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Authors
Bargagliotti, Anna E.
Guarino, Cassandra M.
Mason, William M.

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California Center for Population Research
University of California - Los Angeles

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MATHEMATICS INSTRUCTION IN KINDERGARTEN AND FIRST GRADE IN THE UNITED STATES AT THE START OF THE 21ST CENTURY*

By

Anna E. Bargagliotti,[1] Cassandra M. Guarino,[2] and William M. Mason[3]

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[1] Corresponding author: Department of Mathematical Sciences, University of Memphis, 366 Dunn Hall, Memphis, TN 38152, abargag@yahoo.com.

[2] College of Education and Department of Economics, Michigan State University, 116G Erickson Hall, East Lansing, MI 48824-1038, cguarino@msu.edu.

[3] California Center for Population Research, 4284 Public Affairs Building, PO Box 951484, University of California, Los Angeles, CA 90095, masonwm@ucla.edu.

ABSTRACT

Understanding how mathematics is taught in the classroom is an important first step in connecting mathematics instruction to student learning. This study sheds light on mathematics teaching in kindergarten and first grade—the grades at which initial understandings, as well as obstacles to later progress, begin to emerge. Using the Early Childhood Longitudinal Study Kindergarten Class of 1998-99 (ECLS-K) survey, we consider (i) how much time teachers spend on mathematics on days when they teach this subject, (ii) the content of mathematics instruction, and (iii) the pedagogical techniques used. We find that time spent on mathematics instruction, content coverage, and pedagogical techniques varies between teachers as a function of school location and type, classroom composition, and a range of teacher attributes that includes demographics, preparation, level of effort, and professional development activities.

Key Words: Teaching practices, mathematics teaching, mathematics education, instructional practices, mathematics instruction

I. Introduction

The quality of mathematics teaching is an issue of vital importance to the future prosperity of nations within the global economy and to the prospective earnings and well-being of individual students. Results from large-scale comparative studies suggest that the United States lags behind many developed nations in mathematics achievement (Gonzales, et al., 2004; OECD PISA, 2004). One recent study ranked U.S. fourth-grade students eighth out of 12 comparably developed countries (Ginsburg, Cooke, Leinwand, Noell & Pollock, 2005). Cross-national differences in teacher preparation (Schmidt, et al., 2007; Ma, 1999), curriculum (Schmidt, McKnight, Cogan, Jakwerth & Houang, 1999), and cultural approaches to teaching (Stigler, Fernandez & Yoshida, 1996) may account in part for these achievement differences.

Within the United States, considerable heterogeneity may exist in the way mathematics is taught, and debate over optimal curricular and pedagogical approaches has been intense. An emphasis on mathematical applications at the onset of the 20th century was challenged by an emphasis on unifying mathematical concepts and fundamentals in the "new math" era of the 1950s (Meder, 1959), but this reform thrust was subject to strong opposition by many who maintained that mathematics should be taught less abstractly (Begle, 1962; Kline, 1973; Stanic & Kilpatrick, 1992; Wu, 1996). Several decades later, *A Nation at Risk* (National Commission on Excellence in Education, 1983) spawned further reform, culminating in the 1989 report of the National Council for Mathematics Teachers (NCTM), which established standards emphasizing reform-based instructional practices focused on student-centered instruction. The ensuing debate, termed "math wars," pitted proponents of these student-centered, inquiry-based approaches against advocates of traditional teaching methods (Schoenfeld, 2004), and only recently have participants in the debate tried to devise guidelines for practitioners that emphasize the need for elements of both approaches (e.g., Ball, et al., 2005; Kilpatrick, Swafford & Findell, 2001).

Although a growing body of evidence suggests that teachers vary substantially in their impact on student learning (e.g., Sanders & Horn, 1994, 1998), there is as yet scant evidence regarding which mathematics teaching practices are effective and for whom. Certain teacher characteristics, such as credentials (Croninger, Rice, Rathbun & Nishio, 2007; Jepson, 2005), scores on licensure tests or college entrance examinations (Goldhaber, 2007; Ehrenberg & Brewer, 1995), experience (Hanushek, Kain, O'Brien & Rivkin, 2005), subject-matter expertise (Monk, 1992, 1994), and mathematical knowledge for teaching[1](Ball, Hill, & Bass, 2005; Hill, 2005, 2007) have been linked to effectiveness, but the mechanisms by which these characteristics translate into practice are unclear. Weak and inconsistent relationships between student-centered practices and achievement are found in Le et al. (2006). Parlady and Rumberger (2008) find that the use of math worksheets and calendars raises student mathematics achievement in first grade, whereas the use of geometric manipulations lowers it. Rowan, Correnti and Miller (2002) find that the percentage of time teachers engage in active teaching—time spent on whole class instruction with teachers as the active agents of instruction—is positively related to achievement. Little is known, however, about the pedagogical contexts in which these statistical associations arise. Before efficient policies can be devised to encourage effective teaching practices, we must understand the current range of practices, and the factors associated with their differential use.

This study examines what happens in classrooms as teachers deliver foundational mathematical content to students in kindergarten and first grade. Because the impact of teachers is cumulative (Wright, Horn & Sanders, 1997; Sanders & Rivers, 1996), early learning and intervention strategies affect later outcomes (Currie & Thomas, 2000; Barnett, 1995, Kilpatrick et al., 2001), kindergarten attendance is high, and first grade is compulsory in the United States, it is crucial to understand how the teaching of basic mathematical concepts may differ across different types of schools and population subgroups of children in these grades.

The goal of this study is to describe mathematics instruction in kindergarten and first grade classrooms in the United States at the turn of the twenty-first century, using data from the Early Childhood Longitudinal Study of the Kindergarten Class of 1998-1999 (ECLS-K). We organize teaching activities into identifiable practices, assess variability in their use, and uncover factors related to that variability. We focus on the time teachers allocate to teaching mathematics, and on specific elements of teaching practice related to content coverage and pedagogy—"how much," "what," and "how" mathematics is taught in kindergarten and first grade.

II. Framework

We hypothesize that geographic location, school characteristics, classroom characteristics, and teacher attributes influence variability in time spent teaching mathematics, content coverage, and pedagogical methods. Figure 1 illustrates the framework we use to guide variable selection, which we next discuss.

Figure 1 here

Geographic Context. Geographic context is represented here by region and type of locale (categories in an urbanization classification). Regional differences in mathematics teaching would be expected to arise in a nation that assigns responsibility for education to the states. Although federal efforts to promote reform have been highly influential, particularly through the establishment of standards by the NCTM in 1989, the ensuing adoption of standards reform within each of the 50 states took place at different times and in different forms. For example, in California in 1997, the State Board of Education rejected new mathematics content standards designed by the Standards Commission of California and instead crafted its own version of the standards, emphasizing sets, relations, and functions and de-emphasizing pedagogical techniques (Wilson, 2003). In addition, kindergarten is not compulsory, and regions differ in the extent to which it is emphasized. Although there are few regional differences in overall kindergarten attendance (Wirt et al., 2004), pre-kindergarten programs are more commonly found in the South than in other regions of the U.S. (Smith et al., 2003). Also, children in the South are more likely than those in other regions to enroll in full-day kindergartens programs (approximately 78% in the South, compared with the 60% in the Northeast, 53% in the Midwest, and 44% in the West, according to Wirt et al. (2004)). Compared with kindergarten teachers in the rest of the nation, those in the South have higher academic expectations for their students (Lin, Lawrence & Gorrell, 2003).

There is evidence that teaching strategies do indeed vary by region. Using ECLS-K, Bodovski and Farkas (2007a) find that kindergarten teachers in the South use group activities and interactive approaches to teach mathematics more frequently than teachers in other regions. Also using ECLS-K, Guarino, Hamilton, Lockwood, and Rathbun (2006) find that kindergarten teachers in the Northeast spend less time teaching advanced numbers and operations than those in other regions and that those in the West spent less time than those in the Northeast on numbers and geometry and measurement.

Differences in instructional approaches might emerge across the urban-rural continuum if teaching philosophies and curricular materials adjust to address the different challenges that these contexts offer. For example, Cogan, Schmidt, and Wiley (2001) find that eighth grade students' "opportunity to learn" varies by type of locale, with suburban schools offering more advanced mathematics courses than central city or small town schools.

School Characteristics. Prior research suggests that school characteristics influence content and pedagogy. For example, Catholic schools emphasize a structured teaching style that incorporates a greater use of lectures, traditional practices, computation, repetition, homework review, and tests (Bryk, Lee, & Blakeley, 1993). Kindergarten teachers in religious schools spend less time on group and interactive teaching approaches than those in public schools (Bodovski & Farkas, 2007a). Secondary school size is positively related to time spent on instructional activities and the use of group instruction, and negatively related to discipline and routine instruction (Betts & Shklonck, 1999). School socioeconomic status (SES) and racial/ethnic composition are associated with the material that is taught and may also be associated with teaching practices. Cogan et al. (2001) find that schools with larger percentages of minority students offer fewer challenging mathematics courses and use less advanced textbooks. Teacher experience and qualifications are not uniformly distributed across schools serving different populations of students (e.g., Loeb & Reininger, 2004;Darling-Hammond, 1999), and teachers serving largely low SES and Hispanic students tend to have less mathematical knowledge for teaching (Hill & Lubienski, 2007).

Classroom Characteristics. Classroom sociodemographic composition and other attributes of class composition affect what goes on in the classroom. Stipek (2004) finds that teachers in classrooms with primarily white children emphasize "constructivist" approaches, which allow for individualized instruction, active participation on the part of students, guided use of manipulatives, encouragement in problem-solving, and flexibility in routines. Teachers in classrooms with higher percentages of African-American students are more likely to engage in didactic approaches that emphasize the attainment of universal standards, and are more likely to control classroom conversation, focus on procedural knowledge, teach number facts, rote counting, and emphasize correctness of responses. Betts and Shklonick (1999) find that the greater the percentage of African-American and Hispanic students in the class, the less time teachers spend on instructional activities and new material and the more time they spend on routine and discipline. Bodovski and Farkas (2007a) observe a positive association between the percentages of African-American and Hispanic students in kindergarten classes and time spent teaching practical mathematics and single-digit operations. Tate (1994b, 1995) and Fullilove and Treisman (1990) found that African-American students need to have mathematics connected to their social lives in an interactive cooperative manner that fosters community growth and social action.

Class size may also be associated with teaching practices. Teachers with larger classes may be more likely to rely on techniques that involve the whole class and facilitate classroom management, whereas teachers in small classes may give more individualized attention to students. A comparison of third-grade teachers in reduced and large class sizes following California's Class Size Reduction initiative finds that teachers in larger classes spend more time covering a wider range of mathematical topics than those in reduced-sized classes, whereas teachers in smaller classes engage in a wider range of pedagogical techniques(Stasz & Stecher, 2000). Teachers in reduced-size classes spend less time disciplining students and more time responding to individual student concerns (Betts & Shkolnik, 1999). Molnar et al. (1999) find that smaller classrooms promote small group activity and more individualized learning.

Teacher Attributes. The sociodemographic characteristics, professional qualifications, and professional development activities of teachers may influence their choice of teaching activities. Irvine (2003) maintains that the historical social context of the black community encourages African-American teachers to incorporate social issues into their lessons, establish a nurturing relationship with students, and use group oriented activities that emphasize "cooperative learning," "high involvement", and "active learning."

Age and teaching experience may affect comfort with specific content areas or pedagogical techniques. Borko and Livingston (1989) find that expert teachers are better able than novice teachers to deviate from planned material, respond to student inquiry, generate illustrative examples on the spot, and design long-term goals for the class. Smith, Sheppard, Johnson and Johnson (2005) find that teaching experience is positively associated with an emphasis on student-based reform-oriented practices that promote conceptual learning goals.

