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# NIEER Working Paper

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## Is More Better? The Effects of Full-Day vs. Half-Day Preschool on Early School Achievement

### Executive Summary



Numerous studies demonstrate the positive benefits high-quality preschool programs can have on children's development.

Confident in this knowledge, policymakers have expanded the availability of publicly funded preschool education programs.

What is less well established, however, are the benefits children derive from programs of various durations and intensity.

Preschool programs vary greatly—from less-than-half-day to full-day-plus programs. Little rigorous research is available to inform policy decisions about the relative benefits of programs with shorter and longer hours per day or days per year. To address this need, NIEER conducted a randomized trial in which 4-year-olds in a low-income urban district were randomly assigned to programs of different durations. The programs were otherwise quite similar: all had teachers with college degrees, a low ratio of children to teachers, and used the same curriculum.

Our study compared 85 children assigned to an 8-hour program for 45 weeks to 254 children assigned to a 2.5- to 3-hour program for 41 weeks. Due to the limited number of spaces available in the 8-hour extended year program, a lottery was used to determine entry, providing the basis for random assignment. Such studies are the “gold standard” approach to addressing cause and effect questions in education research. The district's residents were 50 percent Hispanic, 21 percent African-American, and more than 20 percent of the families lived in poverty.

## Executive Summary *(continued)*

*NIEER's study was designed to answer two primary questions:*

1. What are the effects of the additional hours of preschool education offered by the extended-day, extended-year public preschool program on children's learning in literacy and mathematics by the end of the school year?
2. If learning gains from the program are evident for children by the end of one school year, are these gains sustained through kindergarten and beyond?

Results of this study indicate that even students who are far behind at entry to preschool can develop vocabulary, math, and literacy skills that approach national norms if provided with extended-duration preschool that maintains reasonable quality standards. By the Spring kindergarten assessment, children in the extended-duration program had improved 11 to 12 standard points on vocabulary and math skills. Children in half-day programs also improved, but to a lesser degree, 6 to 7 standard score points on vocabulary and math). Thus, the added hours of preschool education were substantially effective at closing the achievement gap between these urban children and their more advantaged peers.

Students in the extended program continued to outperform children in the control group in follow-up testing through the spring of first grade. Some of this lasting effect could be due the difference in duration in kindergarten. The treatment group continued to receive 8 hours a day for 45 weeks, and the control group received 6 hours a day for 41 weeks. However, this was a much smaller difference in hours than in preschool. It is noteworthy that by first grade effects of duration are apparent on more complex measures such as reading comprehension and calculation and not just on simple tasks like letter and number recognition.

While further research is needed to augment this study of half-day vs. extended-day preschool education, the results clearly indicate that duration matters. Extended-day preschool of good quality had dramatic and lasting effects on children's learning across a broad range of knowledge and skills. As many families need full-day programs for their 4-year-olds to accommodate parent work schedules, the evidence that full-day preschool education can meet child care needs and benefit children's learning should be of high interest to parents and policymakers. Indeed, some children, particularly those in low-income working families, will miss out on high quality preschool education altogether if only a half-day public program is available.

## Introduction

Positive effects of high-quality early education have been found for cognitive, linguistic, social, and economic outcomes (Barnett, 2001). This evidence has led to substantial public investment in preschool programs for economically disadvantaged children by federal, state, and local governments. An important question in the design of public preschool programs is whether learning increases as time in preschool is increased. Time in preschool can be increased by extending daily operating hours, adding days to the school year, or offering multiple years of service. Experimental data are not available to address the effects of any of these approaches. However, results from research conducted with model preschool programs such as the Abecedarian Project (Campbell & Ramey, 1994), the Chicago CPC program (Reynolds, 1993), and the High/Scope Perry Preschool Project (Schweinhart, Barnes, Weikart, Barnett, & Epstein, 1993) and numerous short-term studies provide some support for an “increased intensity and duration” hypothesis that longer lasting interventions are more effective for disadvantaged children (Frede, 1998).

