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Am Educ Res J 2008; 45; 365 originally published online Mar 5, 2008;
DOI: 10.3102/0002831207308230

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Classroom Effects on Children's Achievement Trajectories in Elementary School

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This nonexperimental, longitudinal field study examines the extent to which variation in observed classroom supports (quality of emotional and instructional interactions and amount of exposure to literacy and math activities) predicts trajectories of achievement in reading and math from 54 months to fifth grade. Growth mixture modeling detected two latent classes of readers: fast readers whose skills developed rapidly and leveled off, and a typical group for which reading growth was somewhat less rapid. Only one latent class was identified for math achievement. For reading, there were small positive associations between observed emotional quality of teacher-child interactions and growth. Growth in math achievement showed small positive relations with observed emotional interactions and exposure to math activities. There was a significant interaction between quality and quantity of instruction for reading such that at higher levels of emotional quality there was less of a negative association between amount of literacy exposure and reading growth.

KEYWORDS: elementary achievement, teacher-child interactions, classroom effects

As the results of widespread accountability and state standards testing become used for identifying schools that do not meet established proficiency levels and rates of performance, the dynamic of accountability policies and procedures has shifted to focus even more intently on the value of experiences in K-12 classrooms for producing achievement (e.g., Appalachian Regional Advisory Committee [ARAC], 2005; Foundation for Child Development, 2005; Hamre & Pianta, 2007; Perie, Moran, & Lutkus, 2005). States and districts not meeting annual yearly progress levels are scrambling to find the right mix of curriculum, professional development, and instructional supports that will raise students' achievement levels (e.g., ARAC, 2005; Educational Testing Service [ETS], 2004; Lasley, Siedentop, & Yinger, 2006). Given that much of the high-stakes accountability testing begins in third grade and there is ample evidence that achievement trajectories are quite stable as children begin middle school, it seems imperative to understand the extent to which children's actual experiences of instruction and social interactions in elementary school classrooms add value over

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time to achievement growth through the elementary years (Midgley & Edelin, 1998).

Toward that end, although some studies link teachers' observed instructional practices and relationships with students to student achievement gains in a given year (e.g., Cameron, Connor, & Morrison, 2005; Morrison & Connor, 2002; McCaslin et al., 2006; National Institute of Child Health and Human Development [NICHD] Early Child Care Research Network [ECCRN], 2002a, 2005; Pianta et al., 2005), there have been few, if any, attempts to link observed classroom experiences to trajectories of achievement growth over the course of the elementary school years, particularly in samples that include large numbers of children and classrooms. Key among classroom experiences in relation to the production of reading and mathematics achievement in elementary school are both the *quantity* and *quality* of children's exposures to learning and instructional activities in these achievement domains (Entwisle & Alexander, 1999; Hamre & Pianta, 2005; Morrison & Connor, 2002). For example, Entwisle and Alexander (1999) conceptualized schooling effects in terms of "faucet theory" in which student gains accrue as a function of more exposure to school; turn the exposure off and gains stop. On the other hand, Morrison and Connor (2002) summarized studies on the nature of reading instruction and conclude that the type of instruction (not just exposure) matters considerably (poor readers need decoding while good readers need comprehension) and Howes et al. (in press) have established that variance in achievement trajectories in language and reading is in part attributable to qualities of teachers' interactions with children (e.g., sensitivity and feedback processes).

In this article, we continue our prior work on the quality and effects of classroom experiences for the children enrolled in the prospective, longitudinal NICHD Study of Early Child Care and Youth Development (see NICHD ECCRN, 2002a, 2002b, 2005, 2006b; Pianta, Belsky, Houts, Morrison, & NICHD ECCRN, 2007) by examining the contribution of teachers' instructional and emotional interactions (what we call "classroom or teacher quality") and the amount of exposure to reading and math activities in first-, third-, and fifth-grade classrooms to students' growth in reading and math achievement across the same period. Not only do we examine the independent contribution to prediction of achievement growth of the quality of teacher-child interactions and quantity of exposure to instructional activities, but also the extent to which their interactive effects are significant; that is, does amount of exposure matter more when it occurs with high-quality teacher-child interactions? Moreover, given the relatively robust indications that boys and children in poverty are more likely to achieve at lower levels than girls or students from middle-high-income families (Entwisle & Alexander, 1999; Lee & Burkham, 2002; Rouse, Brooks-Gunn, & McLanahan, 2005), we describe patterns of achievement growth across the elementary years in relation to those characteristics.

In terms of key dimensions of experiences in elementary classrooms as an opportunity structure (Pianta et al., 2007), there is an emerging consensus that *both* instructional and emotional aspects of the classroom are predictive

of gains in child achievement (e.g., Bransford, Brown, & Cocking, 1999; Cameron et al., 2005; Eccles & Gootman, 2002; Hamre & Pianta, 2007), particularly as they moderate effects of certain risk factors for poor achievement. In relation to instructional supports provided through teacher-child interactions, small-scale studies of elementary-age students report the value of specific dimensions of instruction such as “feedback” (Burnett, 2003; Matsumura, Patthey-Chavez, Valdes, & Garnier, 2002; Meyer, Wardrop, Hastings, & Linn, 1993); stimulation of conceptual thinking, language, and analysis; providing instructional activities that have relevance and meaning for students; and intense, focused implementation of curricula (Bransford et al., 1999; Cameron et al., 2005; Hamre & Pianta, 2005). There has been an indication, for first-graders, that teachers’ focus on concepts and provision of feedback have an even stronger positive effect for students whose parents have low levels of education themselves (Hamre & Pianta, 2005). Although the apparent dichotomy between child-centered and direct instruction has for some years dominated discussions of learning in the early grades (see Stipek et al., 1998), there is accumulating evidence that teachers’ instructional interactions with children have the greatest value for students’ performance when they are focused, direct, intentional, and characterized by feedback loops involving student performance (Dolezal, Welsh, Pressley, & Vincent, 2003; Meyer et al., 1993; Pianta, La Paro, Payne, Cox, & Bradley, 2002; Torgesen, 2002). The value of intentional, focused interaction and feedback is not limited to reading, but appears to be a key component in other skill domains such as writing (Matsumura et al., 2002) that may extend to cognition and higher-order thinking (Dolezal et al., 2003). Finally, it has been demonstrated that variation in the amount of children’s exposures to instructional activities, simply in terms of time allotted to instruction in a given domain, also has some net effect on achievement in the elementary years (see Entwisle & Alexander, 1999).

It is also clear that the emotional aspects of teacher-child interactions, such as teachers’ sensitivity and emotional warmth, are associated with achievement gains in first-graders (Hamre & Pianta, 2005) and with moderating the negative effects of children’s tendencies toward disruptive behavior (Rimm-Kaufman, La Paro, Pianta, & Downer, 2005). Exposure to positive classroom climates and sensitive teachers is linked to greater self-regulation among elementary and middle school students (D. Skinner, Bryant, Coffman, & Campbell, 1998), greater teacher-rated social competence (Burchinal et al., 2005; Howes, 2000; Pianta et al., 2002), and decreases in mother-reported internalizing problems from 54 months to the end of first grade (NICHD ECCRN, 2003). In the early grades, Pianta et al. (2002) found that when teachers offered a more child-centered climate, kindergarten children were observed to be more often on task and engaged in learning. From a somewhat different theoretical perspective, teachers’ emotional support directly provides students with experiences that foster learning-related processes important to academic functioning (Crosnoe, Johnson, & Elder, 2004; Greenberg et al.,

2003; Gregory & Weinstein, 2004; Pianta et al., 2002; Rimm-Kaufman et al., 2005; Roeser, Eccles, & Sameroff, 2000; Wentzel, 2002; Zins, Bloodworth, Weissberg, & Walberg, 2004). As students age into middle school, the social aspects of the classroom increasingly are features that engage the student in learning (Eccles & Gootman, 2002; Weinstein, 2002). Surveys of middle school students make abundantly clear how important it is that the classroom promote a sense of autonomy and competence and that the teacher be capable of engaging students in a personal relationship in which, to some extent, the student feels known (see Eccles & Gootman [2002] and Weinstein [2002] for summaries). Gains in achievement and reduced levels of disruptive behavior also are evident in classrooms in which expectations are clear, time is used well and productively, roles are clear, and teachers respond effectively to variation in students' motivation and focus (Burnett, 2003; Cameron et al., 2005; McCaslin et al., 2006). In our prior work, observed disruptive behavior was lower and student attention and engagement in learning was greater when elementary classrooms were rated high on productive use of time and effectiveness of behavior management (NICHD ECCRN, 2002b, 2005).