Professional qualifications such as certification type, educational attainment, and experience are also associated with differential use of practices. Guarino et al. (2006) find that prior coursework in methods of teaching mathematics is positively associated with kindergarten teacher emphasis on mixed-achievement grouping as well as student-centered instruction, numbers and geometry, advanced numbers and geometry, and traditional practices and computation. Mathematical knowledge for teaching predicts teaching effectiveness (Hill, Rowan, & Ball, 2005), and presumably affects student learning by shaping instructional practice. Thus, we might expect teacher certification, preparation, and experience to affect the way teachers teach mathematics. Hill (2007) finds that middle school teachers with more mathematical coursework, subject specific certification, and teaching experience score higher on tests of mathematical knowledge for teaching. Precisely how mathematical content knowledge shapes practice has not been fully explored, although Ball, Hill and Bass (2005) note that a teacher possessing mathematical knowledge for teaching has the skills to pick out sound mathematical arguments, use examples that capitalize on the concept being taught, and communicate effectively. Targeted post-degree professional development may increase the use of specific practices in the classroom. Desimone, Porter, Garet, Yoon, and Birman (2002) find that professional development focusing on technology increases the use of technology in the classroom.

The above review guides our investigation. Using ECLS-K, we are able to operationalize many of the factors identified by previous research. We next describe the data.

III. Data and Methods

III.1 Data Source

The ECLS-K survey (National Center for Educational Statistics, 2009a), collected by the National Center for Education Statistics (NCES) within the U.S. Department of Education's Institute of Education Sciences, provides data on a nationally representative sample of children who attended kindergarten during the 1998-99 school year. The children were followed through first, third, fifth, and eighth grades. For the initial wave, the children were selected using a multistage probability design that incorporated the public and private school populations using a dual sampling frame. Counties were sampled by region, schools with kindergartens were sampled within the selected counties, and approximately 24 kindergarteners were sampled in each school, for a total of 21,260. At each wave, the children were assessed in a variety of subjects and their parents, teachers, and school administrators were surveyed.

We analyze public use data from the teacher and school surveys, specifically, from the fall and spring kindergarten waves and the spring first grade wave.[2] The teacher surveys are rich in detail and contain information about teaching practices, classroom characteristics, attitudes toward teaching, perceptions of the school environment, the amount of preparation they put into teaching, and their background characteristics. Our analyses make use of responses from 3,054 kindergarten and 3,827 first grade teachers.

III.2. Variable Construction

Time spent on mathematics, frequency of content coverage, and frequency of use of pedagogical practices are treated as outcome variables; geographic context, school characteristics, class characteristics, and teacher attributes serve as covariates. Time spent on mathematics is also used as a covariate in the content and pedagogy analyses. We next describe the construction of the variables.

III.2.1 Outcome Variables

Teachers were asked how often they teach mathematics and how much time they spend on the subject on the days they teach it. Since the vast majority of teachers in both kindergarten and first grade responded that they teach math daily, we used the latter variable—coded as "minutes per day"—as our measure of time spent on math.[3]

Specific teaching practices are listed as items in the ECLS-K teacher questionnaire under two main questions, one focusing on content coverage and the other on pedagogy. These are "How often is each of the following math skills taught in the class?" and "How often do children in the class do each of the following math activities?" The kindergarten teacher questionnaire includes 29 skill or content areas and 17 activities representing different pedagogical modalities. The first grade teacher questionnaire includes the same items as well as two additional pedagogical modalities, for a total of 19.[4] Using closed response categories, teachers indicated how often children in their classrooms are taught a specific math skill (reflecting a content area), and how often they engage in a specific math activity (reflecting a pedagogical approach). We code teacher responses on all of these items as times per month.[5]

Due to the large number of individual practices, we created scales based on substantive meaning, grouping like practices together. In addition to the benefits of data reduction, aggregating items into scales can improve reliability: self-reports of past activities in survey questionnaires can be affected by recall bias, and responses may suffer from low reliability.[6] When an item could not be grouped with others using substantive criteria, the "scale" consists of a single-item.

We created six content-based scales. In forming these scales, we followed guidelines provided by the NCTM Content and Process Standards as well as reviews of grade-specific mathematics curricula conducted by the Center for the Study of Mathematics Curriculum (2005, 2007). The scales are Basic Numbers and Operations, Advanced Numbers and Operations, Statistics and Probability, Problem Solving, Geometric Shapes, and Relationships. The Basic Numbers and Operations scale includes content that appears in the Focal Points PreK-5 curriculum standards for kindergarten and first grade. This scale describes basic mathematical activities teachers have their students perform. The Advanced Numbers and Operations scale includes content that is not universally present in the kindergarten and first grade curriculum standards but appears in more advanced grade standards. In addition, the content covered in the Advanced Numbers and Operations scale offers a continuation of many of the concepts covered in the Basic category. Geometric Shapes is a single-item—"recognizing and naming geometric shapes"—that describes simple content that one might expect many children to know before entering kindergarten. The Relationships scale is not directly aligned with a single NCTM standard but is linked to multiple standards, such as Connections, Measurement, and Reasoning and Proof. The Relationships scale groups skills that require students to discern relationships among objects or think about symbols and quantities in relation to others. This scale captures fundamental skills that foster the development of abstract reasoning abilities.

We created eight pedagogy scales for kindergarten and nine for first grade. Four of the scales are single-item, either because the items are conceptually distinct or because the frequency with which they were reported is quite rare or quite common. The single-item scales are Games, Calculator, Counting Out Loud, and Drill (the item was asked only of first grade teachers).[7] The multiple-item scales are Group Work, Manipulatives, Creative, Hands-on, and Traditional Resources. All scales are scored as averages over their constituent items. For single-item "scales," this is just the reported number of times per month for that item.

Table 1 displays grade-specific univariate statistics for each scale and the items subsumed within it. There is extensive variation. For both grades, the averages across content-related practices vary from 11.6 days per month for Basic Numbers and Operations to 3.6 days per month for Advanced Numbers and Operations. Pedagogical scale averages range from 14 days per month for Counting Out Loud to .7 days per month for Calculators. Standard deviations range from two to as much as seven days per month across practices.

<u>Insert Table 1 here</u>

<u>III.2.2 Covariates</u>

Time on mathematics on days when the subject is taught is included as a covariate in our content and pedagogical modality analyses to detect whether there are topics whose emphasis is associated with this aspect of global time allocation. In the balance of our discussion, we refer to the variable as "time on math."

Geographic Location. As location indicators we include region (South, West, Midwest, Northeast) and the type of locale in which the school is located (central city, urban fringe, small town) as dummy variable classifications.[8] Univariate summary information for all covariates is presented in Appendix Table 1.

School Characteristics. We include dummy variable classifications for school type (public, private religious, private non-religious), and school size (<300, 300–499, 500–749, ≥750). Minority composition is included here as an ordinal coding of grade-specific quintiled categories.[9]

Classroom Characteristics. Classroom characteristics are operationalized as class size, the racial/ethnic composition of the class, and the percentage of children who are disabled.[10] To reduce the impact of what would otherwise be influential observations in skewed distributions, each of the classroom variables has been quintiled to aid in the detection of monotonic associations with the content and modality scales.

Teacher Attributes. The sociodemographic and professional qualifications used in our analyses are teacher race/ethnicity, age, teaching experience,[11] educational attainment, whether the teacher has regular certification, and whether the teacher has taken more than two courses in methods of teaching mathematics, all treated as indicator variables.[12]

We also use information on the amount of time teachers spent preparing for lessons, including an indicator variable for whether the teacher reports being given more than two hours per week of paid preparation time and a similar variable for whether the teacher spends more than five unpaid hours per week preparing for class. In addition, we include information on professional development activities in which the teacher participated. The series of professional development items in the ECLS-K teacher questionnaires asks whether, during the current academic year, they had taken part in each of nine activities—for example, “peer observation and feedback." Allowable responses were yes/no. We coded the items as dummies and included them in our analyses.

In the kindergarten analyses, we also include a variable indicating whether the teacher taught full-day rather than half-day kindergarten. There is no corresponding variation in the first grade school day; hence this control is specific to kindergarten teachers.

III.3. Statistical Considerations

Using regression, we focus on the contributions of covariates to (i) amount of time spent on math, (ii) mathematics content scales, and (iii) mathematics pedagogy scales, while allowing for the clustering that stems from the hierarchical nesting of teachers within schools.[13] The regressions are of random intercept form

$$Y_{ij} = \alpha_j + x_{ij}^T \beta + z_j^T \gamma + \varepsilon_{ij} \qquad (1)$$

where i=1,…,N indexes teachers and j=1,…,J indexes schools, Y_{ij} is an individual teacher outcome, α_j is a school random intercept, x_{ij}^T is a row vector of teacher- and classroom-level covariates for the i^{th} teacher, β is the associated column vector of coefficients, z_j^T is a row vector of school-level covariates, γ is the associated column vector of coefficients, and ε_{ij} is a teacher random error. To allow for coefficient variability across grades, accommodate the aforementioned grade-specific covariates, and incorporate available weights into the kindergarten regressions, we estimated the regressions separately by grade.[14]

The hierarchical linear model employed here assumes that the α_j are uncorrelated with the included covariates. To check this assumption, we compared random-intercept regressions to fixed-effect regressions of the form

$$Y_{ij} = \alpha_j + x_{ij}^T \beta + \varepsilon_{ij} \qquad (2)$$

where the α_j are fixed parameters instead of realizations of a random variable. The results of visual comparison of coefficients and their precision estimates across models (1) and (2), as well as those of Hausman (1978) tests, support our decision to use the random-intercept specification and thereby gain the descriptive power that derives from inclusion of school-level covariates (whose presence in fixed-effect regressions is precluded).

Due to the large number of variables we consider, missing values greatly reduce sample size in both grades. To counter the loss of information, we imputed missing values using chained multiple imputation (Van Buuren, Boshuizen & Knook, 1999). For each grade, the regression coefficients reported here are based on 20 imputed data sets using standard rules for estimand combination. In the imputed data sets, there are 3,054 kindergarten and 3,827 first grade teachers.[15]

IV. Findings

There are two time on math regressions (one for kindergarten and one for first grade), 12 content scale regressions (six for each grade), and 17 pedagogy scale regressions (8 for kindergarten and 9 for first grade). Because of the large number of regressions, we summarize the results in schematic form in Table 2. Appendix Tables 2-5 present the full regression results. The schematic facilitates our discussion and provides a sense of the overall picture presented by our findings.

The rows of Table 2 correspond to those of the regression tables. The first two columns synthesize results from the time on math regressions; the other four columns synthesize results from the scale score regressions. Mnemonics for the scales for which coefficients are statistically significant ($p<.05$) are listed in separate columns by grade and scale type (content or pedagogy). Where a coefficient is not statistically significant, no entry is made. Upper-case entries denote positive coefficients; lower-case entries denote negative coefficients.

Most of the covariates in the regressions are indicator functions that distinguish between two or more categories, and their coefficients are mean differences. For the scale regressions, the mean differences refer to times per month. To provide a sense of magnitude for these differences, we place an underscore under the scale mnemonic to indicate that the coefficient can be interpreted as a mean difference of at least five times per school year.[16] Thus, for example, <u>BNO</u> in the first row of Table 2 indicates that students in full-day kindergarten receive, over the course of the school year, at least five additional lessons involving instruction in Basic Numbers and Operations, on average, compared with students in half-day kindergarten.

Discussion of the results is centered on Table 2 with occasional references to Appendix Tables 2-5 and proceeds by covariate, beginning with length of school day for kindergarten and time spent on mathematics as controls, and continues with the remaining covariates arranged by type.

<u>Insert Table 2 here</u>

Full-day vs. half-day kindergarten. As expected, relative to teachers of half-day kindergarten, teachers of full-day kindergarten report spending more time on math. In addition, the average number of days per month for most of the content and pedagogy scales are largest for full-day kindergarten.

