students who have mastered level by fall kindergarten	Fall Kindergarten: Proficiency probability scores Mean	Fall Kindergarten: Proficiency probability scores S.D.	Content measures	Teacher reported days/month on content measures Mean	Teacher reported days/month on content measures S.D.
Proficiency level 1	95%	0.94	0.15	Basic Counting and Shapes	12.70	4.11
Proficiency level 2	62%	0.58	0.34	Patterns and Measurement	7.68	4.44
Proficiency level 3	25%	0.23	0.31	Place Value and Currency	8.61	5.12
Proficiency level 4	7%	0.04	0.13	Addition and Subtraction	4.38	4.07

Student n=11,517; Teacher n=2,176

Table 5. Correlations between teacher-reported math content measures

	Basic Counting and Shapes	Patterns and Measurement	Place Value and Currency	Addition and Subtraction
Basic Counting and Shapes	1.00			
Patterns and Measurement	0.60	1.00		
Place Value and Currency	0.36	0.43	1.00	
Addition and Subtraction	0.30	0.36	0.44	1.00

Table 6. Regression coefficients and standard errors from models predicting spring kindergarten math achievement with standardized teacher-reported content measures

Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Basic Counting and Shapes	-0.022***	-0.021***							-0.042***	-0.033***
	(0.008)	(0.008)							(0.010)	(0.010)
Patterns and Measurement			-0.003	-0.007					-0.007	-0.013
			(0.008)	(0.007)					(0.009)	(0.009)
Place Value and Currency					0.036***	0.031***			0.041***	0.035***
					(0.008)	(0.008)			(0.009)	(0.008)
Addition and Subtraction							0.038***	0.035***	0.034***	0.033***
							(0.008)	(0.007)	(0.009)	(0.008)
Full-day kindergarten	0.080***	0.110***	0.072***	0.100***	0.062***	0.100***	0.055***	0.092***	0.065***	0.099***
	(0.018)	(0.019)	(0.018)	(0.019)	(0.017)	(0.019)	(0.018)	(0.019)	(0.017)	(0.019)
Fall kindergarten math test score	0.820***	0.660***	0.820***	0.670***	0.820***	0.660***	0.820***	0.660***	0.820***	0.660***
	(0.010)	(0.014)	(0.010)	(0.014)	(0.010)	(0.014)	(0.010)	(0.014)	(0.010)	(0.014)
Time on math/week		0.023***		0.020***		0.015**		0.014*		0.018**
		(0.008)		(0.007)		(0.007)		(0.007)		(0.007)
Teacher Qualifications		X		X		X		X		X
Student Characteristics		X		X		X		X		X
Cognitive Skills		X		X		X		X		X
Observations	11,517	11,517	11,517	11,517	11,517	11,517	11,517	11,517	11,517	11,517
R-squared	0.688	0.716	0.688	0.716	0.689	0.717	0.689	0.717	0.691	0.719

Note. All models are weighted. Robust standard errors in parentheses. See Tables 2 and 3 and Appendix B for a complete list of variables included. Outcome measure is standardized. All continuous independent variables shown are standardized.
*** p<0.01, ** p<0.05, * p<0.1

Table 7. Regression coefficients and standard errors from models predicting spring kindergarten math achievement with standardized teacher-reported content measures by student proficiency level subgroups

