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The Persistence of Preschool Effects: Do Subsequent Classroom Experiences Matter?

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Abstract

Using rich longitudinal data from the Early Childhood Longitudinal Study – Kindergarten cohort (ECLS-K), we find that children who attended preschool enter public schools with higher levels of academic skills than their peers who experienced other types of child care (effect size of .14). This study considers the circumstances under which the preschool advantage persists, that is, the types of classrooms in which students who did not attend preschool "catch up" to their counterparts who did. Specifically, we focus on two dimensions of the early school environment – class size and the level of academic instruction provided. The findings suggest that most of the preschool-related gap in academic skills at school entry is quickly eliminated for children placed in small classrooms providing high levels of reading instruction. Conversely, the initial disparities persist for children experiencing large classes and lower levels of reading instruction. These results point out that the longer-term effects of early childhood experience partly depend on classroom experiences during at least the first years of school.

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Increases in state and federal support for early education programs suggest a growing commitment to investing in school readiness (Blank, Schulman, & Ewen, 1999). Proponents of such investments argue that higher levels of academic and social skills at school entry translate into long-term benefits for children (Committee for Economic Development, 2002). However, the extent to which early education represents a wise investment of public funds is determined not only by higher levels of school readiness, but also how well subsequent classroom and school experiences serve to maintain these early gains.

The short-term academic benefits of early education or preschool programs are well established. However, for many children the advantages bestowed by early education fade by the second or third year of formal schooling, as their counterparts who did not attend early education programs "catch up" (Barnett, 1995; Lazar, Darlington, Murray, Royce, & Snipper, 1982; McKey et al., 1985). Consequently, formal schooling experiences may play a pivotal role in the extent to which preschool effects persist. Determining how subsequent educational contexts promote or hinder the persistence of preschool effects is critical to constructing a set of education policies that foster and sustain early achievement (Ramey & Ramey, 1992).

Background

Early education research has focused on documenting programs' effects on young children's cognitive, academic, and social development, with some attention to the persistence of these effects into the early school years. Previous analyses suggest that center-based care and preschool programs during the third and fourth years of life raise academic preparedness and performance at school entry (Magnuson, Meyers, Ruhm, & Waldfogel, 2004; NICHD ECCRN, 2002a; NICHD ECCRN & Duncan, 2003; Shonkoff & Phillips, 2000). Particularly sizable benefits are found for disadvantaged children and those who experience high quality care, including high levels of academic instruction (Magnuson et al., 2004; NICHD ECCRN & Duncan, 2003; Stipek et al., 1998).

Experimental evaluations indicate positive *long-term* effects of model high quality early education programs for disadvantaged children's academic achievement and educational attainment (see reviews in Blau & Currie, in press; Shonkoff & Phillips, 2000). Accumulated evidence suggests that more typical large-scale programs may also have persisting effects on school outcomes such as grade retention and special education placement, but the non-experimental studies do not consistently find long-term effects of these programs on academic achievement (Barnett, 1995). For example, Currie and Thomas (1995) show that the gains from Head Start persist through the early elementary school years for white but not African-American children, whereas Barnett & Camilli (2002) find that the effects of Head Start fade out for both (non-Hispanic) white and black children. These results are consistent with previous studies of Head Start and other large scale program evaluations indicating that the initial effects dissipate after a few years of formal education (McKey et al., 1985). However, Barnett and Hustedt (2005) warn that many studies of large-scale programs have been plagued by problems of sample attrition.

Why might the effects of preschool programs persist for some children, but not others? One common explanation is that subsequent school experiences matter. Learning academic skills is a cumulative and complementary process involving both mastering new skills and improving existing abilities (Entwisle & Alexander, 1993; Epps & Smith, 1984; Pungello, Kupersmidt, Burchinal, & Patterson, 1996). Research by the NICHD Early Child Care Research Network (2004c) suggests that early education and child care experiences affect children's academic skills at school entry, which in turn are linked to their later achievement. In addition, their findings indicate that first grade classroom instructional contexts also predict children's later achievement. This research demonstrates that learning experiences both prior to the start of school and in the first school years are important influences on children's achievement. However, it does not consider whether the effects of child care and preschool differ depending on children's subsequent classroom experiences.

Children who attend early education, and thus have higher skills at school entry, may be uniquely positioned to benefit from enriching learning environments if skill acquisition is a cumulative process, whereby early learning facilitates subsequent achievement (Cunha, Heckman, Lochner, & Masterov, 2004; NICHD ECCRN, 2004a). That is, provided with good instruction in classrooms, children with an initial skills advantage may learn more than their less-skilled peers. Conversely, without enriching and stimulating instruction in the initial years of school, the academic skills of preschool attendees may stagnate, and their initial advantages may be lost (Woodhead, 1988; Zigler & Styfco, 1994).

Few researchers expect that a year or two of even high quality early education can alter children's learning trajectories, unless subsequently reinforced by good classroom experiences. Thus, a common explanation for the "fade out" of effects among groups such as African-American children is that these children go on to attend low-quality schools (Currie & Thomas, 2000; Lee & Loeb, 1995). On the other hand, the deficits initially experienced by children, including those who did not attend preschool, might be reduced by enriching early school environments (Downey, Broh, & von Hippel, 2004; Hamre & Pianta, 2005). In this scenario, high quality experiences in the early elementary years compensate for lower levels of skills at school entry.

Pointing to subsequent school experiences as an explanation for the fade out of preschool effects assumes that some classrooms are more enriching than others. Research in early education has considered both process and structural indicators of classroom quality. In terms of process, accumulated research and theory argues that time spent "on task" (engaging in learning activities) and exposure to higher quality instruction lead to academic gains (Phillips & Chin, 2004). Observational studies suggest that early elementary classrooms vary widely along these important dimensions (Hamre & Pianta, 2005; Pianta, La Paro, Payne, Cox, & Bradley, 2002). Yet, identifying links between classroom processes and children's achievement in survey research is challenging because the former are difficult to measure and the effects may vary with children's backgrounds and achievement levels (Connor, Morrison, & Petrella, 2004; Hamre & Pianta, 2005).

One important structural dimension of quality is class size. Small classes are believed to be beneficial because they increase the amount of individual attention that students receive and improve the quality of instruction by, for example, reducing the time spent by teachers on discipline and classroom management (Ehrenberg, Brewer, Gamoran, & Willms, 2001; NICHD Early Child Care Research Network, 2004b). Experimental evidence confirms that smaller classes improve academic skills, with particularly pronounced effects for disadvantaged children (Ehrenberg et al., 1999; Walston & West, 2004; Xue & Meisels, 2004).[1] Similarly, time spent on academic instruction is consistently associated with achievement gains (Hill, Rowan, & Ball, 2005; Myer, Waldrop, Hastings, & Linn, 1993; NICHD Early Child Care Research Network, 2004a; Pianta et al., 2002), presumably because it directly engages young children in academic learning activities and provides evaluative feedback (Harme & Pianta, 2005).

Nearly all scholars agree that teacher quality, including general academic ability and knowledge of the subject taught, is a determinant of student learning. Teachers' IQ, academic test scores, and experience are consistently linked to student achievement (Greenwald, Hedges, & Laine, 1996). The type of instructional method used is also linked to early learning, with more child-centered and less didactic teaching techniques typically proving more beneficial (Huffman & Speer, 2000; Stipek, 2004). Yet teacher quality is difficult to measure and the usefulness of

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[1] There is uncertainty about how small classes need to be. Evidence from the Tennessee Star experiment suggests that class sizes of less than 17 are beneficial (Nye, Hedges, & Konstantopoulos, 2001), whereas recent research by NICHD ECCRN (2004a) indicates that class sizes of less than 21 promote academic skills. See also the review by Krueger (2000).

commonly available survey indicators – such as meeting certification requirements or holding a masters degree – is controversial (Darling-Hammond & Youngs, 2002; Goldhaber & Brewer, 2000).

Previous research has not directly examined whether children in enriching early school environments maintain their academic advantage through the beginning grades or, framed another way, whether, and under what circumstances, their peers are able to overcome their initial deficits and catch up. One reason this may not have received more attention is because few longitudinal studies of early education programs also collected data on later school experiences. Some indirect evidence comes from a quasi-experimental evaluation of the Chicago Child Parent Centers (CPC) programs conducted by Reynolds and Temple (1998). The CPC is a public prekindergarten program for low-income children, consisting of part-day preschool for 3- to 4-year olds taught by teachers with college degrees and early childhood certification, as well as a follow-on program during the early elementary school years. The preschool program emphasized early language development, promoted parental involvement, and offered comprehensive services, such as meals and health screenings. The follow-on program provided reduced class sizes and encouraged parental involvement for the first three years of elementary school (Reynolds, 1994). The evaluation found higher academic achievement among children attending preschool *and* the follow-on program compared with students who attended only preschool, suggesting that high quality early elementary classroom experiences may be crucial for maintaining the positive effects of preschool, at least for disadvantaged children.