Time spent on mathematics. Because teachers who spend more time on mathematics when they teach the subject have more time to cover more content and explore different teaching practices, we expect to observe positive coefficients for time spent on mathematics when it is included as a covariate in the scale score regressions. In fact, with the exception of Counting

Out Loud in kindergarten, all content and pedagogical scales are positively associated with time spent on math.

Region. Between region differences are substantial, with many exceeding a *ten*-time per year differential. Relative to kindergarten teachers in the Northeast, southern kindergarten teachers spend more time on mathematics and report higher average times per month for several content domains and pedagogical practices. This pattern is consistent with previously noted differences at the kindergarten level between the South and other regions. At the first-grade level, a different pattern emerges: Although southern teachers continue to report spending more time on mathematics, frequencies for first grade teachers in the Northeast exceed those of southern teachers for two content domains and one pedagogical practice. And for nearly all content domains and several pedagogical practices, the frequencies for teachers in the Northeast exceed those in the West and Midwest.

Type of place. Compared with teachers in central city schools, teachers in the "urban fringe" and in small towns report less frequent use of Artistic approaches in kindergarten and more frequent use of Traditional Resources and Drill in first grade. Teachers in small towns also report less emphasis on Games in kindergarten. With respect to content, teachers in small towns report less frequent coverage of Statistics and Probability, Problem Solving, and Relationships in kindergarten, and urban fringe teachers report less frequent coverage of Geometric Shapes in first grade. Taken as a whole, these finding suggest that teachers of the early elementary grades in central cities use a less traditional pedagogical style than their counterparts in the urban fringe and in small towns.

School type. At the kindergarten level, private school teachers spend less time on mathematics than public school teachers do—about nine fewer minutes in religious schools and six in nonreligious schools. There is no difference in time spent on mathematics by school type at the first grade level.

Private religious school teachers report less frequent coverage than public school teachers of Geometric Shapes in kindergarten. They report less frequent coverage of Statistics and Probability and Relationships in both grades, suggesting less emphasis on advanced abstract topics. With regard to pedagogy, private religious school teachers place much greater emphasis on Traditional Resources and Drill, and less emphasis on Manipulatives, Group Work, Counting Out Loud, and Calculators, which suggests on the whole a more prescriptive style and a less constructivist or experiential approach to teaching. These findings reinforce results of prior research on public-parochial school differences in classroom pedagogy.

Teachers in nonreligious private schools report more frequent use of both Basic and Advanced Numbers and Operations than do their counterparts in public schools in kindergarten, but less emphasis on Basic Numbers and Operations and Relationships in first grade. With respect to pedagogy, first grade teachers report less emphasis on Counting Out Loud and Hands-on teaching styles. These findings suggest an early push to emphasize challenging numeric content and are consistent with a reduced emphasis on basic content and routine pedagogy in the first grade classrooms of nonreligious private schools.

Percent minority. First grade teachers in high minority schools report spending more time teaching mathematics. In addition, the greater the percent minority the more intense the focus on procedural numerical and geometric content, with greater emphasis on Basic Numbers and Operations in kindergarten, and Advanced Numbers and Operations in first grade. Geometric Shapes is positively associated with percent minority in both grades. With respect to pedagogy, increases in percent minority are associated with increases in traditional modalities in both grades (Traditional Resources in kindergarten and Counting Out Loud in first grade), as well as increases in Group Work in both grades and Creative approaches in first grade. Although Group Work and Creative are not unambiguously traditional approaches, they could be elements of strategies for coping with rambunctious children with little patience for traditional modalities. Percent minority is an imperfect measure of socioeconomic composition at the school level and does not allow for the distinction between demographic minorities and population groups that in addition are economically disadvantaged. Furthermore, percent minority is at best an indirect measure, where direct measures of parental socioeconomic status would be preferred. Nonetheless, the data suggest that mathematics in high minority schools emphasizes fundamentals in content. The results for instructional style are more ambiguous, but suggest greater emphasis on traditional modalities.

School size. School size is unrelated to the amount of time teachers report spending on mathematical instruction in kindergarten or first grade. Although the differences between small and medium sized schools are statistically significant for certain content and pedagogy scales, no monotonic patterns are discernable; thus we are uncertain of the meaning—if any—of the associations.

Classroom characteristics. Class size, percent disabled, and racial/ethnic composition show an overall lack of systematic differentiation in time spent on mathematics and content coverage. Time spent on mathematics is positively associated with percent disabled in kindergarten but not first grade, and negatively associated with percent black in kindergarten but not first grade. Associations with content coverage are small and unsystematic across kindergarten and first grade. The data do hint, however, that mathematics teaching styles may begin to differentiate along compositional lines in first grade. The most notable finding for classroom composition is that the percentage of African-American students in the classroom shows virtually no association with content or pedagogy. This result holds up even when the school percentage of minority students and teacher race variables are removed from the regressions. The lack of association in the ECLS-K data contrasts with Stipek's (2004) findings, possibly because of differences in approach. Stipek's constructivist and didactic teaching measures are based on classroom observations, encompass a wide variety of descriptors of classroom practice, and do not distinguish between mathematics and literacy instruction. Our scales focus only on mathematics instruction and provide a more fine-grained description of specific elements of teaching practice.

Teacher race/ethnicity. In the ECLS-K data, approximately 80% of teachers are white, with the balance distributed approximately evenly across black, Hispanic, and "other." Thus, the possibility of racial/ethnic differences in mathematics teaching are of interest. White teachers report slightly broader content coverage at the kindergarten level, but *narrower* content coverage at the first grade level. In addition, the pedagogical palette of white teachers is narrower than that of black teachers at the kindergarten level, and narrower than that of *each* of the other population groups at the first grade level. Pedagogical style differences are most pronounced between white and black teachers in kindergarten, and differences persist into first grade.[17] Content coverage differentials, however, are most pronounced and consistent across grades between white teachers and the heterogeneous "other" category. Despite having the most extensive portfolio of pedagogical approaches, black teachers spend less time than white teachers on mathematics in first grade, and this black-white contrast is the largest of all first-grade differentials for time spent on mathematics. If, as prior research suggests, African-American teachers view themselves as occupying highly nurturing roles, it is plausible that they focus more on social context than on the subject of mathematics during the first compulsory grade, but that in teaching they draw on a wider variety teaching strategies—both didactic and more student-centered—to enable students to connect with the material. The same interpretation may also apply to the Hispanic and “other” groups, for whom the results are similar but less strong and less consistent.

Teacher age and experience. There are neither age nor experience differences in time spent on mathematics for either grade. Modest differences in scope for content coverage appear only for those age 50 and older and only for kindergarten teachers. At similar levels of experience, older teachers place less emphasis on Basic Numbers and Operations and Statistics and Probability than do younger teachers. Older teachers also exhibit a slightly narrower stylistic repertoire than that of younger teachers, placing less emphasis on Group Work, Counting Out Loud, and Games. There is little consistency in the teaching experience contrasts. Experience is unrelated to time spent on math or to content coverage in kindergarten. In first grade, teachers with ten or more years of experience are less likely than novice teachers to cover Basic Numbers and Operations. With regard to pedagogy, novice teachers tend to rely on Counting Out Loud more than experienced teachers, use less Manipulatives than highly experienced teachers in kindergarten, and use less Games than slightly more experienced teachers in first grade. However, the lack of monotonicity in these relationships make them difficult to interpret.

Teacher educational attainment. There is no association between teacher educational attainment and time spent on mathematics instruction at the kindergarten level, and no consistent association at the first grade level. The same point holds for content coverage. There do, however, appear to be plausible associations of teacher educational attainment with pedagogical style. At the kindergarten level, teachers with post-BA education appear to place more emphasis on more socially oriented styles (Group Work, Games) as well as on learning mathematics through calculator use. At the first grade level, there is again a greater emphasis on calculators, coupled with less emphasis on traditional teaching approaches (Traditional Resources, Drill). Post-BA education may expose teachers to new and more complex teaching techniques, which may explain these results.

Teacher certification, coursework, and preparation time. Certification is unrelated to time spent on mathematics. With regard to content, it is positively associated with the teaching of Statistics and Probability in kindergarten and negatively related to the teaching of Problem Solving in first grade. With regard to pedagogy, certification is negatively related to Traditional Resources in kindergarten and Manipulatives in first grade.

The extent of coursework on methods of teaching mathematics is positively and strongly associated with time spent teaching mathematics, content coverage, and pedagogical styles. The amount of unpaid preparation time teachers spend is consistently and positively associated with content coverage and pedagogical styles, but unrelated to time spent teaching mathematics. Whether a teacher has regular certification is unrelated to time spent teaching mathematics, and associated in no obviously systematic way with emphases in content coverage or pedagogical styles.

Teachers who have taken more than two courses in methods of teaching mathematics average approximately five additional minutes per day on the days mathematics is taught in kindergarten and approximately two and a half additional minutes in first grade, relative to those who have taken fewer courses. It is not surprising that teachers who have had more mathematics teaching-specific courses spend more time teaching the subject. Relative to those who have had less training of this kind, these teachers are probably more comfortable with the subject matter. Across both grades, coursework is also associated with marked increases in content coverage and in the use of most of the pedagogical styles measured by the ECLS-K, although the pattern is less pronounced in kindergarten. These findings suggest that teacher preparation related to mathematics instruction may lead to more frequent content coverage as well as a wider repertoire of instructional techniques.

Teachers spending more than five hours per week of unpaid preparation time report more frequent coverage of topics that develop reasoning skills and greater emphasis on social and physically interactive pedagogies, which suggests that they take a more constructivist approach to teaching. These teachers also report more frequent coverage of Basic Number and Operations, Statistics and Probability, Problem Solving, and Relationships in both grades. Problem Solving and Relationships are content scales that describe mathematical reasoning concepts; teachers who extensively prepare may choose to focus on more open-ended exploratory reasoning concepts instead of procedures. In addition, at the kindergarten level, these teachers report more coverage of Advanced Numbers and Operations. At the first grade level, these teachers report more coverage of Geometric Shapes. With respect to pedagogy, teachers who prepare extensively choose to emphasize Group Work and Hands-on in both grades, as well as Manipulatives, Games, and Calculators in first grade. Emphasis on these modalities suggests that these teachers focus on techniques that require students to communicate with each other, to explore, and to discover.

Whether a teacher is given more than two hours per week of paid preparation time is unrelated to time spent teaching mathematics, and weakly and inconsistently associated with content coverage and pedagogical style.

Professional development. With two grade-specific exceptions, the professional development activities measured in the ECLS-K are contemporaneously unrelated to time spent teaching mathematics. Whether teachers received direct instruction from outside consultants, participated in three or more in-service training days, or visited or observed classes at other schools show little if any association with content coverage or pedagogical style. This is an interesting finding, since instruction from consultants and in-service days are by far the most widespread forms of professional development experienced by teachers (see Appendix Table 1) yet they appear to have little relationship to practice. In contrast, the six remaining professional development items show pervasive and strong positive associations with content coverage and pedagogical style. Within this latter group of items, "participation in peer observation and feedback" and "participated in follow-up support for teachers trying new ideas" (activities reported by fewer than half the teachers), show strong positive relationships with many scales. These indicate active involvement in a professional learning community; thus, it is unsurprising that their associations with content coverage and pedagogical style are especially marked.

Goodness of fit sensitivity analyses. Although states determine content and licensure standards and districts and school administrators promote the teaching of particular skills through curricular choices, professional development, and support for professional learning communities, ultimately it is the individual teacher who decides what topics will be covered in the classroom as well as the manner in which they will be taught. For this reason, regression functions of the content and pedagogy scales can be expected to include considerable random error due to unmeasured factors. It is possible that practices vary by teacher-level characteristics that were not captured by the data, such as mathematical knowledge for teaching. Another possibility is that unmeasured school- or district-level factors may influence practice.

