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Teacher–Child Interactions and Children's Achievement Trajectories Across Kindergarten and First Grade

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This study examined the extent to which the quality of teacher–child interactions and children's achievement levels at kindergarten entry were associated with children's achievement trajectories. Rural students (n = 147) were enrolled in a longitudinal study from kindergarten through first grade. Growth trajectories (initial level and slope) were modeled with hierarchical linear modeling for 3 areas of achievement: word reading, phonological awareness, and mathematics. Cross-classified analyses examined the extent to which quality of teacher–child interactions and children's starting level predicted achievement growth rates over 2 years, and they also accounted for the changing nesting structure of the data. Results indicated that achievement at kindergarten entry predicted children's growth for all 3 outcomes. Further, first-grade teachers' strong emotional support related to greater growth in students' phonological awareness. Emotional and instructional support in first grade moderated the relationship between initial achievement and growth in word reading. Kindergarten classroom organization moderated the relationship between initial achievement and growth in mathematics. The implications of schooling for early growth trajectories are discussed.

Keywords: kindergarten, first grade, teacher–child interactions, achievement gap, cross-classified

Growth trajectories show that children who are behind early in school tend to have more difficulty catching up in later years (Jimerson, Egeland, & Teo, 1999; Juel, 1988; McClelland, Acock, & Morrison, 2006). Existing variation in achievement levels and growth trajectories is most problematic in relation to the so-called achievement gap that exists between children entering school with low versus high levels of initial performance. Findings from a national sample (Early Childhood Longitudinal Study, Kindergarten Class) point to striking variability in achievement levels upon school entrance (see http://nces.ed.gov/ECLS/ for more details about the data set). For example, some children not only can recognize letters and numbers upon the transition to kindergarten but can also sight-read words, do simple addition, and show comprehension of number sequences (West, Denton & Germino-Hausken, 2000). Other children enter school with very few, if any, of these skills. Broadly construed, the achievement gap points to large performance differences among children entering school; some children enter school with substantial academic skills and knowledge, whereas others do not.

Efforts to reduce the achievement gap between high- and low-performing students focus on schools, classrooms, and teachers. Children spend more time in classrooms than anyplace other than their homes (Hofferth & Sandberg, 2001; Rutter, Maughan, Mortimore, Ouston, & Smith, 1979). Further, the explicit statement of purpose of the No Child Left Behind Act (2002) is "to ensure that all children have a fair, equal, and significant opportunity to obtain a high-quality education." Pursuant to this goal, the No Child Left Behind Act explicitly states the importance of "closing the achievement gap between high- and low-performing children," especially "between disadvantaged children and their more advantaged peers." As a result, classrooms are an important context to examine for correlates and predictors of children's achievement as well as solutions to the achievement gap problem (Seidman, Tseng, & Weisner, 2006).

What aspects of classrooms and teachers are likely to be most important in predicting achievement? Existing research has implicated the role of both classroom and teacher factors related to student success (Chatterji, 2006; Pianta, Belsky, Vandergrift, Houts, & Morrison, 2008). In particular, such research points to the important role of classroom processes—interactions among teachers and children—as stronger predictors of child outcomes than distal factors, such as teacher education (Early et al., 2007). Despite a growing body of work on the role of classroom processes, there is virtually no research on the extent to which classroom processes contribute, year to year, toward children's achievement trajectories, especially in relation to raising the achievement levels of low-performing students (Cochran-Smith & Zeichner, 2005; Early et al., 2006; Mashburn et al., 2008). In the present study, we examined the quality of kindergarten and first-

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grade teachers' interactions with children as a set of classroom processes expected to contribute to students' developmental trajectories in early reading and mathematics skills. Additionally, we examined whether high-quality classroom experiences were more or less important for participants who entered kindergarten with different skill levels.

Theoretical Perspective

The theoretical basis for the present work draws from Bronfenbrenner's bioecological model (Bronfenbrenner & Morris, 1998, 2006). This model considers four sources of influence on children's development: process, person, context, and time. In this model, the "primary engines of development" are proximal processes (Bronfenbrenner & Morris, 1998, p. 996). These are increasingly complex, regularly occurring, reciprocal interactions between children and other people, objects, and ideas (Bronfenbrenner, 2005, p. 6). Proximal processes investigated herein refer to the reciprocal interactions between teachers and children; such interactions are hypothesized to be the primary mechanism by which children learn in classrooms.

The other three components constrain and influence the proximal processes that take place and, therefore, influence development indirectly. The *person* component of the model refers to unique attributes that children bring with them to the environment. The primary person characteristic investigated here was children's prior achievement. *Context* refers to environmental influences on proximal processes. This refers to the idea that different contexts (e.g., one classroom vs. another) influence the nature of the proximal processes taking place. Finally, *time* refers to the temporal dimension; children need to be exposed repeatedly to proximal processes over extended periods in order for them to have influence. This study followed participants from kindergarten to first grade; we observed the interactions to which children were exposed in these two different classrooms with multiple observations per year. Use of this framework to investigate teacher–child interactions may uncover the mechanisms through which teachers influence their students' development (Rutter & Maughan, 2002).

Contributors to Early Achievement

The central objective of schools is to promote academic achievement. However, there are large disparities in school readiness as a product of children's early experience and biologically based characteristics (Lee & Burkham, 2002; Rimm-Kaufman, Pianta, & Cox, 2001). Cognitive ability, attentional skills, and prior knowledge all contribute to achievement (e.g., Duncan et al., 2007). These characteristics are rooted in experiences children have prior to school entry and represent important resources or reflect specific risk processes (e.g., maternal education, poverty, poor health) in the child's life (Boyd, Grossman, Lankford, Loeb, & Wyckoff, 2005; Bradley, Corwyn, McAdoo, & Coll, 2001; Hebbeler, Spiker, Mallik, Scarborough, & Simeonsson, 2003). Competence at the start of kindergarten represents the crux of the achievement gap: Wide individual differences in children's early home learning experiences are largely responsible for later, widening differences in achievement manifesting during the school years (Bradley & Corwyn, 2002; Morrison, Bachman, & Connor, 2005). Many children come to school with limited levels of skills, abilities, and family social and economic resources; therefore, careful research is required about the extent to which schools and classrooms can compensate for disparate starting levels of achievement.

Our first goal in the present study was to examine the relation between initial achievement at kindergarten transition and subsequent achievement trajectories through the first grade. There is empirical support for three possible patterns of association. One possibility is that differences at the start of schooling widen over time (Chatterji, 2006; McClelland et al., 2006). This phenomenon, commonly called the "Matthew effect," has been robustly documented in literacy learning (Juel, 1988; McCoach, O'Connell, Reis, & Levitt, 2006, p. 15). A second alternative is that differences in achievement could remain stable after children begin schooling (McCoach et al., 2006). A third alternative is that children with low initial achievement begin closing the gap with their peers (Hamre & Pianta, 2005; Wright, Horn, & Sanders, 1997). These three possibilities rest, in part, on experiences in early schooling. Thus, it is important to consider the nature of children's classroom experiences in kindergarten and first grade.

Teacher–Child Interactions

What occurs in the classroom that can shift children's achievement trajectories in positive directions? We posited that when teachers interact with students in positive ways (whether individually, in small groups, or as a whole class), these interactions have the potential to provide children with support for their learning and may predict positive deflections in achievement trajectories (Pianta, La Paro, & Hamre, 2008). Such interactions can be classified into three domains of support: emotional, organizational, and instructional.

Emotional Support for Learning

Emotional support refers to the ways in which teachers foster positive classroom climate, minimize negative climate, attend sensitively to individual student needs, and emphasize student interests and autonomy (Birch & Ladd, 1998; Howes & Hamilton, 1992; Hyson, Copple, & Jones, 2006). Emotionally supportive classrooms have teachers who notice when students are struggling or need extra support, either academically or socially, and then respond to those needs appropriately (Hamre & Pianta, 2007). Further, emotionally supportive teachers adapt their plans as the lesson unfolds and support children's independence and expression of ideas (Battistich, Schaps, Watson, & Solomon, 1996; Bredekamp & Copple, 1997; Kern & Clemens, 2007).

In a classroom with high emotional support, students are able to take chances in their learning because of the safe environment created through the teacher's sensitive, responsive interactions (Hamre & Pianta, 2007). Perhaps for this reason, high-quality emotional support has been linked with higher achievement (Pianta, La Paro, Payne, Cox, & Bradley, 2002) and lower levels of problem behaviors (Mashburn et al., 2008). Nationally, elementary classrooms are often rated as providing medium-to-high levels of emotional support (Hamre, Pianta, Mashburn, & Downer, 2007).

Classroom Organization

Classroom organization refers to proactive management of the classroom that ensures productive use of time and materials and supports student attention and behavior. Teachers who offer high levels of classroom organization prevent classroom behavior problems through the use of proactive strategies, optimize learning opportunities, minimize wasted time, and guide children's attention to learning objectives. When misbehavior does occur, teachers show high-quality classroom organization by efficiently and effectively reestablishing order and reengaging students (Emmer & Stough, 2001). Teachers also use orienting statements about the sequence of events in the classroom and establish regular, predictable routines (Bohn, Roehrig, & Pressley, 2004). Finally, organization also includes the quality of students' classroom activities, because varied and engaging instruction helps students learn (Stipek & Byler, 2004).