Clear conclusions regarding the impact of time spent in early education on child development have been elusive, and findings are not entirely uniform. Though long hours in child care (especially during the early years) are sometimes associated with less positive social and emotional development, greater benefits are generally associated with participation in the most intensive, earliest starting and longest lasting programs (Barnett, 1998). Studies specifically designed to measure the effects of preschool duration have tended to focus on the number of years or age at start, rather than daily or yearly time in school (Reynolds, 1994; Sammons et al., 2004; Weikart, 1967) and have found better results for longer duration. One exception to this is the NICHD child care study which examined the effects of hours per week and number of years in non-maternal child care and linked increased time in non-maternal childcare arrangements with non-compliant and aggressive behaviors at 54 months of age and in kindergarten (NICHD Early Child Care Research Network, 2001, 2003). The NICHD study considered total time spent in non-maternal care through the first 4.5 years of life, so infant and toddler care was included in analyses. The actual implication of these non-experimental findings to the question of preschool intensity and duration as an educational intervention is unclear.

Using a similar approach, the Effective Provision of Preschool Education (EPPE) Project (Sammons et al., 2004) studied a representative sample of nearly 3,000 children from different regions of England who attended targeted types of preschool care. The number of months a child attended was found to be statistically significant for both math and reading achievement at age 6, with longer preschool duration associated with better cognitive outcomes. Effects were particularly strong for the highest quality programs. The EPPE findings may underestimate the effects of longer duration in that nearly 25% of the sample spent time in a non-target preschool setting during the course of the study, and time in these settings was not included in the data used for analyses.

Findings from the EPPE project also provide evidence that changes in preschool quantity and changes in preschool quality may offer different types of benefits (Sammons et al., 2003). While duration was significantly related to children’s cognitive development, data did not reveal similar effects of duration on social-behavioral gains during the preschool year. Neither number of months in attendance nor age-at-start of preschool was significantly related to any of four social outcome measures but in contrast to the NICHD findings more time in preschool was also not associated with lower social outcomes. In fact, this study found quality to matter, with higher scores on the Social Interaction and Language and Reasoning subscales of the Early Childhood Environment Rating Scale-Revised (ECERS-R) (Harms, Clifford, & Cryer, 1998) related to positive gains on social-behavioral measures.

More research exists comparing the effects of full- and half-day kindergarten programs though much of it was completed over two decades ago and few studies used randomized trials. In addition, kindergarten outcomes may not generalize to younger ages. Findings indicate that participation in full-day kindergarten has positive effects on academic and social outcomes (Clark & Kirk, 2000; Gullo, 2000).

In reviews of the earlier literature, authors selected studies for review based on different criteria such as population studied or research design but all concluded that students who attended full-day kindergarten showed significantly greater achievement than half-day attendees (Fusaro, 1997; Karweit, 1987; Olsen & Zigler, 1989; Puleo, 1988; and Stinard, 1982). Children in full-day programs scored higher on standardized tests, had fewer grade retentions, demonstrated more regular school attendance, and had fewer Chapter I placements than those who attended half or alternating days. Positive effects of increased kindergarten duration were generally sustained through the early elementary years.

Lee and colleagues (2006) found in a recent review that, although rare, studies that used random assignment and matched control group designs regularly found advantages for full-day kindergarten across varying groups of children.

Studies with the largest sample use data from the Early Childhood Longitudinal Study – Kindergarten cohort (ECLS-K), a nationally representative sample of over 17,000 first-time kindergarteners. Approximately 58% of the children who participated in the ECLS-K attended full-day programs. Among public school children, gains in reading and math achievement over the kindergarten year favor children who attended full-day classes with the effectiveness of full-day kindergarten roughly equal for children of different social backgrounds (Denton, West, & Walston, 2003; Lee, Burkam, Honigman, and Meisels, 2001; Lee, Burkam, Ready, Honigman, and Meisels, 2006).

Other reports based on ECLS-K data offer qualifications to these findings. One study including both public and private schools in the analyses failed to find that kindergarten achievement in reading and math differed by length of day (West, Denton, & Reaney, 2001). A more recent report shows no significant differences by length of program day in math, science or reading achievement at the end of third grade for public and private school children collectively (Rathbun, West, & Germino-Hausken, 2004), though small positive initial effects did exist. However, high attrition, including only children tested at grade level (i.e. those not retained in grade or placed in special education), and the exclusion of children who were ever tested in a language other than English raise serious concerns about drawing conclusions from these analyses.