Although the random effects models we estimate do not yield standard goodness of fit measures, we were able to explore this issue and the factors contributing to fit in sensitivity analyses. The design of ECLS-K, with teachers nested within schools, allowed us to explore whether schools could influence the practices of teachers within them. To do so, we estimated eq. (2) with OLS, suppressing the school-specific intercepts (α_j) while including the school-level covariates and excluding schools represented in the sample by a single teacher and found the average R^2 over all scales to be about .12 in kindergarten and .09 in first grade. We then estimated eq. (2) with the school-specific intercepts (i.e., a school "fixed effects" model), and thus captured the additive contributions of all possible covariates that are constant within schools. In these specifications, the average R^2 over all scales was about .49 in kindergarten and .41 in first grade. These are substantial improvements in fit. It is reasonable to ascribe the improvements in fit to within-school similarities in approach induced, for example, by curricular decisions, formal and informal peer consultations, and top-down decision-making—all of which operate in addition to region, type of locale, and other factors we have found to be associated with teacher responses to the scale items.

Further evidence of within-school clustering is provided by differential fits across scales. For example, the R^2 for the eq. (2) school fixed-effects regression of the Traditional Resources scale is about .64 in kindergarten and about .53 in first grade. These are the best fits for all scales in the respective grades. Two of the items in the Traditional Resources scale are "do mathematics worksheets" and "do mathematical problems from the textbook." This is a relatively structured approach, and it is one that is quite straightforward to implement with some uniformity across different classes within schools. In contrast, the R^2 for the eq. (2) school fixed-effects regression for Creative is about .39 in kindergarten and .32 in first grade, and these are the weakest fits for the pedagogy scales in the respective grades. This is consistent with our impression that the incorporation of music and drama into foundational mathematics teaching was less standardized as well as our finding that it was relatively rare in academic years 1998-1999 and 1999-2000.

V. Summary and Conclusions

Using ECLS-K data, this study has provided a systematic analysis of mathematics teaching in kindergarten and first grade classrooms nationwide in 1998-2000. The scope of the study exceeds that of prior studies in both scale and detail, and permits macro-level patterns of variation in practice to emerge. We show that kindergarten and first grade teachers' reports of time spent on mathematics instruction, mathematical content coverage, and pedagogical style vary by the time available in the school day, geographic location, school characteristics, teacher attributes, and professional development activities.

Full-day kindergarten is associated with greater emphasis on most content areas and instructional modalities. Mathematics instruction in kindergarten is emphasized more in the South than other regions; in first grade the emphasis is greater in the Northeast. Teachers in schools in urban fringe areas and small towns place greater emphasis on traditional pedagogy than those in central cities. Teachers in private, religious schools engage in more traditional pedagogy than those in public schools. Teachers' race/ethnicity is associated with practice, with white teachers spending more time on mathematics than black teachers in first grade but less likely to cover certain topics or employ a wide variety of pedagogical techniques than black or other nonwhite teachers. Courses in methods of teaching math and voluntary preparation time are associated with active engagement in mathematics teaching. Certain forms of professional development activities show significant associations with the practices identified in our data, although some of these are rare, whereas the most commonly sponsored forms of professional development show little association with practice.

In addition, controlling for factors that are constant within schools increases the explanatory power of the analyses and suggests that institutions play an important role in influencing practice. In fact, those practices that one would expect to be curriculum driven, such as Traditional Resources, are more fully explained than others by our models when we include school fixed effects. These findings suggest that more prescriptive and curriculum driven approaches to teaching on the part of schools, districts, and states might substantially decrease overall variation.

Although our results are derived from nonexperimental data and may not be causal, they suggest the existence of several significant relationships between practice and factors that can be influenced by policies pertaining to teacher training, professional development, and curriculum. In order for a policy agenda to promote effective mathematics teaching to be devised, however, these findings need to be coupled with an exploration of how the practices identified and described in this study are associated with student learning. An investigation of the impact of these practices on student achievement is currently in progress by the authors, the results of which will be presented in a future paper. Thus, the present study lays the foundation for a comprehensive analysis of early elementary mathematics teaching and the development of policy implications that hinge on an understanding of both effectiveness and the distribution of practice across different contexts.

Future research that utilizes ECLS-K:11 a planned survey of the kindergarten class of 2010-2011 (National Center for Education Statistics, 2009b), will afford interesting comparisons with the findings of this study. The new survey will allow us to assess whether changes in practice have occurred since the passage of the No Child Left Behind Act (NCLB) of 2001. By tying Title 1 funding to the implementation of high-stakes testing regimes aligned with a set of content standards, the federal government has encouraged a greater degree of conformity across states than previously existed, as states find it in their interest to exchange ideas and adopt models that meet federal approval. In addition to NCLB, federally sponsored curricular reforms initiated by the National Science Foundation (NSF) to align mathematics curricula with the NCTM standards have resulted in the development of three curricula for early elementary mathematics—Everyday Math, Math Trailblazers, and Investigations in Number, Data, and Space. These curricula encourage teachers to use manipulatives, data, and interactive approaches, and they now account for a large portion of the textbook market. The results of the present study will thus provide a baseline for a future assessment of the impact of NCLB and the change in the teaching materials market on early elementary mathematics instruction.

Endnotes

1. "Mathematical knowledge for teaching" embodies both mathematical content knowledge and knowledge of ways to teach specific content and is a form of pedagogical content knowledge, such as that described by Schulman (1986, 1987).

2. The kindergarten teacher sample is nationally representative for 1998-1999, using the sampling weight variable supplied by NCES. There is no corresponding weight variable for the first grade teacher sample, which we do not claim to be nationally representative. To check for differences between the kindergarten and first grade teacher samples, however, we used log-

linear analysis to analyze the four-way distribution over teachers of grade by region by type of locale by type of school and found only modest differences. Relative to first grade teachers, kindergarten teachers in the data are slightly more concentrated in the South and West and correspondingly less concentrated in the Northeast and Midwest. Again relative to the first grade teacher sample, the kindergarten teacher sample is concentrated slightly more in central cities, and a little less in urban fringe areas, with no cross-grade difference in percent small town and rural. Kindergarten teachers are slightly less likely than first grade teachers in the data to be working in public schools, with no other apparent differences by school type across grades. Thus, despite between-grade differences in ECLS-K sample construction, the evidence available to us suggests that the two teacher samples are similar in composition.

3. The response categories for time spent on mathematics on days when the subject is taught are scaled as interval midpoints with an assigned top code: 1-30 minutes →15; 31-60 minutes →45; 61-90 minutes→75; more than 90 minutes→100. Note that for the number of days per week mathematics is taught, about 98% of kindergarten teachers (unweighted) include mathematics in their lessons at least three days per week, and 82% include mathematics every day. For first grade teachers, the corresponding percentages are 99% and 95%.

4. The additional first grade items are how often teachers "do worksheets that emphasize routine practice or drill" and how often they "work on problems for which there are several appropriate methods or solutions."

5. We recode the response categories for mathematics activities using what is essentially interval midpoint scaling: "never" → 0 times per month; "once a month or less" → 1 times per month; "two or three times a month" → 2.5 times per month; "once or twice a week" → 6 days per month; "three or four times a week" → 14 days a month; "daily" → 20 times per month.

Our metric assumes that "times a week" is roughly synonymous with "days per week" and assumes a standard of four weeks in a month and five working days per week. The response categories for the skills (content) items are the same as those for the activities (pedagogical modalities) items, except that the "never" category was named "not taught" and comprised two subcategories "taught at a higher grade level" and "children should already know." We code both "not taught" categories as 0 times per month.

6. In a comparative study of observer-coded and self-reported teacher activity frequencies in a single school district, Mayer (1999) finds that the two forms of measurement are weakly correlated for single items, but quite highly correlated for a scale constructed from the items. Mayer (1999) also finds that self-reported frequencies of teacher activities tend to be greater than observer-coded frequencies. However, observer coding took place over just three class periods, only nine teachers were observed, and the activity frequency differences are relatively modest. In another study with two forms of measurement of teacher instructional practices, Stipek and Byler (2004:375) assert that their data reveal "meaningful, predictable" associations between self-reports and observer-coded measurements for two teaching style scales, but do not report specific levels of association.

7. Using calculators for mathematics is the practice that teachers reported doing the least—an average of about .6 times a month in kindergarten and 1.44 in first grade. Counting Out Loud was the most frequently reported technique used—an average of about 18 times a month in kindergarten and about14 times per month in first grade.

8. In the ECLS-K public use data files, the complete names of the categories are "central city (large city and mid-size city)," "urban fringe and large town" (includes urban fringes of large cities and mid-size cities), and "small town and rural." Note that the allocation of

observations to these categories in the kindergarten data has been updated to correct for classification errors in the original public use data release.

9. Percent minority was grouped into approximate quintiles, which in turn defined the categories of the dummy variable classification used for data exploration. To obtain the results presented in the paper, we ordinally coded the quintiles to robustly check for the presence of monotonic associations with outcomes. The coding scheme is 1:[0,10), 2:[10,25), 3:[25,50), 4:[50,75), 5:[75,100].

10. In exploratory analyses, the percentage of children in the classroom with limited English proficiency was found not to have statistically significant effects on the content and modality scales. Most teachers (97 percent of kindergarten teachers and 68 percent of first grade teachers) in the ECLS-K data indicated that they had no children with limited English proficiency in their classes.

11. The kindergarten and first grade teacher experience variables differ. Teachers in both grades were asked how long they had taught at specific grade levels and in specific kinds of programs (e.g., bilingual). In addition, first grade teachers were asked how many years they had been teaching. Answers to this added question correspond to what is commonly thought of as "experience," and we use this version for first grade teachers. Unfortunately, combining years taught in specific grades and programs does not yield total years of experience. Thus, our kindergarten analyses use years of experience teaching kindergarten, and our first grade analyses use years of overall teaching experience.

12. We do not include gender. Ninety six percent of kindergarten teachers are women; the corresponding percentage of first grade teachers is suppressed in the public use version of the ECLS-K.

13. In the kindergarten teacher sample used here, about eight percent of teachers are sample singletons in their school, about 82 percent are in clusters ranging in size from 2 to 8, and about nine percent are in clusters ranging in size from 9 to 18. For first grade teachers, about 15 percent are sample singletons in their school, about 81 percent are in clusters ranging in size from 2 to 8, and about four percent are in clusters ranging in size from 9 to 13.

14. In our review of the regression results, we focus on $\hat{\beta}$, $\hat{\gamma}$, and their precision estimates; $\hat{\alpha}_j$ and $\hat{\sigma}_\alpha$ are of not of primary interest. All regressions were computed using Stata 10 (Statacorp., 2007). Note that, owing to a programming particularity, the regressions for kindergarten teachers were computed using generalized estimating equations with exchangeable working correlation matrix. The equivalence of the coefficients and standard errors with the random intercept model in the Gaussian case is well established (Diggle, Heagerty, Liang & Zeger, 2002).

15. Prior to imputation, we dropped 251 kindergarten and 1,221 first grade teachers who were missing on all time allocation items due to ECLS-K design decisions. At that point, remaining nonresponse reduced working sample size by about 41 percent for kindergarten and 42 percent for first grade teachers. Most versions of imputation assume that, for a given item, the probability that an observation is missing is independent of the true value of the item conditional on variables contained in the data set. This is the *m*issing *a*t *r*andom (MAR) assumption, the validity of which is critical to the usefulness of the imputations. In the present instance, the sample selectivity with the potential to produce missingness *not* at random was largely determined in the design stages of the ECLS-K, when exclusion criteria were established for the administration of entire blocks of questions. In our use of the data, those teachers were set aside as a result of our decision to drop anyone who answered none of the time allocation

questions. On inspection, remaining missingness consisted of a modest amount of nonresponse scattered across a large number of items that cumulated to a large reduction in observations were complete case analysis to be used. Given our exclusion criterion, we think the MAR assumption is plausible. Imputations were carried out in Stata using Royston's (2004, 2005, 2007) implementation of chained multiple imputation. Post-estimation was also carried out in Stata using a related routine (Carlin, Galati & Royston, 2008).