Strong organizational interactions among teachers and students have been linked to children's engagement (Rimm-Kaufman, Curby, Grimm, Nathanson, & Brock, 2009), which in turn relates to higher academic achievement (Brophy & Good, 1986; Ponitz, Rimm-Kaufman, Grimm, & Curby, 2009). Further, when teachers spend more time orienting and organizing their classrooms early in the school year, students spend less time engaging in unproductive transitions during the rest of the year (Cameron, Connor, & Morrison, 2005). Worth noting, on average, elementary classrooms in the United States are often found to have medium-to-high levels of classroom organization (Hamre et al., 2007).

Instructional Support for Learning

Instructional support involves teachers' encouragement of higher order thinking as students learn new concepts, provision of constructive and specific feedback, and stimulation of children's use of language. Teachers who offer high-quality instructional support make connections to the real world and focus less on having their students learn a set of facts and more on helping students learn the facts as part of larger themes and concepts (Battistich et al., 1996; Bredekamp & Copple, 1997; Committee on Learning Research and Educational Practice, National Research Council, 1999). Another component of high-quality instruction, quality of feedback, occurs when teachers focus on expanding learning and understanding instead of simply indicating whether an answer was correct (Franke, Kazemi, & Battey, 2007). Teachers who provide high levels of instructional support also use appropriate language modeling during frequent conversations with children.

Higher quality instructional support measured in these ways has been linked to higher scores on standardized tests of mathematics and reading achievement in prekindergarten (Curby et al., 2009; Mashburn et al., 2008) as well as teacher-reported achievement in kindergarten (Pianta et al., 2002) and first grade (Hamre & Pianta, 2005). Higher levels of instructional support have also been linked to more observed on-task behavior (Pianta et al., 2002). However, although relatively high levels of emotional support and classroom organization occur in American classrooms, the typical American classroom provides low levels of instructional support (Hamre et al., 2007).

Various approaches exist in the assessment of classroom characteristics, including teacher report (e.g., Wachs, Gurkas, & Kontos, 2004), student report (e.g., Brody, Dorsey, Forehand, & Armistead, 2002), and, most germane to the present study, observational methods (e.g., Burchinal et al., 2008; Mashburn et al., 2008; National Institute of Child Health and Human Development Early Child Care Research Network [NICHD ECCRN], 2002). Among observational methods, there are both high- and low-inference measures. For example, within the NICHD Study of Early Child Care and Youth Development, multiple methods were used to assess the positive climate of the classroom (more information is available at https://secc.rti.org/). One method used a Likert scale to rate the positive emotional climate over a 10-min period (high inference). The other method used the number of times the teacher displayed positive affect in another 10-min period (low inference). Although there are advantages to each method, high-inference methods have the advantage of being able to take multiple indicators into account at the same time (Pianta et al., 2008) and, in this way, they may be more representative of children's experience. Perhaps for these reasons, there has been a growing interest in the use of higher inference classroom observation measures (e.g., Howes et al., 2008; Mashburn et al., 2008; Pianta et al., 2002). Because of this, we have used a high-inference observational measure to assess the nature of teacher–child interactions in early childhood classrooms. To further strengthen our ability to tap into students' experience in the present study, we used repeated observations over the course of each school year to achieve a clear picture of what kindergarten and first-grade children were experiencing.

Potential Moderating Effects of Teacher–Child Interactions

Thus far, we have emphasized classrooms as potentially positive contributors to children's achievement in a main effect framework. However, evidence indicates that particular teacher practices are not equally effective for all children (Connor, Morrison, & Katch, 2004). The most extensive literature in this vein focuses on literacy learning (Foorman, Francis, Fletcher, Schatschneider, & Mehta, 1998). Connor, Morrison, and Underwood (2007) found that children's growth in letter–word reading depended both upon their starting level and the type of instruction they received. Children with lower skills benefited more in classrooms where instruction focused on the basic building blocks of reading.

Maternal education (Hamre & Pianta, 2005), cognitive ability (National Institute of Child Health and Human Development Early Child Care Research Network & Duncan, 2003), and instructional contexts (Downer, Rimm-Kaufman, & Pianta, 2007) have been explored as moderators of the relation between teacher–child interaction quality and student outcomes. Studies have examined whether teacher–child interactions serve a protective role for children with limited skills because the interactions compensate for early experiences not present in the child's home life (Luthar, Cicchetti, & Becker, 2000). Yet, to our knowledge, no researchers have examined the potential moderating role of interactional quality on starting level to predict children's achievement trajectories over multiple years. In the present study, we sought to replicate and extend this work by examining whether the quality of teacher–child interactions moderates the relation between prior achievement and children's academic growth over 2 years.

Research Questions

The present study examined whether quality in teacher–child interactions differentially predicted children's academic trajectories over kindergarten and first grade on the basis of children's initial achievement. Four research questions and associated hypotheses were posed. First, is there child-level variability in the level of achievement at the beginning of kindergarten and in the rates of achievement growth? On the basis of the literature documenting individual differences in the achievement of American children (West et al., 2000), we expected significant variability in both level and growth rate in the three areas of achievement (word reading, sound awareness, and mathematics).

Second, do children's starting achievement levels predict children's growth rates? We expected that children who had higher levels of achievement at the beginning of kindergarten would grow at faster rates (i.e., we expected a Matthew effect).

Third, does quality of kindergarten and first-grade teacher–child interactions predict children's growth rates? We hypothesized that interactions with high-quality emotional, organizational, and instructional support would predict improved growth rates. Also, we expected that teacher–child interactions would be more predictive of literacy skills than math skills, because literacy instruction predominates in the early years of school.

Fourth, does the quality of kindergarten and first-grade teacher–child interactions moderate the association between children's academic starting level and growth rate? We expected, in line with work on the compensatory role of early schooling for disadvantaged children, that high-quality interactions would be more beneficial for children entering kindergarten with low levels of achievement than for children entering kindergarten with high levels of achievement.

Method

Participants

Data for the present inquiry were collected as part of a larger study examining the relative contributions of classroom supports and children's self-regulation over the kindergarten–first-grade transition. Children were recruited from seven schools in four rural districts serving a large number of poor and working-class families. During kindergarten registrations and open houses, parents were invited to enroll their children in the study. After agreeing and signing consent forms, parents completed a questionnaire that provided sociodemographic information on the family and child. The parents of 333 kindergarteners consented, and 4–7 children were selected from each classroom to participate in the study. The resulting kindergarten sample contained 171 children. These children were followed through first grade.

At kindergarten entry, children's mean age was 5.4 years (range 4.7–6.3 years). There were 79 female and 92 male children, 143 Caucasians, 23 African Americans, and 5 of other ethnicity. Family income was reported within \$15,000 ranges; the modal family income fell between \$15,000 and \$29,000 (39 families) but varied from less than \$15,000 (19 families) to more than \$100,000 (10 families). Most mothers and fathers (101 mothers, 92 fathers) had indicated high school as their highest level of education. The final sample included 147 children who had achievement data available over both years of the study. These 147 children were not statistically different from the original sample in gender, prekindergarten experience at age 4, maternal education (high school education vs. more than high school education), or family income (less than \$30,000 per year vs. more than \$30,000 per year).

The 147 child participants were enrolled in 36 kindergarten classrooms. Kindergarten teachers averaged 18.1 years of teaching experience (range 1–37 years). Most of the kindergarten teachers ($n = 31$) had full certification and licensure; all of them had at least a bachelor's degree, and 11 held a master's degree. Of the kindergarten teachers, 35 were Caucasian and 1 was Hispanic; all were female. The 147 children had 37 different first-grade teachers. The first-grade teachers averaged 14.3 years of teaching experience (range 2–30 years). Almost all of the first-grade teachers ($n = 35$) had full certification and licensure; all of them had at least a bachelor's degree, and 4 also held a master's degree. Of the first-grade teachers, 35 were Caucasian and 2 were African American; one teacher was male.

Procedure

Data were gathered from three sources: parents (see above), children, and classroom observations. At the start of kindergarten, trained research assistants went to each school and administered achievement tests to all child participants. Researchers returned in the spring of kindergarten and the fall and spring of first grade to readminister the alternating forms of the achievement tests.

Research assistants blind to the purpose of the study conducted classroom observations throughout children's kindergarten and first-grade years. Each year was divided into three observation windows (fall: October–December; winter: January–March; spring: March–May). Each teacher was observed at least once during each observation window for a total of three to five times. The most common schedule was to have two cycles of observation on 1 day in the fall, another two cycles of observation in the winter, and then a final cycle of observation in the spring. In total, this amounted to 300–375 min of observation for each teacher.

Measures

Teacher–child interaction quality. The Classroom Assessment Scoring System (CLASS; Pianta, La Paro, & Hamre, 2004, 2008) measures the quality of interactions that teachers have with children. Ten observable dimensions of quality are scored on a 7-point Likert scale from 1 (*low*) to 7 (*high*). These 10 dimensions comprise three superordinate domains: emotional support, classroom organization, and instructional support.