Although this explanation is intuitively appealing, evidence is sparse and several studies of preschool follow-on programs provide more mixed support (Campbell & Ramey, 1995; Ramey et al., 2000). For example, another intensive early education program, the Carolina Abecedarian Project, had positive long-term effects on disadvantaged children's academic achievement but an experimental evaluation indicated that a parent-focused follow-on program in early elementary school did not independently contribute to the persistence of the program's benefits (Campbell & Ramey, 1995). However, because both control and experimental children in this program attended high quality schools, the follow-on program might not have been instrumental in assuring that children experienced enriching educational environments.

The present study investigates whether the benefits of preschool persist longer for children subsequently experiencing enriching academic learning environments. The present study builds on earlier research investigating effects at school entry and the spring of first grade (Magnuson et al., 2004; Magnuson, Ruhm, & Waldfogel, in press) by examining whether the consequences of preschool differ according to children's subsequent classroom experiences. Specifically, we use regression analysis to estimate the effects of preschool on academic achievement through the spring of third grade for a sample of public school children. We focus on two measures of classroom quality: the average amount of reading instruction and class size.

Methods

Sample

Data were taken from the Early Childhood Longitudinal Study – Kindergarten Class (ECLS-K). Conducted by the National Center for Educational Statistics (NCES, 2004), the ECKS-K collects information for a large, nationally representative sample of children who entered kindergarten in the fall of 1998, with additional data available on their families, schools and classrooms. Currently, five waves of the survey are available, beginning in the fall of kindergarten and continuing through the spring of third grade.

Our sample consists of 7,748 children who were in kindergarten for the first time in the fall of 1998 and who subsequently attended public schools. We limited the sample to those in public schools because the student population and many characteristics of the classroom environment may be different in private schools.[2] We restricted our sample in two other ways. First, we excluded children without parent reported survey information during the fall of kindergarten – because this is the source of information on children's preschool experiences – or without teacher-reported information on classroom characteristics, which are the key explanatory variables. Second, we included only those who completed math and reading assessments in the fall of kindergarten, spring of first grade and spring of third grade.

The full kindergarten fall sample included 18,790 students for which there is at least partial assessment data. From this total, we excluded 7,443 children with incomplete data on reading and math skills in the fall of kindergarten, spring of first grade, or spring of third grade (this includes children who changed schools a proportion of whom were not followed by design), 596 for missing parent survey data during the fall of kindergarten, 419 who were not first time kindergartners in the fall of 1998, 2,462 private school attendees and 122 with missing measurements of teacher and classroom contexts over the first four years of school.[3]

These exclusions create a consistent sample with which to estimate preschool's initial associations with academic skills and the persistence of these associations. By design the ECLS-K study followed only half of the students who changed schools, and consequently, our sample contains only a portion of children who changed schools prior to third grade spring. Although these sample restrictions should be noted when interpreting our findings, the proportion of children in preschool in the year before kindergarten was nearly identical among the excluded and included students, suggesting that the analysis sample is reasonably representative with respect to this important dimension.

In the fall of kindergarten, our sample contains an average of 13 children from each school and about 6 children per classroom. By the spring of third grade, there are approximately

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[2] Similar results were obtained in preliminary analyses that included private school students, although there were some disparities in the predicted effects of class size when restricting the sample to private school students.
[3] Reading assessments were not conducted with children who were not found to be proficient in English. All other children were included (thus, children were not dropped if they did not achieve a particular threshold score).

11 students per school and 4 students per classroom. Moreover, in the spring of first grade nearly 33% of the children in our sample are in a classroom with only at most one other sampled child, and by the spring of third grade this proportion had risen to 42%. One explanation for the increased sample dispersion is that some students moved to schools not in the original sampling frame.

Measures

Reading and Math Skills. Reading and math skills during the spring of third grade are the primary outcomes of interest. These measures, which are derived from one-on-one assessments of children, are transformations of latent ability scores into standardized t-scores that have a mean of 50 and standard deviation of 10 (based on the full sample distribution). Comparable standardized t-scores are available for skill assessments in the fall and spring of kindergarten and spring of first grade. T-scores were used because they measure children's performance relative to their peers, rather than their absolute level of skills, and thus are well suited to identifying changes in skill gaps over time. Our sample of 7,748 children scored slightly better than the full ECLS-K sample, likely reflecting the disproportionate attrition of less-skilled children. Reading and math skills were highly correlated at each survey wave (ranging from .69 to .75, $p<.01$).

The third grade spring reading test assesses phonemic awareness, single word decoding, vocabulary, and passage comprehension. The math assessment tests for conceptual knowledge, procedural knowledge and problem-solving. NCES created these assessments and reports high reliabilities for them (National Center for Educational Statistics, 2004).

Changes in children's academic skills are also sometimes examined. The mean change in math skills from kindergarten fall to third grade spring is .29 (with a standard error of .08) and that of reading skills is 1.01 (with a standard error of .10). Changes in children's reading and math skills were moderately correlated ($r=.39$, $p<.01$).

Preschool and Child Care. During interviews in the fall of kindergarten, parents were asked if their child had ever been in: center-based child care (referred to hereafter as "preschool"), relative care, non-relative care, or Head Start. [4] We use the term "preschool" because when asked what type of center-based care their children were in, the vast majority of parents indicated it was a preschool or prekindergarten program. For children in these arrangements in the year prior to kindergarten, parents were asked a series of additional questions, such as the number of hours of care during a typical week. Using this information, we created three mutually exclusive dichotomous variables indicating whether the child experienced preschool (including preschool, prekindergarten, nursery school, and day care), Head Start, or other non-parental child care (e.g. relative care, babysitters, family day care) in the year before kindergarten.[5]

Preschool and Head Start both represent forms of early education. We distinguish between them, and focus primarily on preschool, in part because of difficulties in constructing an appropriate comparison group in the ECLS-K for the very disadvantaged Head Start attendees (Magnuson et al., in press). Preschool was the most common care arrangement in the year before kindergarten among this sample (57 percent), followed by parental care (18 percent). On average, children attending preschool did so for about 20 hours a week and those in Head Start attended for about 23 hours per week.

Classroom Contexts. Class size and the amount of language arts instruction are our measures of the educational environment. Selection of these classroom contexts was guided by previous literature, which suggests that each is linked to academic gains, as well as limited data

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[4] These surveys were primarily conducted with mothers. If the mother was unable to complete the interview, another knowledgeable adult in the household did so.

[5] The use of mutually exclusive categories makes it easier to interpret the results. These were created by placing children experiencing preschool and other non-parental care in the preschool category, those in Head Start and other non-parental care in the Head Start group; those with both Head Start and preschool were categorized according to the type of care where they spent the greatest number of hours per week. Approximately 35% of children in preschool, and 42% in Head Start, were also in other non-parental care arrangements. Overlap between preschool and Head Start was much lower – only 4% of children who attended preschool were also in Head Start.

for other dimensions of quality.[6] In each case, we created a child-specific average across three waves of data collection (kindergarten spring, first grade spring, third grade spring) and then created two indicators of classroom context by dividing the sample at the median value. We chose this approach because neither prior research nor theory provides clear guidelines about how to best categorize classrooms along these dimensions, and also because it created subsamples of roughly equal size, ensuring that differences in statistical power do not influence our interpretation of the findings.[7] Sensitivity analyses demonstrated that the results are robust to slightly varying definitions of the subgroups.

Median class size – averaged over the spring of kindergarten, first and third grade – is 20.5 students. Children whose average class size exceeds this (about 47% of the sample) were coded as having experienced large classes. Over 96% of teachers indicated that they engaged in reading and language arts lessons and projects on a daily basis, with almost all of the remainder doing so three or four times a week. For this reason, our measure of academic instruction focuses on the time spent in these activities. The teacher survey includes four response categories measured in 30 minute increments, ranging from 1-30 minutes (1) to more than 90 minutes (4). The median level of reading instruction (averaged across the three grade levels) is 3, corresponding to 61- 90 minutes a day. Therefore, we defined low levels of reading instruction as 61- 90 minutes a day or less of this activity. About 54% of students fall into this category.[8]

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[6] For example, the only available measure of teacher quality is educational attainment, which is less strongly predictive of children's learning than the teacher's subject knowledge, intelligence or teaching experience (which are not available for all waves of data).

[7] Teacher survey responses are missing for some children. As noted, we excluded children who did not have at least one valid observation of class size and the amount of reading instruction (n=122). For the remainder, we created averages based on all non-missing data. Nearly all of the students had at least two valid measurements across the three survey waves. Excluding children with fewer than two valid measurements on any one dimension (n=1,036) does not materially change the results.

[8] We chose not to characterize classrooms according to math instruction because only 81% of classrooms engaged in math activities on a daily basis; thus an accurate indicator would need to consider both how often and how much time was spent on math lessons and projects. However, the amount of math and reading instruction children experience is highly correlated (r=.50).

The correlation between the two indicators (class size and academic instruction) is surprisingly low (r=.02, n.s.), suggesting that they measure different aspects of classroom quality.