16. The length of the school year is assumed to be 180 days (nine months). Since the metric for the contrasts is days per month and we assume that one time corresponds to one lesson on one day and there are five days in one week, we use the criterion $9\,|\hat{\beta}| \geq 5$, from which it follows that $|\hat{\beta}| \geq .5556$. The five-times flag is of course arbitrary, and there is no way of discerning from the data the average time per day spent on a particular content domain, or using a particular pedagogic modality. Other useful magnitudes include 10 times ($|\hat{\beta}| \geq 1.1111$), 15 times ($|\hat{\beta}| \geq 1.6667$), and 20 times ($|\hat{\beta}| \geq 2.2222$) per school year.

17. We checked for interactions between classroom percent black and whether the teacher is black, and found none. This suggests that the pervasive differential pedagogical emphases found between white and black teachers has its locus in teacher-centered ideation, rather than in the teacher-class dynamic.

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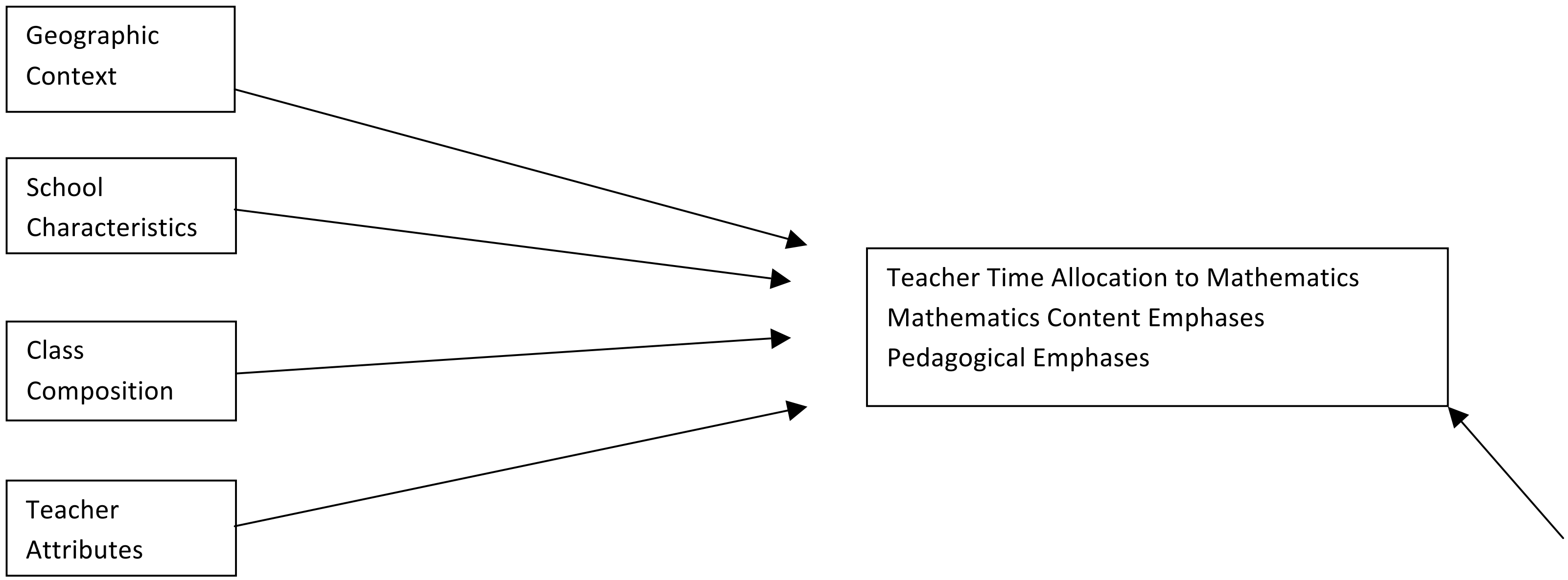

Figure 1. Framework used to guide regressions of teacher time allocated to mathematics, and mathematics content and pedagogical emphases.

Table 1. *N*s, means, and standard deviations for time on math, math activities, and math pedagogical practices reported by kindergarten and first grade teachers, ECLS-K[a]

	Kindergarten			First Grade		
	N[b]	Mean	SD	*N*[b]	Mean	SD
Time on Math	2,948	39.61	21.70	3,539	54.32	18.24
Content Scales						
Basic Numbers & Operations (BNO)	3040	9.69	4.83	3825	11.63	4.50
Writing all numbers from 1 to 10	2998	11.63	7.01	3770	7.53	8.40
Adding single-digit numbers	3003	8.88	7.06	3808	14.88	5.67
Subtracting single-digit	2952	6.84	6.87	3796	14.41	5.85
Reading two-digit numbers	2988	12.68	7.77	3776	14.06	6.54
Ordinal numbers (e.g., first, second, third)	2995	8.32	7.45	3781	7.26	6.73
Advanced Numbers & Operations (ANO)	3050	3.62	3.18	3826	6.72	3.81
Adding two-digit numbers	2999	1.24	4.08	3690	6.93	6.67
Carrying numbers in addition	3014	0.45	2.53	3760	1.97	4.80
Subtracting two-digit numbers	2992	0.72	3.23	3745	5.59	6.48
Mixed operations	2986	0.73	3.03	3763	3.42	5.63
Counting by 2s, 5s, and10s	3001	9.71	7.74	3791	11.34	6.97
Counting beyond 100	2975	6.09	7.83	3747	7.40	7.32
Writing all numbers from 1 to 100	2975	3.19	5.50	3755	5.82	6.25
Fractions	2985	1.82	3.45	3769	3.85	4.52
Reading three-digit numbers	2979	5.48	7.94	3769	8.55	7.84
Place values	2982	6.72	8.57	3783	12.12	7.13
Geometric Shapes (SHP)	3007	8.73	6.99	3791	5.35	5.67
Recognizing and naming geometric shapes	3007	8.73	6.99	3791	5.35	5.67
Statistics & Probability (SP)	3041	4.52	4.41	3819	5.78	4.73
Reading simple graphs	2997	7.20	6.94	3777	7.79	6.52
Estimating probability	2991	1.38	3.45	3725	3.18	4.52
Performing simple data collection and graphing	3013	4.96	5.92	3804	6.34	6.12

Table 1—Continued (1)

	Kindergarten			First Grade		
	N[b]	Mean	SD	*N*[b]	Mean	SD
Problem Solving (PS)	3049	6.11	4.76	3826	9.86	4.88
Explain how a mathematics problem is solved	3009	8.34	7.22	3808	13.19	6.64
Work on mathematics problems that reflect real-life situations	3027	8.01	6.78	3805	10.35	6.56
Work on problems for which there are several solutions	NA	NA	NA	3781	7.63	6.75
Writing mathematics equations to solve word problems	3013	1.99	4.31	3767	8.23	6.72
Relationships (REL)	3041	8.36	4.16	3824	7.58	4.18
Estimating quantities	2953	4.49	5.38	3717	6.21	5.85
Correspondence between numbers and quantity	2957	14.27	6.19	3711	9.73	8.26
Identifying relative quantity	3010	9.87	6.82	3801	9.91	6.72
Sorting objects into subgroups according to a rule	3001	7.41	6.14	3781	5.22	5.13
Ordering objects by size or other properties	3000	6.68	5.84	3769	4.80	4.94
Recognizing the value of coins and currency	2993	6.19	6.63	3787	9.97	7.14
Making, copying, or extending patterns	3007	9.63	7.04	3791	7.22	6.56
Pedagogy Scales						
Group Work (GW)	3042	7.54	5.61	3825	8.62	5.46
Solve mathematics problems in small groups or with a partner	3026	6.46	6.37	3813	8.53	6.41
Work in mixed achievement groups	3024	10.22	8.00	3787	9.94	7.47
Peer tutoring	3011	5.90	7.11	3773	7.38	6.91
Manipulatives (MNP)	3043	11.19	5.58	3816	9.04	5.07
Work with geometric manipulatives	3021	9.66	6.58	3776	6.35	5.65
Work with counting manipulatives	3030	12.74	6.17	3788	11.69	6.44
Creative (CRT)	3043	3.68	4.58	3817	1.71	3.05
Use creative movement or drama to understand mathematics concepts	3023	3.30	4.73	3794	1.76	3.43
Use music to understand mathematics concepts	3031	4.04	5.56	3803	1.65	3.50
Hands-on (HND)	3051	7.94	3.18	3827	9.35	3.76
Work with rulers, measuring cups, spoons, or other measuring instruments	3030	3.71	4.60	3796	4.34	5.00
Using measuring instruments accurately	2978	2.82	3.99	3740	4.31	4.83
Engage in calendar-related activities	3029	18.79	4.12	3803	17.89	5.10
Telling time	2974	6.22	6.98	3757	10.67	7.40

Table 1—Continued (2)

	Kindergarten			First Grade		
	N[b]	Mean	SD	*N*[b]	Mean	SD
Traditional Resources (TR)	3048	6.22	5.25	3825	11.69	5.45
Do mathematics worksheets	3024	9.70	7.25	3815	14.36	6.37
Do mathematics problems from the textbook	3003	3.87	6.98	3791	11.26	8.53
Complete mathematics problems on the chalkboard	3031	5.07	6.45	3813	9.42	7.23
Drill (DRL)						
Do worksheets or workbook page emphasizing routing practice or drill	NA	NA	NA	3813	11.44	6.77
Games (GMS)	3016	10.62	6.56	3788	8.75	6.15
Play mathematics-related games	3016	10.62	6.56	3788	8.75	6.15
Counting out loud (COL)	3049	17.95	4.29	3800	14.02	6.76
Count out loud	3049	17.95	4.29	3800	14.02	6.76
Calculator (CLC)	3023	0.64	2.35	3805	1.44	2.85
Use calculator	3023	0.64	2.35	3805	1.44	2.85

Source: U.S. Department of Education, National Center for Education Statistics, Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K), Public-Use File, spring 1999 and spring 2000.

Note: Means and Standard deviations for kindergarten teachers are weighted.

[a]Time on Math is coded as number of minutes per day. All practice items are coded as number of days per month with range [0,20]. The coding assumes a four-week month and five working days per week. Scales reported in this table are averages over nonmissing items. When used in regressions, the content and pedagogy scales are based on items that have been multiple-imputed. That is, imputations are item-specific, not scale-specific. See text for discussion.

[b]Sample size varies for time on math and the practice items due to missing data. The scale-specific *N*s are based on the number of teachers who provided at least one valid response to the items in a given scale.