Not surprisingly, the emotional and instructional elements of the classroom are also related to one another (Hamre & Pianta, 2005; Weinstein, 2002). In the best classrooms, these dimensions are integrated into instructional activities, discussions, and even transitions in a combination of respectful interactions and personal relationships, high expectations, a productive learning orientation, engaging activities that stimulate thinking as well as social interaction, and regular critical feedback and questioning (e.g., Berliner, 1987; Brophy & Good, 1986; Pianta & Allen, 2006; Stipek, 1988). Unfortunately, it is all too evident that levels of these assets are quite low and variable across years in American elementary classrooms (see NICHD ECCRN, 2002b, 2005, 2006a; Pianta et al., 2007). This picture of generally low or uneven quality of teacher-child interactions and instructional exposures can be seen in any given grade and from year to year and has emerged from both cross-sectional and across-time studies of the classrooms of the children enrolled in the NICHD Study of Early Child Care and Youth Development (SECCYD) in first, third, and fifth grades (NICHD ECCRN, 2002b, 2005, 2006a) and of students in fifth grade enrolled in a study of Comprehensive School Reform (McCaslin et al., 2006). Overall, these studies lead to the general impression that learning takes place in a passive instructional environment that places few demands on children for cognitive growth beyond factual knowledge.

Thus, there is ample evidence that everyday classroom interactions between teachers and children do indeed predict more positive development for all children (Brophy & Good, 1986; Gage & Needels, 1989; Howes et al., in press; NICHD ECCRN, 2003; Pianta et al., 2002; Rimm-Kaufman et al., 2005; Skinner & Belmont, 1993; Stipek et al., 1998) as well as contribute to closing achievement gaps for children from different risk groups (Hamre & Pianta, 2005). Educational effects are, at least theoretically, cumulative in nature: what

one learns in a given time period contributes to learning a more difficult skill in the next. Thus, learning accumulates over time, and presumably classroom experiences add value to learning in this way. Particularly for children at risk of school failure, continuous exposure to learning opportunities is important to producing individual gains in learning (Entwisle & Alexander, 1999; Sanders & Rivers, 1996). Evidence from the use of state standards tests to identify effective teachers suggests that exposure to such teachers over the course of several years in a row is particularly important to stabilizing the achievement trajectories and gains of low-achieving students (e.g., Sanders & Rivers, 1996). Thus, in the present investigation we are particularly interested in examining how associations between patterns of exposures to quality and quantity of learning opportunities across the elementary grades contribute (individually and in combination) to achievement growth over this multiyear span.

The Present Study

Identifying the conditions under which experiences in school settings, such as teachers' instructional or social interactions or the quantity of student exposure to instruction in certain domains, can alter the early trajectories of children's social or academic functioning has important implications for understanding pathways to children's positive adaptation. Of particular interest is whether experiences across the elementary grades contribute differentially to achievement gains for children at risk of school failure, particularly in the elementary grades when small increments in achievement play a large role in eventual outcomes (Alexander, Entwisle, & Kabbani, 2001; Ferguson, 1998; Phillips, Crouse, & Ralph, 1998; Ross, Smith, Slavin, & Madden, 1997). Thus, the current investigation examines the association between observed classroom supports—emotional and instructional—and trajectories of achievement from 54 months to fifth grade, in the sample of children and classrooms involved in the NICHD SECCYD. Based on prior work in this and other samples, it was expected that observed qualities of teacher-child interactions would show a more pronounced association with outcome trajectories and, more specifically, that the cognitively demanding instructional interactions would show an even greater association with outcomes. It was also expected that variability in exposure to math instruction, because it is considerable (see Pianta et al., 2007) would be associated with math achievement and that variation in classroom supports would be more strongly associated with outcomes for children from economically disadvantaged backgrounds.

Method

Participants

The recruitment and selection of child participants in the NICHD SECCYD is described in several documents that are publicly available, to which interested readers are referred for background information (<http://secc.rti.org>); a

summary of that information is presented here. Between January and November 1991, families were recruited through hospital visits to mothers shortly after the birth of a child at 10 locations in the United States (Little Rock, AR; Irvine, CA; Lawrence, KS; Boston, MA; Philadelphia, PA; Pittsburgh, PA; Charlottesville, VA; Morganton, NC; Seattle, WA; and Madison, WI). During selected 24-hour intervals, all women giving birth were screened for eligibility and willingness to be contacted. Of the 8,986 mothers who gave birth during the sampling period, 5,416 (60%) agreed to be contacted and met the eligibility requirements (mother older than 18, spoke English; mother healthy, baby not multiple birth or released for adoption, live within an hour of research site, move from the area not planned in the next year, neighborhood not deemed too dangerous to visit by police). Of that group, a conditionally random sample of 3,015 was selected (56%) for a 2-week phone call. The conditioning ensured adequate representation (at least 10%) of single mothers, mothers without a high school degree, and ethnic minority mothers. At the 2-week call, families were excluded if the baby had been hospitalized for more than 7 days, the family expected to move in the next 3 years, or they could not be reached with at least three attempts at contact. A total of 1,525 selected for the call were eligible and agreed to an interview. Of these, 1,364 completed a home interview when the infant was 1 month old and became study participants.

The resulting sample was diverse, including 24% children of color, 11% of the mothers did not complete high school, and 14% were single. Mothers had an average of 14.4 years of education. Average family income was 3.6 times the poverty threshold. The 1,364 participating families were very similar to the eligible hospital sample in terms of maternal education, percentage in different ethnic groups, and presence of a husband/partner. All eligible children were contacted and invited to participate in all assessments; however, sporadic missed assessments contributed to missing data. In the present study, we used standardized achievement tests obtained at 54 months and first, third, and fifth grades as well as observations in classrooms at first, third, and fifth grades; a total of 791 children were included in the final analysis. The full information maximum-likelihood (FIML) estimator, a widely used method of estimation, uses information from all cases including those with missing values on the dependent variable (Arbuckle, 1996; Schafer & Graham, 2002). Table 1 presents information on demographic characteristics of the final sample used in the analysis, Table 2 presents descriptive statistics for classroom quality indicators, and Table 3 presents similar information for child outcome assessments.

In order to test for significant differences between the children included in the analysis and those who were not, ANOVAs with an indicator of attrition were conducted on continuous variables and a logistic regression with attrition as a dependent variable was conducted for the categorical variables. On average, the final sample had slightly higher classroom Emotional Quality at first grade ($D = 0.15$), 54-month Woodcock Johnson Psychoeducational

Table 1
Frequencies for Time-Invariant Child Demographics

Variable	Level	Frequency	Percentage
Gender	Female	404	51.1
	Male	387	48.9
Poverty	Not poor	618	78.1
	Poor	173	21.9

Battery (WJ) Math Scores ($D = 2.91$) (Woodcock & Johnson, 1989), and a slightly higher level of maternal education ($D = 0.66$). There were a somewhat disproportionate number of males with missing data; the final sample was 51.1% female, while the original sample was 44.5% female. Overall, the retained sample on which results are reported is very similar to the original sample at the time of enrollment in the study.

Measures

Classroom observations took place during the spring of the child's first-, third-, and fifth-grade years between January and late April. In those same grades, children were administered individual achievement tests in reading and mathematics. In addition, mothers reported on family demographic characteristics at those same occasions.

Classroom Observations

Classroom observations took place using the Classroom Observation System for First, Third, or Fifth Grade (COS-1, COS-3, COS-5). The COS-5 is identical to the COS-3, used in the fifth- and third-grade classroom visits for this sample (NICHD ECCRN, 2005, 2006a), both of which are an upward extension and extensive revision of the COS-1 (NICHD ECCRN, 2002). The focus of the observation is the classroom as well as a specific child and his or her experiences in the classroom. It is important to note that the COS observations were intended to describe selected experiences in elementary classrooms for the specific children enrolled in the NICHD SECCYD and not determined by any characteristics of the child, the child's family, or the school. Observations were recorded for teacher interactions with the target child and the activities in which the child was engaged.