Children are not placed into different classroom environments entirely at random. For example, those in classes with low levels of reading instruction were less likely than their counterparts to be Hispanic (11% vs. 15%) or Asian (4% vs. 6%), had slightly greater income to needs ratios (3.07 vs. 2.83) and higher levels of maternal education (57% vs. 55% had more than a high school degree). Children in large classes were less likely to be Native American (1% vs. 2%), had more educated mothers (58 % vs. 55% had more than a high school degree), and were less likely to live with step-parents (7% vs. 9%). These comparisons suggest that children in low quality classrooms may have been slightly more advantaged than their peers, but the magnitude of these differences is small.

Covariates. Most regressions contained exhaustive controls for child, family background, and neighborhood characteristics. These include demographic and family measures such as race/ethnicity, age, health status at birth, height, weight, gender, household income-to-needs ratio, parental education, region of the country, family structure and size, and language spoken in the home. Appendix Table 1 provides details on all of the covariates.

We also used data from the fall and spring of kindergarten parent surveys to create controls for an extensive set of home and family resources as well as parenting practices that may be related to early child care, education experiences, academic skills, and behaviors. The learning environment was proxied by activities such as reading books and singing songs, children's participation in structured activities outside of the home, their use of home computers, and the number of books in the home. Also included were parental expectations of the child's educational attainment, attitudes about the importance of particular skills, family members' involvement in the child's schooling, parental responses to questions about the warmth and affection of the relationship with their child, the frequency of physical discipline, a composite measure of parental depressive symptoms, and several measures of the regularity of the family routines (e.g., eating meals together).

Neighborhood characteristics were captured through a composite quality index based on parent-reported information about the prevalence of crime, abandoned buildings, drugs, and safe places for children to play in the neighborhood. We also controlled for the log of state per capita income and public spending on welfare and education programs in 1998, using data from US Bureau of the Census (2001).

Information on one or more background characteristics is lacking for some children; however, rates of missing data are quite low, below 3% for most child and family characteristics. To retain these cases, the relevant regressors were set to zero and dummy variables were created to denote the presence of missing values (Allison, 2002). For example, when parents did not report the child's birthweight, the two low birthweight variables were coded as having a value of zero, and a dummy variable indicating missing birthweight data (1=yes; 0=no) was created.

Procedures

Using multivariate OLS regressions, the data analysis proceeded in three steps. First, we estimated associations between preschool attendance and children's math and reading skills measured at school entry (fall of kindergarten), spring of first grade, and spring of third grade. Second, the persistence of the initial effects of preschool was assessed by examining how preschool attendance is related to *changes* in math and reading test scores from the fall of kindergarten to the spring of third grade. This analysis was conducted for the full sample and separately for children in differing classroom environments. Third, interaction terms were entered into full sample regressions to formally test for the moderation of preschool effects by classroom contexts.

The following OLS regression was used to estimate the effects of preschool on academic skills:

$$(1)\ \ SKILLS_{it} = ß_1 + ß_2 PRE_i + ß_3 HS_i + ß_4 OC_i + ß_5 COV_{it} + \xi_i ,$$

where $SKILLS_{it}$ is a measure of the reading or math performance for child *i* at time *t,* PRE_i is a dummy variable for attending preschool in the year prior to kindergarten, HS_i is a dummy variable for Head Start attendance, OC_i is a dummy variable for the receipt of other non-parental care, and COV_{it} is a set of covariates measuring the child, family, neighborhood and policy characteristics described in Appendix Table 1. The comparison group consists of children without regular non-parental care in the year prior to kindergarten.

The regression coefficient, $ß_2$, estimates the effect of preschool attendance on academic skills in the fall of kindergarten, as well as the persistence of these effects through the spring of first and third grades. The tables display Huber-White robust standard errors, which correct for the non-independence of observations within schools (the primary sampling unit). In the text, we report effect sizes (proportion of a standard deviation) for all estimates.

Next, we examined the relationship between preschool attendance and *changes* in children's skill levels (ΔSKILLS) over the first three years of formal schooling, as estimated by:

$$(2)\ \ \Delta SKILLS_i = ß_1 + ß_2 PRE_i + ß_3 HS_i + ß_4 OC_i + ß_5 COV_{it} + \xi_i ,$$

with all variables defined as previously described. Given that preschool is associated with higher skill levels at school entry, we anticipated that other children will at least partially make up these initial deficits over time, implying that preschool enrollment will be negatively associated with changes in achievement (between fall of kindergarten and spring of third grade). Equation (2) has the advantage of adjusting for observed covariates and unobserved time invariant characteristics associated with early achievement and preschool enrollment, which might otherwise lead to biased estimates (NICHD ECCRN & Duncan, 2003).

To determine whether children's classroom experiences in the early grades moderate the persistence of preschool effects, OLS regressions were conducted with subgroups defined by reading instruction and class size. We also estimated models where these quality indicators are interacted with preschool attendance, to test for statistical differences in effects across subgroups, using changes in math and reading skills between the fall of kindergarten and spring of third grade as dependent variables.

One concern is that children's preschool experiences are not randomly determined. As detailed in Table 2, children who attended preschool appear to be more advantaged than those who did not. Some aspects of their advantage, such as higher household income, may translate into superior levels of achievement and thus, if not adequately controlled for, bias the estimates of preschool effects. Our analysis uses an exceptionally rich set of covariates (described above and in Appendix Table 1) to account for these differences.

Since most family characteristics used as covariates were measured during kindergarten, they could be influenced by preschool attendance. This problem is usually minor (e.g. parents are unlikely to base meal routines on the availability of preschool) but some components of the home learning environment could be shaped by early education experiences. For example, preschool teachers may instruct parents to read frequently to their children or provide information about the availability of structured activities such as art classes. The inclusion of these covariates may therefore absorb a portion of the effects of preschool. This seems likely to result in an understatement of any positive impacts of preschool.

Hierarchical linear modeling (HLM) methods might seem appropriate for this analysis, given that the study has longitudinal data on children who are clustered in classrooms and schools. We chose not to employ such methods, however, primarily because children are dispersed across multiple classrooms after the kindergarten year, and the modeling of such cross-classified data is more complicated then conventional HLM analyses (Raudenbush & Bryk, 2002). We discuss this issue further at the end of the results section.

Results

Does preschool influence children's academic achievement in the fall of kindergarten?

The descriptive statistics presented in Table 1 demonstrate that children who attended preschool had higher levels of academic achievement, at all three waves of data collection, than those who did not. However, sample characteristics presented in Table 2 indicate that these children were also more advantaged. For example, their families had higher household income-to-needs ratios and their mothers had higher levels of education. Consequently, we conducted multivariate regressions which included controls for these differences in background characteristics.

Insert Tables 1 & 2 about here

Table 3 presents results from OLS models examining academic outcomes in the fall of kindergarten, with increasing amounts of covariates included to better account for potential selection effects in higher numbered columns. Absent other controls (model 1), preschool is positively and strongly associated with children's reading and mathematics skills – attendance is predicted to raise the standardized scores by 4.12 and 4.02, translating into effect sizes of .41 and .40. The addition of covariates reduces the preschool effects by about 60 percent, mostly due to the inclusion of child and family demographic characteristics (see columns 2 and 3). In model 3, the specification we focus on below since it includes the most comprehensive set of controls for family, neighborhood, and state conditions, the effect sizes of preschool are .14 for reading and .15 for math skills.[9]

Insert Table 3 about here

The model also includes indicators for attending Head Start, or other non-parental care. The results suggest that other types of non-parental care have a negligible effect on test scores. In addition, children who attended Head Start enter school with lower levels of academic skills than their peers, but most of this difference appears to be due to their relatively disadvantaged family backgrounds (see Table 3). Because the most recent experimental evaluation shows positive effects of Head Start on achievement (Puma et al., 2005), we suspect that the cumulative number of disadvantages that Head Start attendees experience may limit our ability to detect program effects. Other researchers have encountered a similar difficulty using regression methods with nationally representative datasets, even those with large proportions of disadvantaged children (Currie & Thomas, 1995). Therefore, in the remainder of the paper, we focus the discussion on the effects of preschool. Nevertheless, our analysis includes all children and the regression specification always contains dichotomous indicators for Head Start and other non-parental care, as well as the preschool indicator.

Do the effects of preschool persist over time?

Our initial results suggest that preschool boosts reading and math scores at school entry, but some prior research finds that these early advantages last only through one or two years of elementary school (Barnett, 1995; Barnett & Hudstedt, 2005). We explored this question by analyzing children's skills in the spring of first and third grade. The results in Table 4 suggest

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[9] Previous work with the ECLS-K (Magnuson et al., 2004) finds that the estimated benefit of preschool on kindergarten test scores is robust to a host of model specifications, suggesting the difference is not likely due to omitted variable biases, and reports especially large gains for disadvantaged children.

that although much of the initial advantage associated with preschool dissipates, a small effect remains through the spring of third grade. For example, reading skill gains associated with attending preschool (compared with experiencing only parental care) are 1.4 (effect size .14) in the fall of kindergarten and 0.56 (effect size .06) in the spring of third grade. Similar results were obtained for math skills. What is particularly interesting, however, is that estimated benefits of preschool appear to increase between spring of the first and third grades, suggesting that the benefits measured in the third grade may persist into subsequent school years and even raising the possibility of "sleeper effects" that increase in size in later grades. For example, the predicted effects of preschool on reading skills are a non-significant 0.25 in the spring of first grade but have increased to 0.56 (p-value<.05) by the spring of third grade.