Emotional support includes four dimensions. Positive climate measures the degree to which there is evidence for positive relationships between teachers and students (e.g., smiling, laughter, a general tone of respect in the classroom). Negative climate (reversed for analysis) captures teachers' negative affect (e.g., irritability, harsh tone) and the use of punitive control (e.g., yelling, threats, physical punishment). Teacher sensitivity primarily measures teachers' awareness of individual student needs and response to those needs. Regard for student perspectives encompasses teachers' flexibility and student focus (e.g., following students' lead in a discussion), support for children's autonomy (e.g., providing a choice among activities), and encouragement of students' expression. Across these four dimensions, internal consistency was strong across each year of the study (kindergarten, $\alpha = .93$; first grade, $\alpha = .87$).

Classroom organization includes three dimensions. Behavior management primarily focuses on teachers' use of proactive measures to avoid behavior problems (e.g., clear expectations) and the efficient redirection of misbehavior when it does occur. Productivity captures the degree to which teachers maximize learning time by providing activities for students to engage in (including when they are finished with one activity) and having brief transitions between activities. Instructional learning formats captures the degree to which teachers effectively involve students in classroom activities and use a variety of instructional modalities to maximize student interest. High internal consistency was evident across these three dimensions (kindergarten, $\alpha = .87$; first grade, $\alpha = .86$).

Instructional support comprises three dimensions. Concept development indicates the degree to which teachers push for more conceptual instead of rote understanding of the material by providing opportunities for students to analyze, reason, create, and integrate knowledge. Quality of feedback encompasses teachers' ability to promote student understanding primarily through the use of scaffolding and feedback loops (i.e., teacher–child interactions when teachers and children are responding to each other). Language modeling measures how much teachers promote conversation in the class and elaborate on students' language with more advanced language. Across these three dimensions, there was high internal consistency each year (kindergarten, $\alpha = .94$; first grade, $\alpha = .93$).

To create variables for analyses, we computed average scores for each teacher in each domain (emotional support, classroom organization, and instructional support) from the multiple ratings obtained at each observation time point (Pianta, La Paro, & Hamre, 2004, 2008). Thus, each teacher had a score with possible range from 1 to 7 for each domain. This score represented the average teacher–child interaction quality within each domain provided in that classroom.

The framework we used to evaluate interrater reliability is based on the CLASS authors' recommendations. Observers went through an intensive training program that involved 2 days of training and culminated in a test of reliability. In order for raters to be deemed reliable, 80% of codes (both within and between dimensions) must be within one scale point of agreement for a gold standard rating across five 20-min video segments of elementary classrooms. All raters met or exceeded this level of reliability. We took two additional steps to ensure that reliability was maintained throughout the study. First, weekly discussions were held to discuss any coding difficulties. The focus of these meetings was to have coders agree on ratings for ambiguous coding situations and to link their rationale to the CLASS coding manual. Second, we conducted drift tests at three points during the study using a similar procedure that had been used to establish reliability during the CLASS training. Again, coders met or exceeded the 80% reliability standard.

The CLASS originated in the NICHD Study of Early Child Care and Youth Development (as the Classroom Observation System) and has been used in several large-scale studies to measure the quality of teacher–child interactions in thousands of classrooms (e.g., NCEDL Multi-State and SWEEP studies; see also http://www.fpg.unc.edu/~ncedl/). The three-factor model has been validated by comparing the fit of one-, two-, and three-factor models with confirmatory factor analysis (Hamre et al., 2007). Of these, the three-factor model provided the best fit. These domains have been differentially related to children's development across several studies, with emotional support being related to social outcomes, classroom organization being related to some social outcomes and some achievement outcomes, and instructional support being related most strongly to children's academic outcomes (e.g., Howes et al., 2008; Mashburn et al., 2008; Pianta et al., 2002).

Academic achievement. Growth in children's academic achievement was measured with the Woodcock–Johnson III Tests of Achievement (WJ III; Woodcock, McGrew, & Mather, 2001). Three subtests were individually administered in the fall and spring of kindergarten and first grade. Letter–Word Identification was used to measure children's word reading achievement. Sound Awareness was used as a measure of phonological awareness. The other subtest, Applied Problems, was used to measure mathematical skills. The WJ III was chosen to tap aspects of children's early reading and mathematics ability that undergo significant development in the early years of formal schooling. The selected subtests of the WJ III correspond to the skills that are targeted in kindergarten and first-grade instruction: letter–word identification, sound awareness skills, and the ability to solve mathematical problems. The WJ III offers two alternate forms that were used for fall and spring testing.

At each time point, a *W*-score was created for each outcome. *W*-scores are transformations of the Rasch ability scores (McGrew & Woodcock, 2001). These scores take into account children's age at the time of the assessment and are vertically equated so they can be compared over time. The *W*-score for each subtest is centered on a mean of 500, which is the expected score for a 10-year-old North American child (Mather & Jaffe, 2002).

Data Analysis

Descriptive statistics were run, then analyses were pursued that examined preliminary associations among children's achievement variables, classroom membership, and classroom outcomes. We then used HLM 6.0 software (Raudenbush, Bryk, Cheong, & Congdon, 2004) to model growth trajectories with achievement measures nested with children and specified cross-classified hierarchical models with children nested within classrooms.

Variability in starting points and growth rates. The first research question examined variability in children's achievement growth during kindergarten and first grade. To address this question, we constructed a linear growth model for each outcome (Letter–Word Identification, Sound Awareness, and Applied Problems). Each model was specified as a two-level model with four achievement time points nested within each child (see the Appendix). We verified the simple structure of the data to be linear growth (vs. quadratic) by comparing model fit statistics. Each baseline linear model included random effects for both an initial starting level and a linear slope in achievement for each child. Statistical significance of the intercept and slope indicated child-level variability, such that there were individual differences in children's initial values as well as individual differences in children's growth trajectories. Empirical Bayesian estimates of the intercept and slope for each child were obtained with the HLM software and were treated as new child-level variables. The slope coefficient for each achievement test was used as the outcome, and the initial starting level was used as a predictor in further analyses.

Child and classroom predictors of growth rates. The remaining research questions used child achievement initial levels and classroom interaction quality to predict achievement growth (the slope variable). Because children changed classroom membership from kindergarten to first grade, traditional hierarchical linear models could not be used with classroom-level predictors. Thus, a series of cross-classified random effects models (Raudenbush & Bryk, 2002) were used. This modeling feature, known as HCM2, is available in the HLM 6.0 program (Raudenbush et al., 2004). HCM2 is able to account for this data structure by allowing children to be classified as having one kindergarten teacher and having a separate classification with a different first-grade teacher. A cross-classified model functions similarly to HLM, except that it models Level 1 nested within two different Level 2 structures simultaneously. However, there is an important limitation of HCM2; it cannot yet account for a three-level model (measurements within child within two different classrooms). Therefore, slopes from the previous HLM analyses were used as the outcomes, such that Level 1 included child characteristics and Level 2 included predictors and random effects for kindergarten and first grade. Despite the fact that the kindergarten and first-grade teachers are not fully crossed, the model can still accommodate these data (Raudenbush & Bryk). In fact, Connor et al. (2007) used crossed classified models with 86 students nested within 40 first-grade and 33 second-grade classrooms. Our sample showed no model convergence problems that tend to occur when the sample size is too small.

The first cross-classified model specified was the unconditional model. This unconditional model is represented by the following equations:

$$\text{Level 1: } Y_{ijk} = \pi_{0jk} + e_{ijk} \quad (1)$$

$$\text{Level 2: } \pi_{0jk} = \theta_0 + b_{00j} + c_{00k} \quad (2)$$

Equation 1 states that the expected slope of child i who is in kindergarten classroom j and first-grade classroom k (Y_{ijk}) is equal to an average slope (π_{0jk}) plus an individual error associated with that particular child (e_{ijk}). Equation 2 states that the Level 1 average slope (π_{0jk}) is equal to a grand mean slope (θ_0) plus a random effect for kindergarten classroom j (b_{00j}) plus a random effect for first-grade classroom k (c_{00k}).

After these unconditional models were created, parsimonious final models were constructed for each achievement outcome, consistent with recommended practice for saving degrees of freedom in these complex models (Raudenbush & Bryk, 2002). In parsimonious model specification, a model is built in several iterations. Each predictor is added to the model separately. If a predictor is significant, it stays in the model. If it is not significant, it is removed. Thus, our final models include only those predictors that were significant. Main effects were entered first (e.g., kindergarten emotional support). After all main effects had been tested, each interaction was tested (e.g., Kindergarten Emotional Support × Initial Achievement). In other words, the final model included only significant predictors, which varied depending on the outcome. As a predictor of the slope, initial achievement was entered at Level 1. Other child factors (gender, maternal education) were entered but were never significant with initial achievement in the model. Then, main effects for classroom quality (emotional support, classroom organization, and instructional support) were entered separately for both kindergarten and first grade at Level 2. Finally, we examined whether kindergarten and first-grade classroom quality interacted with initial achievement to predict the slope. Next are the equations for the final model of the Applied Problems, in which kindergarten classroom organization moderates the relation between initial Applied Problems scores and the slope. Final cross-classified models for Letter–Word Identification and Sound Awareness are provided in the Appendix.

$$\text{Level 1: } Y_{ijk} = \pi_{0jk} + \pi_1 \text{ (initial)} + e_{ijk} \quad (3)$$

$$\text{Level 2: } \pi_{0jk} = \theta_0 + b_{00j} + c_{00k} \quad (4)$$

and

$$\pi_1 = \theta_1 + \gamma_{11} \text{ (K organization)} \quad (5)$$

The main distinction from the unconditional model equations is in the addition of Equation 5. In this equation, the estimate for the contribution of initial achievement to the slope, π_1, is shown to have a main effect and a moderated effect. As Equation 5 shows, there is a main effect for initial achievement, θ_1, and the effect of initial achievement varies as a function of kindergarten classroom organization, γ_{11}.