All observations occurred during the morning and began with the official start of the school day. The entire observation took approximately 3 hours for the COS-1 and 6 hours for the COS-3 and COS-5. Global ratings of the classroom and teacher were made using a set of 7-point rating scales. A detailed manual describes these codes and the coding procedures (see <http://secc.rti.org>), which are presented in summary form below.

Table 2

Descriptive Statistics for Time-Varying Classroom Quality Measures

Variable	Grade	Mean	Standard Deviation	Minimum	Maximum
Emotional quality	1	5.81	0.90	2.3	7.0
Emotional quality	3	5.85	0.60	3.0	7.0
Emotional quality	5	5.88	0.49	3.4	6.8
Instructional quality	1	3.92	1.03	1.0	7.0
Instructional quality	3	3.49	0.67	1.3	6.2
Instructional quality	5	3.95	0.83	1.8	6.2
Literacy exposure	1	36.11	14.67	0.0	60.0
Literacy exposure	3	28.58	9.34	0.0	54.0
Literacy exposure	5	21.96	8.65	0.0	48.0
Math exposure	1	8.26	10.95	0.0	50.0
Math exposure	3	14.58	6.75	0.0	44.3
Math exposure	5	14.55	6.46	0.0	42.8

Note. $N = 791$.

Time-sampled exposure to instructional activities. Each grade-level observation included six to eight 10-minute observational cycles during which observers made time-sampled recordings of discrete codes. These codes were entered for a 10-minute period consisting of alternating 30-second "observe" and 30-second "record" intervals. Time-sampled codes included measures of the *setting* (e.g., whole class, small group, individual), *activities* (e.g., literacy, math, science, social studies, transition/management), *teacher behavior* (e.g., attends to child, teaches basic skills, teacher analysis/inference, managerial instruction, affect positive, affect negative, disciplines), and *child engagement* (e.g., whether the child was engaged in the assigned activity). It is important to note that these codes reflect the settings, activities, and teacher behaviors to which all children were exposed (individually or in group settings). For the purposes of this investigation, the child's exposure to instruction in math and in reading was of interest. The final codes were a combination of time-sampled exposures during instructional periods dedicated to math or reading (i.e., the time the teacher labeled as "math") and exposures to math or reading that occurred in other classes, such as science. For example, when any instructional activity (in any time period or lesson) involved a literacy component (e.g., a literacy lesson on decoding or a social studies lesson in which a book was being read), coders also assigned a "literacy" activity code. Similarly, if any activity had a mathematics component (e.g., a math lesson on multiplication or a science lesson involving calculation), math was also coded as an activity. Math codes included not only calculation and number skills but problem-solving and math concepts. Literacy codes included letter-sound skills, word-level skills, comprehension, spelling, and writing. The system of codes is not designed to be exhaustive; also, coding of more than one activity-type within

an interval is allowed if two different types are evident in that interval (e.g., a science lesson that includes math calculations). The number of intervals in which a child was exposed to a literacy or math activity was coded, summed, and scaled to a 60-minute base. The variables Literacy Exposure and Math Exposure indicated the total minutes of exposure to activities in these areas in a 60-minute window.

Global ratings. Observers were assigned 5 minutes before each time-sampling period, as well as 10 minutes at the conclusion of the time-sampled period, to conduct observations and take notes about the classroom environment. Coders relied on these dedicated periods of observation as well as used what they observed during the “observe” intervals of time sampling to make global ratings of classroom quality, teacher, and child using a set of 7-point rating scales. The focus of these ratings is the quality of teachers’ interactions with students; observers record key indicators and patterns and use a behaviorally anchored set of rating scales to record a final code.

Global ratings of *classroom-level* dimensions included overcontrol, chaos, positive emotional climate, negative emotional climate, detachment of the teacher, teacher sensitivity, productive use of instructional time, and richness of instructional methods. These classroom-level ratings ranged from 1 to 7. A rating of 1 was assigned when that code was *uncharacteristic* of the classroom, a 3 was assigned when the description was *minimally characteristic*, a 5 was assigned when the description of the code was *very characteristic*, and a 7 was assigned under circumstances in which the code was *extremely characteristic*. It is important to note that the global codes at the “high” end of the rating scale(s) reflect the extent to which the classroom or teacher demonstrates that particular dimension to an exceptional degree. For example, overcontrol was marked by very little autonomy or choice in the classroom and a high degree of teacher control; chaos reflected lack of effective behavior management and disorganization; positive emotional climate was a function of teachers’ emotionally warm and supportive gestures and verbalizations; while sensitivity was observed in teachers’ accurate detection and interpretation of children’s cues, provision of comfort, and responsiveness to distress. Instructionally, productive use of time was indicated by efficient transitions, evidence of preparation, and consistent provision of appropriate activities and pacing. Richness of instructional methods reflected teachers’ focus on conceptual aspects of tasks, problem and reasoning, encouragement of discussion, and use of a variety of methods for eliciting and stimulating student learning of a particular skill.

At each grade, we created two factor-based composites: Emotional Support (overcontrol-reflecting, chaos-reflecting, positive emotional climate, negative emotional climate-reflecting, sensitivity) and Instructional Support (productive use of time, richness of instructional methods), reflecting those qualities of the classroom setting. Each of these composites was created on the basis of factor analyses of a set of global ratings, and although the nature of these ratings shifted

Table 3

Descriptive Statistics for Woodcock Johnson Psychoeducational Battery-Revised (WJ-R) Tests of Achievement

Variable	Grade	<i>N</i>	Mean	Standard Deviation	Minimum	Maximum
Broad reading	PK	769	369.45	21.05	316.0	479.0
Broad reading	1	776	452.27	24.05	356.0	517.0
Broad reading	3	765	494.53	15.84	393.0	528.0
Broad reading	5	751	507.69	14.51	396.0	544.0
Broad math	PK	766	425.51	19.40	332.0	473.0
Broad math	1	776	470.19	15.51	408.0	516.0
Broad math	3	767	493.78	12.70	404.0	521.0
Broad math	5	751	510.90	13.19	418.0	548.0

slightly over time to accommodate developmental changes as well as additional focus on instruction in later grades, factors reflecting these two dimensions were found consistently at each grade, and several common scales were among the highest loading at each grade (see NICHD ECCRN, 2002a, 2005, 2006a). Thus, these composites reflect global aspects of the classroom that could be justified as similar across grades.

Training and reliability. Observers from all 10 sites trained on practice videotapes using a standardized manual that provided extensive descriptions of codes and anchor points, prior to attending a centralized training workshop. After the central training workshop, coders returned to their sites, conducted pilot observations, and trained on two more videotaped cases. Following this training regimen, all observers had to pass a videotaped reliability test involving six cycles of time-sampled coding and qualitative ratings. Criteria for passing were at least a 60% match with a master coder on time-sampled codes and an 80% match (within 1 scale point) on the global rating scales. All coders passed at these levels on a reliability test before being certified to conduct observations in the field.

Average exact agreement with the master-coded videotape test for the time-sampled codes, estimated by correlation with master-coders' scores, was .848. For the global ratings, reliability was estimated as within 1 scale point on the 7-point rating scales. Average reliability for the child and classroom global ratings on the videotaped test was .793, again estimated by correlation with master coders' ratings. Observers each also conducted a minimum of two paired visits scheduled randomly during the data collection window for the purposes of estimating live reliability. Correlations between observers exceeded .840 for all but 1 of the 38 time-sampled codes, with the lower estimate (.617) due to the infrequency of the observed behavior. Average live reliability across all global ratings, estimated using correlation, was .714

As a final check on the reliability of the observational data, we examined the associations between codes for classrooms observed more than once. That is, because some classrooms were attended by more than one study child, we had a sample of classrooms ($N = 54$) in which we could examine stability of the observations across days/different children, a form of test-retest reliability. For the time-sampled codes, the average cross-day correlation was .83 ($SD = .09$). For the global qualitative ratings of the classroom environment, the average cross-day correlation was .88 ($SD = .10$). Thus, it appears that the one-day observations reported for these fifth-grade classrooms were reflective of aspects of the classroom setting that remained stable across days (and different children). We found similar results for the first-grade observations when the average cross-day correlation ($N = 63$ classrooms) for the time-sampled codes was .79 ($SD = .15$) and .71 ($SD = .30$) for the qualitative ratings; as well for the third-grade observations, when the average cross-day correlation ($N = 52$) was .87 ($SD = .08$) for the time-sampled codes and .91 ($SD = .08$) for the qualitative ratings. In short, it appeared these observations reflected stable aspects of the classroom setting. See Table 2 for descriptive information and Table 4 for correlations between the observed classroom indicators.