	< Level 1		Level 1		Level 2		Level 3		Level 4+	
Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Basic Counting and Shapes[a]	-0.005	0.052**	-0.032**	-0.032**	-0.053***	-0.042***	-0.019	-0.034*	-0.044	-0.039
	(0.038)	(0.025)	(0.014)	(0.013)	(0.012)	-0.012	(0.020)	(0.020)	(0.058)	(0.071)
Patterns and Measurement[b]	-0.033	-0.067**	-0.011	-0.015	0.008	-0.001	-0.034	-0.037*	-0.038	-0.064
	(0.030)	(0.026)	(0.013)	(0.012)	(0.012)	(0.011)	(0.021)	(0.021)	(0.059)	(0.071)
Place Value and Currency[c]	0.037	0.019	0.052***	0.044***	0.025**	0.023*	0.049***	0.035*	0.061	0.071
	(0.026)	(0.024)	(0.012)	(0.012)	(0.012)	(0.012)	(0.018)	(0.018)	(0.052)	(0.064)
Addition and Subtraction	0.007	0.011	0.013	0.014	0.040***	0.037***	0.056***	0.059***	0.024	0.055
	(0.024)	(0.025)	(0.012)	(0.010)	(0.011)	(0.011)	(0.019)	(0.017)	(0.045)	(0.048)
Full-day kindergarten	0.110**	0.150***	0.054**	0.092***	0.058***	0.089***	0.090**	0.100**	0.200**	0.220*
	(0.044)	(0.048)	(0.022)	(0.022)	(0.021)	(0.023)	(0.037)	(0.039)	(0.090)	(0.125)
Fall kindergarten math test score	1.330***	0.620***	1.090***	0.780***	1.010***	0.820***	0.880***	0.780***	0.710***	0.610***
	(0.112)	(0.131)	(0.030)	(0.035)	(0.027)	(0.030)	(0.033)	(0.038)	(0.054)	(0.056)
Time on math/week		-0.027		0.025**		0.012		0.055***		-0.028
		(0.023)		(0.010)		(0.010)		(0.020)		(0.053)
Teacher Qualifications		X		X		X		X		X
Student Characteristics		X		X		X		X		X
Cognitive Skills		X		X		X		X		X
Observations	553	553	3,613	3,613	4,345	4,345	2,175	2,175	494	494
R-squared	0.274	0.574	0.331	0.435	0.373	0.428	0.372	0.435	0.473	0.610

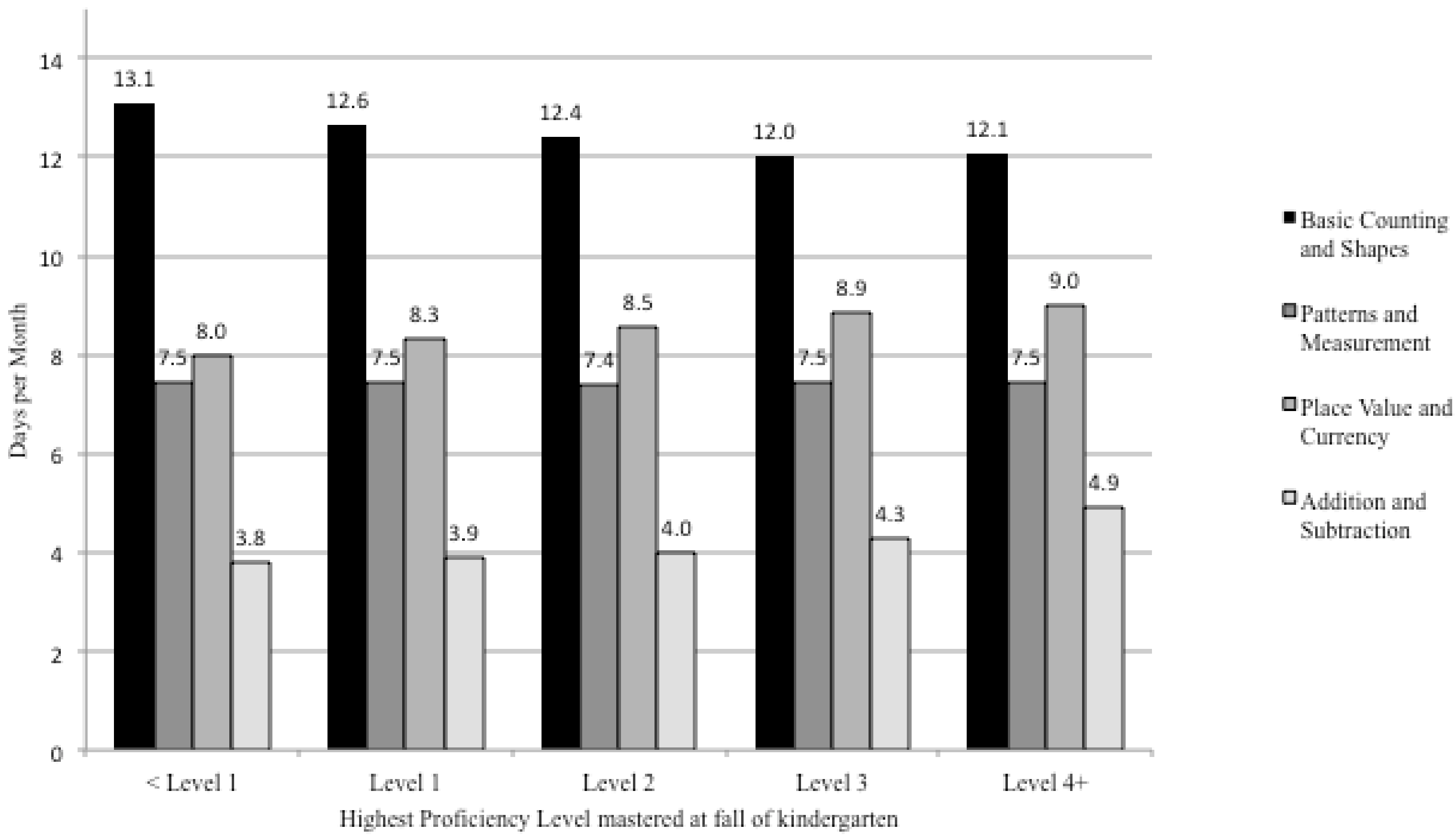
Note. All models are weighted. Robust standard errors, clustered by school, in parentheses. See Tables 2 and 3 and Appendix B for a complete list of variables included. Outcome measure is standardized. All continuous independent variables shown are standardized.
*** p<0.01, ** p<0.05, * p<0.1