Insert Table 4 about here

The dependent variable in the final row of Table 4 is the change in test scores between the fall of kindergarten and the spring of third grade. Consistent with the results just presented, preschool attendance is associated with smaller relative gains in academic skills over this time, as children receiving only parental care in the year prior to kindergarten partially catch up. The effect sizes for preschool are around -.09 for changes in both reading and math skills.[10]

The coefficients for Head Start and other non-parental care variables (results not shown) indicate that neither was predictive of children's achievement in the fall of kindergarten or the spring of first or third grades. That is, children in these types of care had reading and math skills comparable to children experiencing only parental care at all three assessments.

[10] Following NICHD ECCRN & Duncan (2003), we also estimated models for changes in academic skills as a function of kindergarten skill levels , written as: $SKILLS_{i3} - SKILLS_{i1} = ß_1 + ß_2 PRE_i + ß_3 HS_i + ß_4 OC_i + ß_5 COV_i + ß_6 SKILLS_{i1} + \xi_i$ or equivalently $SKILLS_{i3} = ß_1 + ß_2 PRE_i + ß_3 HS_i + ß_4 OC_i + ß_5 COV_i + (1+ß_6) SKILLS_{i1} + \xi_i$. In these models, $ß_2$ represents the effects of preschool on changes in achievement, conditioned on achievement at school entry. This specification is of interest because a child's position in the distribution of skills at school entry influences subsequent gains or losses relative to peers (e.g. if the assessments had ceiling effects). Using this model, the estimated effects of preschool are about half the size of those reported in Tables 4 and Table 6.

Do the effects of preschool depend on subsequent classroom experiences?

We next allowed the effects of preschool to differ across classroom contexts by estimating models for subsamples stratified by class size (large versus small) and the amount of reading instruction provided (high versus low).[11] Results of these analyses are summarized in Table 5. As shown in the first two columns, the effects of preschool on math and reading skills at school entry are similar for the four subgroups. There is some indication of larger effects for children subsequently experiencing small classes or high levels of instruction, but these differences are not statistically significant.[12] By spring of first grade, the differences associated with preschool attendance have largely dissipated, particularly for children experiencing small class sizes or high levels of reading instruction (see the third and fourth columns of Table 5). This pattern is even more pronounced by spring of third grade, when the preschool advantage has entirely disappeared for children receiving high levels of reading instruction or in small classes; by contrast, a marked advantage persists among their counterparts in low instruction or large classes (see columns 5 and 6 of Table 5).

Insert Table 5 about here

Table 6 elaborates on these patterns by showing the results of regressions in which *changes* in standardized test scores between the fall of kindergarten and the spring of third grade are the dependent variable. The negative coefficients for preschool attendance indicate that children cared for by their parents in the year before kindergarten had larger gains in academic skills than did preschool attendees. The negative associations are largest for reading in high instruction and small classes (effect size of -.16, $p<.01$ for each, Table 6 rows 2 and 4 of column

[11] Low reading instruction was associated with a -.42 point reduction ($p<.05$, effect size of .04) in reading and math scores, controlling for the full set of covariates. By contrast, class size was not predictive of third grade test scores.
[12] These may partly reflect differences in kindergarten classroom contexts. When limiting the sample to children tested during September and October of kindergarten, no differences were observed.

1). In contrast, children cared for by their parents and subsequently experiencing less enriching contexts (large class sizes or lower levels of reading instruction) did not catch up to their peers who attended preschool.

Insert Table 6 about here

Figures 1 and 2 plot predicted standardized achievement levels for the "average" child in the sample, varying only by preschool attendance and subsequent classroom contexts.[13] Children cared for exclusively by their parents in the year prior to kindergarten were more likely to "catch up" to their peers experiencing preschool if they had small classes or high levels of reading instruction (see Figure 1). In contrast, those who were not exposed to enriching learning environments remained well behind their preschool-educated peers. A similar, although not identical, pattern is apparent for math skills, where a differential rate of catch up is evident across subgroups defined by class size and levels of reading and language instruction (see Figure 2).[14]

Insert Figures 1 & 2 about here

Given the starkly different patterns of "catch up" across classroom contexts just described, we formally tested for disparities in academic skill gains by estimating full sample regressions that included interaction terms for preschool attendance and the different classroom experiences.[15]

[13] This was done by regressing children's academic skills on dummy variables indicating the possible combinations of preschool and classroom experiences, then creating predicted values for each combination for all sample members and averaging over these. For simplicity, we present scores only for children attending preschool and those cared for by their parents in the year prior to kindergarten. Patterns of achievement for children experiencing other non-parental care (e.g, babysitters, nannies, family day care, relatives) are similar to those in parent-only care.

[14] These differential rates of catch-up do not appear to reflect heterogeneity of performance at school entry – children experiencing parental care but entering different class contexts had similar scores in kindergarten, with the exception that those entering large classes had somewhat higher math scores (.92, $p<.01$). We also note that reading and math achievement children who attended preschool did not differ by class size or instruction level, once a basic set of demographic variables was taken into consideration.

[15] Our preferred models use dichotomous measures of class contexts because they require fewer assumptions about the linear effects of classroom contexts and thus allow a more flexible function form. However, to insure that the results were not sensitive to these methods, we also estimated specifications that interacted continuous measures of

Table 7 summarizes the results. Each set of subgroup indicators and interactions terms was first entered separately (models 1 and 2) and then together (model 3). The subgroup coefficient (e.g., low instruction) represents the average effect of the classroom context for children who had experienced parental care, Head Start or other (non-preschool) child care. The parameter estimate for preschool identifies the average effect of preschool for children in the reference classroom context subgroup (e.g., high instruction classes). The interaction terms, on which we focus our discussion, capture the differential effect of preschool for those experiencing the specified classroom environment (e.g., low instruction classes)

Looking first at the standardized reading skills, children experiencing low instruction classrooms retain more of the benefits of preschool than those in high instruction classrooms (see model 1). This is indicated by the significant positive coefficient on the interaction term for low instruction and preschool (effect size of .10, column 1). Similarly, children who experience large classes retain more of the benefit from preschool than children in smaller classes (effect size of .11, column 2). Remarkably consistent findings are obtained when the two dimensions of classroom contexts are considered simultaneously, suggesting that the differential effects of low instruction and large class size classrooms are independent of each other (Table 7, model 3).

Insert Table 7 about here

The results are slightly different for math skills. Coefficients on the interaction terms suggest that preschool math benefits are not maintained in low reading instruction settings (Table 7, models 1 and 3). However, the interaction between preschool and large class size is positive (effect size of .07 in model 2 and 3, Table 7), indicating that children in large classes retain more of the initial math advantage from preschool than children in smaller classes.

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classroom size and reading instruction with preschool attendance. The results are largely consistent with those reported in Table 7, although with some evidence of non-linearities in class size effects.

We found no differences in performance at school entry or in the effects of classroom contexts on subsequent achievement for children who attended Head Start or experienced non-parental care other than preschool. Because these children performed comparably to children cared for only by their parents, in the fall of kindergarten, (after adjusting for background factors), we did not expect that they systematically gain or lose ground as a function of classroom experiences. Results confirmed that experiencing other types of non-parental care did not predict changes in either math or reading achievement in any of the classroom characteristic subgroups and that attending Head Start, with one exception, also did not predict changes in scholastic performance (results not shown). The exception is that children who attended Head Start and subsequently experienced low reading instruction classrooms lost ground in reading achievement relative to their peers who experienced parental care (-1.37, p-value<.05, results not shown). Including these additional interaction terms in our regression models did not substantially change the results in Table 7.

Additional specifications and robustness tests

We examined whether the effects of classroom contexts were additive by regressing changes in academic skills on preschool attendance for additional subgroups (results not shown). Among children who experienced *both* large classes and low levels of reading instruction (n= 2,180), preschool attendance is not associated with changes in either reading or math skills (effect sizes of -.003, n.s. and -.021, n.s. respectively), suggesting that their peers who were cared for exclusively by parents did not catch up at all. On the other hand, preschool is associated with slower growth in reading and math scores (effect sizes of -.23, p<.01 and -.22, p<.01 respectively) for children experiencing small classes *and* high levels of instruction (n=1,711), indicating that children cared for by parents prior to school entry do catch up to their counterparts when placed in small and high instruction class settings.

One concern is that our controls for class size and academic instruction may be correlated with other important dimensions of classrooms or schools. With this in mind, we tested the sensitivity of our results to including main effects and interactions (with preschool attendance) of the following characteristics: percent of minority students in the school, amount of whole class and small group instruction, teachers' certification, and teachers' number of years teaching at the school. The findings were similar to those obtained above.