Child and Family Characteristics

Mothers reported on levels of family income during interviews conducted in person and on the phone at repeated intervals throughout the birth to fifth-grade period. These reports were divided by the federal standard for household poverty to derive an income-to-needs ratio at each occasion, which were then averaged over time to produce an index of financial resources. This average index was then sorted into categories reflecting values less than or equal to 2.0 (the Federal poverty standard is 1.0) and above 2.0. This dichotomous variable was described as *poor/nonpoor*.

Achievement Outcomes

Children were assessed in spring of first, third, and fifth grades using the Woodcock Johnson Psychoeducational Battery-Revised (WJ-R; Woodcock & Johnson, 1989), with four subtests: Letter-Word Identification (Grade 1), which assesses prereading skills in identifying isolated letters and words; Broad Reading (Grades 3 and 5), which adds assessment of passage comprehension to the assessment of identification of words; Applied Problems, which measures skill in analyzing and solving practical problems in mathematics; and Picture Vocabulary, which measures children's ability to name objects depicted in a series of pictures. Items are presented in order of increasing difficulty and are scored 0 = incorrect or no response; or 1 = correct response, with basal and ceiling levels established. Typically, raw scores are converted to standard scores with a mean of 100 and a standard deviation of 15, but for this study we relied upon *W* ability

Table 4

Correlation of Quantity of Exposure to Literacy and Math and Quality by Grade

Exposure Quantity	Classroom Observation System (COS) Quality of Teacher-Child Interaction					
	Emotional (F1)			Instructional (F2)		
	F1 G1	F1 G3	F1 G5	F2 G1	F2 G3	F2 G5
Literacy Grade 1	-.02					
Literacy Grade 3		.00				
Literacy Grade 5			-.02			
Math Grade 1	-.05					
Math Grade 3		-.02				
Math Grade 5			-.04			
Language Grade 1				.15**		
Language Grade 3					-.01	
Language Grade 5						.02
Math Grade 1				-.14**		
Math Grade 3					.08*	
Math Grade 5						.08*

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

scores so that change over time could be more easily documented. The W ability scores are transformations of the Rasch raw ability scores designed to eliminate the need for decimal fractions and negative values. See Table 3 for descriptive information on the Broad Reading (Letter-Word and Picture Vocabulary) and Broad Math (Applied Problems) scores used in the present study.

The WJ-R is one of the most widely used individualized, standardized tests of achievement, having been included as an outcome assessment in several major studies, including evaluations of Head Start enrollment (Administration on Children, Youth and Families, 2002) and the nationally representative Early Childhood Longitudinal Study-Kindergarten Cohort. One advantage of the WJ-R for this study was that it provided a common achievement assessment, nationally normed, for students throughout the elementary grades attending a wide range of schools and exposed to highly variable curricula. This is also a shortcoming of the test with regard to assessment of classroom effects because it may underestimate the value of classroom experiences when aggregating across this variation, particularly various curricula. Presumably an assessment more closely linked to curriculum would be more sensitive to effects. Nonetheless, any standardized assessment used across schools and districts would be subject to this concern and at the time of the study, the WJ-R was the standard for this purpose. We also point out that in the case of the WJ-R

Broad Reading composite, it may be the case, particularly by fifth grade, that the combination of skills assessed by letter-word identification and picture vocabulary is not a good depiction of the type of advanced reading skills, such as comprehension and depth of interpretation, that are often the focus of instruction at this age, and so the composite used in this study would underestimate growth in reading at the later ages.

Results

Our approach to analysis was aimed to exploit the longitudinal nature of the outcomes available across the elementary years as well as to best capture grade-specific as well as overall classroom effects, adjusting for family demographic backgrounds of the children. It was also important not to obscure variation in patterns of growth among individuals in the sample as well as between groups of children for whom trajectories fit certain profiles or patterns. In order to concurrently model individual and possibly group-related trajectories of math and reading development over time, we used a contemporaneous latent curve model (LCM), with unknown groups using finite mixture modeling. This is also known as a growth mixture model (GMM) (Muthén & Shedden, 1999), which has grown in popularity as a model for change over time with unknown groups.

We began by plotting achievement trajectories in reading and math, which confirmed evidence of two distinct groups of readers. Figure 1 shows a random sample of 100 children's observed reading trajectories that have been smoothed using a polynomial smoothing technique. The plot shows two distinct groups of readers, one with rapidly increasing growth early then deceleration (a group we call "fast readers") and a second in which growth is steady and extends for a longer period of time (a group we call "typical readers"). Patterns of growth consistent with these results have been reported elsewhere in the literature on reading development (Morrison & Connor, 2002). There was only one group for the math trajectory.

Given the above considerations, analyses proceeded as follows. The overall model tested four components: (a) an LCM for math; (b) a two-group GMM for reading; (c) time-invariant child demographic variables that functioned as covariates; and (d) time-varying estimates at first, third, and fifth grade of classroom instructional and emotional quality and estimates of the quantity of instruction in reading and math. In this approach, the LCM and the GMM were estimated jointly. The model was estimated using the FIML estimator in MPlus 3.12 (Muthén & Muthén, 1998). This widely used method of estimation uses information from all cases including those with missing values (Arbuckle, 1996; Schafer & Graham, 2002).

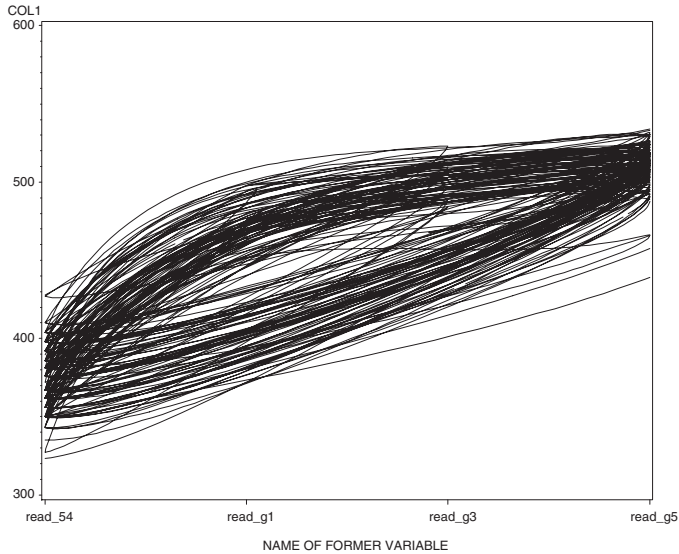


Figure 1. Random sample of $n = 100$ observed reading trajectories using polynomial smoothing.

Trajectories of Growth in Math and Reading Achievement

Math was modeled using the unstructured latent curve model (ULCM) (McArdle, 1988, 1989; Meredith & Tisak 1984, 1990). The ULCM has two qualities that made it ideal choice for this research. First, it is a highly flexible approach. Second, because we were primarily interested not in the functional form of the math and reading trajectories, but rather the covariate effects, the ULCM suits this goal well. The ULCM fits the mean structure of a trajectory without the supposition of functional form (unlike a linear trajectory, for example); therefore, the covariate effects can be interpreted net the trajectory without having to worry about misspecification of the functional form of the trajectory.

The structural model contains a latent variable that represents the intercept and a latent variable that represents total change over the window of observation. The parameters of interest in the ULCM were the mean of the intercept latent variable (μ_{β_0}) and its variance ($\text{VAR}[\zeta_{0i}]$), the mean of the total change latent variable (μ_{β_1}) and its variance ($\text{VAR}[\zeta_{1i}]$), and the freely estimated factor loading. The factor loadings that were freely estimated (λ_{22} and λ_{23}) were interpreted as the proportion of the total change that has occurred to that occasion of measurement.

