# Mathematics Content Coverage and Student Learning in Kindergarten

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Analyzing data from two nationally representative kindergarten cohorts, we examine the mathematics content teachers cover in kindergarten. We expand upon prior research, finding that kindergarten teachers report emphasizing basic mathematics content. Although teachers reported increased coverage of advanced content between the 1998–1999 and 2010–2011 school years, they continued to place more emphasis on basic content. We find that time on advanced content is positively associated with student learning, whereas time on basic content has a negative association with learning. We argue that increased exposure to more advanced mathematics content could benefit the vast majority of kindergartners.

**Keywords:** achievement; descriptive analysis; early childhood; educational policy; mathematics education; regression analyses; secondary data analysis

Despite evidence of and advocacy for the importance of mathematics education for young children, mathematics is underemphasized in kindergarten, particularly when compared with reading (Engel, Claessens, & Finch, 2013). Teachers of young children report being uncomfortable and unsure teaching mathematics (Ginsberg, Lee, & Boyd, 2008). This discomfort is concerning, particularly in light of evidence that young children are able to understand and learn a wide range of mathematical concepts in early childhood (Clements & Sarama, 2011, 2014).

Children's mathematics skills at kindergarten entry, as well as their mathematics learning during kindergarten, are key predictors of their subsequent success in both reading and mathematics (Claessens, Duncan, & Engel, 2009; Claessens & Engel, 2013; Duncan et al., 2007; Watts, Duncan, Siegler, & Davis-Kean, 2014). Key advocacy groups have also noted the importance of mathematics instruction for young children. The National Council for Teachers of Mathematics (NCTM), the National Association for the Education of Young Children (NAEYC), and the National Mathematics Advisory Panel (NMAP) have all argued that children younger than 6 are ready to learn, and will benefit greatly from exposure to, a variety of mathematics content (NAEYC & NCTM, 2002; NCTM, 1989, 2000, 2007; NMAP, 2008).

Research using nationally representative data from the late 1990s found that the majority of the mathematics content to which most kindergarteners were exposed covered topics they had already mastered (Engel et al., 2013). Although most kindergartners entered school proficient in basic counting and knowledge of basic shapes, kindergarten teachers reported emphasizing this content far more than topics that students had yet to learn, such as addition and subtraction. Further, exposure to advanced content was associated with larger cross-kindergarten test score gains in mathematics, whereas exposure to basic content was associated with smaller gains for almost all students (Claessens, Engel, & Curran, 2014; Engel et al., 2013). Despite this evidence, there is little agreement among advocates and educators about what mathematics kindergarteners should be taught.

There have been shifts in both public discourse and public policy toward an increased academicization of kindergarten (Russell, 2011). Yet research suggests that this increased focus on academic content has been primarily centered on reading instruction. Bassok, Latham, and Rorem (2016) found that kindergarten teachers reported dramatic increases in time spent on reading between 1998 and 2006. Further, they reported a rise in teachers' expectations with regard to children's school readiness skills across content areas during this period. These changes to

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kindergarten have been controversial, however, with some advocates arguing that an increased academic focus interferes with the important role of play and socialization in kindergarten (Miller & Almon, 2009).

We investigate which areas of mathematics content are most beneficial to students during kindergarten. We hypothesize that students will learn more mathematics when teachers report emphasizing topics that are more advanced. Much of the extant scholarship on early childhood mathematical development has focused on the cognitive processes that underlie mathematical learning (e.g., Booth & Siegler, 2006) and the pedagogical methods through which mathematics should be taught (Clements & Sarama, 2014; Griffin, 2004, 2009). This work is crucial to our understanding of mathematics teaching and learning. In a complement to this work, we describe the mathematics content that teachers report emphasizing for nationally representative samples of kindergarteners in 1998–1999 and 2010–2011. We investigate whether these topics predict student achievement gains in mathematics. Our study helps provide a better understanding of how the mathematics content covered in kindergarten predicts student achievement growth and can help inform ongoing refinement of standards for kindergarten mathematics.

## The Current Study

Engel and colleagues (2013) found kindergarten mathematics content to be poorly aligned with student knowledge and skills in mathematics at school entry. Although evidence suggests that kindergarten has become more academic (Bassok et al., 2016; Russell, 2011), we know little about whether and how the mathematics content taught in kindergarten has changed.