Results

A preliminary analysis of variance revealed significant differences in initial achievement according to kindergarten classroom membership for Letter–Word Identification, $F(35, 111) = 1.64$, $p < .03$; Sound Awareness, $F(35, 111) = 1.68$, $p = .02$; and Applied Problems, $F(35, 111) = 3.00$, $p < .001$. These differences suggested some mechanism of tracking children into classrooms. However, when children's achievement starting level was correlated with aspects of kindergarten teachers' quality, only two statistically significant and positive correlations emerged (out of a possible nine correlations). These were between the starting levels of Letter–Word Identification ($r = .19$, $p < .02$) and Sound Awareness ($r = .20$, $p < .02$) with kindergarten classroom organization.

Descriptive statistics for the predictors and outcomes are presented in Table 1. The average estimated initial scores were 358.36 for Letter–Word Identification, 457.70 for Sound Awareness, and 425.69 for Applied Problems, and there was an average monthly growth rate of 5.21, 1.69, and 1.90 points per month, respectively. On the CLASS 7-point scale (with 1, 2 = *low*; 3, 4, 5 = *moderate*; and 6, 7 = *high quality*), kindergarten and first-grade classrooms typically provided moderate levels of emotional support and classroom organization but low levels of instructional support. One noticeable difference was that instructional support was significantly higher in kindergarten (M = 3.00) than in first grade (M = 2.36), $t(71) = 3.80$, $p < .001$). This

Table 1
Descriptive Statistics for Predictors and Outcomes

Statistic	*M*	*SD*	Range
Letter–Word Identification, initial	358.36	16.38	321.33–418.49
Letter–Word Identification, slope	5.21	0.28	4.67–5.91
Sound Awareness, initial	457.70	9.74	435.38–479.93
Sound Awareness, slope	1.69	0.14	1.23–2.10
Applied Problems, initial	425.69	12.88	386.79–456.77
Applied Problems, slope	1.90	0.19	1.47–2.61
Kindergarten			
Emotional support	4.77	0.94	1.92–6.25
Classroom organization	4.23	1.03	1.97–5.94
Instructional support	3.00	0.84	1.60–5.13
First grade			
Emotional support	4.94	0.56	3.54–5.96
Classroom organization	4.27	0.79	2.70–5.81
Instructional support	2.36	0.58	1.60–4.59

indicates that kindergarten teachers' emotional support and classroom organization were not statistically different from those of first-grade teachers but that kindergarten teachers had higher levels of instructional support. Additionally, the standard deviations tended to be smaller across first grade than kindergarten, although these differences were statistically significant only for emotional support, Levene's $F(1, 71) = 8.16$, $p < .01$. This result indicates there was more variability in the quality of teachers' emotionally supportive interactions during kindergarten than first grade.

Child-Level Variability in Achievement Growth

Growth curves were first modeled for each achievement outcome, with the four measurements of achievement nested within each child. Results are presented for all three outcomes in Table 2. Random intercept and slope coefficients were significant for all three outcomes, and this indicated that children varied in their starting points and their growth rates over kindergarten and first grade. On the basis of these models, for Letter–Word Identification, children entered kindergarten scoring on average 358.36 *W*-score points and grew at an average rate of 5.21 *W*-score points per month. Likewise, for Sound Awareness, children's mean initial score was 457.70 *W*-score points, and children grew at 1.69 *W*-score points per month. For Applied Problems, children, on average, scored 425.69 *W*-score points at kindergarten entry and grew at a rate of 1.90 *W*-score points per month.

The variability in children's initial achievement and growth was rather large from a practical standpoint (see Table 1). For example, for Letter–Word Identification, the standard deviation was 16.38 *W*-score points. Given that the average child improved by 5.21 *W*-score points per month, two children whose scores differed by one standard deviation were approximately 3 months apart in skill level. Along the same lines, children one standard deviation apart on Sound Awareness and Applied Problems were over 5 months and 6 months apart in skills, respectively.

Children's Starting Level Predicting Growth Rate

The slope values from the growth curves for each child were used as the outcomes in all subsequent analyses. For all three outcomes, children's starting achievement levels were significant predictors of individual growth rates. In other words, the skills with which children entered kindergarten predicted how quickly children improved. Surprisingly, the associations were not all in the same direction. For Letter–Word Identification, starting level was positively associated with children's growth, so that children at a higher starting level showed more growth; this was consistent with our hypothesis. For Sound Awareness and Applied Problems, however, the relation was in the opposite direction. The coefficient for the initial score was statistically significant and negative for both Sound Awareness (−.007) and Applied Problems (−.01). This indicated that children who started higher grew at a slightly slower rate.

The magnitude of these associations can be assessed relative to the growth rates. If we use Letter–Word Identification as an example, by multiplying the standard deviation (16.38) by the initial score coefficient (.01), we can determine that a child one standard deviation below the mean grew at a rate of 0.16 *W*-score units per month slower, relative to the growth rate for children with mean starting values (5.21). In other words, the modeled difference between two children starting 16.38 points apart in kindergarten was 19.26 points apart by the end of first grade. Based solely on differences in growth due to initial scores, the child starting behind initially would be approximately 2 weeks further behind at the end of first grade.

The estimates for Sound Awareness and Applied Problems outcomes were in the other direction. If we use the same method, for Sound Awareness, children starting one standard deviation below the mean gained on the average-scoring child by almost 3 weeks. But it is important to keep in mind that, given initial differences, these students would still be about 5 months apart at the end of first grade. For Applied Problems, children starting one standard deviation below the mean gained on the average-scoring child by about a week but were still over 6 months behind at the end of first grade.

Teacher–Child Interactions and Children's Growth Rate

To assess the third research question, all models tested for main effects of kindergarten and first-grade teacher–child interactions on children's growth rates. However, only one significant main effect for teacher–child interactions emerged. There was a positive relation between first-grade emotional support and Sound Awareness growth (see Table 3). For every 1-point increase in emotional support, children's rate of growth increased by 2.4% (coefficient for emotional support [.04] divided by the growth rate [1.69]). It is worth estimating the typical cumulative gains associated with a 1-point increase in

Table 2
Children's Achievement Growth Over Kindergarten and First Grade

	Letter–Word Identification			Sound Awareness			Applied Problems		
Statistic	Coefficient	*df*	*t* ratio	Coefficient	*df*	*t* ratio	Coefficient	*df*	*t* ratio
Fixed effect									
Intercept	358.36	146	195.31***	457.70	146	466.51***	425.69	146	328.52***
Slope	5.21	146	50.92***	1.69	146	36.73***	1.90	146	31.44***
	Variance	*df*	χ^2	Variance	*df*	χ^2	Variance	*df*	χ^2
Random effects									
Intercept	326.85	146	432.89***	110.03	146	656.94***	192.34	146	663.90***
Slope	0.28	146	176.49*	0.08	146	190.14**	0.13	146	189.79**
Level 1 effects, *r*	226.52			41.89			73.32		

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 3
Predictors of Children's Sound Awareness Growth

Predictor	Sound Awareness slope Coefficient	*df*	*t* ratio
Fixed effects			
Average slope (intercept)	1.69	144	157.92***
Initial score on test	−0.007	144	−5.99*
First-grade emotional support	0.04	144	2.17*
	Variance	*df*	χ^2
Random effects			
Kindergarten (row)	<.001	34	42.62
First grade (column)	<.001	35	26.51
Level 1	.017		

Note. The intercept in this cross-classified model is actually a slope representing gains in *W*-score points per month.
* $p < .05$. *** $p < .001$.

emotional support over the course of a school year; an additional 0.04 *W*-score units per month equals a difference of 0.32 *W*-score units at the end of the academic year. Consideration of this 0.32 difference in light of the growth rate of 1.69 indicates that every 1-point difference of emotional support was associated with about a 1-week difference in phonological skills by the end of the year.

Moderating Effects of Teacher–Child Interactions on Children's Starting Level and Growth Rate

Teacher–child interactions moderated the relation between initial achievement and growth both for Letter–Word Identification and for Applied Problems. For Letter–Word Identification, two significant interactions were identified (see Table 4). First-grade instructional support and first-grade emotional support each interacted with children's initial achievement level. Figure 1 shows that for first-grade instructional support, children with lower initial Letter–Word Identification scores benefited the most from higher quality instructional support but that children with higher initial scores benefited the most from lower quality instructional support. Figure 2 shows that for first-grade emotional support, children with higher initial Letter–Word Identification scores scored higher in classrooms with higher quality emotional support but that children with lower initial scores scored higher in classrooms with lower quality emotional support.