The developmental trajectories for reading were also modeled using an ULCM, except that we allowed multiple groups using the GMM framework. That is, we allowed the model-based classification of children into two possible groups, based on the results available from the preliminary plots. The

two-group solution was preferable to the one-group solution for three reasons: (a) the observed smooth curves, (c) the literature on reading development, and (c) the Lo-Mendell-Rubin likelihood ration test ($p = .02$) for two classes being a better fit than one class. The final model contained two groups with the same trajectory and covariate effects for the two reading groups that were described above for math for the entire sample.

Model Covariates and Correlates

There were two types of covariates: (a) time-invariant child characteristics and (b) time-varying classroom measures. The child covariates were used as exogenous predictors of the latent variables, and their coefficients are interpreted as effects on the parameters of the trajectory. These predictors were also used to predict class membership for the reading class trajectories. The invariant predictors were gender and poverty, which was defined as an income-to-needs ratio of less than 2. The effects of time-invariant covariates on the latent class entails that the latent class assignments for the GMM are after the effect of the time-invariant predictors have been partialled out. The time-varying covariates were classroom emotional and instructional quality and the quantity of instruction in reading and math. The classroom quality measures were taken from the COS Classroom Quality factors at first grade, third grade, and fifth grade (see Pianta et al. [2006] for a more detailed description). The quantity of instruction measures were time-sampled codes also obtained at first grade, third grade, and fifth grade (see Pianta et al., 2007). The coefficients for these effects were interpreted as effects at the time of measurement (e.g., third grade), that is, the unique effect of classroom quality or quantity of instruction on the child outcome at that grade. Since the growth parameters and the time-varying effects are jointly estimated in these models, there is a choice to make in the interpretation which depends on the theoretical framework. Either the growth parameters can be thought of as being estimated with the conditional values of the indicators (i.e., reading with the effect COS Quantity conditioned out) or with the time-varying covariates predicting the values of the indicators net the growth parameters (e.g., the amount of an indicator that is not explained by the growth process).

Final Model Results

Results of the final model(s) are presented in Table 5. The estimates reported correspond to the description of model parameters outlined above. For results pertaining to the reading outcome latent classes, readers should refer to the two columns under the header "Reading," and for math outcomes, the column under "Math." The top half of Table 5 presents descriptive results related to the GMM. The bottom half of the table presents results pertaining to prediction of latent classes for reading and math using the time-invariant and time-varying predictor sets. When recoding results pertaining to the time-varying predictors (quality and quantity of classroom experiences) in relation to latent

class membership, the table presents these results for the achievement outcomes at each grade (first, third, fifth) with the "quantity" pertaining to the quantity of exposure in the specific content area (reading or math) corresponding to the column header on the right side of the table.

Reading trajectories. For reading, there were 235 children in the first latent class (i.e., fast readers) and 556 in the second latent class (i.e., typical readers). The probability that the latent class a child was assigned to was also the latent class he or she was most likely to be a member of if the latent class were known was .95 for the first class and .88 for the second class. The first latent class had fewer members, a higher initial value, a higher total change, and a higher percentage of total change at third grade than the second latent class. Therefore, we labeled this class the *fast readers*. The fast readers had an average initial reading level of 384.6 points and an average total change in reading by the fifth grade of 122.7 points. The average proportion of total change by first grade was .93 and the average proportion of total change of .98 by third grade. Hence, about 93% of the total change in reading was achieved by the first grade and 98% by the third grade.

The second latent class obtained for reading trajectories was labeled the *normal readers*. The normal readers had an initial reading level of 370.9 points and the total change in reading by the fifth grade was 117.1 points. The average proportion of total change by first grade was .80 and the average proportion of total change of .98 by third grade. Thus, about 80% of the total change in reading was achieved by the first grade and 98% by the third grade. (Although both trajectories reach 98% of total change by third grade, remember that it was 98% of different amounts of total change.)

The time-invariant effects on class membership were determined by the regression of the child covariates on latent class. This can be thought of as a logistic regression with latent class as the outcome; therefore, following Long (1997), the coefficients for these were interpreted as odds ratios where the exponentiated parameter estimate is compared to 1. In our case, because the coefficients were negative, there were lower odds of being in the fast reading group. On the first latent class of fast readers, there was no significant effect of gender, but there was a significant effect for poverty. Poor children had an odds ratio of .36 (which is the exponentiated value of the parameter -1.03), indicating they had odds 64 points less of being in the fast readers group than children who were not poor. It is important to remember that this parameter represents the effect of poverty on the latent class, which was jointly determined by the underlying reading trajectory, so it will not agree with the overall distribution of children into reading groups.

Fast-reading poor children had an initial value 21.2 points lower than children who were not poor. However, poor children had a total change that was 12.5 points higher, indicating that they made up part of the deficit, on average. There were no significant effects of classroom instructional or emotional quality or quantity of reading instruction on the growth parameters of fast readers' trajectories. This indicated that the fast readers' literacy skills

Table 5
Contemporaneous Change Growth Mixture Model (GMM)
for Math and Reading Growth

Domain	Parameter	Coefficient		
		Fast	Normal	Math: All
Latent class membership	<i>N</i>	235	556	791
	Proportion (correct class membership)	0.88	0.96	1.00
Predictors of class membership	Male	-0.15	0.00	
	Poor	-1.03*	0.00	
Growth model parameters	Intercept	384.6*	370.9*	436.5*
	Variance of intercept (I)	333.8*	315.5*	265.0*
	Total change	122.7*	117.1*	62.8*
	Variance of total change	215.5*	240.5*	148.3*
	Proportion total change by Grade 1	0.93*	0.80*	0.76*
	Proportion total change by Grade 3	0.98*	0.98*	1.01*
Time-invariant effects on growth parameters	Male on intercept	-6.27	-4.06*	-4.50*
	Poverty on intercept	-21.17*	-14.15*	-17.82*
	Male on total change	5.01	3.13*	6.04*
	Poverty on total change	12.54*	1.09	6.88*
Time-varying class roomeffects				
Outcome	Predictor			
Grade 1 WJ-R	Emotional quality	-3.84	-5.95*	-0.79
	Instructional quality	-0.19	2.42	-0.52
	Quantity of exposure	-0.36	-0.36	-0.32
	Quantity by emotional quality	0.06	0.13*	0.06
	Quantity by instructional quality	0.03	-0.05	0.01
Grade 3 WJ-R	Emotional quality	0.50	1.60*	-0.16
	Instructional quality	-0.53	-0.28	0.22
	Quantity of exposure	0.12	0.06	0.28*
	Quantity by emotional quality	-0.02	0.00	-0.02
	Quantity by instructional quality	-0.01	-0.01	-0.03

(continued)

Classroom Effects on Children's Achievement Trajectories

(continued)

Grade 5 WJ-R	Emotional quality	0.90	3.65*	2.41*
	Instructional quality	0.49	-0.27	0.56
	Quantity of exposure	0.27	0.19	0.35*
	Quantity by emotional quality	-0.02	-0.04	-0.01
	Quantity by instructional quality	0.01	0.01	-0.04

Note. WJ-R = Woodcock Johnson Psychoeducational Battery-Revised. Bayesian Information Criteria = 48,011.9; Sample Size Adjusted Bayesian Information Criteria = 47,729.3; entropy = .781.

* $p < .05$.

were developing outside of any influence of the classroom included in our assessments.

On the second latent class of typical readers, there were significant effects for gender on both the initial value and the total change, but there was a significant effect for poverty only on initial value. Male typical readers had an initial value 4.1 points less than females; however, they did have an average total change 3.1 points higher than females. Typical readers classified as poor had an average initial value 14.2 points lower than those children who were not poor.

Although there was no significant main effect of quantity of exposure to reading instruction on reading among typical readers, several effects of quality of teacher-child interactions emerged for typical readers. For third and fifth grade, higher emotional quality in these interactions predicted positive change in reading for typical readers. But counterintuitively, the opposite proved to be the case in first grade; further consideration of this latter finding is deferred to the next paragraph, as it was qualified by an interaction involving quantity of reading instruction. The just-mentioned positive effects of emotional quality indicated that for every point above the mean in third grade, the reading score increased by 1.6 points, and for every point above the mean in fifth grade, the reading score increased by 3.7 points. These two positive effects indicated that there were beneficial consequences for reading development, above the average developmental change for typical readers, due to the positive emotional climate of the classroom.