[a] Coeffient for <Level 1 is significantly different from coefficient for Level 1, Level 2, and Level 3 in columns (2), (4), (6), and (8) p<.05

[b] Coefficient for <Level 1 is significantly different from coefficient for Level 2 in columns (2) and (6) p<.05

[c] Coefficient for Level 1 is significantly different from coefficient for Level 3 in columns (4) and (8) p<.05

Figure 1. Average teacher reported mathematics content by student Proficiency Level at kindergarten entry



Appendix A. Descriptive statistics for curriculum and instructional practices for analysis sample

	Mean	S.D.
Lessons or projects in content areas (minutes per week)		
Math	188.18	107.26
Reading and language arts	297.01	122.95
Science	69.80	73.12
Social studies	76.09	77.85
Math Skills (days/month children are taught these skills)		
Correspondence between number and quantity	14.31	6.10
Writing numbers 1-10	11.53	6.92
Count by 2s, 5s, and 10s	9.76	7.70
Count beyond 100	6.18	7.83
Write numbers 1-100	2.99	5.32
Recognize and name geometric shapes	8.70	6.97
Identify relative quantity	10.06	6.78
Sorting objects into subgroups according to rules	7.65	6.21
Ordering objects by size and other properties	6.88	5.94
Making, copying, extending patterns	10.00	7.06
Recognizing the value of coins and currency	6.11	6.58
Adding single-digit numbers	8.74	6.97
Subtracting single-digit numbers	6.82	6.81
Place value	6.92	8.63
Reading two-digit numbers	12.95	7.68
Reading three-digit numbers	5.83	8.08
Mixed operations	0.66	2.87
Reading simple graphs	7.41	6.96
Performing simple data collection and graphing	5.07	5.95
Ordinal numbers	8.46	7.43
Using measuring instruments correctly	2.89	3.96
Telling time	6.11	6.92
Estimating quantities	4.60	5.43
Adding two-digit numbers	1.25	4.12
Carrying numbers in addition	0.42	2.47
Subtracting two-digit numbers without regrouping	0.69	3.19
Estimating probabilities	1.43	3.53
Writing math equations to solve word problems	2.02	4.27
Math Activities (days/month children do the following)		
Count out loud	18.00	4.12
Work with geometric manipulatives	9.81	6.60
Work with manipulatives to learn basic operations	12.74	6.09
Play math-related games	10.77	6.54
Use calculator for math	0.63	2.32
Use music to understand math concepts	3.87	5.40