Table 5 presents results for Applied Problems. There was one significant interaction between the initial score and kindergarten classroom organization (see Figure 3). Children with lower initial Applied Problems scores grew at a faster rate in classrooms with higher quality classroom organization. Conversely, children with higher initial scores grew the fastest in classrooms with lower quality classroom organization.

The magnitude of effects on children's growth rates for all statistically significant interactions was small. In general, the effect sizes of the interactions are eclipsed by the differences between the low versus high initial ability (±1 *SD*). For example, for Letter–Word Identification, the difference between these higher and lower scoring groups was about 33 *W*-score points and the difference between the growth rates between children receiving high or low instructional quality (±1 *SD*) was about 0.1 *W*-score points per month. Thus, the accumulated benefit over an entire

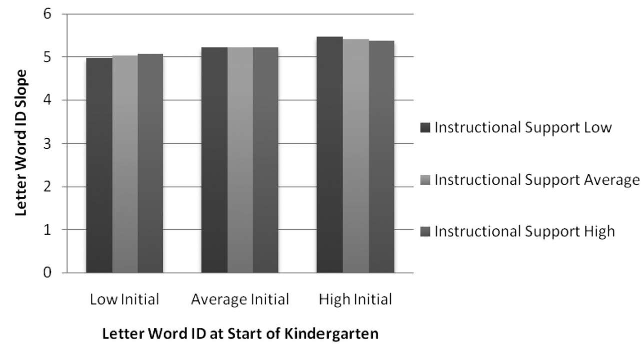

Figure 1. Moderating effects of first-grade instructional support. Low = −1 *SD*; High = +1 *SD*.

Table 4
Predictors of Children's Letter–Word Identification Growth

Predictor	Letter–Word Identification slope Coefficient	*df*	*t* ratio
Fixed effects			
Average slope (intercept)	5.22	143	270.68***
Initial score on test	0.01	143	10.79***
Initial Score × First-Grade Emotional Support	0.006	143	2.95**
Initial Score × First-Grade Instructional Support	−0.005	143	−2.01*
	Variance	*df*	χ^2
Random effects			
Kindergarten (row)	<.001	35	38.78
First grade (column)	.002	36	46.12
Level 1	.038		

Note. The intercept in this cross-classified model is actually a slope representing gains in *W*-score points per month.
* $p < .05$. ** $p < .01$. *** $p < .001$.

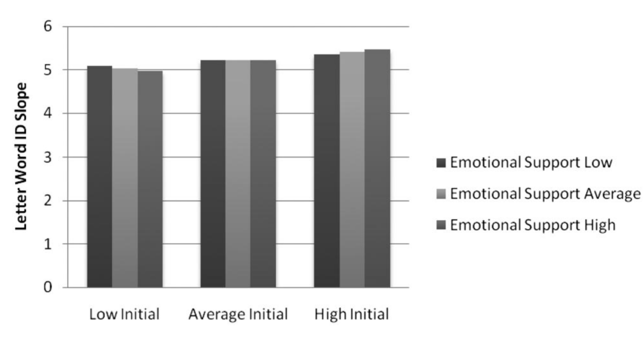

Figure 2. Moderating effects of first-grade emotional support. Low = −1 *SD*; High = +1 *SD*.

Table 5
Predictors of Children's Applied Problems Growth

Predictor	Applied Problems slope Coefficient	*df*	*t* ratio
Fixed effects			
Average slope (intercept)	1.90	144	141.86***
Initial score on test	−0.01	144	−11.87***
Initial Score × Kindergarten Classroom Organization	−0.003	144	−2.89**
	Variance	*df*	χ^2
Random effects			
Kindergarten (row)	<.001	35	43.78
First grade (column)	.002	36	49.58
Level 1	.016		

Note. The intercept in this cross-classified model is actually a slope representing gains in *W*-score points per month.
** $p < .01$. *** $p < .001$.

school year (8 months) was an additional gain of less than 1 *W*-score point.

Discussion

We examined the extent to which classroom processes contributed to children's trajectories in three different achievement outcomes over kindergarten and first-grade year. Four findings emerged: (a) Children's initial levels and growth rate varied significantly in word reading, phonological awareness, and mathematics over kindergarten and first grade; (b) achievement at kindergarten entry strongly predicted children's rate of growth; (c) first-grade teachers' emotional supportiveness contributed to growth in phonological awareness; and (d) the contribution of interaction quality to the development of word reading and mathematics depended partially on children's prior skill level.

Variability in Children's Initial Achievement and Growth

For all three achievement outcomes tested, children varied in starting level of achievement and in their rate of growth during the kindergarten and first-grade years. There were large, practically important differences in children's initial achievement; a child initially scoring below average (−1 *SD*) appeared 3–6 months behind, compared to a child initially scoring at the average. Also, children exhibited notable disparities in their growth trajectories over the first 2 years of school. If differences in initial achievement were controlled for, differences in growth rates alone could lead to children being several weeks apart in their learning by the end of first grade. Projecting forward, these differences in growth could be quite consequential for children's later schooling.

The initial differences among children, combined with their different rates of growth, mean that kindergarten and first-grade teachers are faced with the challenge of tailoring instruction to the learning needs of a number of students who may be a year or more apart in their academic skills. The diversity in initial levels of achievement combined with variability in growth during the early years speaks to the challenge of meeting some of the primary objectives established in the No Child Left Behind Act, including closing the achievement gap between disadvantaged children and their privileged counterparts and providing all students with high-quality instruction.

Achievement at Kindergarten Entry

Children's achievement at kindergarten entry predicted children's growth rates, although the nature of the relation (positive or negative) varied by domain. Consistent with the Matthew effect hypothesis, for word reading, participants who started higher grew faster, whereas those who started lower grew more slowly. That is, children's scores became more divergent those of other children over time. In contrast, for phonological awareness and mathematics, students who started higher grew more slowly and those who started lower grew faster. In other words, for these achievement domains, children's scores converged somewhat over time.

These varying associations are likely due to the skills themselves and to classroom affordances for developing those skills. Letter–Word Identification tests children's early word reading abilities, which are a central focus in the early years of school. Because of the many reading opportunities in a classroom, children who enter school with some reading proficiency may be better able to improve their skills than are those who cannot read. In contrast, Sound Awareness tests phonological knowledge, a foundational set of skills that underlie reading. Teachers may focus more of their efforts on children who lack basic phonological skills, whereas average- and higher achieving children may not receive as much attention. Similar processes could be operating that would explain our results for Applied Problems, a measure of mathematical ability. For example, a teacher may spend more time with children who do not know their numbers than with students who are proficient in this area. As a result, higher achieving children may not improve as quickly.

The Contribution of Emotional Support to Early Phonological Skills

The quality of emotional support offered by first-grade teachers was associated with faster rates of growth phonological awareness, regardless of children's achievement at kindergarten entry. That is, higher levels of quality of first-grade emotional support were associated with higher rates of growth in Sound Awareness. Sur-

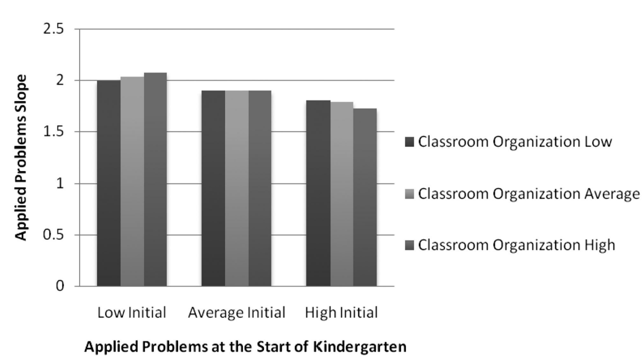

Figure 3. Moderating effects of kindergarten classroom organization. Low = −1 *SD*; High = +1 *SD*.

prisingly, this was the only main effect found for emotional support, classroom organization, or instructional support across all three achievement domains.

Associations between emotional support and children's achievement have been documented previously (Pianta et al., 2002, 2008). One explanation has to do with children's connectedness to school. Teachers who offer more emotional support are warm and responsive, and they foster relationships with students that would facilitate children's connectedness to school. Such relational closeness and school connectedness foster an environment conducive to learning (Baker, 2006; Birch & Ladd, 1998). An alternative explanation has to do with the phonological skills measured by the Sound Awareness subtest, which represents a complex set of related microskills shown to be receptive to direct instruction (Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001; Runge & Watkins, 2006). In particular, the Sound Awareness test taps a child's ability to substitute sounds for one another (e.g., substituting the /b/ sound in *bow* with /sl/ to make the word *slow*). To help students learn such specific skills, teachers must attend to individual children's knowledge of the sounds that comprise words. Teachers who are sensitive will notice that a child is having difficulty, determine the reason for the difficulty, and respond appropriately (Connor, Son, Hindman, & Morrison, 2005).

Effective Supports for Children's Development Depended on Their Initial Achievement

The present study indicates that development in the early years of school depends in part on children's initial skill level. Some findings were counterintuitive and were specific to some domains of classroom quality but not others. For word reading, children who entered kindergarten with lower scores had greater growth in classrooms with better first-grade instructional interactions but lower levels of emotional support. For mathematics, lower achieving children had greater growth in classrooms with better kindergarten classroom organization. The most likely explanation for this pattern is that the prediction of multiyear trajectories differs from prediction of within-year trajectories. Multiyear trajectories represent children's cumulative experience and thus may be more difficult to deflect.