Concerns have been raised about child stress, fatigue and irritability caused by increased kindergarten duration (Good, 1996), but research does not support the existence of these effects (da Costa & Bell, 2000; Elicker & Mathur, 1997). Hough and Bryde (1996) found no difference between fatigue levels of full- and half-day kindergarten attendees. Elicker and Mathur (1997) suggest that a full day in class may be less stressful for young children because it allows time for more developmentally appropriate instruction. Teachers spend more time in one-to-one instruction and less time engaged in large group activities, children take part in more self-directed learning, and parents report greater satisfaction. Research has found a deleterious effect of highly structured, skills-based practices in kindergarten which could be exacerbated if these same practices were just increased in longer day (Burts, Hart, Charlesworth & Kirk, 1990).

There is less research on length of the kindergarten year. Using a matched-pairs quasi-experimental design, Frazier & Morrison (1998) compared an extended-year (210 days) kindergarten program to a traditional program (180 days). No differences existed between groups at kindergarten entry. Test results at entrance to grade 1 favored children from the extended-year program in math, reading, and general knowledge. Benefits for extended-year students were not associated with program quality or teacher characteristics.

The study described here is a randomized trial in which outcome comparisons are made between children who attended an extended-day, extended-year public preschool program and peers who attended half-day public school programs. Although it is obvious that full-day, year round schedules are more accommodating of parental work schedules, it is less clear how much they might contribute to children's learning and development. Nevertheless, preschool policy makers across the nation face costly decisions about operating hours within the limitations of available resources. In 2002, 10 of 44 state preschool initiatives (23%) operated on a full-day schedule (Barnett, Hustedt, Robin, & Schulman, 2004). Many other states allowed local providers to determine the length of the operating day. Yearly schedule, or number of days offered per year, was also usually decided locally. Most state preschool providers followed the academic year and offered about 180 days of service, but in a few states such as Hawaii, Massachusetts, and Connecticut, preschool programs operated year-round.

Between 1997 and 2003, the percent of funded slots in federal Head Start reported to be full-day, 5 days per week nearly doubled, from 24% to 46% (U.S. Department of Health and Human Services, 1998, 2004a). The addition of nearly 250,000 full-time slots over 6 years exceeded the increase in total funded slots, and contributed to a substantial increase in cost per child. Adjusting for inflation, cost per child in Head Start increased by nearly 20% between fiscal years 1998 and 2003 (U.S. Department of Health and Human Services, 1999, 2004b). Evidence regarding the impacts of duration on the educational benefits of preschool would provide information about the value of Head Start's movement toward longer hours of service.

*Three principle research questions are addressed by this study:*

1. What are the effects of attending an extended-day, extended-year public school on children's learning in literacy and mathematics by the end of the preschool year?
2. If learning gains are evident for children in the extended duration school, are these gains sustained through kindergarten and beyond?
3. How is children's learning affected by family background characteristics?

## Research Design & Methods

### *Setting*

This research was conducted in a low-income, urban school district in the northeastern United States with a total population of about 120,000 (U.S. Census 2000). The district's residents were 50% Hispanic or Latino, 21% African-American, and over 20% of families with children less than 5 years of age lived in poverty. The educational attainment of adults age 25 and over was relatively low, with 38% not completing high school and only 12% holding a bachelor's degree. The median household income in 1999 was \$35,175, compared to a national average of \$41,994 and a state average of \$55,146. The percentage of pupils eligible for free or reduced lunch was approximately 75%.

The district was one of then 28 urban, low-income districts involved in a long-standing school funding court case in New Jersey, *Abbott v. Burke*. As part of the New Jersey Supreme Court effort to ensure a "thorough and efficient" education as required by the state constitution, the Court ordered at least half-day preschool for 3 and 4 year olds in the 28 districts. The district studied here began a magnet program that offered an 8 hour, 10 month program for 4 year olds while providing only half-day, 9 month programs for other children.

### *Sample*

Study participants were selected from the pool of preschoolers registered in a lottery to attend the extended-day, extended-year program for either the 1999-2000 or 2000-2001 school years. Preschool eligibility criteria required that a child reach the age of 4 on or before October 1<sup>st</sup> in order to enroll. Lottery registration was open to all parents or guardians of such children in the school district.

Those who were not offered enrollment through the lottery were offered enrollment in half-day classrooms in the district. A few parents elected either a private full-day child care program or some other non-center-based arrangement. All of these programs were supported by state dollars, and curriculum training and other oversight was provided by the school district.