Table 2. Summary of Covariate Relationships with Time on Math, Content Scales, and Pedagogical Scales, Kindergarten and First Grade Teachers, ECLS-K

	Time on Math		Content		Pedagogy	
	Kindergarten	First Grade	Kindergarten	First Grade	Kindergarten	First Grade
Teaches all-day kindergarten	X[b]		BNO,[cd] ANO, SHP, PS, REL		GW, MNP, HND, TR, GMS	
Time spent on math (minutes per day)			BNO, ANO, SHP, SP, PS, REL	BNO, ANO, SHP, SP, PS, REL	GW, MNP, CRT, HND, TR, GMS, CLC	GW, MNP, CRT, HND, TR, GMS, CLC, COL, DRL
Geographic Location						
Region						
Northeast[a]	–	–	–	–	–	–
West			ANO, shp, sp	bno, shp, sp, ps, rel	hnd	gw, mnp, tr, gms, clc
South	X	X	BNO, ANO, PS, REL	bno, rel	GW, MNP, CRT, HND	gms
Midwest			ANO	bno, ano, shp, sp, ps, rel		gw, mnp, tr, gms
Type of place						
Central city[a]	–	–	–	–	–	–
Urban fringe				shp	crt	TR, DRL
Small town			sp, ps, rel		crt, gms	TR, DRL
School Characteristics						
School type						
Public[a]	–	–	–	–	–	–
Private religious	x		geo, sp, rel	sp, rel	mnp, TR, col	gw, mnp, TR, clc, DRL
Private nonreligious	x		BNO, ANO	bno, rel		hnd, col
% minority students		X	BNO, SHP	ANO, SHP	GW, TR	GW, CRT, COL
School size						
<300[a]	–	–	–	–	–	–
300 to 499 students			ano		mnp, hnd, tr	
500 to 749 students					mnp, hnd	
≥ 750 students						TR, clc
Classroom Composition (quintile coded)						
Class size				shp, SP		CLC
% disabled	X					tr, COL, drl
% black	x		shp			
% Asian/Pacific Islander			BNO		MNP	tr, drl
% Hispanic				PS	tr	GW, MNP
Teacher Attributes						
Race/ethnicity						
White[a]	–	–	–	–	–	–
Black		x	sp	ANO	MNP, CRT, TR, GMS	GW, MNP, CRT, TR, GMS, CLC, DRL
Hispanic				SHP		MNP, CRT, CLC, COL
Other			sp, ps	ANO, SP, PS		GW, MNP, TR, CLC
Age						
<35[a]	–	–	–	–	–	–
35-49						
50 or older			bno, sp		gw, col	gms, col

Table 2—Continued

	Time on Math		Content		Pedagogy	
	Kindergarten	First Grade	Kindergarten	First Grade	Kindergarten	First Grade
Teaching experience						
<4 years[a]	–	–	–	–	–	–
4-9 years					col	GMS
10 years or more				bno	MNP	hnd, col
Educational attainment						
BA degree or less[a]	–	–	–	–	–	–
BA degree plus additional coursework		X			GW	CLC, drl
MA degree or above				ano	GMS, CLC	GW, tr, CLC, drl
Certification/Coursework/Preparation						
Regular certification			SP	ps	tr	Mnp
More than 2 courses on methods of teaching math	X	X	BNO, ANO, PS, REL	BNO, ANO, SHP, SP, PS, REL	MNP, HND, TR, CLC, COL	GW, MNP, CRT, HND, TR, GMS, CLC, COL, DRL
More than 2 hours of paid time preparing				PS		GMS
More than 5 hours of unpaid time preparing			BNO, ANO, SP, PS, REL	BNO, SHP, SP, PS, REL	GW, HND	GW, MNP, HND, GMS, CLC
Professional Development Activities in Current Academic Year						
Received direct instruction from outside consultant				BNO		
Participated in 3 or more in-service training days			SHP, REL			
Visited or observed other schools						COL
Received release time for early childhood conferences			SP	SP	MNP, CRT, GMS	CRT, GMS
Participated in workshops involving small groups	X		BNO, PS, REL	ANO, SHP, SP, PS, REL	CRT, COL	GW, MNP, GMS, COL
Participated in peer observation and feedback			BNO, SHP, SP, PS, REL	BNO, ANO, SHP, SP, PS, REL	GW, CRT, HND, GMS	GW, MNP, CRT, HND, TR, GMS
Participated in follow-up support for teachers trying new ideas		X	PS, REL	BNO, ANO, SP, PS, REL	GW, MNP, CRT, HND, GMS	GW, MNP, HND, GMS, CLC, COL
Enrolled in college or university courses			SP	SP, PS		GW, GMS
Attended workshops on technology			PS	SHP, SP, PS	GW, CRT, TR	CRT, GMS, CLC

Source: Appendix Tables 2-5.

[a] Reference category for dummy variable classification.

[b] For time on math, lowercase "x" indicates the coefficient is negative and significant at $p < .05$; uppercase, uppercase "X" indicates that the coefficient is positive and significant at $p < .05$.

[c] The scale abbreviations expand as follows. *Content:* BNO = Basic Numbers & Operations; ANO = Advanced Numbers and Operations; SHP = Geometric Shapes; SP = Statistics & Probability; PS = Problem Solving; REL = Relationships. *Pedagogy:* GW = Group Work; MNP = Manipulate; CRT = Creative; HND = Hands-on; TR = Traditional Resources; GMS = Games; CLC = Calculator; COL = Counting Out Loud; DRL = Drill (first grade only).

[d] An abbreviation in lowercase indicates that the coefficient is negative and significant at $p < .05$, an uppercase abbreviation indicates that the coefficient is positive and significant at $p < .05$; an underscore signifies that the contrast amounts to a difference of at least five days in a school year.

Appendix Table 1. *N*s, means, and standard deviations of covariates in the time on math, math activities, and pedagogical practice regressions, kindergarten and first grade teachers, ECLS-K

	Kindergarten			First Grade		
Variable Name	*N*	Mean	SD	*N*	Mean	SD
Geographic Location						
Region[a]	3051			3829		
Northeast		.164			.167	
West		.222			.242	
South		.404			.382	
Midwest		.211			.210	
Type of Place[a]	3051			3051		
Central city		.370			.386	
Urban fringe		.391			.428	
Small town		.238			.186	
School Characteristics						
School type[a]	3051			3829		
Public		.801			.898	
Private religious		.128			.086	
Private nonreligious		.072			.016	
% minority students in school[b]	2992	2.800	1.538	3783	2.941	1.551
School size (students)[a]	3035			3231		
< 300		.290			.141	
300-499		.264			.280	
500-749		.275			.325	
≥750		.171			.254	
Classroom Characteristics[c]						
Class size (quintiled)	2638	2.804	1.379	3814	2.636	1.440
Kindergarten 10-16, First grade 12-18		.163			.287	
Kindergarten 17-19, First grade 19-20		.227			.277	
Kindergarten 20-21, First grade 21-21		.256			.089	
Kindergarten 22-24, First grade 22-24		.185			.207	
Kindergarten 25-52, First grade 25-35		.170			.140	
% of students who are disabled (quintiled)	2635	2.820	1.584	3721	2.813	1.624
Kindergarten 0-0, First grade 0-0		.379			.405	
Kindergarten 3.0-4.0		.026			0	
Kindergarten 4.2-8.3, First grade 2.8-7.7		.201			.185	
Kindergarten 8.7-16.7, First grade 8.0-14.3		.209			.196	
Kindergarten 17.4-90.0, First grade 14.8-50.0		.185			.214	
% of students who are black (quintiled)	2563	2.703	1.639	3618	2.855	1.642
Kindergarten 0-0, First grade 0-0		.427			.404	
Kindergarten 1.9-9.5, First grade 2.8-7.1		.167			.150	
Kindergarten 9.6-26.7, First grade 7.4-26.3		.208			.229	
Kindergarten 27.0-100.0, First grade 26.7-100.0		.197			.217	
% of students who are Asian/Pacific Islander (quintiled)	2567	2.113	1.692	3618	2.190	1.712
Kindergarten 0-0, First grade 0-0		.658			.669	
Kindergarten 1.9-5.3, First grade 2.8-5.5		.131			.137	
Kindergarten 5.6-71.0, First grade 5.7-42.0		.211			.195	
% of students who are Hispanic (quintiled)	2568	2.576	1.686	3618	2.863	1.694
Kindergarten 0-0, First grade 0-0		.440			.421	
Kindergarten 2.0-5.6, First grade 2.8-5.3		.100			.122	
Kindergarten 5.7-21.4, First grade 5.6-21.1		.193			.208	
Kindergarten 21.7-100.0, First grade 21.4-100.0		.266			.249	

Appendix Table 1—Continued

Variable Name	Kindergarten *N*	Kindergarten Mean	Kindergarten SD	First Grade *N*	First Grade Mean	First Grade SD
Teacher Characteristics						
Teacher race[a]	3051			3829		
White		.821			.787	
Black		.066			.069	
Hispanic		.060			.080	
Other		.053			.064	
Teacher age[a]	2935			3658		
≤ 34		.299			.339	
35-49		.466			.367	
≥50		.235			.294	
Teaching experience[a]	3032			3746		
< 4 years		.375			.186	
4-9 years		.277			.254	
≥ 10 years		.348			.561	
Educational attainment[a]	2860			3727		
BA or less		.314			.292	
BA plus additional coursework		.344			.323	
MA degree or above		.342			.385	
Certification/Coursework/Preparation						
Regular certification	2933	.839		3712	.879	
More than 2 courses on methods of teaching math	2858	.407		3530	.450	
More than 2 hours of paid preparation time	2723	.716		3624	.718	
More than 5 hours of unpaid preparation time	2785	.403		3746	.448	
Teaches all-day kindergarten	3051	.644		NA	NA	NA
Professional Development Activities in Current Academic Year						
Received direct instruction from outside consultant	3016	.765		3742	.756	
Participated in three or more in-service training days	3021	.873		3752	.885	
Visited or observed other schools	3012	.289		3755	.228	
Received release time for early childhood conferences	3011	.360		3740	.285	
Participated in workshops involving small groups	3008	.562		3741	.611	
Received peer observation and feedback	3011	.422		3748	.453	
Received follow-up support	2997	.384		3736	.440	
Enrolled in college or university courses	3008	.294		3755	.309	
Attended workshops on computers and technology	3015	.575		3756	.593	

Source: U.S. Department of Education, National Center for Education Statistics Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K), Public-Use File, fall 1998, spring 1999, and spring 2000.

Note: Means and standard deviations for Time on Math are included in Table 1. Kindergarten means and standard deviations are based on weighted data. *N*s fluctuate due to missingness. Most variables are 0-1 indicators (dummies); we show standard deviations only for non-dummies. Means for dummies are always proportions, and they sum to one (within rounding) for dummy variable classifications.

[a] Dummy variable classification.

[b] Made available by ECLS-K as a grouped ordinal variable coded as 1:[0%,10%), 2:[10%,25%), 3:[25%,50%), 4:[50%,75%), and 5:[75%,100%]. We used minority composition as a dummy variable classification in exploratory analysis, and as an ordinal variable coded 1,...,5 in the regressions presented in Tables 3-6 for a robust assessment of monotonicity.

[c] Class size and the classroom composition variables are each separately grouped into approximate quintiles with the lowest coded 1 and the highest coded 5. We present means and standard deviations for the ordinally coded versions, and also display the distributions over quintiles as proportions. The quintile cut-points are conditional on grade. Due to uneven point mass concentration in the underlying distributions, the quintiles are not rectangularly distributed, and the groupings can collapse to fewer than five categories. See footnote b and the text for further discussion.