We conduct a cross-cohort comparison exploring changes in kindergarten mathematics content coverage over time. We use data from two nationally representative cohorts of kindergarteners and their teachers to extend prior research (Engel et al., 2013). We explore the association between teacher-reported content coverage and student learning, addressing the following questions:

1. Has the mathematics content that kindergarten teachers report teaching changed between 1998–1999 and 2010–2011?
2. Has the relationship between mathematics content exposure in kindergarten and student learning changed across this period?

## Methods

### *Data*

We use data from two longitudinal, nationally representative studies of kindergarteners conducted by the National Center for Educational Statistics (NCES): the Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K) and the Early Childhood Longitudinal Study, Kindergarten Class of 2010-11 (ECLS-K:2011). As shown in Table 1, the analysis samples for the original ECLS-K ($n$ = 17,810) and the ECLS-K:2011 ($n$ = 15,090) differ in a number of ways. In 1998–1999, 61% of kindergarteners attended a full-day program, whereas 87% did so in 2010–2011. Further, one quarter of kindergarteners identified as Hispanic in 2010–2011, a 32% increase from 19% in 1998–1999. Both data sets include over 3,000 kindergarten teachers who had taught kindergarten for over 8 years, on average. All sample sizes we report are rounded to the nearest 10, in compliance with NCES restricted data use agreements.

For the ECLS-K:2011, restricted base-year data can be requested from NCES. These data allow for cross-cohort comparisons across the ECLS-K and the ECLS-K:2011 in terms of children's classroom experiences. Child cognitive assessment scores that have been released for the newer cohort are, at this time, not directly comparable to scores from the original ECLS-K. Information about the ECLS-K comes from its user's manual (Tourangeau, Nord, Lê, Sorongon, & Najarian, 2009), and information about the sample and measures for the ECLS-K:2011 is drawn from its base-year user's manual (Tourangeau et al., 2012).

The ECLS-K and the ECLS-K:2011 are large, longitudinal, nationally representative studies of children who were in kindergarten in 1998–1999 and 2010–2011, respectively. Both data sets contain extensive information about sample children and their families, classrooms, teachers, and schools. For the analyses that follow, we draw our independent variables of interest from the teacher surveys administered in the spring of 1999 and 2011. Our dependent variables are student achievement test scores in mathematics from the spring of kindergarten. Controls are drawn from parent, student, teacher, and school-level data. To address the issue of missing data, we use multiple imputation, imputing independent and dependent variables for both data sets. See the online appendix (available on the journal website) for details on our multiple imputation procedures.

### *Measures*

*Student achievement.* In both cohorts, student achievement in mathematics and reading was assessed at kindergarten entry and again in the spring of kindergarten. The mathematics assessments were designed to measure conceptual and procedural knowledge and problem-solving ability. The assessments were developed using Item Response Theory (IRT) to allow researchers to use the measures to examine growth in student achievement longitudinally (Tourangeau et al., 2009). We control for fall test scores, and spring mathematics test scores are our dependent variable of interest. We use the IRT scale scores provided in each dataset, which we standardize to a mean of zero and a standard deviation of one within each cohort.

For the original ECLS-K, NCES used the hierarchical structure of the assessments to create proficiency probability scores measuring student mastery of various levels or topical areas in mathematics and reading. Individual scores on these "proficiency levels" are included as variables in the data files for the original ECLS-K. The most basic proficiency level in mathematics measured student knowledge of "Basic Counting and Shapes," and the most advanced proficiency level (for kindergarteners) measured "Basic Addition and Subtraction." Proficiency probability scores and proficiency levels have not been released for the ECLS-K:2011.

**Table 1**
**Descriptive Statistics for Children and Teachers From the ECLS-K and the ECLS-K:2011**

| | ECLS-K | ECLS-K:2011 | Difference | *p*-Value |
|---|---|---|---|---|
| Child characteristics | | | | |
| Full-day kindergarten | .61 | .87 | .26 | .001 |
| White | .58 | .52 | −.06 | .001 |
| African American | .15 | .13 | −.02 | .010 |
| Hispanic | .19 | .25 | .06 | .001 |
| Asian | .03 | .04 | .01 | .001 |
| Female | .49 | .49 | 0 | .828 |
| Age (in months at fall assessment) | 68.44 | 68.48 | 0.04 | .579 |
| Observations | 17,810 | 15,090 | | |
| Teacher characteristics | | | | |
| Female | .98 | .98 | .00 | .826 |
| White | .86 | .83 | −.03 | .004 |
| Hispanic | .04 | .08 | .04 | .001 |
| African American | .07 | .06 | −.01 | .709 |
| Years teaching kindergarten | 8.24 | 8.74 | 0.50 | .033 |
| Observations | 3,020 | 3,060 | | |