Skills related to Letter–Word Identification were particularly sensitive to children's starting level (Connor, Morrison, & Petrella, 2004). Letter–Word Identification largely captures word reading abilities or orthographic knowledge (Rayner et al., 2001). In the present analyses, both first-grade emotional and instructional support were significant moderators of the relationship between children's initial levels of ability and growth. For word reading, students who had more to gain (those with low initial achievement) benefited the most from high-quality instruction. Surprisingly, participants with higher initial achievement benefited more from lower quality instruction. We suggest that, given that the mean of instructional support was so low, even in the higher quality classes, the small relative increase in concept development or language modeling may still have targeted the lower achieving students. In other words, relatively higher quality teachers in this sample were still not having high-quality instructional interactions (in absolute scores as measured by the CLASS). Thus, these counterintuitive findings could be a result that lacks generalizability. It is not clear whether the association between higher initial achievement level and lower quality instruction would prevail in a group of classrooms with higher levels of instructional support. This is an issue worthy of further inquiry.

Analyses also revealed that children with higher initial word reading scores showed greater gains in word identification in classrooms with higher levels of emotional support. In contrast, children with lower initial word reading showed greater gains in classrooms with lower levels of emotional support. The present findings are consistent with other work linking emotional support with student achievement. For example, Connor et al. (2005) found that students who had more warm and responsive teachers had better vocabulary and word-decoding skills. The present finding extends earlier work suggesting that emotional support may be even more important for children with higher, rather than lower, levels of initial ability. One explanation for this finding is that in classrooms with higher levels of emotional support, teachers tend to follow children's leads rather than adhere rigidly to their own plans and ignore student input. If the teacher is following the lead of high-achieving children, this may not benefit the lower achieving children. For example, if during a whole class activity a higher achieving child asks the teacher about the meaning of an advanced word that the lower achieving child does not recognize, students with lower ability will be unlikely to benefit from the answer.

In terms of mathematics achievement, children with lower initial ability showed more growth when they were in kindergarten classrooms with more classroom organization. In contrast, those with higher initial mathematics achievement grew more in classrooms with lower kindergarten classroom organization. This counterintuitive finding should be interpreted in context of the small percentage of instructional time typically devoted to mathematics during kindergarten (~11%; La Paro et al., in press). What does good classroom organization do for learning, and why might it be more important for some children than others? Better classroom organization may contribute to more mathematics learning time (Rimm-Kaufman et al., 2009) and in turn relate to gains in mathematics achievement for low math achievers. The association between classroom organization and mathematics learning time may be less consequential for children with high levels of mathematics achievement. Higher achieving students may actually function well in poorly managed classes. For example, a child who already knows math in a poorly organized classroom might choose to work independently on activities, whereas children with poor math skills might use the free time to disengage academically. It is also possible that high math achievers in a more organized class may receive more exposure to math but that the activities might still be too simple to challenge them.

Implications

Three primary implications follow from these findings. First, of the three interactions and one main effect for classroom processes, three were from first grade. Taken together, these findings suggest the importance of first grade, relative to kindergarten, for deflecting children's achievement trajectories (Perry, Donohue, & Weinstein, 2007). It has been found that developmental trajectories are established early in children's school careers (Juel, 1988) and become increasingly more stable as students progress through school (Alexander & Entwisle, 1988). A body of work emphasizes first grade as a critical developmental context with more stringent pressures and higher academic expectations than kindergarten (Alexander & Entwisle, 1988). For example, first graders are likely to be exposed to more activities relevant to early reading and mathematics content learning and achievement than are kindergarteners (La Paro et al., in press; NICHD ECCRN, 2002). Although the present design does not allow for causal inferences, our findings suggest the importance of first grade and thereby imply that experiences children had in first grade were powerful enough to override a trajectory established in kindergarten.

The second implication regards young students' differential experiences of quality. It is of note that all interactions were disordinal interactions (Glass & Hopkins, 1996). In other words, lower achieving children did comparatively better in one classroom condition, and higher achieving children did comparatively better in a different classroom condition. This fact suggests that children with low initial achievement may have had different classroom needs than did children with high initial achievement. It could have been the case that all children benefited from teacher–child interactions but that those with lower initial scores benefited more than students with higher initial scores. This raises a question: What type of teacher is effective in boosting the achievement of high achievers? Existing research suggests that only the most effective teachers can boost learning in the best students (Sanders & Horn, 1998). These results suggest that many classrooms may lack sufficient affordances for high-achieving (or gifted) children and that instruction may be aimed at the lower or average-achieving children. Another consideration is that the amount of time spent teaching in a particular academic domain might have differential effects for high- and low-achieving students. In the CLASS measure, time and quality are confounded. Research is currently emerging that examines how quality and quantity may interact to explain children's development (Pianta, Belsky, et al., 2008).

Third, this study adds to an emerging body of work examining the lasting effects of early school experiences (e.g., Magnuson, Ruhm, & Waldfogel, 2007; Sanders & Rivers, 1996). Many studies have found within-year associations between children's development and instruction. The present study examined whether teacher–child interactions from 1 year altered the achievement trajectory for students based on 2 years. Arguably, a greater number of associations, or stronger associations, could have been found by looking within year. These longitudinal effects have been emphasized in the preschool literature, in particular. For example, Belsky et al. (2007) found that higher quality teacher–child interactions during preschool were associated with higher assessed vocabulary in fifth grade. The results from the present study are compatible. That is, learning trajectories can be altered by a kindergarten or first-grade experience, but the extent of that alteration is contingent upon achievement level when children begin school.

Limitations

Two limitations require mention. First, consistent with the theoretical underpinnings of the measure (Hamre & Pianta, 2007), the CLASS domains are positively correlated with one another (Hamre et al., 2007). This can present a problem of multicollinearity, particularly when testing interactions. This concern was partially mitigated by the fact that predictors were centered and parsimonious model building techniques were used (Raudenbush & Bryk, 2002). Second, growth rates herein did not account for summer learning loss, which has been shown to disproportionately affect children at-risk for school failure (Burkam, Ready, Lee, & LoGerfo, 2004). Although the data supported linear growth, this may not have been true for all students (McCoach et al., 2006). Linear growth rates for children who had summer losses would have appeared lower than for students without summer losses. A study powered by more participants and time points should examine the possibility of a nonlinear growth trajectory.

Conclusion

This study indicates that teachers face a significant and practical challenge in their classrooms as they strive to support the learning of students with varied abilities. Improving teachers' emotional support toward children is one step toward this goal; it appears to have positive implications for young students' achievement in sound awareness. However, large disparities exist in children's academic skill levels and growth, and the kind of teaching that is appropriate for lower achieving students may be somewhat different from the type of teaching that is well suited for higher achieving students. Thus, a nuanced understanding of classroom quality requires that we consider not only what constitutes good-quality instruction but also what facets of quality are more or less important depending on children's level of achievement upon school entry.

Many policymakers view the reduction of the achievement gap as a primary goal of schools. The present study found that the lower achieving students grew faster than higher achieving students in two important domains, phonological and mathematics skills. This finding suggests that the playing field is being leveled in these areas but that it may be happening at the expense of higher achieving students—at least in the relatively poor, rural districts that we studied. This study raises the question as to whether teachers are helping lower achieving students catch up to the higher achieving students or whether higher achieving students are not provided sufficient supports for reaching their potential.

The present study points to the need for more work to be done that follows the contribution of teaching to children's learning for more than a single year. Indeed, very little work has been done that examines teachers' accumulated effects on children. Children grow and change each year. Some of those changes reflect biologically based patterns of development, whereas others occur as a consequence of children's interactions with important adults. The fact that children move in and out of various classrooms provides us with a unique perspective from which to understand the contribution of individual teachers to student achievement.

References

Alexander, K. L., & Entwisle, D. R. (1988). Achievement in the first 2 years of school: Patterns and processes. *Monographs of the Society for Research in Child Development, 53*(2, Serial No. 218).

Baker, J. A. (2006). Contributions of teacher–child relationships to positive school adjustment during elementary school. *Journal of School Psychology, 44,* 211–229.

Battistich, V., Schaps, E., Watson, M., & Solomon, D. (1996). Early findings from an ongoing multisite demonstration trial. *Journal of Adolescent Research, 11,* 12–35.

Belsky, J., Vandell, D. L., Burchinal, M., Clarke-Stewart, K. A., McCartney, K., & Owen, M. T. (2007). Are there long-term effects of early child care? *Child Development, 78,* 681–701.

Birch, S. H., & Ladd, G. W. (1998). Children's interpersonal behaviors and the teacher–child relationship. *Developmental Psychology, 34,* 934–946.

Bohn, C. M., Roehrig, A. D., & Pressley, M. (2004). The first days of school in the classrooms of two more effective and four less effective primary-grades teachers. *Elementary School Journal, 104,* 269–287.

Boyd, D., Grossman, P., Lankford, H., Loeb, S., & Wyckoff, J. (2005, December). *How changes in entry requirements alter the teacher workforce and affect student achievement* (Working Paper 11844). Cambridge, MA: National Bureau of Economic Research.