As noted above, we also were interested in examining a question of moderation: the extent to which *quality* of teacher-child interactions moderated effects of *quantity* of instruction on achievement trajectories. As mentioned above and as presented in Table 5 and plotted in Figure 2, there was a significant interaction in first grade between observed emotional quality of teacher-child interactions and quantity of exposure to instruction in reading. Inspection of Figure 2 reveals, counterintuitively perhaps, that more time spent on reading instruction (i.e., quantity) was related to less improvement in reading and that this was more so the case when the emotional quality of the classroom was low than when it was medium or high, though the same negative relation emerged under these latter classroom conditions as well. To some extent the results are consistent with the general finding that higher-quality emotional

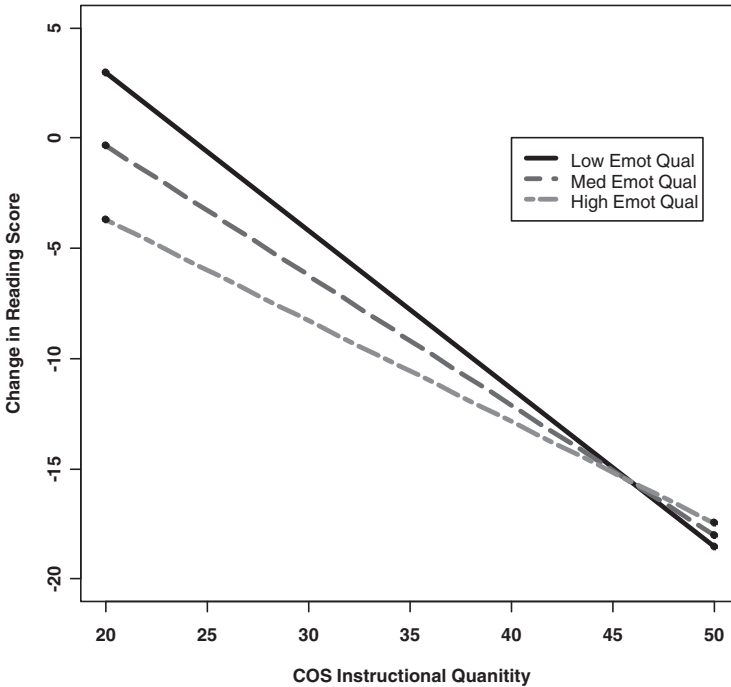


Figure 2. Associations between amount of exposure to literacy instruction and change in reading outcomes at three levels of emotional quality. COS = Classroom Observation System.

interaction was related to more positive outcomes, yet in this case the overall pattern was to reduce the (counterintuitive) somewhat negative effects of more exposure to reading instruction.

Follow-up descriptive analysis. We were also interested in describing the composition of the latent classes in reading, particularly with respect to poverty. In doing this, we must include the caveat noted by Bauer and Curran (2003a, 2004) that the assignment to latent classes is probabilistic in nature, not deterministic; therefore, we only examined descriptive statistics of the classes rather than providing any follow-up models. Figure 3 shows the trajectories of observed means for the fast readers, the typical readers, and both groups together. The clear difference between the fast readers and the typical readers is apparent in terms of starting points, rate of growth, and ending points. Figure 4 shows the trajectories for the fast readers and the typical readers and also by whether they were poor. Descriptively, it is evident that the fast readers who were poor started off lower, at levels more similar

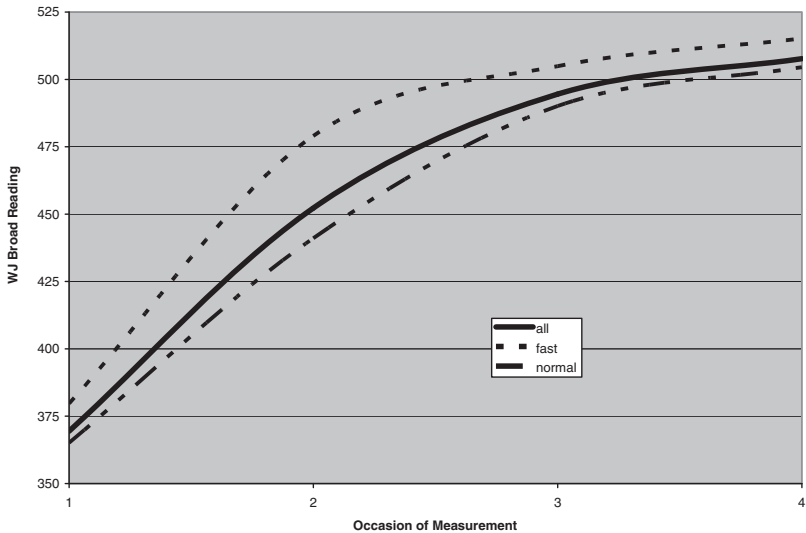


Figure 3. Observed adjusted mean trajectories for reading. WJ = Woodcock Johnson Psychoeducational Battery.

to the poor typical readers, and never actually caught up to the typical readers who were not poor, despite their relatively faster *rates* of growth. Overall, it should be noted that the differences observed are less than half a standard deviation. In the typical reader group, the poor children started below and stayed below all the other children, showing the flattest trajectory of the four groups depicted in Figure 4; that is, their reading developed at the slowest rate. These descriptive results should be interpreted in light of the fact that it was very unlikely for a poor child to be in the fast readers class; only 25 (3.2% of the entire sample) of the fast readers were poor even though 21.9% ($N = 173$) of the entire sample is poor.

Math trajectory. Results for math achievement outcomes are also presented in Table 5. Recall that descriptive plots as well as the modeling framework applied to math outcomes indicated support for only one latent class of growth trajectories. The math trajectory had an average initial value at 54 months of 436.5 points with the average total change by the fifth grade being 62.8 points. The average proportion of total change by first grade was 0.76 and the average proportion of total change of 1.01 by the third grade. Thus, about 76% of the total change in math was achieved by the first grade and, more or less, 100% by the third grade. The fact that the proportion of growth was more than 1 by third grade indicates that the *conditional* trajectory was slightly nonmonotonic. That is, depending on the time-varying effects of observed classroom experiences (quantity and quality of exposures), the

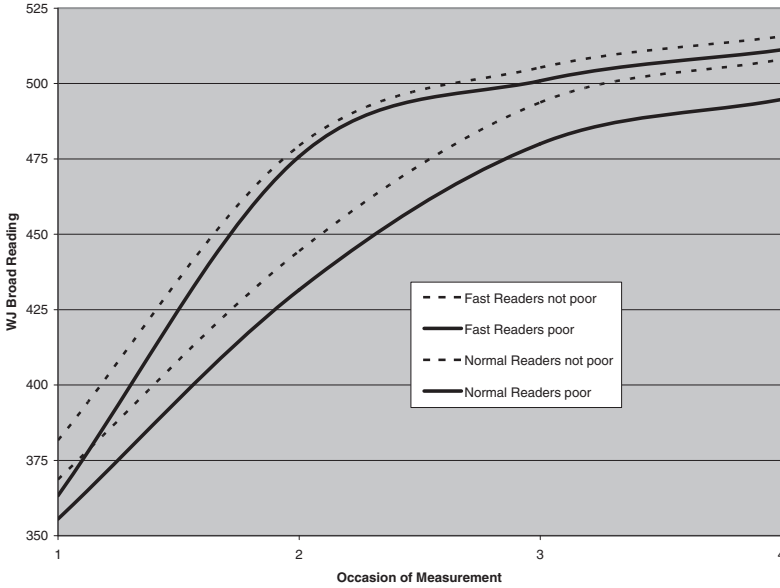


Figure 4. Observed adjusted mean trajectories of reading by poverty. WJ = Woodcock Johnson Psychoeducational Battery.

conditional fifth-grade score was not necessarily higher than the conditional third grade score. Given that exposure to math activities in third grade predicted higher math scores (see Table 5), it is not surprising that the condition growth parameter could be greater than 1 representing the lack of monotonically increasing conditional values.

There were significant effects of gender and poverty for both the intercept and total change parameters. Males had an intercept of 4.5 points lower than females, but the total change for males was 6.0 points higher than for females. Children classified as poor had an initial value 17.8 points less than those not so classified, but they changed 6.9 points more than other children. Only one effect of classroom quality emerged, and this effect was at fifth grade: For every point above the mean on observed emotional quality, a child's math score increased by 2.4 points. There were also effects for quantity of math instruction at both third and fifth grades: For every point above the mean on amount of math instruction, a child's math score increased by 0.28 points in third grade and 0.35 points in fifth grade. Unlike the case for reading outcomes, there was no evidence that quality of instruction moderated the quantity of exposure to math instruction. These effects are all in the range of small in terms of various effect size metrics.