Appendix Table 2. Time on math and math content regressions, kindergarten teachers, ECLS-K[a]

	Time on Math and Math Content Scales						
Covariates	ToM	BNO	ANO	SHP	SP	PS	REL
Teaches all-day kindergarten	11.294**	1.114**	0.378*	0.024**	0.298	0.025**	0.766**
Time spent on math (minutes per day)	NA	0.017**	0.018**	0.093**	0.009*	0.975**	0.014**
Geographic Location							
Region							
Northeast	–[b]	–	–	–	–	–	–
West	-1.117	-0.099	0.684*	-1.739**	-1.469**	-0.298	-0.685
South	3.902*	1.412**	1.461**	0.504	-0.037	0.829*	0.848*
Midwest	0.450	0.248	0.844**	-0.077	-0.338	-0.141	-0.075
Type of place							
Central city	–	–	–	–	–	–	–
Urban fringe	0.214	0.019	0.181	-0.255	0.101	-0.284	-0.161
Small town	-1.791	-0.464	0.011	-0.468	-0.742*	-0.684*	-0.763*
School Characteristics							
School type							
Public	–	–	–	–	–	–	–
Private religious	-8.801**	-0.014	-0.403	-1.445*	-1.067**	-0.195	-1.012*
Private nonreligious	-5.736*	1.907*	2.186**	1.891	-0.371	0.247	0.948
% minority students	0.510	0.279*	0.112	0.517**	-0.047	0.168	-0.001
School size							
<300	–	–	–	–	–	–	–
300 to 499 students	-0.084	-0.244	-0.550*	0.280	0.237	-0.282	-0.073
500 to 749 students	0.804	-0.016	-0.225	0.166	0.236	-0.195	-0.145
≥ 750 students	2.231	0.554	-0.129	0.772	0.478	0.085	0.158
Classroom Composition (quintile coded)							
Class size	0.734	0.140	0.074	0.108	0.014	0.014	0.039
% disabled	0.693*	0.057	0.015	-0.023	0.000	-0.012	-0.043
% black	-0.822*	-0.187	-0.079	-0.261*	0.009	-0.002	-0.094
% Asian/Pacific Islander	0.200	0.138*	0.080	-0.020	-0.008	-0.031	0.108
% Hispanic	0.249	0.078	-0.035	0.067	0.122	0.021	0.033
Teacher Characteristics							
Race/ethnicity							
White	–	–	–	–	–	–	–
Black	1.049	0.317	0.115	0.836	-0.964**	0.211	-0.064
Hispanic	3.272	-0.740	-0.241	0.503	-0.246	-0.396	-0.020
Other	-0.022	0.031	0.328	1.055	-1.037**	-0.840*	0.338
Age							
<35	–	–	–	–	–	–	–
35-49	0.818	-0.288	-0.150	-0.076	-0.205	-0.075	-0.059
50 or older	-0.342	-0.719*	-0.228	-0.525	-0.814**	-0.025	-0.325
Teaching experience							
<4 years	–	–	–	–	–	–	–
4-9 years	1.685	-0.017	0.159	-0.031	-0.003	-0.078	0.101
10 years or more	0.876	0.166	0.057	0.579	0.101	-0.008	0.410
Educational attainment							
BA degree or less	–	–	–	–	–	–	–
BA degree plus additional coursework	-0.612	-0.095	-0.086	0.172	0.360	-0.028	0.200
MA degree or above	-1.069	-0.277	-0.013	0.197	0.332	0.230	0.191
Certification/Coursework/Preparation							
Regular certification	-0.484	-0.107	-0.156	-0.792	0.952**	0.343	-0.052
More than 2 courses on methods of teaching math	4.783**	0.808**	0.292*	0.541	0.364	0.597**	0.864**
More than 2 hours of paid time preparing	0.433	-0.320	0.033	0.151	-0.062	0.047	0.099
More than 5 hours of unpaid time preparing	1.737	0.570**	0.376**	0.178	0.667**	0.613**	0.452*
Professional Development Activities in Current Academic Year							
Received direct instruction from outside consultant	-1.758	0.089	0.148	0.044	-0.202	-0.095	-0.158
Participated in 3 or more in-service training days	2.419	-0.063	0.140	1.276*	0.277	0.328	0.775*
Visited or observed other schools	0.779	-0.129	0.101	-0.098	-0.083	-0.421	-0.047

Appendix Table 2—Continued

Covariates	Time on Math and Math Content Scales						
	ToM	BNO	ANO	SHP	SP	PS	REL
Received release time for early childhood conferences	0.076	0.266	0.213	-0.046	0.457*	0.095	0.335
Participated in workshops involving small groups	2.357*	0.431*	0.099	0.313	0.302	0.451*	0.577**
Participated in peer observation and feedback	0.081	0.868**	0.192	1.175**	0.440*	0.610**	0.708**
Participated in follow-up support for teachers trying new ideas	0.207	0.266	0.266	0.354	0.274	0.850**	0.647**
Enrolled in college or university courses	1.120	-0.086	0.219	-0.232	0.457*	0.248	-0.030
Attended workshops on technology	1.276	0.317	0.050	0.074	0.120	0.417*	0.241
Constant	21.091**	5.589**	0.648	4.836**	2.341**	2.107**	4.992**

*$p < .05$, **$p < .01$

Source: see Table 1.

Note: ToM = Time on Math; BNO = Basic Numbers & Operations; ANO = Advanced Numbers & Operations; SHP = Geometric Shapes; SP = Statistics & Probability; PS = Problem Solving; REL = Relationships.

[a] The data have been multiple-imputed. Within each imputed data set, the regressions are weighted, and are estimated using the method of generalized estimating equations with clustering at the school level. The coefficients and significance levels reported here are based on 20 imputed data sets. See text for further discussion.

[b] Throughout the table, "–" indicates a reference category for a set of dummy variables, for which no coefficient is estimated.

Appendix Table 3. Time on math and math content regressions, first grade teachers, ECLS-K[a]

Covariates	Time on Math and Math Content Scales						
	ToM	BNO	ANO	SHP	SP	PS	REL
Time spent on math (minutes per day)	NA	0.023**	0.030**	0.027**	0.026**	0.040**	0.030**
Geographic Location							
Region							
Northeast	–[b]	–	–	–	–	–	–
West	0.750	-0.868**	0.078	-0.951*	-1.098**	-1.272**	-1.265**
South	2.553*	-0.608*	0.176	-0.394	-0.441	-0.163	-0.704**
Midwest	-0.380	-0.910**	-0.569*	-0.835*	-0.916**	-0.823**	-1.113**
Type of place							
Central city	–	–	–	–	–	–	–
Urban fringe	0.272	0.268	0.311	-0.575*	0.077	-0.051	-0.033
Small town	-0.491	0.162	-0.072	-0.616	-0.518	-0.163	-0.124
School Characteristics							
School type							
Public	–	–	–	–	–	–	–
Private religious	-2.508	0.235	-0.032	-0.231	-0.870*	-0.290	-0.959**
Private nonreligious	-1.307	-1.270*	0.798	-0.520	-1.159	0.082	-2.021**
% minority students	1.430**	0.093	0.198**	0.286**	-0.029	0.013	0.026
School size							
<300	–	–	–	–	–	–	–
300 to 499 students	0.578	0.047	-0.272	-0.237	0.045	0.155	-0.019
500 to 749 students	2.172	0.180	-0.176	0.104	0.211	0.106	-0.008
≥ 750 students	2.002	0.395	-0.158	0.081	0.371	0.522	0.246
Classroom Composition (quintile coded)							
Class size	-0.426	0.048	0.064	-0.155*	0.143*	0.071	0.085
% disabled	0.097	-0.021	-0.052	-0.064	-0.080	-0.076	0.005
% black	0.327	0.022	-0.051	-0.019	0.050	0.020	0.048
% Asian/Pacific Islander	-0.258	-0.078	-0.064	-0.090	-0.072	0.008	-0.037
% Hispanic	-0.500	0.097	0.068	-0.011	-0.027	0.150*	0.099
Teacher Characteristics							
Race/ethnicity							
White	–	–	–	–	–	–	–
Black	-3.250*	-0.470	0.603*	0.656	-0.186	-0.033	0.048
Hispanic	1.129	-0.087	0.440	1.067**	0.326	-0.018	0.455
Other	-1.819	-0.094	0.653*	0.755	0.776*	0.707*	0.497
Age							
<35	–	–	–	–	–	–	–
35-49	-0.277	-0.115	-0.033	-0.013	0.027	0.236	0.247
50 or older	-0.960	-0.126	-0.099	-0.092	-0.238	0.155	0.237
Teaching experience							
<4 years	–	–	–	–	–	–	–
4-9 years	-0.159	-0.439	0.184	-0.104	0.436*	0.370	0.264
10 years or more	1.251	-0.756**	-0.177	-0.455	0.051	0.275	-0.231
Educational attainment							
BA degree or less	–	–	–	–	–	–	–
BA degree plus additional coursework	1.731*	-0.111	-0.279	0.180	-0.008	0.247	0.014
MA degree or above	1.218	-0.380	-0.342*	0.452	-0.210	0.409	0.088
Certification/Coursework/Preparation							
Regular certification	1.009	-0.117	-0.250	-0.540	-0.089	-0.624*	-0.279
More than 2 courses on methods of teaching math	2.558**	0.700**	0.680**	0.732**	0.677**	0.702**	0.756**
More than 2 hours of paid time preparing	-0.167	0.095	-0.263	-0.324	0.063	0.571**	0.008
More than 5 hours of unpaid time preparing	1.101	0.309*	0.210	0.461*	0.626**	0.637**	0.554**
Professional Development Activities in Current Academic Year							
Received direct instruction from outside consultant	1.044	0.359*	0.057	-0.044	0.110	0.262	0.162
Participated in 3 or more in-service training days	-0.540	0.301	0.003	0.493	0.135	0.180	0.388
Visited or observed other schools	0.949	0.034	0.150	-0.256	0.058	0.086	0.124

Appendix Table 3—Continued

	Time on Math and Math Content Scales						
Covariates	ToM	BNO	ANO	SHP	SP	PS	REL
Received release time for early childhood conferences	0.443	0.079	0.174	0.305	0.543**	0.304	0.193
Participated in workshops involving small groups	-0.314	0.296	0.277*	0.471*	0.415*	0.657**	0.335*
Participated in peer observation and feedback	-0.513	0.472**	0.408**	0.855**	0.363*	0.623**	0.556**
Participated in follow-up support for teachers trying new ideas	1.538*	0.489**	0.394**	0.004	0.499**	0.751**	0.537**
Enrolled in college or university courses	0.328	0.256	0.225	-0.178	0.363*	0.336*	0.238
Attended workshops on technology	-0.076	-0.096	0.211	0.582**	0.367*	0.375*	0.141
Constant	45.326**	9.398**	3.852**	3.440**	3.034**	4.758**	4.190**

*$p < .05$, **$p < .01$

Source: see Table 1.

Note: ToM = Time on Math; BNO = Basic Numbers & Operations; ANO = Advanced Numbers & Operations; SHP = Geometric Shapes; SP = Statistics & Probability; PS = Problem Solving; REL = Relationships.

[a] The data have been multiple-imputed. Within each imputed data set, the regressions are estimated using random intercept regression with clustering at the school level. The coefficients and significance levels reported here are based on 20 imputed data sets. See text for further discussion.

[b] Throughout the table, "–" indicates a reference category for a set of dummy variables, for which no coefficient is estimated.