We considered whether preschool effects differ for disadvantaged children, as suggested by previous research. Using a broad definition of disadvantage –children in poverty at school entry or whose mother or father did not graduate from high school (n=2,146) – we find modestly larger benefits of preschool on academic skills at school entry (effect sizes of .18 for both reading and math). When limiting the sample to this group and regressing changes in achievement (between fall of kindergarten and spring of third grade) on the two classroom context indicators and interactions of these with preschool (corresponding to model 3 from Table 7), we obtained results similar to those in Table 7, although the differential effects of preschool across classroom contexts were sometimes more pronounced. In particular, children in low instruction classrooms retained considerably more of the benefits of preschool 1.72 ($p<.05$) than their peers in high instruction classrooms.

About 62% of children who attended preschool did so for less than 20 hours a week, raising the possibility that the persistence of preschool effects might differ depending on hours of attendance. We tested for this by including in our regression models dichotomous indicators of attendance in preschool for 20 hours or less and more than 20 hours (two variables). The results suggested beneficial effects for math and reading in kindergarten fall for both groups (results not shown). Moreover, this distinction failed to yield a different pattern of results with respect to the persistence of preschool effects through the spring of third grade and subsequent classroom characteristics. Similar results were also obtained when alternative hour thresholds (e.g., 10 hours a week of preschool) were considered.

Another concern is whether we have sufficiently taken into account the complex nested structure of the data. Children are observed repeatedly and are at least initially clustered within classrooms and schools. Clustered data are often analyzed through hierarchical linear modeling (HLM) techniques, which are designed to analyze multi-level data (children, classrooms, schools) (Raudenbush & Bryk, 2002). HLM is recognized as providing a precise and reliable way of estimating associations within and across levels (Raudenbush & Bryk, 2002).

However, conventional HLM analyses are problematic in the context of our study. Although the ECLS-K follows children over time, mobility within and across grades and schools means that children are not nested in the same schools or classrooms in all periods. A limitation of conventional HLM models is that they require individuals to remain in a single setting over the course of the study (Raudenbush & Bryk, 2002). Modeling the ECLS-K data using HLM would require a multilevel model (time, children, classrooms, and schools) with the cross-classification of children across classrooms and schools. Such an approach is more complicated than conventional HLM and requires both more assumptions and sufficient observations within cells defined by the differing levels (e.g., schools and classrooms). This last condition is unlikely to be met in our data because children in the same kindergarten class disperse across different classrooms in later grades. Our regression models can be seen as treating the accumulated average of classroom experiences as an individual characteristic, which is a useful way to handle the dispersion of children across classrooms (over time) without excluding those who do not share classrooms with other children.

Some of our analyses consider changes within children over time (by modeling changes in achievement over time as a function of preschool and classroom experiences). HLM models are sometimes credited for providing particularly reliable estimates of individual growth, and thus are often recommended for longitudinal data analysis. However, Allison (1990) demonstrated that when change scores are used as dependent variables, regression models of the type we employ yield unbiased estimates if measurement error is uncorrelated with the predictors (NICHD & Duncan, 2003). Given the high reliability of the ECLS-K achievement measures and the low likelihood that our predictors (e.g., preschool, class size, and reading instruction) are systematically correlated with measurement error, we are confident that our regressions of changes in achievement are likely to yield unbiased estimates of the associations between our key predictors. Moreover, since we are analyzing just three points of data, the OLS models provide an adequately flexible method for analyzing changes in achievement over time.

Finally, we addressed the concern that effects of interactions between preschool experience and children's classroom experiences may differ across (rather than within) schools by estimating models containing school fixed-effects where changes in reading and math scores from the fall of kindergarten to the spring of first grade were predicted by the interaction of classroom characteristics and preschool (model 3 in Table 7). These specifications compare children with their peers within the same third grade school who had different preschool and classroom experiences. In doing so, they hold constant school-level effects.

To be useful, the fixed-effect models require sufficient within-school variation in students' preschool and classroom experiences. In the spring of third grade, only 15% of third graders were in a school where all of the other sample participants had the same preschool experience. Likewise, about one third of students in our sample were in schools in which all the children had similar amounts of reading instruction over the first three years of school. However, nearly two-thirds had similar class sizes as other students in their school, implying that the school fixed-effect models will be less useful for detecting differences in the persistence of preschool effects across differing size classes.

Results from the school fixed-effects analyses indicate an even larger interaction between low instruction and preschool on changes in reading, but smaller effects of class size for changes in reading and math skills (results not shown). For example, the resulting coefficient for low instruction was -1.33 (p-value <.01) and for the interaction of preschool by low instruction was 1.57 (p-value<.01). The coefficient for large class was -.18 (ns) and for the interaction of preschool and large classes it was .47 (ns). Given the small variability of class sizes within schools, it is not surprising that these findings are less robust in school-fixed effects models.

Discussion

This study provides an important first step in understanding how the benefits of early education are influenced by later classroom experiences. Consistent with previous studies, our results suggest that children attending preschool enter kindergarten with somewhat higher levels of academic skills than other children. Whether their peers overcome their early deficits, or whether preschool attendees maintain their advantage, is in part a function of the subsequent classroom environment. Children cared for by their parents in the year before kindergarten demonstrate relatively large gains in academic skills by the spring of first grade, when exposed to small classes or high levels of reading instruction, and they maintain these gains through the spring of third grade. In contrast, they catch up much less when placed in large classes or those providing low levels of reading instruction.

Although the reported associations between preschool and student's skills are significant, the magnitude of these effects is small at school entry (e.s=.14) and diminishes in later grades for both the full sample (e.s.= .06 to .07) and for children in less enriching classes (lower levels of instruction and larger classes, e.s=.09 to .10). This suggests that after school entry, meaningful differences in academic performance between children who attended preschool and those who were cared for by their parents may be hard to detect. For example, an effect size of .14 would raise the average child from the 50th to the 56th percentile in the achievement distribution. An effect size of .09 to .10 corresponds with an increase from the 50th to the 54th percentile. However, it is also important to note that our estimates capture the effects of the average preschool program attended in the year before kindergarten and prior research suggests that few of such programs are of high quality (Helburn & Bergmann, 2002). High quality preschools may have larger and more lasting effects (NICHD ECCRN, 2002b; Shonkoff & Phillips, 2000; Smolensky & Gootman, 2003).

One reason why we find that the effects of preschool persist through the spring of third grade, whereas other studies have not (Barnett, 1995), may be because our large sample size increases the statistical power to detect such associations. We also uncover some indication of "sleeper" effects – a larger impact of preschool in the spring of third grade than in the first grade. This suggests that future studies should follow children into later grades, and that a decline in preschool effects between kindergarten and first grade may conceal larger impacts that would be observed subsequently. Whether the initial associations persist into later grades or manifest in other ways (such as lower rates of grade retention and higher levels of completed education) is an important question for future research. Although it is unclear why preschool effects are larger in third grade than first, it is important to better understand these potential sleeper effects. One possible explanation is that teachers in the early grades focus on ensuring that all students have a basic set of skills, and that the advantages resulting from preschool are not fully realized until later grades, when more advanced material is introduced.

Future studies should also distinguish more carefully between "fade out" and "catch up." Our findings suggest that initial preschool effects do not persist among children in small and high instruction classrooms, because their peers were able to "catch up" to their level of performance. This interpretation differs markedly from one in which the performance of children experiencing preschool declines over time to the level of their counterparts. The results of this analysis indicate that the persistence of preschool effects in large and low instruction classes is explained by the continued low performance of children cared for exclusively by parents, rather than improvements by preschool attendees. Put another way, preschool attendees achieved at relatively high levels, regardless of the type of classrooms experienced, whereas the classroom context mattered more among children who did not attend preschool.

Why might the early advantages of preschool fade more quickly in small and high instruction classrooms? We speculate that not only do classroom contexts influence learning, but that the effects of the same instructional context might differ across children, perhaps as a function of their levels of achievement or previous educational experiences. For instance, large class sizes have been linked with more teacher-directed activity, less teacher-student interaction, and lower levels of instructional support (Blatchford, Moriarty, Edmonds, & Martin, 2002; NICHD ECCRN, 2004b). Less skilled children benefit most from smaller classes, presumably because these provide more individualized and supportive instruction. On average, children attending preschool enter school with higher levels of academic skills and so their counterparts may disproportionately benefit from the small classes.

Extra time spent on reading lessons and projects may also be particularly helpful to low-achieving students. Most related research focuses on the effects of different *types* rather than *amounts* of instruction (Connor et al., 2004). However, Leppanon, Pekka, and Aunola (2004) conclude that systematic reading instruction in elementary school provides greater benefits for Finnish children with low rather than high literacy. Machin and McNally (2005) report similar findings from an evaluation of a curriculum change in British primary schools. Finally, Connor and colleagues (2004) found that higher levels of teacher-managed instruction during first and third grade predicted larger gains for low-skilled than higher skilled-students.