All of the 1999 applicants to the lottery participated in this study. Of the 180 total children, 40 were admitted to the extended-duration program. The 1999 applicants are referred to in this study as Wave 1. In 2000, 318 children applied to the lottery and 45 were admitted. Due to a limited research budget, the first half of the lottery applicants were recruited for this study. Thus, Wave 2 consisted of 45 experimental and 114 control group children. The total sample invited to participate, across waves, was 339 (85 experimental + 254 control).

Of the 217 control group children who completed baseline assessments, 186 (86%) enrolled in half-day programs in public schools. The remaining 31 received care at home (13), or at one of 16 available private child care programs (18). The private centers offered full-day, year-round programs.

### *Attrition*

Baseline child assessments were completed in Fall 1999 and Fall 2000 with 297 of the 339 children invited to participate. Of the 42 who were not assessed, 7 were in the treatment group and 35 in the control group. Reasons for non-assessment included: parental refusal (25), child did not speak English or Spanish (9), assessors were unable to arrange a meeting with the parent and child (6), and child refusal to cooperate with the testing conditions (2). Three of the children tested at baseline were excluded from analyses after a review of their test protocols indicated that valid administration had not been possible. All three of these children were referred for evaluation for special education services. Analyses reported are thus based on an initial sample of 294 children, 77 of whom attended the treatment program. Parent interviews were completed at baseline for all but 12 of the children who were assessed. In 7 of these cases, parents were unreachable after repeated phone calls and at least two home visits. Five parents declined to be interviewed.

The majority of post baseline attrition was due to geographic movement, with children either moving out of state or “missing” from their reported address and school. Overall rate of attrition at Spring kindergarten testing was the same for both groups at 14%. By the Spring of first grade, 26 of the initial sample of 158 Wave 1 students had left the study (16%). No statistically significant characteristic differentiated children who left the study from those who remained involved.

### *Description of Treatment*

In 1998, the district involved in this study began an extended-day, extended-year program for children in prekindergarten through grade 8 as a district-wide magnet school. This program was designed to be more attractive to working parents due to daily operating hours from 7:30am to 3:30pm, and an academic calendar beginning in late August and running through the end of June. The district’s other preschool classrooms operated for 2.5 to 3 hours and followed a standard academic-year schedule, operating from early September through late June (4 weeks fewer than the extended program).

Children who were admitted to the treatment program were assigned to one of three classrooms. In 1999 – 2000, two classrooms were comprised of 16 4-year-olds, and one classroom offered a mixed-age program with eight 4-year-olds and eight 5-year-olds. Each room was staffed by a certified teacher and a teaching assistant. Class sizes in the public half-day programs varied, with an average of 18.5 during Year 1 (1999-2000) and 13.2 in Year 2. The reduction was due to the state requirement that preschool programs in Abbott districts maintain class sizes of 15 or fewer. Although class size for children in the control group was generally smaller for children in Wave 2, regression analyses did not reveal differential treatment impact by Wave. A certified teacher and a teaching assistant staffed all rooms in half-day programs. All preschool classrooms in the district, regardless of duration, used the High/Scope curriculum and all other services and supports were identical.

Classrooms were rated twice each year using the Early Childhood Environment Rating Scale - Revised (ECERS-R; Harms, Clifford and Cryer, 1998). The ECERS-R is a widely used measure of program practices in early childhood care and education. Classrooms are rated on seven subscale content areas by a trained observer, and each item is scored from 1 to 7, with 1 being inadequate and 7 being optimal. Analyses examined total ECERS scores and subscale scores. The mean total ECERS-R score for extended-day classrooms was 4.80 (N=6), while half-day classrooms averaged a nearly identical 4.79 (N=62). ECERS-R scores were not obtained for private full-day programs, so data are unavailable for those classrooms.

### *Data Collection*

A letter explaining the nature of the research with an informed consent form was sent in early September to all families recruited for the study. Consenting parents completed a Parent Interview of Family Characteristics and Home Activities (Center for Early Education Research, 1999) by telephone each Fall. The interview gathers information regarding family background characteristics such as ethnicity, home language, maternal employment and income. Children were tested near the beginning and end of each preschool and kindergarten year, and at the end of first grade for Wave 1 only. Program quality in public school preschool classrooms was assessed through systematic observations in both the Fall and Spring.