Appendix Table 4. Math pedagogy regressions, kindergarten teachers, ECKS-K[a]

	Math Pedagogy Scales							
Covariates	GW	MNP	CRT	HND	TR	GMS	CLC	COL
Teaches all-day kindergarten	1.055**	0.941**	-0.339	0.483*	1.749**	0.910*	0.208	-0.340
Time spent on math (minutes per day)	0.032**	0.038**	0.012*	0.014**	0.021**	0.039**	0.005*	0.008
Geographic Location								
Region								
Northeast	–[b]	–	–	–	–	–	–	–
West	0.433	0.104	0.295	-0.725*	0.157	0.016	-0.002	0.148
South	1.243**	1.131*	1.412**	0.704*	-0.239	1.143	0.129	0.635
Midwest	-0.345	-0.157	0.195	-0.340	-0.723	0.165	0.027	0.374
Type of place								
Central city	–	–	–	–	–	–	–	–
Urban fringe	-0.536	-0.096	-0.769**	-0.056	0.604	-0.459	0.135	0.201
Small town	0.130	-0.643	-0.889**	-0.421	0.917	-1.620**	0.104	0.117
School Characteristics								
School type								
Public	–	–	–	–	–	–	–	–
Private religious	-0.581	-1.117*	-0.547	-0.558	2.307**	-0.731	-0.245	-1.520**
Private nonreligious	0.775	1.082	0.072	0.150	0.708	1.716	0.256	-1.034
% minority students	0.331*	0.145	0.112	0.084	0.546**	-0.230	-0.007	-0.006
School size								
<300	–	–	–	–	–	–	–	–
300 to 499 students	-0.431	-1.430**	0.128	-0.592*	-1.197*	-0.760	-0.269	0.070
500 to 749 students	-0.039	-1.043**	-0.085	-0.745**	-0.992	-0.418	-0.246	0.208
≥ 750 students	-0.103	-0.802	0.061	-0.466	-0.228	-0.130	-0.221	0.185
Classroom Composition (quintile coded)								
Class size	0.145	0.218	-0.002	-0.068	-0.056	0.150	0.054	0.102
% disabled	0.052	-0.156	0.073	-0.087	-0.060	-0.048	-0.041	0.020
% black	-0.143	-0.064	-0.099	-0.061	-0.085	-0.101	0.040	0.107
% Asian/Pacific Islander	-0.012	0.164*	-0.050	0.038	-0.117	0.091	-0.030	-0.043
% Hispanic	-0.035	0.082	0.014	0.036	-0.181*	0.021	-0.031	0.031
Teacher Characteristics								
Race/ethnicity								
White	–	–	–	–	–	–	–	–
Black	0.379	1.601**	1.053*	-0.303	1.863**	1.628**	0.590	0.202
Hispanic	-0.347	0.395	0.527	-0.042	0.666	0.071	0.216	-0.114
Other	-0.756	0.689	0.544	-0.173	0.769	-0.035	-0.060	0.471
Age								
<35	–	–	–	–	–	–	–	–
35-49	-0.055	0.139	0.088	-0.242	-0.027	-0.151	0.046	-0.428
50 or older	-0.760*	-0.264	-0.213	-0.288	0.157	-0.603	0.159	-0.781*

Appendix Table 4—Continued

Covariates	Math Pedagogy Scales							
	GW	MNP	CRT	HND	TR	GMS	CLC	COL
Teaching experience								
<4 years	–	–	–	–	–	–	–	–
4-9 years	0.134	-0.174	-0.118	0.013	-0.061	-0.350	0.051	-0.567*
10 years or more	0.505	0.788*	0.468	0.024	0.217	0.522	-0.115	-0.003
Educational attainment								
BA degree or less	–	–	–	–	–	–	–	–
BA degree plus additional coursework	0.716*	-0.128	0.080	0.053	-0.367	0.466	0.086	0.115
MA degree or above	0.550	0.391	0.454	0.255	-0.255	0.966*	0.381*	0.065
Certification/Coursework/Preparation								
Regular certification	-0.153	0.184	-0.034	0.268	-0.983**	-0.310	0.102	-0.030
More than 2 courses on methods of teaching math	0.419	0.854**	0.284	0.313*	0.526*	0.507	0.389**	0.396*
More than 2 hours of paid time preparing	0.425	0.147	-0.080	-0.101	-0.407	0.244	-0.244	0.426
More than 5 hours of unpaid time preparing	0.940**	0.129	0.145	0.460**	0.152	0.199	0.066	0.244
Professional Development Activities in Current Academic Year								
Received direct instruction from outside consultant	0.527	0.370	-0.044	0.153	0.172	-0.081	-0.057	0.240
Participated in 3 or more in-service training days	0.477	0.848	0.472	0.266	0.077	0.983	0.225	0.123
Visited or observed other schools	-0.050	0.314	-0.087	-0.019	0.084	0.223	-0.038	-0.333
Received release time for early childhood conferences	0.212	0.506*	0.688**	0.279	-0.074	0.815**	0.106	0.055
Participated in workshops involving small groups	0.391	0.203	0.461*	0.065	0.359	0.347	0.086	0.522*
Participated in peer observation and feedback	1.150**	0.519	0.551**	0.517**	0.196	0.885**	0.118	0.196
Participated in follow-up support for teachers trying new ideas	0.959**	1.048**	0.771**	0.398**	0.057	0.867**	0.014	0.331
Enrolled in college or university courses	0.175	0.197	0.445	0.016	-0.250	0.044	0.138	-0.284
Attended workshops on technology	0.654**	0.232	0.488*	0.176	0.608**	0.526	0.094	-0.027
Constant	0.881	5.346**	0.815	6.498**	4.170**	6.202**	-0.332	16.240**

**p* < .05, ***p* < .01

Source: see Table 1.

Note: GW = Group Work; MNP = Manipulate; CRT = Creative ; HND = HND = Hands-on; TR = Traditional Resources; GMS = Games; CLC =Calculator; and COL = Counting Out Loud.

[a] The data have been multiple-imputed. Within each imputed data set, the regressions are weighted, and are estimated using the method of generalized estimating equations with clustering at the school level. The coefficients and significance levels reported here are based on 20 imputed data sets. See text for further discussion.

[b] Throughout the table, "–" indicates a reference category for a set of dummy variables, for which no coefficient is estimated.

Appendix Table 5. Math pedagogy scale regressions, first grade teachers, ECLS-K[a]

Covariates	Math Pedagogy Scales								
	GW	MNP	CRT	HND	TR	GMS	CLC	COL	DRL
Time spent on math (minutes per day)	0.042**	0.028**	0.013**	0.020**	0.025**	0.043**	0.013**	0.031**	0.015*
Geographic Location									
Region									
Northeast	–[b]	–	–	–	–	–	–	–	–
West	-1.121**	-1.157**	-0.198	-0.1115	-1.338**	-1.234**	-0.752**	-0.035	0.441
South	-0.406	-0.507	0.107	-0.006	0.126	-1.198**	-0.159	-0.561	0.391
Midwest	-1.175**	-0.932**	-0.155	-0.374	-1.172**	-1.074**	-0.310	-0.075	-0.096
Type of place									
Central city	–	–	–	–	–	–	–	–	–
Urban fringe	-0.014	-0.340	0.188	0.062	0.749**	0.154	-0.013	0.180	0.898**
Small town	-0.107	-0.048	0.210	-0.206	1.085**	0.165	-0.424*	0.329	1.796**
School Characteristics									
School type									
Public	–	–	-	–	–	–	–	–	–
Private religious	-1.295**	-1.060**	-0.114	-0.351	2.661**	-0.100	-0.497*	-0.729	2.139**
Private nonreligious	-0.574	0.373	-0.063	-1.423*	-0.664	0.367	0.211	-3.207**	0.017
% minority students	0.192*	0.024	0.127*	-0.038	0.100	-0.070	-0.057	0.426**	0.165
School size									
<300	–	–	–	–	–	–	–	–	–
300 to 499 students	0.087	0.137	-0.018	-0.108	-0.297	0.309	0.156	0.816	-0.541
500 to 749 students	0.310	-0.070	-0.026	0.060	-0.035	0.026	-0.249	0.845	0.100
≥ 750 students	0.179	-0.093	-0.038	0.101	0.836*	-0.053	-0.532**	0.751	0.710
Classroom Composition (quintile coded)									
Class size	-0.059	-0.092	0.038	0.020	0.116	-0.076	0.079*	-0.049	-0.031
% disabled	0.041	-0.044	0.043	0.037	-0.256**	-0.035	-0.021	0.140*	-0.138*
% black	-0.035	0.064	-0.043	-0.022	0.065	0.048	-0.003	0.090	-0.021
% Asian/Pacific Islander	0.037	-0.037	0.010	-0.052	-0.129*	0.049	0.051	-0.022	-0.145*
% Hispanic	0.182**	0.192**	0.063	0.057	0.034	0.087	0.003	0.065	-0.078
Teacher Characteristics									
Race/ethnicity									
White	–	–	–	–	–	–	–	–	–
Black	0.867*	1.125**	1.101**	-0.087	1.408**	0.950*	1.009**	-0.849	1.975**
Hispanic	0.413	1.506**	0.490*	0.285	0.628	0.060	0.627**	1.104*	0.208
Other	0.893*	1.362**	0.316	0.288	1.300**	0.063	0.512**	-0.362	0.449
Age									
<35	–	–	–	–	–	–	–	–	–
35-49	0.471	-0.001	-0.057	-0.082	0.120	-0.366	-0.111	0.165	0.211

50 or older	0.557	-0.279	-0.126	-0.002	0.291	-1.095**	-0.083	-0.843*	0.029

Appendix Table 5—Continued

Covariates	Math Pedagogy Scales								
	GW	MNP	CRT	HND	TR	GMS	CLC	COL	DRL
Teaching experience									
<4 years	–	–	–	–	–	–	–	–	–
4-9 years	0.002	0.289	0.011	-0.085	0.058	0.586*	0.155	-0.569	-0.420
10 years or more	-0.597	0.402	-0.053	-0.500*	-0.077	0.520	0.223	-1.651**	-0.334
Educational attainment									
BA degree or less	–	–	–	–	–	–	–	–	–
BA degree plus additional coursework	0.062	-0.089	0.060	-0.048	-0.359	0.158	0.266*	-0.121	-0.641*
MA degree or above	0.507*	0.407	0.233	-0.006	-0.536*	0.238	0.434**	-0.174	-0.604*
Certification/Coursework/Preparation									
Regular certification	-0.336	-0.611*	0.036	-0.044	-0.542	-0.078	0.146	-0.240	-0.627
More than 2 courses on methods of teaching math	0.767**	0.789**	0.538**	0.574**	0.595**	0.864**	0.300**	0.886**	0.727**
More than 2 hours of paid time preparing	0.241	0.080	0.217	-0.056	-0.302	0.565*	0.068	0.092	-0.376
More than 5 hours of unpaid time preparing	0.679**	0.773**	0.146	0.489**	0.239	0.688*	0.243**	0.055	0.177
Professional Development Activities in Current Academic Year									
Received direct instruction from outside consultant	0.119	0.057	0.125	0.220	-0.091	-0.020	-0.001	0.407	-0.103
Participated in 3 or more in-service training days	0.043	0.387	0.263	0.256	0.223	0.088	-0.119	0.034	0.011
Visited or observed other schools	0.152	0.021	0.187	0.151	-0.102	0.173	0.075	0.540*	-0.304
Received release time for early childhood conferences	0.375	0.308	0.359**	0.075	-0.246	0.451*	0.109	0.237	-0.410
Participated in workshops involving small groups	0.907**	0.934**	0.205	0.246	0.150	0.969**	0.184	0.497*	-0.018
Participated in peer observations and feedback	0.785**	0.573**	0.281*	0.301*	0.706**	0.930**	0.176	0.446	0.275
Participated in follow-up support for teachers trying new ideas	0.877**	0.726**	0.195	0.357**	-0.309	0.842**	0.220*	0.464*	0.083
Enrolled in college or university courses	0.778**	0.319	0.155	0.041	-0.075	0.625**	0.096	0.146	-0.154
Attended workshops on technology	0.314	0.295	0.237*	0.205	0.174	0.652**	0.270**	0.243	-0.122
Constant	3.047**	5.304**	-1.387**	7.218**	10.091**	3.795**	-0.113	9.531**	11.118**

*p < .05, **p < .01

Source: see Table 1.

Note: GW = Group Work; MNP = Manipulate; CRT = Creative; HND = Hands-on; TR = Traditional Resources; GMS = Games; CLC =Calculator; COL = Counting Out Loud; and DRL = Drill.

[a] The data have been multiple-imputed. Within each imputed data set, the regressions are estimated using random intercept regression with clustering at the school level. The coefficients and significance levels reported here are based on 20 imputed data sets. See text for further discussion.

[b] Throughout the table, "–" indicates a reference category for a set of dummy variables, for which no coefficient is estimated.