Our study can not describe how instructional and learning processes vary across the classrooms contexts we have considered, so we do not know the specific processes that facilitate the persistence of preschool effects. Observational process-oriented studies will be needed to accomplish this (for example, Hamre & Pianta, 2005). Moreover, we rely on teachers' survey responses to describe the time spent on reading lessons and projects, raising the possibility of reporting errors. Previous research provides some indication that teachers tend to overstate the time they spend on instruction, but also finds that teacher-report data are temporally reliable and comparatively valid (Mayer, 1999; Winsler & Carlton, 2003). Nevertheless, problems may remain if the inaccuracies are not randomly distributed across teachers and so it would be useful to replicate this analysis with observational or time diary data measuring classroom time spent on reading lessons or projects.

Several additional limitations of our work should be noted. First, since over half of our sample experienced preschool (57 %), somewhat different results might be obtained in situations where preschool was less common, or more common. For example, it may be that children without preschool who are placed in educationally enriching environments are only able to catch up if most of their classmates have benefited from preschool. It might also be the case that if a larger share of a class has attended preschool, those who did not attend could catch up more quickly. Therefore, we do not know to what extent small classes and higher levels of instruction can or should substitute for high quality preschool experiences for most children, or how the patterns we observe may change as preschool experience becomes more widespread. Whether the persistence of preschool effects is influenced by the proportion of children in a classroom who experienced preschool is an important question for future research.

Second, the nesting of children within schools and classrooms suggests that greater attention should be given to how these processes differ within and between classrooms. One possibility is to use hierarchical linear modeling techniques. However, as discussed above, such analysis would require careful cross-classification modeling of students who initially experience the same classrooms (in kindergarten) but may not remain together in later grades. Provided that data can support such an analysis, we recommend future research consider these questions using cross-classified HLM models (Raudenbush & Bryk, 2002).

Third, lacking experimental data randomly assigning children to classrooms, we are unable to rule out the possibility of differential selection into classroom contexts that is not fully accounted for by our statistical methods. For example, smarter students might be more often placed into small classrooms or those offering high levels of instruction. However, we doubt that this type of selection explains the pattern of results. Recall that our initial examination revealed few differences across classroom contexts in either observable characteristics or kindergarten fall test scores. In addition, we control for an extensive array of possible confounding factors and some of our analyses focus on *changes* in test scores, eliminating the effects of unobserved child characteristics and initial skill levels.

Fourth, our analysis does not consider the role of non-educational experiences. Academic performance does not only depend on classroom and school experiences, but also on what occurs outside of the educational system. For instance, parental expectations matter, as does children's participation in learning activities with parents and peers in after-school activities during the school year and in summer (Alexander & Entwisle, 1996; Entwisle, Alexander, & Olson, in press; Downey et al., 2004; NICHD ECCRN, 2004c). Future research should consider whether these dimensions of learning environments help to explain, or moderate, the persistence of preschool effects.

Finally, academic skills are only one component of school success, albeit an important one. Consequently subsequent studies should consider how preschool is associated with other dimensions of early school adjustment, and how subsequent classroom characteristics might contribute to the persistence (or attenuation) of these associations. For instance, this analysis does not consider behavioral and social outcomes, because the classroom and school contexts that affect them are likely to be different from those influencing math and reading progress (Finn & Pannozzo, 2004; Pianta et al., 2002).

In conclusion, our analysis suggests that subsequent classroom experiences help to determine whether the initial advantages conferred by preschool persist through the middle of primary school. Specifically, children who did not attend preschool in the year before kindergarten tend to catch up more to their peers who did when placed in small classes or those offering high levels of academic instruction. Our research and that of others (e.g. NICHD ECCRN, 2004b; Connor et al., 2004) suggests that associations between classroom characteristics and child outcomes are complex and may depend on the skills and experiences with which children enter school. These findings point to the importance of using an ecological or person-in-environment framework to understand children's academic success (Bronfennbrenner & Morris, 1998; Burchinal, Peisner-Feinberg, Pianta, & Howes, 2002).

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Table 1

Means and Standard Errors for Reading and Math Test Scores for Study Sample and by Child Care Arrangements in the Year Prior to Kindergarten

	All (N=7,748)		Preschool (N=4,402)		Parental care (N=1,368)		Other non-parental care (N=1,010)		Head Start (N=968)	
	M	SE	M	SE	M	SE	M	SE	M	SE
Reading test T-score										
Kindergarten fall	50.14	.11	52.31	.14	48.19	.26	48.14	.29	45.07	.26
First grade spring	51.24	.10	52.60	.12	50.44	.24	50.51	.27	47.00	.30
Third grade spring	51.16	.11	52.93	.13	49.93	.25	50.50	.28	45.50	.30
Math test T-Score										
Kindergarten fall	51.03	.11	53.11	.14	49.09	.25	49.51	.30	45.84	.27
First grade spring	51.29	.10	52.8	.13	50.19	.25	50.51	.28	46.66	.30
Third grade spring	51.33	.11	53.16	.14	50.21	.26	50.32	.30	45.62	.29

Notes: Math and reading T-scores are standardized scores (mean=50, sd=10).

Table 2

Descriptive Statistics for Selected Sample Demographic Characteristics by Child Care Arrangements in the Year Prior to Kindergarten

	All (N=7,748)			Preschool (N=4,402)			Parental care (N=1,368)			Other non-parental Care (N=1,010)			Head Start (N=968)		
	%	M	SE	%	M	SE	%	M	SE	%	M	SE	%	M	SE
Black	15			12			11			12			39		
Hispanic	13			10			17			14			17		
Asian	5			5			6			6			3		
Native American	2			1			1			2			5		
Maternal years of completed schooling <=12	44			32			58			49			68		
Single parent family	20			18			15			25			36		
Blended/step family	8			7			7			10			12		
Income-to-needs ratio		2.96	.03		3.59	.05		2.28	.06		2.67	.07		1.24	.03
Number of children in household		2.47	.01		2.33	.02		2.76	.04		2.37	.03		2.78	.04
Percent of full study sample	*100*			*57*			*18*			*13*			*13*		

Notes: Percent of sample in child care categories may not add to 100% due to rounding.

Table 3

Summary of Coefficients and Standard Errors from Regressions of Academic Skills in Kindergarten Fall on Early Education and Child Care Arrangements in the Preceding Year and Covariates (N=7,748)

	Reading			Math		
Independent variables	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Preschool	4.12**	1.69**	1.42**	4.02**	1.76**	1.49**
	(0.31)	(0.28)	(0.27)	(0.31)	(0.27)	(0.26)
Other child care	-0.05	-0.24	-0.09	0.43	0.36	0.49
	(0.39)	(0.36)	(0.35)	(0.41)	(0.37)	(0.36)
Head Start	-3.11**	-0.38	-0.32	-3.26**	0.03	0.12
	(0.39)	(0.36)	(0.35)	(0.41)	(0.38)	(0.36)
Controls						
Child & family characteristics		X	X		X	X
Home, neighborhood, & policy environments			X			X
R-squared	0.08	0.29	0.35	0.08	0.31	0.36

** p-value<.01; *p-value<.05. Huber-White standard errors are presented to correct for the clustering of observations within schools. Parental care is the excluded reference group. Model 2 includes a set of covariates for child and family demographic characteristics. Model 3 includes controls for home, neighborhood, and policy environments (see appendix Table 1 for a detailed description of the covariates, and appendix Table 2 for full results from this model). Reading and math T-scores are standardized to have a mean of 50 and standard of 10. See notes to Table 1.

Table 4

Summary of Coefficients and Standard Errors from Regressions of Academic Skills and Changes in Academic Skills on Preschool Enrollment and Covariates (N=7,748)

Independent variables	Reading	Math
Kindergarten fall		
Preschool	1.42**	1.49**
	(0.27)	(0.26)
First grade spring		
Preschool	0.25	0.52*
	(0.25)	(0.25)
Third grade spring		
Preschool	0.56*	0.67*
	(0.27)	(0.28)
Change from kindergarten fall to third grade spring		
Preschool	-0.91**	-0.87**
	(0.29)	(0.24)

** p-value<.01; *p-value<.05. Table shows the predicted effect of attending preschool in the year before kindergarten on academic skills or changes in skills. Huber-White standard errors are presented to correct for the clustering of observations within schools. Parental care is the excluded reference group, and all analyses include controls for Head Start attendance and experiencing other non-parental care. All models include a set of covariates for child and family demographic characteristics, home, neighborhood and policy environments (model 3 from Table 2). See Appendix Table 1 for detailed description of the covariates. Reading and math outcomes are standardized to have a mean of 50, and standard deviation of 10.