Bradley, R. H., & Corwyn, R. F. (2002). Socioeconomic status and child development. *Annual Review of Psychology, 53,* 371–399.

Bradley, R. H., Corwyn, R. F., McAdoo, H. P., & Coll, C. G. (2001). The home environments of children in the United States: Part I. Variations by age, ethnicity, and poverty status. *Child Development, 72,* 1844–1867.

Bredekamp, S., & Copple, C. (Eds.) (1997). *Developmentally appropriate practice in early childhood programs* (Rev. ed.). Washington, DC: National Association for the Education of Young Children.

Brody, G. H., Dorsey, S., Forehand, R., & Armistead, L. (2002). Unique and protective contributions of parenting and classroom processes to the adjustment of African American children living in single-parent families. *Child Development, 73,* 274–286.

Bronfenbrenner, U. (2005). *Making human beings human: Bioecological perspectives on human development.* Thousand Oaks, CA: Sage.

Bronfenbrenner, U., & Morris, P. (1998). The ecology of developmental process. In W. Damon (Series Ed.) & R. M. Lerner (Vol. Ed.), *Handbook of child psychology: Vol. 1. Theoretical models of human development* (5th ed., pp. 993–1028). New York: Wiley.

Bronfenbrenner, U., & Morris, P. (2006). The bioecological model of human development. In R. M. Lerner (Ed.), *Handbook of child psychology: Vol. 1. Theoretical models of human development* (6th ed., pp. 793–828). Hoboken, NJ: Wiley.

Brophy, J. E., & Good, T. L. (1986). Teacher behavior and student achievement. In M. C. Wittrock (Ed.), *Handbook of research on teaching* (3rd ed., pp. 328–375). New York: Macmillan.

Burchinal, M., Howes, C., Pianta, R., Bryant, D., Early, D., Clifford, R., et al. (2008). Predicting child outcomes at the end of kindergarten from the quality of pre-kindergarten teacher–child interactions and instruction. *Applied Developmental Science, 12,* 140–153.

Burkam, D. T., Ready, D. D., Lee, V. E., & LoGerfo, L. F. (2004). Social-class differences in summer learning between kindergarten and first grade: Model specification and estimation. *Sociology of Education, 77,* 1–31.

Cameron, C. E., Connor, C. M., & Morrison, F. J. (2005). Effects of variation in teacher organization on classroom functioning. *Journal of School Psychology, 43,* 61–85.

Chatterji, M. (2006). Reading achievement gaps, correlates, and moderators of early reading achievement: Evidence from the Early Childhood Longitudinal Study (ECLS) kindergarten to first grade sample. *Journal of Educational Psychology, 98,* 489–507.

Cochran-Smith, M., & Zeichner, K. M. (2005). *Studying teacher education: The report of the AERA panel on research and teacher education.* Mahwah, NJ: Erlbaum.

Committee on Learning Research and Educational Practice, National Research Council. (1999). In M. S. Donovan, J. D. Bransford, & J. W. Pellegrino (Eds.), *How people learn: Bridging research and practice.* Washington, DC: National Academy Press.

Connor, C. M., Morrison, F. J., & Katch, E. L. (2004). Beyond the reading wars: The effect of classroom instruction by child interactions on early reading. *Scientific Studies of Reading, 8,* 305–336.

Connor, C. M., Morrison, F. J., & Petrella, J. N. (2004). Effective reading comprehension instruction: Examining Child × Instruction interactions. *Journal of Educational Psychology, 96,* 682–698.

Connor, C. M., Morrison, F. J., & Underwood, P. S. (2007). A second chance at second grade: The independent and cumulative impact of first- and second-grade reading instruction and students' letter–word reading skill growth. *Scientific Studies of Reading, 11,* 199–233.

Connor, C. M., Son, S., Hindman, A., & Morrison, F. (2005). Teacher qualifications, classroom practices, family characteristics, and preschool experience: Complex effects on first graders' vocabulary and early reading outcomes. *Journal of School Psychology, 43,* 343–375.

Curby, T. W., LoCasale-Crouch, J., Konold, T. R., Pianta, R., Howes, C., Burchinal, M., et al. (2009). The relations of observed pre-k classroom quality profiles to children's academic achievement and social competence. *Early Education and Development, 20,* 346–372.

Downer, J. T., Rimm-Kaufman, S. E., & Pianta, R. C. (2007). How do classroom conditions and children's risk for school problems contribute to children's engagement in learning? *School Psychology Review, 36,* 413–432.

Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., et al. (2007). School readiness and later achievement. *Developmental Psychology, 43,* 1428–1446.

Early, D. M., Bryant, D. M., Pianta, R. C., Clifford, R. M., Burchinal, M. R., Ritchie, S., et al. (2006). Are teachers' education, major, and credentials related to classroom quality and children's academic gains in pre-kindergarten? *Early Childhood Research Quarterly, 21,* 174–195.

Early, D. M., Maxwell, K. L., Burchinal, M., Alva, S., Bender, R. H., Bryant, D., et al. (2007). Teachers' education, classroom quality, and young children's academic skills: Results from seven studies of preschool programs. *Child Development, 78,* 558–580.

Emmer, E. T., & Stough, L. M. (2001). Classroom management: A critical part of educational psychology, with implications for teacher education. *Educational Psychologist, 36,* 103–112.

Foorman, B. R., Francis, D. J., Fletcher, J. M., Schatschneider, C., & Mehta, P. (1998). The role of instruction in learning to read: Preventing reading failure in at-risk children. *Journal of Educational Psychology, 90,* 37–55.

Franke, M. L., Kazemi, E., & Battey (2007). Mathematics teaching and classroom practice. In F. K. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (2nd ed.). Charlotte, NC: Information Age Publishing.

Glass, G. V., & Hopkins, K. D. (Eds.) (1996). *Statistical methods in education and psychology* (3rd ed.). Boston: Allyn & Bacon.

Hamre, B., & Pianta, R. C. (2005). Can instructional and emotional support in the first grade classroom make a difference for children at risk for school failure? *Child Development, 76,* 949–967.

Hamre, B. K., & Pianta, R. C. (2007). Learning opportunities in preschool and early elementary classrooms. In R. C. Pianta, M. J. Cox, & K. Snow (Eds.), *School readiness and the transition to kindergarten* (pp. 49–84). Baltimore: Brookes.

Hamre, B. K., Pianta, R. C., Mashburn, A., & Downer, J. (2007). *Building and validating a theoretical model of classroom effects in over 4,000 early childhood and elementary classrooms.* Retrieved June 1, 2008, from the Foundation for Child Development Web site: http://www.fcd-us.org/resources/resources_show.htm?doc_id=507559

Hebbeler, K., Spiker, D., Mallik, S., Scarborough, A., & Simeonsson, R. (2003). *Demographic characteristics of children and families entering early intervention.* Menlo Park, CA: SRI International.

Hofferth, S. L., & Sandberg, J. F. (2001). How American children spend their time. *Journal of Marriage and Family, 63,* 295–308.

Howes, C., Burchinal, M., Pianta, R., Bryant, D., Early, D., Clifford, R., et al. (2008). Ready to learn? Children's pre-academic achievement in pre-kindergarten programs. *Early Childhood Research Quarterly, 23,* 27–50.

Howes, C., & Hamilton, C. E. (1992). Children's relationships with child care teachers: Stability and concordance with parental attachments. *Child Development, 63,* 867–878.

Hyson, M., Copple, C., & Jones, J. (2006). Early childhood development and education. In K. A. Renninger & I. E. Sigel (Eds.), *Handbook of child psychology: Vol. 4. Child psychology in practice* (6th ed., pp. 3–47). Hoboken, NJ: Wiley.

Jimerson, S., Egeland, B., & Teo, A. (1999). A longitudinal study of achievement trajectories: Factors associated with change. *Journal of Educational Psychology, 91,* 116–126.

Juel, C. (1988). Learning to read and write: A longitudinal study of 54 children from first through fourth grades. *Journal of Educational Psychology, 80,* 437–447.

Kern, L., & Clemens, N. H. (2007). Antecedent strategies to promote appropriate classroom behavior. *Psychology in the Schools, 44,* 65–75.

La Paro, K. M., Hamre, B. K., LoCasale-Crouch, J., Pianta, R. C., Bryant, D. M., Early, D. M., et al. (in press). Quality in kindergarten classrooms: Observational evidence for the need to increase children's learning opportunities in early education classrooms. *Early Education and Development.*

Lee, V. E., & Burkham, D. T. (2002). *Inequality at the starting gate: Social background differences in achievement as children begin school.* Washington, DC: Economic Policy Institute.

Luthar, S. S., Cicchetti, D., & Becker, B. (2000). The construct of resilience: A critical evaluation and guidelines for future work. *Child Development, 71,* 543–562.

Magnuson, K. A., Ruhm, C., & Waldfogel, J. (2007). The persistence of preschool effects: Do subsequent classroom experiences matter? *Early Childhood Research Quarterly, 22,* 18–38.

Mashburn, A. J., Pianta, R. C., Hamre, B. K., Downer, J. T., Barbarin, O., Bryant, D., et al. (2008). Measures of classroom quality in prekindergarten and children's development of academic, language and social skills. *Child Development, 79,* 732–749.