*Note.* Means were generated with the sample weights designed for nonresponse for each type of survey used. See supplementary materials for information regarding the weights used. All nonmissing cases for each variable were used to calculate each respective mean. Values in the “difference” column represent the change in average teacher and student characteristics between 1998–1999 and 2010–2011. *p*-Values denote the level of statistical significance for the average change for each characteristic. Statistical significance was calculated using dummy-variable regressions in which the two cohorts were pooled into a single dataset. *p*-Values smaller than .001 were rounded to .001.

Thus, it is not possible to compare proficiency levels across the two cohorts.

Both the mathematics and reading assessments created for the ECLS-K were developed from national and state standards, and they were also designed to align with the National Assessment of Educational Progress (NAEP). Although the NAEP is not administered until fourth grade, the principles and content within the NAEP were extrapolated to the kindergarten level. The mathematics assessment was designed in consultation with the NCTM.

*Mathematics content measures*. Replicating the measures used by Engel et al. (2013), we create mathematics content measures for each cohort using teacher reports. Teacher surveys in both cohorts included items asking teachers about their instruction with regard to mathematics content and activities. Teachers responded on a 6-point scale ranging from *never* to *daily*. We converted these scales to a measure of number of days per month ranging from 0 to 20.[1]

We matched these items to the proficiency levels created by NCES staff using results from the fall of kindergarten mathematics test for the original ECLS-K. We include only items that matched the mathematics content described in the proficiency levels. Using this procedure, we generated four categories of classroom-mathematics content that were, again, aligned with the four proficiency levels in mathematics in which kindergarteners in the original ECLS-K were scored. These correspond to the measures used in Engel et al. (2013).

We calculate these as the average number of days per month teachers reported covering the items contained within each category: *Basic Counting and Shapes; Patterns and Measurement; Place Value and Currency*; and *Addition and Subtraction*. Alpha values for the eight measures (four for each data set) range from .58 to .88. Table A1 in the online appendix shows the individual items (with their means and standard deviations) used to create each of the four scales. The online appendix provides additional detail on measure creation. Correlations between the four measures within the two respective data sets are provided in Table A2 of the online appendix.

*Control variables*. We control for fall of kindergarten mathematics and reading test scores. Additional control variables included in all of our models are student gender, race/ethnicity, age at kindergarten entry, preschool attendance, mother’s education, family income, whether the child lived with a biological parent, number of siblings in the household, number of books in the home, and whether English was the primarily language spoken in the home. We also control for teacher-reported overall time on mathematics and whether the classroom was full-day kindergarten. Teacher characteristics we control for include teacher gender; ethnicity; age; whether the teacher had obtained a master’s degree; years of teaching experience; whether the teacher had taken a pedagogical development class in mathematics, reading, and/or early education; and certification level. Finally, we included administrator-reported measures of school region, urbanicity, and the percentage of the student body eligible for free or reduced-price lunch. Table A3 of the online appendix reports descriptive statistics for control variables.

## *Analysis Plan*

We investigate the association between measures of teacher-reported mathematics content emphasis and student achievement in mathematics. We estimate separate ordinary least squares (OLS) regression models for each cohort in which we predict student mathematics achievement as a function of mathematics instructional content and student, teacher, family and school characteristics. Our model is specified as follows:

$$MathAch_{isk} = a_1 + \beta_1 Content_{ik} + \beta_2 Ach_{ifk} + \beta_3 Child_i + \beta_4 Family_{ifk} + \beta_5 Teacher_{ik} + \beta_6 School_{ik} + e_i,$$

where $MathAch_{isk}$ represents the mathematics achievement of child $i$ measured at the spring of kindergarten ($sk$). $Content_{ik}$ represents the days per month spent on the set of each of the respective *Mathematics Content Measures* (*Basic Counting and Shapes, Patterns and Measurement, Place Value and Currency*, and *Addition and Subtraction*) for child $i$ during kindergarten ($k$). $Ach_{ifk}$ represents the mathematics and reading achievement for child $i$ measured in the fall of kindergarten ($fk$). $Child_i$ represents background characteristics (e.g., race/ethnicity, gender). $Family_{ifk}$ includes family background characteristics (e.g., parental income). $Teacher_{ik}$ includes teacher characteristics (e.g., certification level, race/ethnicity) measured during kindergarten. $School_{ik}$ represents administrator-reported school characteristics (e.g., proportion of students eligible for free or reduced-price lunch) measured during the kindergarten year. $e_i$ represents a random error term.