Table 5

Summary of Coefficients and Standard Errors from Regressions of Academic Skill Levels on Preschool Enrollment and Covariates, By Classroom Characteristic Subgroups

	Kindergarten fall		First grade spring		Third grade spring	
Independent variables	Reading	Math	Reading	Math	Reading	Math
			Low instruction (n=4,185)			
Preschool	1.37**	1.56**	0.63	0.82*	0.95**	1.00**
	(0.38)	(0.36)	(0.35)	(0.36)	(0.37)	(0.37)
			High instruction (n=3,563)			
Preschool	1.68**	1.39**	-0.21	0.14	0.11	0.14
	(0.41)	(0.39)	(0.38)	(0.38)	(0.40)	(0.42)
			Large classes (n=4,032)			
Preschool	1.21**	1.32**	0.56	0.71*	0.89*	1.04**
	(0.37)	(0.36)	(0.35)	(0.34)	(0.36)	(0.39)
			Small classes (n=3,716)			
Preschool	1.55**	1.54**	-0.26	0.20	0.00	0.12
	(0.41)	(0.38)	(0.36)	(0.37)	(0.40)	(0.39)

** p-value<.01; *p-value<.05. Standard errors are in parentheses. Table shows the predicted effect of attending preschool in the year before kindergarten on academic skills or changes in skills. Huber-White standard errors are presented to correct for the clustering of observations within schools. Parental care is the excluded reference group. All models include controls for Head Start attendance and other non-parental care, as well as covariates for child and family demographic characteristics, home, neighborhood and policy environments (model 3 from Table 2). See Appendix Table 1 for detailed description of the covariates. Reading and math outcomes are standardized to have a mean of 50 and standard deviation of 10.

Table 6

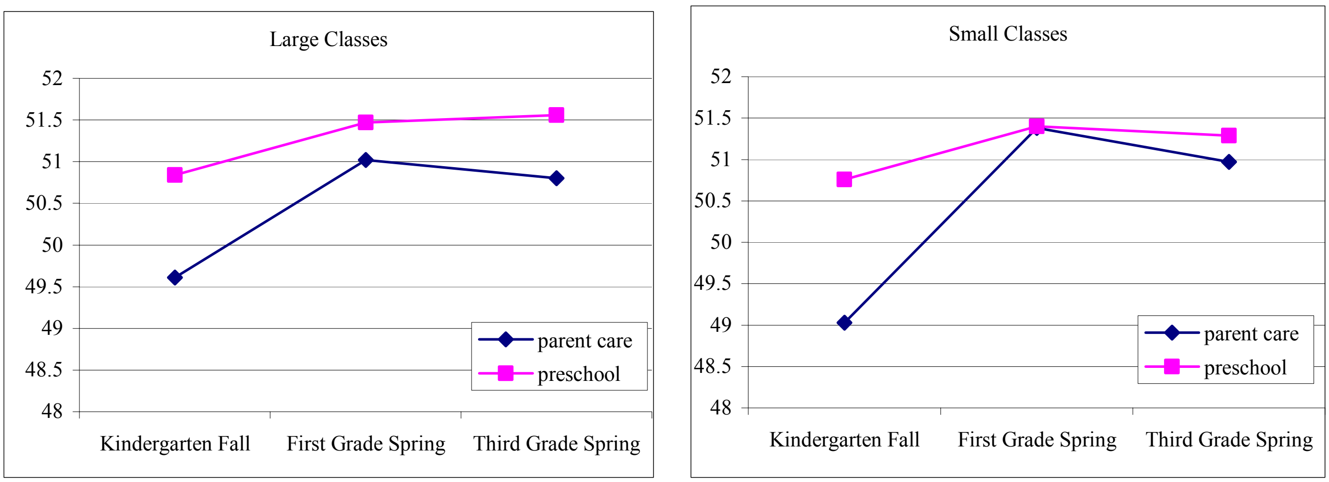
Summary of Coefficients and Standard Errors from Regressions of Changes in Academic Skills on Preschool Enrollment and Covariates, By Classroom Characteristic Subgroups

	Changes kindergarten fall to third grade spring	
Independent variables	Reading	Math
	Low instruction (n=4,185)	
Preschool	-0.45	-0.64*
	(0.40)	(0.31)
	High instruction (n=3,563)	
Preschool	-1.63**	-1.30**
	(0.45)	(0.38)
	Large classes (n=4,032)	
Preschool	-0.33	-0.32
	(0.39)	(0.35)
	Small classes (n=3,716)	
Preschool	-1.58**	-1.48**
	(0.46)	(0.34)

** p-value<.01; *p-value<.05. Standard errors are in parentheses. Huber-White standard errors are presented to correct for the clustering of observations within schools. Parental care is the excluded reference group. All models include controls for head start attendance and other non-parental care, as well as covariates for child and family demographic characteristics, home, neighborhood and policy environments (model 3 from Table 2). See Appendix Table 1 for detailed description of the covariates. Reading and math outcomes are standardized to have a mean of 50 and standard deviation of 10.

Figure 1: Predicted Reading Scores for "Average" Child in Sample

Panel A



Panel B

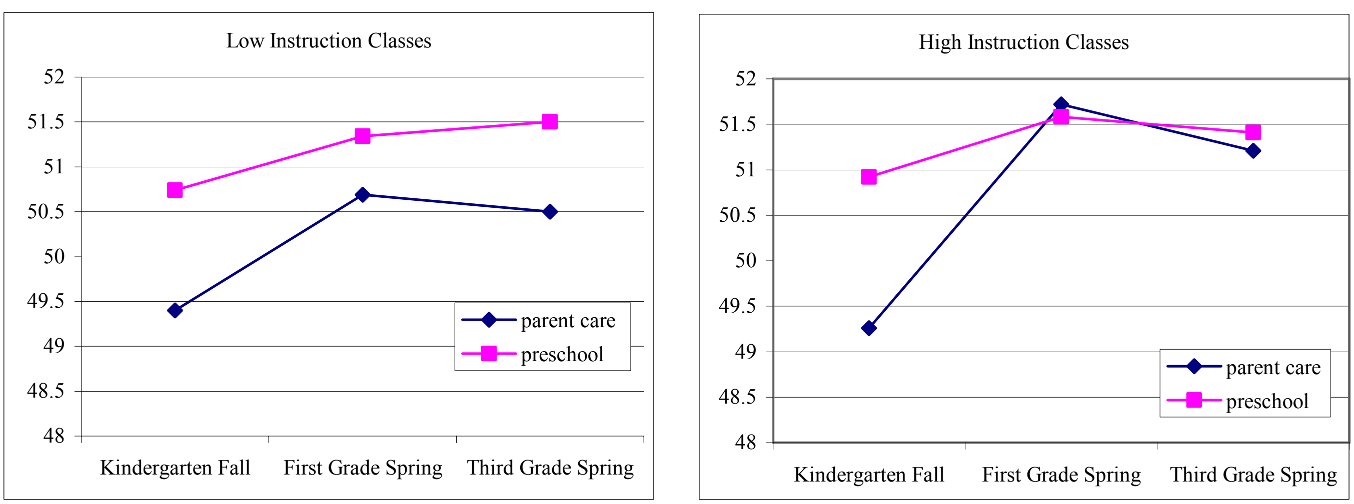
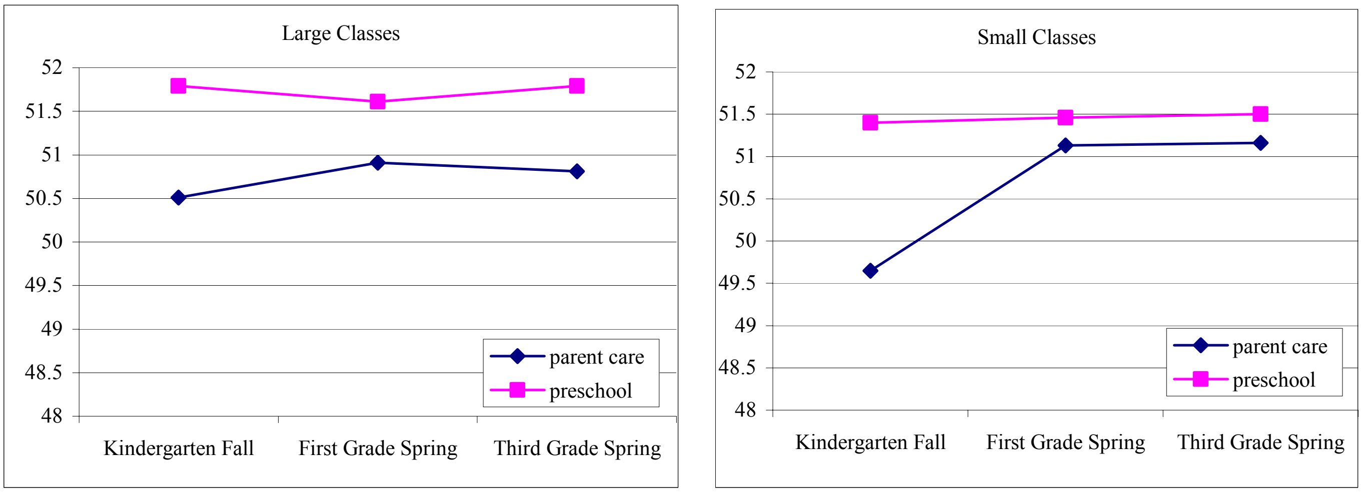