Mather, N., & Jaffe, L. E. (2002). *Woodcock–Johnson III: Reports, recommendations, and strategies.* New York: Wiley.

McClelland, M. M., Acock, A. C., & Morrison, F. J. (2006). The impact of kindergarten learning-related skills on academic trajectories at the end of elementary school. *Early Childhood Research Quarterly, 21,* 471–490.

McCoach, D. B., O'Connell, A. A., Reis, S. M., & Levitt, H. A. (2006). Growing readers: A hierarchical linear model of children's reading growth during the first 2 years of school. *Journal of Educational Psychology, 98,* 14–28.

McGrew, K. S., & Woodcock, R. W. (2001). *Woodcock–Johnson III technical manual.* Itasca, IL: Riverside Publishing.

Morrison, F. J., Bachman, H. J., & Connor, C. M. (2005). *Improving literacy in America: Guidelines from research.* New Haven, CT: Yale University Press.

National Institute of Child Health and Human Development Early Child Care Research Network. (2002). The relation of first grade classroom environment to structural classroom features, teacher, and student behaviors. *Elementary School Journal, 102,* 367–387.

National Institute of Child Health and Human Development Early Child Care Research Network & Duncan, G. (2003). Modeling the impacts of child care quality on children's preschool cognitive development. *Child Development, 74,* 1454–1475.

No Child Left Behind Act of 2001, 115 Stat. 1425 (2002). [Pub. L. No. 107–110]. Retrieved June 18, 2008, from http://www.ed.gov/policy/elsec/leg/esea02/pg1.html#sec1001

Perry, K. E., Donohue, K. M., & Weinstein, R. S. (2007). Teaching practices and the promotion of achievement and adjustment in first grade. *Journal of School Psychology, 45,* 269–292.

Pianta, R., Belsky, J., Vandergrift, N., Houts, R. M., & Morrison, F. J. (2008). Classroom effects on children's achievement trajectories in elementary school. *American Educational Research Journal, 45,* 365–397.

Pianta, R. C., La Paro, K. M., & Hamre, B. K. (2004). *Classroom Assessment Scoring System—K-3.* Unpublished manuscript.

Pianta, R. C., La Paro, K. M., & Hamre, B. K. (2008). *Classroom Assessment Scoring System—K-3.* Baltimore: Brookes Publishing.

Pianta, R. C., La Paro, K. M., Payne, C., Cox, M. J., & Bradley, R. (2002). The relation of kindergarten classroom environment to teacher, family, and school characteristics and child outcomes. *Elementary School Journal, 102,* 225–238.

Ponitz, C. C., Rimm-Kaufman, S. E., Grimm, K. J., & Curby, T. W. (2009). How kindergarten classroom quality translates into reading achievement: The critical role of student engagement. *School Psychology Review, 38,* 102–120.

Raudenbush, S., & Bryk, A. (2002). *Hierarchical linear models: Applications and data analysis methods.* Thousand Oaks, CA: Sage.

Raudenbush, S., Bryk, A., Cheong, Y. F., & Congdon, R. (2004). *HLM 6: Hierarchical linear and nonlinear modeling.* Lincolnwood, IL: Scientific Software International.

Rayner, K., Foorman, B. R., Perfetti, C. A., Pesetsky, D., & Seidenberg, M. S. (2001). How psychological science informs the teaching of reading. *Psychological Science in the Public Interest, 2,* 31–74.

Rimm-Kaufman, S. E., Curby, T. W., Grimm, K., Nathanson, L., & Brock, L. L. (2009). The contribution of children's self-regulation and classroom quality to children's adaptive behaviors in the kindergarten classroom. *Developmental Psychology, 45,* 958–972.

Rimm-Kaufman, S. E., Pianta, R. C., & Cox, M. J. (2000). Teachers' judgments of problems in the transition to kindergarten. *Early Childhood Research Quarterly, 15,* 147–166.

Runge, T. J., & Watkins, M. W. (2006). The structure of phonological awareness among kindergarten students. *School Psychology Review, 35,* 370–386.

Rutter, M., & Maughan, B. (2002). School effectiveness findings 1979–2002. *Journal of School Psychology, 40,* 451–475.

Rutter, M., Maughan, B., Mortimore, P., Ouston, J., & Smith, A. (1979). *Fifteen thousand hours: Secondary schools and their effects on children.* Cambridge, MA: Harvard University Press.

Sanders, W. L., & Horn, S. P. (1998). Research findings from the Tennessee value-added assessment system (TVAAS) database: Implications for educational evaluation and research. *Journal of Personnel Evaluation in Education, 12,* 247–256.

Sanders, W. L., & Rivers, J. C. (1996). *Cumulative and residual effects of teachers on future student academic achievement.* Knoxville: University of Tennessee Value-Added Research and Assessment Center.

Seidman, E., Tseng, V., & Weisner, T. S. (2006). Social setting theory and measurement. In *Report and resource guide 2004–2005*. New York: William T. Grant Foundation.

Stipek, D., & Byler, P. (2004). The Early Childhood Classroom Observation Measure. *Early Childhood Research Quarterly, 19,* 375–397.

Wachs, T. D., Gurkas, P., & Kontos, S. (2004). Predictors of preschool children's compliance behavior in early childhood classroom settings. *Applied Developmental Psychology, 25,* 439–457.

West, J., Denton, K., & Germino-Hausken, E. (2000). America's kindergarteners: Findings from the Early Childhood Longitudinal Study, kindergarten class of 1998–1999: Fall 1998. *Education Statistics Quarterly, 2,* 7–13.

Woodcock, T. A., McGrew, K. S., & Mather, N. (2001). *Woodcock–Johnson III Tests of Achievement.* Itasca, IL: Riverside Publishing.

Wright, S. P., Horn, S. P., & Sanders, W. L. (1997). Teacher and classroom context effects on student achievement: Implications for teacher evaluation. *Journal of Personnel Evaluation in Education, 11,* 57–67.

Appendix

Specifications for Hierarchical Linear Models and Cross-Classified Models

The first step in the analyses involved analyzing unconditional growth models for children's achievement (Letter–Word Identification, Sound Awareness, and Applied Problems). These models accounted for growth across four time points (fall and spring of kindergarten and first grade). These unconditional models can be represented by the following equations:

$$\text{Level 1 Model: } Y_{ij} = \beta_0 + \beta_1(\text{time}) + r$$

$$\text{Level 2 Model: } \beta_0 = \gamma_{00} + u_0$$

$$\beta_1 = \gamma_{10} + u_1$$

The Level 1 equation models achievement across the four time points. It states that achievement, Y, for child i at time point j is equal to the intercept for that achievement measure (in the fall of kindergarten), β_0, plus slope, β_1, plus individual error. The Level 2 equations model between-child variance. They state that the intercept, β_0, is equal to a grand mean for the intercept, γ_{00}, plus an individually varying (random) effect, u_0. Likewise, the slope, β_1, is equal to a grand mean for the slope, γ_{10}, plus an individually varying (random) effect, u_1. Implicit in this model is that individually varying intercepts and slopes were computed for each child.

The intercept (initial) and slope values from the above models were used in the cross-classified analyses. The final cross-classified model for Applied Problems is presented in the main text. Herein, final models are presented for Letter–Word Identification and Sound Awareness. First, the final model for Letter–Word Identification is represented by the following equations:

$$\text{Level 1: } Y_{ijk} = \pi_{0jk} + \pi_1(\text{initial}) + e_{ijk}$$

$$\text{Level 2: } \pi_{0jk} = \theta_0 + b_{00j} + c_{00k}$$

$$\pi_1 = \theta_1 + \gamma_{11}(\text{first-grade emotional support}) + \gamma_{12}(\text{first-grade instructional support})$$

The Level 1 equation states that the expected Letter–Word Identification slope (Y_{ijk}) of child i who is in kindergarten classroom j and first-grade classroom k is equal to an average slope (π_{0jk}), plus an effect for where that child started (i.e., initial), π_1, plus an individual error associated with that particular child (e_{ijk}). The Level 2 equations state that the Level 1 average slope (π_{0jk}) is equal to a grand mean slope (θ_0) plus a random effect for kindergarten classroom j (b_{00j}) plus a random effect for first-grade classroom k (c_{00k}). Additionally, the statistical effect that the initial score has on the slope varies as a function of the first-grade emotional support, γ_{11}, and the first-grade instructional support, γ_{12}, the child received.

Likewise, presented below are the final cross-classified equations for Sound Awareness.

$$\text{Level 1: } Y_{ijk} = \pi_{0jk} + \pi_1(\text{initial}) + e_{ijk}$$

$$\text{Level 2: } \pi_{0jk} = \theta_0 + b_{00j} + c_{00k}$$

$$\pi_1 = \theta_1$$

The Level 1 equation states that the expected Sound Awareness slope (Y_{ijk}) of a child i who is in kindergarten classroom j and first-grade classroom k is equal to an average slope (π_{0jk}), plus an effect for his or her initial score, π_1, plus an individual error associated with that particular child (e_{ijk}). The Level 2 equations state that the Level 1 average slope (π_{0jk}) is equal to a grand mean slope (θ_0), plus a main effect for first-grade emotional support, plus a random effect for kindergarten classroom j (b_{00j}), plus a random effect for first-grade classroom k (c_{00k}).

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