Language of child assessment was either English or Spanish, based on the judgments of parents and teachers regarding which language was most often and most comfortably used by each child. Of the 297 baseline assessments, 31% were conducted in Spanish. Over the course of the study, as English proficiency increased for many children, and they became accustomed to classroom activities being in English, language of testing was switched to maintain the goal of optimal performance. By the beginning of their kindergarten year, only 6% of children were assessed in Spanish.

### *Measures*

*Woodcock-Johnson Psycho-Educational Battery - Revised (WJ-R)*. Five subtests of the WJ-R (Woodcock & Johnson, 1989) were used to assess cognitive ability and achievement: Picture Vocabulary, Letter-Word Identification, Passage Comprehension, Calculation, and Applied Problems. The WJ-R provides a standardized measure of children's individual progress over time in basic skill areas widely endorsed by practitioners as critical for the young child's success in school. These include early literacy, language, and math skills and knowledge. The same subtests from the Woodcock-Muñoz Revised, the Spanish-language version of the WJ-R, were used for Spanish-language assessments.

*Peabody Picture Vocabulary Test, Third Edition (PPVT III)*. The PPVT-III (Dunn and Dunn, 1997) is a norm-referenced measure of listening comprehension and a quick test of verbal ability from age 2<sup>1</sup>/<sub>2</sub>. Reliability coefficients for the PPVT-III range from .85 (test-retest) to .97 (internal consistency), and concurrent validity has been established through correlations with general intelligence tests of between .4 and .8. Children assessed in Spanish were tested using the Test de Vocabulario en Imagenes Peabody (TVIP; Dunn, Padilla, Lugo, & Dunn, 1986), a Spanish version of the PPVT.



## Data Analyses

Multiple methods were used to estimate the effects of duration on child outcomes. Simple t-tests and regression analyses were used to estimate effects at the end of preschool, the beginning and end of kindergarten, and the end of grade 1. Independent variables in the regression analyses include treatment, maternal employment and education, income, ethnicity, primary home language, and baseline test score. Growth curve modeling was used to estimate the pattern of effects over time by creating a continuous trajectory of change for both the treatment and comparison groups. The growth curve model allows for more precise estimates of impact (Love et al., 2002), and provides for an exploration of both linear and quadratic effects. The Passage Comprehension and Calculation subtests proved difficult for most study participants in preschool and kindergarten. Prior to first grade, the vast majority of raw scores were either 0 or 1, and valid standard scores could not be computed. Growth curve analyses were conducted on these two outcome measures using raw scores. In addition, all analyses were conducted with experimental vs. full control (all children from the waiting list) and experimental vs. half-day control (just children who attended the half-day program) to determine if the choice of a full-day, full-year child care program by a small subset of the parents biased the results.

## Results

### Baseline Comparison

Table 1 provides baseline data for child outcome measures. The simple comparison of posttest means using a t-test assumes that initial baseline test differences are due to differences existing prior to baseline assessment. The regression analyses control for differences in baseline test scores and selected demographic characteristics. These data were collected primarily during October and November of students' preschool year. Children in the extended-day program scored significantly higher than controls on the PPVT, as well as the Picture Vocabulary and Applied Problems subtests of the WJ-R at baseline. The treatment and control groups also differed significantly on the average number of hours that mothers worked per week. Mothers with children in extended-day preschool spent an average of 39.9 hours per week at work, compared to 35.4 hours for mothers whose children attended half-day programs. Controlling for ethnicity and maternal education, treatment was a significant ( $p < .05$ ) predictor of weekly maternal employment hours. The control group also contained a somewhat higher percentage of children identified by parents as Latino (78% compared to 66% for the experimental group), though this difference was not statistically significant. Group differences on the PPVT and Picture Vocabulary tests were significant whether comparing the treatment group to all control children (including those in private daycare), or to half-day students only. The baseline difference on Applied Problems was slightly reduced by restricting the comparison group to half-day attendees, but remained significant at  $p < .10$ .