Discussion

Extensive interest has arisen in recent years in the policies, practices, and procedures needed to enhance the performance of America's schools in educating children and preparing them to compete in the knowledge-intensive and globalized economy of the 21st century (e.g., Foundation for Child Development, 2005). Although much attention has been paid to the structural features of schools that are regulated by state and local policy, such as class size, and of teachers, such as level of formal education, most thinking about the importance of such distal factors presumes they exert their influence on children's school performance via instructional and social processes in the classroom, including patterns of teacher-child interaction. And consistent with such thinking, there is indeed a body of evidence showing that the "proximal processes" of everyday interactions between teachers and children are indeed associated with children's academic functioning (e.g., Burnett, 2003; Cameron et al., 2005; Dolezal et al., 2003; Howes et al., in press).

In light of the importance of such everyday classroom activities, the multiyear longitudinal extension of the NICHD Study of Early Child Care (2005)—the NICHD Study of Early Child and Youth Development—sought to investigate schooling effects adopting methods and procedures used successfully in prior phases of the study to illuminate the conditions under which children's development appears (in the context of a nonexperimental research design) to be enhanced or undermined by nonmaternal rearing experiences. Thus, we observed the quality and quantity of instruction the target child received at school, along with the emotional support he or she encountered, while also conducting repeated assessments of outcomes of interest, resulting in a large-scale observationally-based field studies linking classroom experiences with student achievement.

Before proceeding to discuss the general pattern of results as well as specific findings emerging from this study, limits of this work must be acknowledged. A major limitation is our inability to draw strong causal inferences, as implied in the preceding paragraph, with language purposefully noting the nonexperimental, correlational nature of this field study. A second limit of the study involves the sample. Ideally, we would have randomly sampled children from randomly selected classrooms in randomly selected schools so as to produce a representative sample of American children in American schools. This was not possible in the current inquiry, however, as it was designed from its inception as a study of child care to follow children born in 10 locales, selected exclusively on the basis of where investigators worked, into whatever schools (like earlier child-care arrangements) in which they were enrolled. It also would have been preferable to observe classrooms for more hours each day and for more days at each age of measurement, thereby increasing the reliability of measurement of classroom quality; and to study multiple children in each classroom so that multilevel modeling could have been employed, thereby increasing confidence that the (statistical) "effects" detected in this inquiry applied to more than just the target children enrolled

in the longitudinal study. Clearly the observational assessments of the quality of teacher-child interactions were limited in the sense that they were neither exhaustive of the possible constructs that could be assessed nor intentionally aligned with the specific curricula being implemented by the teacher. For both of these reasons, these observations may reflect a more molar approach that could have led to an underestimation of classroom effects. Finally, the use of a common standardized test for achievement across a very wide range of classrooms and curricula, although providing a common metric, most likely obscures the possibility that classroom effects can be smaller or larger than those estimated if the outcome assessment was better aligned with the nature and focus on instruction. These limitations argue for caution in the interpretation of results.

Results of the present investigation, which took advantage of observational data gathered when study participants were in first, third, and fifth grades in hundreds of elementary schools and of repeated assessments of children's academic achievement at these ages, revealed significant, albeit limited, relations between proximal classroom processes and children's development in reading and math. The correlational evidence suggests, but does not causally demonstrate, that observed classroom experiences, particularly in terms of socioemotional qualities of interactions and instruction, matter somewhat when it comes to producing gains in children's performance. Before proceeding to discuss these results, it needs to be reiterated that this evidence of such potential, even if limited, impact of classroom processes emerged after taking into account not only family poverty status and child gender but also the child's tested literacy and numeracy skills before starting school. In other words, the current study was an investigation, again in the context of a nonexperimental design, of the potential "added value" that classroom experience contributes to the prediction of individual differences in children's academic development over and above what the child brings to school, both developmentally and in terms of family background.

Predicting Math Achievement

The limited evidence suggestive of the potential influence of proximal classroom processes in the case of math achievement called attention to both the amount of exposure to math instruction and the emotional support the child experienced from their classroom teacher. Consistent with expectations that "time on task" matters (Entwisle & Alexander, 1999), and thus that greater exposure to math instruction would facilitate math achievement, more time spent being taught math in both third and fifth grades predicted better math achievement over and above what would have been expected on the basis of general developmental trajectories (which took into consideration family poverty, child gender, and prior math achievement). It is perhaps not surprising that higher levels of exposure to math instruction would be related to gains in math achievement (see Nye, Konstantopolous, & Hedges, 2004), and it is important to point out that other results we have

reported from these classroom observations show that the amount of math instruction offered to students is, on average, higher in third and fifth grades than in first grade but still quite variable from classroom to classroom (see NICHD ECCRN, 2002, 2005; Pianta et al., 2006), and overall quite low in terms of absolute time.

But it is not just quantity of math instruction that appeared to contribute to math achievement in this correlational study. Recall that greater emotional support in fifth-grade classrooms also predicted enhanced math achievement in fifth grade, suggesting the child's experience of the classroom as a social/emotional setting may contribute to improved math performance, perhaps as a function of increasing motivation, attention, and engagement (Crosnoe et al., 2004; Pianta et al., 2002; Zins et al., 2004). It has been widely reported that early adolescents respond more positively in terms of learning gains and motivation when classroom settings are cooperative and regarded by students and others as emotionally supportive (Eccles, Early, Fraser, Belansky, & McCarthy, 1997; Eccles, Wigfield, & Schiefele, 1998; Wentzel, 2002). Although it was true that the measurements of classroom emotional support took into account the child's experience throughout the school day, not just during math instruction, not to be forgotten is that for the vast majority of students studied, classroom experiences in math involved teachers who instructed them in most of the other subjects. In view of other evidence from this study showing that emotional support during math was systematically related to emotional support during other times of day (see Pianta et al., 2007), it could be that the results reported above are either due to math-specific emotional support or accrue as a consequence of the child's general experience of school. This is especially interesting because math is perhaps not a subject where teacher-student relations are as much a focus, because math involves more technical skills and focus than literature or social studies, which can often include content with a "humanistic" slant.

Predicting Reading Achievement

When it came to the prediction of reading achievement, it proved necessary to examine relations between proximal classroom processes and development separately for two subgroups of readers because trajectory analyses revealed two distinct groups, a larger one that seemed to be developing at a normal rate and a smaller one that proved to be developing substantially faster. Distinguishing between these two groups, identified in other work (e.g., Cameron et al., 2005), represents one of the strengths of the current investigation, a strength borne out by evidence that classroom processes differentially predicted reading achievement for these two groups.

For the fast readers, whose growth trajectories accelerated rapidly between 54 months and first grade, observed classroom processes (quality or quantity of instruction, or their combination) failed to predict growth parameters across the period through fifth grade. Importantly, then, the quality or quantity of literacy activities in the classroom across the primary school years

could not account (statistically) for why the deficit in 54-month literacy skills for poor students within the fast-reading group was reduced somewhat by the time children's reading achievement was tested in fifth grade. That is, the quality or quantity of literacy activities in the classroom across the primary school years cannot explain, even in this correlational study, why the deficit in 54-month literacy skills within the fast-reading group was reduced by the time children's reading achievement was tested in fifth grade. Given reference in the introduction to other work on this sample suggesting that quality (not quantity) of classroom experience contributed to the elimination of the achievement gap between risk and nonrisk groups in first grade (Hamre & Pianta, 2005; Rimm-Kaufmann et al., 2005), this was somewhat surprising. This apparent discrepancy is likely a product of these studies' using very different methods for identifying risk groups, which in the case of the present study was quite broad whereas in the two cited studies risk was defined in terms of children's behavioral indicators tied to classroom interactions.

We suspect there are several reasons for the lack of effects detected in reading, which involve combinations of the flaws in both the observational system and the assessment of reading outcomes. Specifically, as noted earlier, for fast readers it is likely that the assessments of reading skill were insensitive to growth in unassessed skill domains (e.g., comprehension) that are the focus of instruction in the higher grades, thereby reducing the likelihood that any observation of classroom process could predict growth. It should be noted, however, that others have reported reading growth to be insensitive to classroom-level inputs by third grade (Nye et al., 2004). In terms of classroom effects on reading in the early grades, we note that in this case the observational system was somewhat insensitive to qualities of instruction that are curriculum-specific, and that may be the driving force in predicting growth, as has been reported by Morrison and Connor (2002).