Using the sample weights, we adjust all standard errors for nonindependence due to sample-designed clustering in classrooms and schools. We also tested models in which standard errors were adjusted at only the classroom level. The resulting standard errors were nearly identical. We standardize all measures of instructional content within cohort. Thus, coefficients estimated for our measures of instructional content ($\beta_i$) estimate the effect of a standard deviation increase in reported coverage of specific mathematics content on end-of-kindergarten mathematics achievement. The online appendix provides detailed information regarding the multiple imputation procedures and sample weights that we use.

We estimate these models separately for the 1998 and 2010 cohorts, respectively, and compare coefficients calculated for the *Mathematics Content Measures* for each cohort.

## Results

### *Descriptive Results*

Table 2 presents Cronbach's alpha values and descriptive statistics for the four *Mathematics Content Measures* by cohort. Average days per month reported on two of the four *Mathematics Content Measures*—those that measure more advanced mathematics content—increased, with magnitudes that are both statistically significant and substantively large. Reported coverage of *Place Value and Currency* grew from approximately 8.5 days per month in 1999 to over 10.5 days per month, on average ($p < .001$), in 2011. Similarly, reported time on *Basic Addition and Subtraction* rose from under 8 days per month to over 9.5 days per month ($p < .001$). In contrast, average time on *Basic Counting and Shapes* increased by only 0.4 days per month. Time on *Patterns and Measurement* also increased very slightly (by 0.29 days per month). On average, teachers reported teaching content in these two more basic areas approximately 13 and 8 days per month, respectively, for both cohorts of kindergarteners.

Figure 1 highlights the poor fit between the mathematics content teachers report covering and what students know at kindergarten entry. We contrast the number of reported days per month on the most basic and most advanced content measures with the percentage of students who had mastered a more basic and a more advanced content area, as defined by student mastery rates, at kindergarten entry in 1998. In both cohorts, teachers reported the greatest emphasis—approximately 13 days per month—on *Basic Counting and Shapes*, content that over 90% of kindergarteners in 1998 had already mastered. They reported less emphasis on *Addition and Subtraction*, which few students in the original ECLS-K cohort had already mastered at school entry.

### *Regression Results*

We estimated separate ordinary least squares (OLS) regressions for each cohort in which we model student mathematics achievement in the spring of kindergarten as a function of our measures of mathematics content, controlling for relevant student, teacher, family and school characteristics including student mathematics achievement at kindergarten entry. We adjust all standard errors for nonindependence due to sample-designed clustering in classrooms and schools. We also standardize all measures of instructional content within cohort. Thus, coefficients estimated for our measures of instructional content estimate the effect of a standard deviation increase in reported coverage of specific mathematics content on end-of-kindergarten mathematics achievement.

Table 3 shows results from regressions using the *Mathematics Content Measures* we developed based on those used by Engel and colleagues (2013). The two columns show results from regressions that are identically specified, with coefficients in Column 1 generated from the original ECLS-K and Column 2 displaying coefficients generated from the ECLS-K:2011.

Results in Column 1 for the original ECLS-K are consistent with results reported by Engel and colleagues (2013). Moreover, the coefficients estimated using the more recent ECLS-K:2011 are similar to estimates for the original ECLS-K cohort, indicating that the association between mathematics instructional content and student achievement in kindergarten did not change over this time period.

Coefficients are small in magnitude, ranging from an absolute value of .015 ($p < .05$) for *Patterns and Measurement* for the ELCS-K to .046 ($p < .001$) for *Addition and Subtraction* for the ECLS-K:2011. Results suggest that, on average, students benefit from additional exposure to content that is more advanced including *Place Value and Currency* and *Addition and Subtraction*. Further, we find that in both 1998–1999 and 2010–2011, students gained less when teachers reported spending more days per month on *Basic Counting and Shapes* or *Patterns and Measurement*; content that is more basic and that prior research indicates that most students have mastered by kindergarten entry (Engel et al., 2013).