Appendix A. Desc. stats. for curriculum and instructional practices, continued

	Mean	S.D.
Use creative movement or creative drama to understand math concepts	3.25	4.62
Work with rulers, measuring cups, spoons, or other measuring instruments	3.79	4.64
Explain how a math problem is solved	8.26	7.15
Engage in calendar-related activities	19.04	3.60
Do math worksheets	9.46	7.21
Do math problems from textbooks	3.83	6.98
Complete math problems on the chalkboard	4.88	6.34
Solve math problems in small groups or with partner	6.41	6.25
Work on math problems that reflect real-life situations	8.07	6.70
Work in mixed achievement groups on math activities	10.46	7.96
Peer tutoring	5.93	7.13
Use computers to learn math	7.02	6.83

Results are weighted using teacher weights.

Appendix B. Child and family background descriptives for analytic sample

	Mean	S.D.
Age	68.555	4.260
Birth weight (in pounds)	6.950	1.347
Missing birth weight	0.022	
Premature (child over 2 weeks early)	0.171	0.376
Missing premature	0.013	
Parent report of overall child health (1 = excellent, 5 = poor)	1.640	0.795
Missing health	0.001	
Geographic Controls		
West	0.187	
Midwest	0.253	
Northeast	0.185	
South	0.375	
Urban	0.347	
Rural	0.230	
Suburban	0.423	
Home Environment		
Number of siblings	1.410	1.091
Number of siblings, squared	3.178	5.358
Number of siblings, cubed	9.655	33.603
Child part of multiple birth	0.026	
Missing multiple birth	0.002	
Two biological parents	0.664	
Adopted	0.014	
Guardian	0.024	
Single biological parents	0.213	
One biological parents and one other parent	0.085	
Missing language	0.001	
Number of preschool moves	0.136	0.343
Missing moves	0.006	
Parent reads to child (days/week)	5.099	2.051
Missing read	0.001	
Parent tells stories to child (days/week)	3.703	2.394
Missing story	0.002	
Number of children's book in home	78.453	58.910
Missing number of books	0.008	
Watched Sesame Street pre-school	0.600	0.490
Missing Sesame Street	0.012	
Mother's age at child's birth	27.524	6.504
Missing mother's age	0.019	
Mother's age at first birth	23.905	5.436
Missing mother's age at first birth	0.066	
Mother's education (in years)	13.704	2.547
Missing mother's education	0.014	
Father's education (in years)	13.816	2.880
Missing father's education	0.191	
Mother worked between birth and kindergarten	0.773	0.419
Missing mother worked	0.040	
Income	54663	55252
Mother's occupation (prestige score)	43.841	11.217
Missing mother's occupation	0.314	

Appendix B. Child and family background descriptives for ECLS-K, continued

	Mean	S.D.
Father's occupation (prestige score)	43.424	11.041
Missing father's occupation	0.252	
WIC	0.384	
Missing WIC	0.029	
Food stamp	0.170	
Missing food stamp	0.004	
AFDC	0.097	
Missing AFDC	0.005	
Child care arrangement		
Relative pre-school care	0.135	
Center-based pre-school care	0.446	
Non-relative pre-school care	0.108	
Head Start	0.094	
varied pre-school care	0.040	
Missing pre-school care	0.014	
Child ever in center-based pre-school care	0.787	
Missing ever in center	0.002	
Neighborhood Characteristics (1 = Big problem, 3 = No problem)		
Neighborhood safety	2.703	0.512
Missing neighborhood characteristics	0.002	
Neighborhood litter	2.871	0.384
Neighborhood drug use	2.882	0.391
Neighborhood burglary	2.875	0.364
Neighborhood violence	2.965	0.219
Neighborhood vacancies	2.943	0.276
Years of education parent expects child to complete	16.638	2.320
Missing years of education	0.005	
How important is it that your child does the following by kindergarten? (1= "Essential", 5 = "Not important")		
Count	2.337	0.899
Missing count and other variables below	0.005	
Share	1.705	0.571
Draw	2.071	0.777
Calm	1.936	0.686
Knows letters	2.198	0.837
Communicates	1.693	0.585

Note. Control variables also included squared and cubed terms for child age and mother's and father's occupation prestige scores.