In the case of the larger group of typical readers, classroom processes proved related to the development of reading skills, but the statistical relations discerned between predictors and outcomes varied by grade level. Somewhat surprisingly, improvement in reading from 54 months to first grade was predicted, as a main effect, by classrooms observed as less rather than more emotionally supportive (see Figure 2), a finding that could be related to the possibility that a more basic-skills, structured focus to instruction in first grade, which has been shown to be effective for many students (Morrison & Connor, 2002), could have been judged by raters as somewhat less supportive emotionally than classrooms lacking in this instructional focus. An alternative interpretation arises, however, in the face of the interaction between emotional support and quantity of reading instruction that qualified the main effect of emotional quality just considered. The fact that more reading instruction was related to less progress in reading when emotional quality was low raises the prospect that when great effort—in terms of time on task—is spent teaching reading, but the emotional climate of the classroom is limited, the effort may prove counterproductive. It should also be noted that the overall amount of instruction in literacy is less varied and quite high (on average

more than an hour a day) in the typical classroom, which may attenuate correlations between amount of exposure and outcomes in literacy.

Whatever the reasons for the above results in first grade, findings proved rather different in later grades—and far more in line with straightforward commonsense expectations: Emotional quality of the classroom predicted better third- and fifth-grade literacy outcomes, just as it did math achievement in fifth grade.

Overall, the reading and math achievement results, at least in third and fifth grade, call attention to the potential importance of the general emotional climate of the classroom and the specific social-emotional experiences children have with teachers within the classroom. A reasonable interpretation of this correlational result calls attention again to the importance of feeling emotionally comfortable and supported in the classroom and thus, conceivably, of liking school and the ways in which an emotionally secure relationship provides support for the child's exploration and mastery of difficult tasks (Eccles et al., 1998; Gregory & Weinstein, 2004; Rimm-Kaufman et al., 2005), even in middle childhood. A reasonable, albeit noncausal, implication of these results is that efforts to improve children's achievement by changing schooling processes should attend to the social and emotional side of the learning process in addition to instruction. We also note that in the present study it is likely the case that the observations of classroom interactions may have been more robust for socioemotional qualities of interaction and less so for the instructional dimensions of teacher-child interactions, for which there were a smaller number of scales.

As we noted earlier, the scales used to assess the quality of instruction, particularly at first grade, were small in number and we suspect perhaps too global. In fact, in subsequent scale-development work following from these initial efforts (see Hamre & Pianta, 2007; Pianta & Allen, 2006; Pianta et al., 2005), teacher-child interactions in classrooms have been reconceptualized into three broad domains (emotional, organizational, and instructional) and scales created to better sample instructional processes. Initial findings suggest that this effort provides a better sampling of classroom processes relevant for learning than were assessed by the initial versions of the COS. Given both the shortcomings of the outcome assessments in relation to measuring higher order reading and curriculum-aligned skills and the shortcomings just noted in the observation instrument for assessing instruction, as well as the scale of the study, which spanned hundreds of different classrooms, all of which implemented varying curricula in different ways, it is not surprising that the effects detected for classroom processes were small or nonexistent.

The Development of Reading and Math Achievement

Although the primary goal of the current inquiry was to examine relations between proximal classroom processes and children's achievement, it was necessary to describe patterns of reading and mathematics development in order to make progress toward this end. Beyond the identification of two

reading subgroups, several interesting observations derive from the trajectories identified, especially with respect to patterns of change over time, gender differences, and poverty differentials.

In the case of both mathematics and reading, it seems noteworthy that most of the change that took place in tested achievement did so by first grade. In fact, 76% of measured change in mathematics occurred by first grade, with 93% and 80% of total improvement in reading taking place by this same time in the case, respectively, of fast and normal readers. No change in the case of mathematics and virtually no change (i.e., 2%) in the case of reading (of both reading groups) took place after third grade. It comes as little surprise that poverty was associated with poorer performance in both mathematics and reading. Children who were poor scored lower than their nonpoor counterparts in math as early as 54 months, a difference that remained over time. Poor children were also less likely to be in the fast-reading group (2% probability vs. chance probability of 19%). In fact, despite more than 20% of the sample being categorized as poor, fewer than 5% of poor children were in the fast-reading group. And even though, as already noted, poor children in this group improved in reading faster than did their nonpoor counterparts, with the 54-month deficit decreasing by almost 60% by fifth grade, they never caught up with their more economically advantaged age-mates. Within the normal reading group, poor children also manifest an initial deficit, but this time one that remained more or less as large at the last time of measurement as the first. These findings are consistent with studies showing that by the end of third grade school achievement over the long term is highly predictable (Entwisle & Alexander 1999) and provide yet one more source of empirical support for the argument that closing achievement gaps between groups of students is best addressed through educational services delivered well before kindergarten starts (Lee & Burkham, 2002; Rouse et al., 2005).

However, it would be premature to embrace this conclusion about the locus and timing of classroom effects on achievement. Clearly there is strong support for focusing early and intensively, particularly on literacy. But it is also the case that the measurement weaknesses of the present study, both for outcomes and classroom inputs, as well as the broad scope and scale of the study crossing so many different curricula, make any conclusions about the potential impotence of elementary-age interventions premature or simply incorrect. Rather, the results may warrant attention to the potential need for more well-developed assessments of late-elementary classroom processes as well as studies in which such observations are examined in relation to outcome assessments that are better aligned with the curriculum being taught.

In sum, this comprehensive, nonexperimental field study revealed limited and modest predictive associations between observed classroom experiences of quantity and quality of instruction and rates of achievement growth in reading and math during elementary school. That such (statistically significant) effects are modest is not surprising given that prior achievement was included in these models, thus the focus on growth, and that there is ample evidence that classroom settings are not particularly potent environments for

producing achievement growth beyond the contributions of family factors to such outcomes. That emotional quality of the classroom setting—the warmth of adult-child interactions, as well as the adults' skill in detecting and responding to individual children's needs—was a consistent predictor of both reading and math skill growth confirms theoretical frameworks emphasizing the importance for child development of relationships with adults—even beyond early childhood—and frame the need for practices and policies that emphasize not only instruction but also relationships (Midgley & Edelin, 1998), a conclusion that has both theoretical and empirical support.

Note

This study was directed by a steering committee and supported by the National Institute of Child Health and Human Development (NICHD) through a cooperative agreement (U10), which calls for scientific collaboration between the grantees and the NICHD staff. Participating investigators, listed in alphabetical order, are Jay Belsky, Birkbeck University of London; Cathryn Booth-LaForce, University of Washington; Robert Bradley, University of Arkansas, Little Rock; Celia A. Brownell, University of Pittsburgh; Margaret Burchinal, University of North Carolina, Chapel Hill; Susan B. Campbell, University of Pittsburgh; K. Alison Clarke-Stewart, University of California, Irvine; Sarah L. Friedman, CNA Corp., Alexandria, Virginia; Kathryn Hirsh-Pasek, Temple University; Renate Houts, Research Triangle Institute; Aletha Huston, University of Texas, Austin; Jean F. Kelly, University of Washington; Bonnie Knoke, Research Triangle Institute, Research Triangle, NC; Nancy Marshall, Wellesley College; Kathleen McCartney, Harvard University; Fred Morrison, University of Michigan; Marion O'Brien, University of North Carolina at Greensboro; Margaret Tresch Owen, University of Texas, Dallas; Robert Pianta, University of Virginia; Wendy Robeson, Wellesley College; Susan Spieker, University of Washington; Deborah Lowe Vandell, University of California, Irvine; and Marsha Weinraub, Temple University. We express our appreciation to the study coordinators at each site who supervised the data collection, the research assistants who collected the data, and especially to the families and child-care providers who welcomed us into their homes and workplaces and cooperated willingly with our repeated requests for information. Correspondence concerning this article should be addressed to NICHD Early Child Care Research Network, CRMC, NICHD, 6100 Executive Blvd., 4B05, Rockville, MD 20852.

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