In addition to the results described above, we conducted a series of alternative model specifications and robustness checks. We used listwise deletion as well as missing data indicators as

**Table 2**
**Cronbach's Alphas, Means, and Standard Deviations for Mathematics Content Measures Created From Teacher Survey Items**

| | ECLS-K | | | ECLS-K: 2011 | | | | |
|---|---|---|---|---|---|---|---|---|
| Mathematics Content Measures | α | Mean (days/month) | SD | α | Mean (days/month) | SD | Mean Difference | *p*-Value |
| Basic Counting and Shapes (four items) | .58 | 12.73 | 4.16 | .58 | 13.17 | 3.94 | 0.44 | .925 |
| Patterns and Measurement (five items) | .78 | 7.55 | 4.47 | .78 | 7.84 | 4.43 | 0.29 | .071 |
| Place Value and Currency (four items) | .60 | 8.47 | 5.18 | .59 | 10.76 | 5.30 | 2.29 | .001 |
| Basic Addition and Subtraction (two items) | .88 | 7.84 | 6.57 | .86 | 9.66 | 6.52 | 1.82 | .001 |

*Note.* Means were generated with the sample weights designed for nonresponse in each cohort for the spring kindergarten teacher survey. See the online appendix text for information regarding the weights used. Only observations in the analysis samples were used (ECLS-K: teacher $N = 3,020$; ECLS-K:2011: teacher $N = 3,060$), and all nonmissing cases on each variable were used to calculate each respective mean. See the appendix for means for each item used to generate the content measures. Values in the "difference" column represent the change in the amount of time teachers reported spending on each topic between 1998–1999 and 2010–2011. Positive values indicate that teachers reported spending more time on a given topic in 2010–2011. *p*-Values denote the level of statistical significance for the average change in each reported content measure. They were estimated using dummy-variable regressions in which both cohorts were pooled into a single dataset. *p*-Values smaller than .001 were rounded to .001.

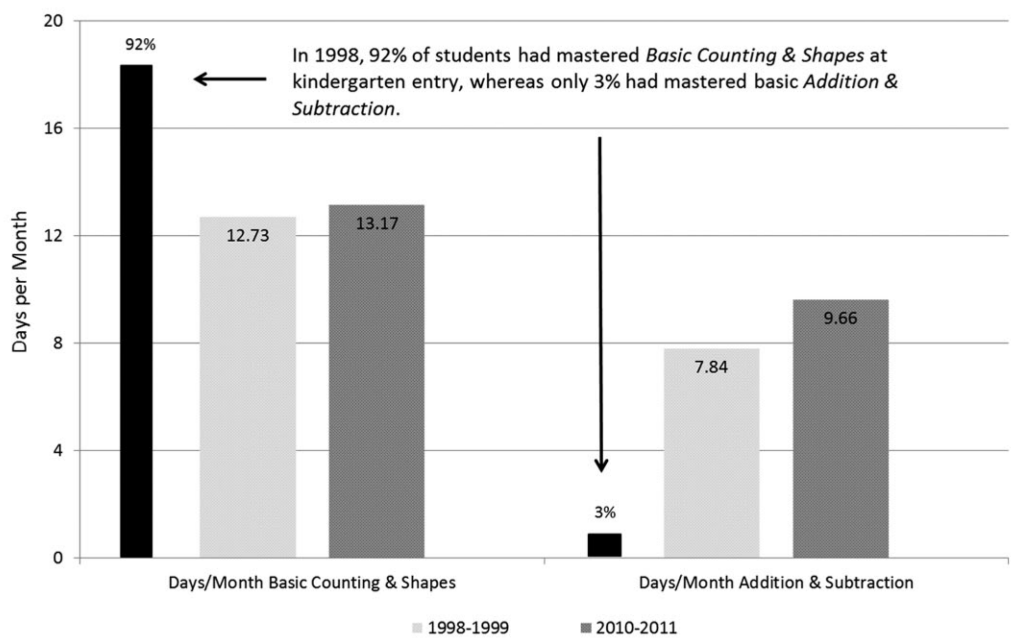


FIGURE 1. *Student mastery rates and teacher reported coverage of mathematics content in kindergarten*

alternative means for dealing with missing data. We also tested specifications using more extensive, but not directly comparable, sets of control variables for each cohort. Finally, we explored whether results differed for subgroups by student race/ethnicity, socioeconomic status, and school entry mathematics achievement. Results were similar across all model specifications and for all subgroups. Please see online appendix for additional details.