Figure 2: Predicted Math Scores for "Average" Child in Sample

Panel A



Panel B

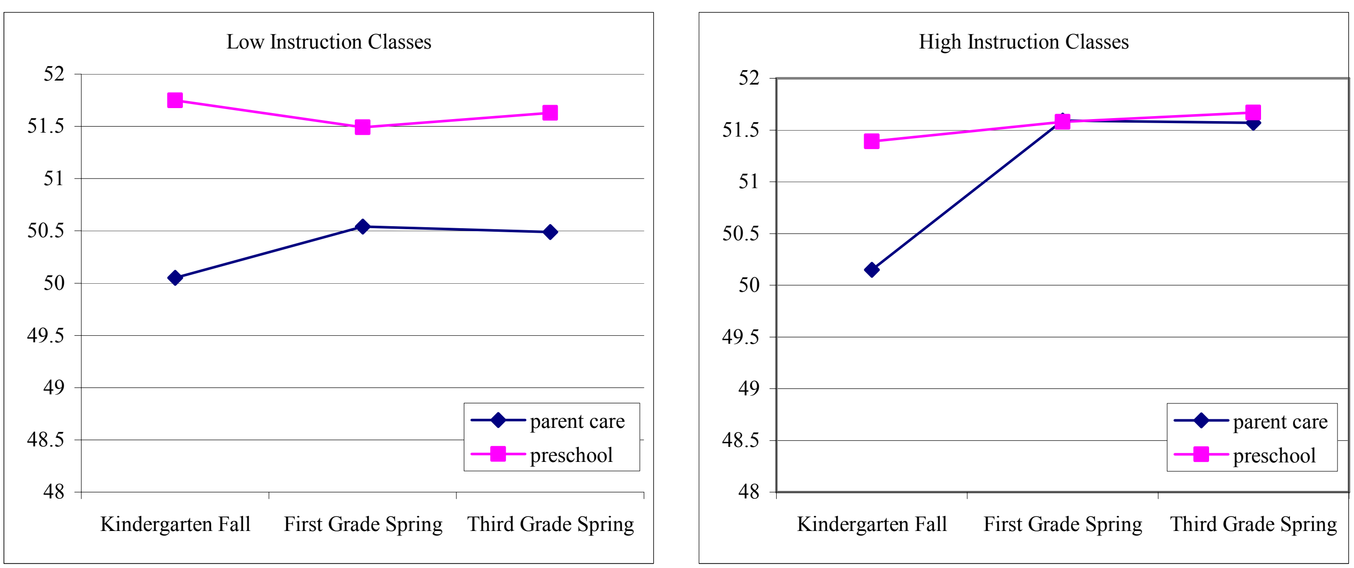


Table 7

Summary of Coefficients and Standard Errors from Regressions of Changes in Academic Skills on Preschool Enrollment, Classroom Characteristics, and Covariates

	Changes kindergarten fall to third grade spring					
	Reading			Math		
Independent Variables	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Low instruction	-0.71*		-0.71*	-0.47		-0.47
	(0.34)		(0.34)	(0.27)		(0.26)
Low instruction X preschool	0.95*		0.96*	0.06		0.06
	(0.40)		(0.40)	(0.33)		(0.33)
Large class		-0.86*	-0.86*		-0.83**	-0.82**
		(0.35)	(0.35)		(0.29)	(0.29)
Large class X preschool		1.12**	1.12**		0.74*	0.74*
		(0.41)	(0.41)		(0.34)	(0.34)
Preschool	-1.43**	-1.50**	-2.02**	-0.90**	-1.26**	-1.30**
	(0.37)	(0.38)	(0.44)	(0.32)	(0.30)	(0.36)
R-squared	0.09	0.09	0.09	0.12	0.12	0.12

** p-value<.01; *p-value<.05. Standard errors are in parentheses. Huber-White standard errors are presented to correct for the clustering of observations within schools. The dependent variable is the change in test score between the fall of kindergarten and spring of the third grade. Parental care is the excluded reference group. All models include controls for head start attendance and other non-parental care, as well as covariates for child and family demographic characteristics, home, neighborhood and policy environments (model 3 from Table 2). See Appendix Table 1 for detailed description of the covariates. Reading and math outcomes are standardized to have a mean of 50 and standard deviation of 10.

Appendix Table 1: Definitions, Additional Details, and Notes about Covariates Used in Analyses

Constructs and Variables	Definition, Details, and Notes
Child characteristics: Time varying characteristics are specific to timing of assessment	
Child age*	Continuous variable. Child age in months.
Child gender*	Dummy variable (boy=1).
Birth weight*	Two dummy variables for: < 1500 grams, 1500-2500 grams.
Child weight*	Average of two interviewer assessed measurements in lbs.
Child height*	Average of two interviewer assessed measurements in inches.
Race and ethnicity*	Black, Hispanic, Native American, Asian. Four dummy variables. Omitted reference group is White, non-Hispanic.
Parental reports of family characteristics: Time varying characteristics are specific to timing of assessment	
Number of children in household*	Ordinal variable. Ranges from 1 to 11.
Family structure*	Single parent (one biological parent), blended family (one biological and one non-biological parent), adopted or foster parents. Three dummy variables.
City or town residency*	Residence in city or town. Two dummy variables. Omitted reference group is rural residence.
Region of country*	North, South, Midwest. Three dummy variables. Omitted reference group is East.
Early maternal employment	Mother ever employed between child's birth and entry into kindergarten.
Father and mother education*	Less than high school degree through advanced post-graduate degree. Five dummy variables for each parent. Omitted reference group is some college.
English only spoken in home*	Mother never speaks foreign language to child (dummy variable measured only at kindergarten fall).
Father's & mother's employment*	Full-time (35 or more hours per week), part-time work (fewer than 35 hours per week). Omitted reference group is no work. Two dummy variables for each parent.

Appendix Table 1 Continued

WIC participation*	Mother or child ever participated in Women, Infants and Children nutritional supplement program. Dummy variable measured at kindergarten fall.
Household income-to-needs ratio*	Household income compared to federal poverty threshold. Nine dummy variables measured only at kindergarten fall. Omitted reference group is household income-to-needs ratio greater than 4.5.
<u>Home, neighborhood, and policy environment variables: Kindergarten</u>	
Parental reports of educational expectations, kindergarten fall	
Educational expectations*	Parental expectations for child's educational attainment. Four dummy variables. Omitted reference group is advanced post-graduate degree (e.g, PhD or MD).
Importance of skills at kindergarten entry*	Parents' report of the importance of skills at the start of kindergarten: counting, sharing, communication, drawing, knowledge of letters. Five variables with responses ranging from 1 (essential) to 5 (not important).
Parental reports of home learning activities, kindergarten fall	
Parent selected home because of school	Parents chose home location for current school (dummy variable).
Home learning activities*	Frequency of parent engaging the child in 7 activities: building things, teaching about nature, playing sports, doing art, doing chores, singing songs, playing games. Responses range from 1 (not at all) to 4 (everyday).
Number of children's books in home*	Ordinal variable. Ranges from 0 to 200.
Number of music tapes, CDs, or records in home	Ordinal variable. Ranges from 0 to 100.
Reading outside of school*	Frequency of child looking at picture books and reading outside of school. Two variables with response ranging from 1 (never) to 4 (everyday).

Appendix Table 1 Continued

Family member school involvement, kindergarten fall	
Attendance or participation in school activities*	Attendance since beginning of school year at PTA meetings, open houses, parent-teacher conferences, parent advisory meetings; volunteered at school, participated in school fundraiser. Six dummy variables.
Parental reports of parent-child relationship, kindergarten spring	
Parenting stress and depression composites*	Two continuous variables (averages of 8 and 12 items). Higher scores indicate more parenting stress or depression.
Spanking	Parent spanked child in past week.
Parental reports of family routines, structured activities, and learning opportunities, kindergarten spring	
Eating habits*	Days per week family usually eats breakfast and dinner together and at regular time. Four variables ranging from 0 to 7.
Family has computer*	Dummy variable.
Television viewing	Number of hours that the child watches TV on weekdays. Responses range from 0 to 15.
Frequency of reading	Frequency of child looking at picture books and reads outside of school. Responses range from 1 (never) to 4 (everyday).
Visits to educational settings outside of school*	In past month, the child visited a zoo, library, museum, or concert. Four dummy variables.
Other non-school activities*	Child has ever taken art, craft, music, or drama lessons; participated in performing arts, organized clubs, or athletic teams outside of school. Seven dummy variables.
Parental reports of neighborhood quality, kindergarten spring	
Neighborhood quality composite	Mean of 6 items asking about neighborhood problems such as violence and drug activity. Responses range from 1 (big problem) to 3 (no problem).

Appendix Table 1 Continued

State Characteristics, kindergarten fall	
Log of state per capita public spending on education and welfare programs*	Ranges from 6.7 to 8.0
Log of state's per capita income*	Ranges from 9.9 to 10.5

Notes: * denotes that one or more variables in the group predicted children's reading or math skills in the fall of kindergarten.