## Discussion

Our investigation of the mathematics content covered in kindergarten classrooms in 2010–2011 showed a pattern of results that was similar to what Engel and colleagues (2013) found using data from the 1998–1999 school year. We find that kindergarten teachers continue to report spending more days per month teaching simpler mathematics content. In particular, they continue to report spending extensive time on *Basic Counting and Shapes*. Teachers reported teaching simple counting and shape recognition an average of 13 days per month in both 1998–1999 and 2010–2011. Moreover, coverage of this content was negatively associated with student achievement gains for both cohorts of kindergarteners.

Thus, the possibility that there is a mismatch between content coverage and student knowledge in kindergarten remains. Our results show no evidence of a reduction in time on basic counting and shapes. These results suggest that spending extensive time on content students have already mastered may be detrimental for their learning. Future research should explore the

**Table 3**
**Coefficients and Standard Errors From Ordinary Least Squares Regressions Predicting Spring of Kindergarten Mathematics Achievement With Mathematics Content Measures**

| | 1998–1999 | 2010–2011 |
|---|---|---|
| **Independent Variables** | **(1)** | **(2)** |
| Mathematics content measures | | |
| Basic Counting and Shapes | −.031*** | −.023** |
| | (.006) | (.007) |
| Patterns and Measurement | −.015* | −.020** |
| | (.006) | (.007) |
| Place Value and Currency | .035*** | .042*** |
| | (.006) | (.006) |
| Addition and Subtraction | .037*** | .046*** |
| | (.006) | (.007) |
| Covariates | Inc. | Inc. |
| Observations | 17,810 | 15,090 |

*Note.* Coefficients and standard errors were generated from 10 multiply imputed (MI) datasets for each cohort, and both datasets were weighted using the "svyset" commands in Stata 13.0 with the "base year" weights designed for use with student, parent, and teacher-level measures. All coefficients displayed were generated from fully controlled models. See Table A3 in the online journal for a full list of covariates.
**p* < .05. ***p* < .01. ****p* < .001.

quality of instruction on basic (e.g., simple counting) versus more advanced (e.g., addition and subtraction) mathematics topics in kindergarten classrooms.

Our study extends prior research on kindergarten mathematics (Engel et al., 2013). We find that the mathematic content covered by teachers during kindergarten relates to student learning gains in predictable ways; covering content that is basic (likely because many students have already mastered it) may hinder student learning. In contrast, our results suggest that covering content that is more advanced promotes mathematics achievement.

We find that reported days per month on more advanced topics—*Place Value and Currency* and *Addition and Subtraction*—increased between the 1998–1999 and 2010–2011 school years. This increase may be due to the accountability policies ushered in with No Child Left Behind (NCLB), as NCLB required states to set academic standards in mathematics and reading for elementary school students. It is unclear how NCLB might have affected kindergarten teachers, since accountability testing is not mandated prior to third grade. Empirical work has shown that kindergarten teachers' academic expectations rose during the years following NCLB (Bassok et al., 2016), and those expectations may influence the content teachers cover.

Recent policy changes continue to emphasize academic instruction in kindergarten. In 2010, the Common Core State Standards for Mathematics (CCSSM) were introduced. They have been fully or partially adopted by 43 states. The CCSSM were designed to guide teachers' mathematics instruction by emphasizing both processes and proficiencies (Common Core Standards Initiative, 2010) with the goal of deepening students' knowledge of mathematics (Schmidt & Burroughs, 2013). For kindergarten teachers, the CCSSM contain detailed standards outlining the mathematics content that should be taught during the kindergarten year. Indeed, the CCSSM recommends that kindergarten teachers cover many of the competencies assessed in the current study, including counting, measurement, place value, operations, and geometry. The CCSSM also emphasize the importance of deep conceptual knowledge within each of these domains.

Thus, although our results suggest that spending time on simple counting and shape recognition is not likely to advance student achievement, we do not want to overstate the knowledge that can be gleaned from our measures. Our *Basic Counting and Shapes* measure does not distinguish, for example, between rote counting by ones and more complicated counting by ones. Counting by ones starting from a nonzero number, such as counting from four to nine, might be considered a more complicated counting task than rote counting or counting objects. Research on mathematics learning and curricula has shown that use of number line games can improve number sense and learning and may be associated with learning gains (Clements & Sarama, 2007; Ramani & Siegler, 2008). Conversely, although we found teacher reported days per month on addition and subtraction to be positively associated with student achievement, this does not mean that time spent on adding and subtracting will automatically advance young children's understanding of mathematics. For example, it is possible that having students simply memorize addition and subtraction facts may do less to advance student understanding of foundational mathematical principals than having them spend time on counting activities that require cognitively challenging engagement with concepts related to number and quantity.

Consequently, our results should not be interpreted to suggest that all counting activities hinder student achievement or all addition and subtraction activities promote it. Yet our findings do suggest that teachers who report spending time on basic counting content are probably not engaging in the kind of highly conceptual counting activities recommended by the CCSSM and supported by empirical work as foundational (e.g., understanding magnitude through number line activities; Ramani & Siegler, 2008). Instead, the negative coefficients on our measures of *Basic Counting and Shapes* and *Patterns and Measurement* suggest that, on average, teachers were probably teaching this content at a level that was below the cognitive abilities of their students.

Our key results regarding the association between basic and advanced content and student achievement in kindergarten were found across two cohorts of kindergarteners. However, it is important to note that the effect sizes that we find, while statistically significant, are small, ranging in absolute value from .015 to .046. Although small in magnitude, we note that these effects are larger than those found for teacher credentials (e.g., master's degree in education) in many studies (Croninger, Rice, Rathburn, & Nishio, 2007; Palardy & Rumberger, 2008). Further, although these effects are small, supporting teachers' efforts to shift mathematics instructional time to coverage of more advanced topics may be much less costly than other potentially effective interventions such as reducing class size or lengthening instructional time (Krueger, 2003; Lee, Burkam, Ready, Honigman, & Meisels, 2006; Votruba-Drzal, Li-Grinning, & Maldonado-Carreno, 2008).

There are several limitations to the current study. First, we note that our measures of mathematics instructional content are constrained by the fact that they are drawn from teacher reports on a survey, that the survey was administered at a single point in time for each cohort, and that the survey included a relatively limited bank of items on mathematics content and instruction. The fact that our measures are limited in these ways is important to keep in mind. This may help to explain the small magnitude of our estimates, which may be due, in part, to classical measurement error. This would bias our coefficient estimates downward, resulting in smaller effect size estimates.

The limited nature of our measures means that our study should be seen as a starting point for spurring additional research. Future studies are needed that provide a more in-depth understanding of mathematics instruction in kindergarten. These studies should use classroom observations to provide data that would allow researchers to present a richer and more nuanced analysis of kindergarten mathematics instruction that would include what content is taught, how that content is taught, and why kindergarten teachers teach the mathematics content that they do.

Further, our results should be interpreted as adjusted correlations due to the observational nature of the data we use. As such, we cannot rule out possible omitted variables that could be driving our estimates. Teachers who spend more time on advanced content could be qualitatively different from teachers who emphasize basic topics in a variety of unobserved ways. Through the inclusion of an extensive set of control variables we aim to substantially reduce bias due to omitted variables. Further, some experimental evidence suggests that designing professional development sessions that prevent early-grade teachers from spending too much time on content that students had already mastered can produce larger student-achievement gains (Clements, Sarama, Wolfe, & Spitler, 2013). This evidence suggests that professional development may be a means for supporting kindergarten teachers in shifting some of their mathematics instructional time to more advanced, as opposed to very basic, content.

### *Conclusion*

Our central findings suggest that teaching kindergarten students more advanced mathematics content (e.g., basic addition and subtraction) is positively associated with mathematics achievement gains during kindergarten. Previous research indicates that time on more advanced content in kindergarten benefits virtually all students, including those who attended preschool and those who did not (Claessens et al., 2014; Engel et al., 2013). The results of our study and related research suggest that education policy and practice may profit from efforts to help kindergarten teachers shift some of their time on mathematics instruction from basic content to increased coverage of mathematics topics that students have not already mastered at kindergarten entry.

## NOTES

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[1]The categories on the ECLS-K teacher survey for the items we used to construct our content measures were "never," "once a month or less," "two or three times a month," "once or twice a week," "three or four times a week," or "daily." Thus, we recode the items to interpret them on a "times per month" scale, assuming an average of 20 school days per month. The recoded categories become 0, 1, 2.5, 6, 14, or 20 days per month.

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