**Table 1**  
**Sample Characteristics at Baseline**

<b>Characteristic</b>	<b>(N = 77)</b>	<b>(N = 217)</b>
<b>Children:</b>	<b>Treatment</b>	<b>Control</b>
<b>(N = 294)</b>		
Average age	52 months	52 months
% female	49%	51%
Average PPVT standard score*	85.4	81.1
Average WJ-R standard scores		
Picture-Vocabulary*	83.0	79.1
Letter-Word Ident.	93.1	91.5
Applied Problems*	89.4	84.6

(N = 273)

% Spanish-speaking	33%	42%
% Latino	66%	78%
% African American	20%	12%
% White non-Latino	9%	5%
% Other or Missing Race	5%	5%

**Families: <sup>1</sup>**

Average # people in household (N = 272)	4.3	4.3
% married (N = 271)	62%	64%
% mothers working (N = 273)	49%	61%
Average # work hours/week* (N = 158)	39.9	35.4
% high school graduate (N = 250)	79%	73%
% income below \$25,000 (N = 247)	52%	53%

\* Groups differ significantly at  $p < .05$

<sup>1</sup> Sample size reflects # of respondents to specific survey questions

Regression analyses were conducted to examine the degree to which differences in test scores at baseline could be explained by incidental differences between groups in background characteristics such as ethnicity, language spoken at home, mother's employment status, and mother's education. Baseline test score differences were reduced somewhat by controlling for these family background characteristics. Scores no longer differed significantly on any test at  $p < .05$ , though the treatment group remained favored by about 3 raw score points on the PPVT, and 1 point on Applied Problems. Without considering background characteristics, these differences were about 5 and 1.4 points, respectively.

Some children in both the treatment and control groups had attended a preschool program for over 2 months before baseline testing was conducted. A reasonable explanation for baseline differences is that initial exposure to treatment improved the test performance of children in the experimental group. However, regression analyses failed to find that the number of days between program inception and baseline testing had a statistically significant effect on baseline scores. There is some evidence that children who were least proficient on the measures may have benefited most from the first few weeks of extended-day preschool duration. When raw scores of less than 2 were removed from analyses of WJ-R baseline scores, initial group differences were reduced. A larger percentage of the control group scored 0 or 1 on all three valid WJ-R subtests at baseline compared to children in the treatment group. Analyses were conducted omitting children with these very low scores in order to evaluate the extent to which this difference in baseline scores affected the results. As discussed below, the treatment effects over time remained essentially unchanged when the lowest WJ-R scores were omitted from the analyses, indicating that estimated effects are not explained by the larger percentage of control children who tested poorly at baseline.

**Table 2**  
**Mean Raw Child Test Scores by Group and Time**

		<b>PK-Fall</b> (N=216, 77)	<b>PK-Spring</b> (N=203, 73)	<b>K-Fall</b> (N=197, 71)	<b>K-Spring</b> (N=186, 66)	<b>G1-Spring</b> (N=100, 32)
<b>PPVT</b>	Control	27.85	40.77	49.50	62.79	79.89
	Treatment	32.70	49.51	58.52	74.00	93.13
	Difference	4.85*	8.74*	9.02*	11.21*	13.24*
<b>Picture Vocabulary</b>	Control	16.53	18.50	19.93	22.03	24.28
	Treatment	17.49	19.58	20.94	23.20	26.22
	Difference	.96*	1.08*	1.01*	1.17*	1.94*
<b>Letter-Word Identification</b>	Control	4.84	7.23	8.32	12.80	23.94
	Treatment	5.22	8.89	10.31	13.45	25.56
	Difference	.38	1.66*	1.99*	.65	1.62
<b>Passage Comprehension</b>	Control	.71	1.02	1.46	1.66	8.85
	Treatment	.97	1.27	1.70	2.17	11.84
	Difference	.26	.25	.24	.51	2.99*
<b>Calculation Treatment</b>	Control	.05	.20	.50	1.90	8.02
	.03	.33	.62	2.65	9.72	
	Difference	-.02	.13	.12	.75*	1.70*
<b>Applied Problems</b>	Control	5.99	10.09	12.38	16.06	22.41
	Treatment	7.36	11.48	14.03	18.33	26.28
	Difference	1.37*	1.39*	1.65*	2.27*	3.87*

p < .05

### *Comparison of Means*

Table 2 presents mean raw test scores by group and time. Because there was no significant difference in age between groups, comparisons of mean test performance can be made using raw scores, with age entered as a factor. The treatment group scored better on all measures at all post-tests, with statistically significant differences on all measures at one or more post-tests. With the exception of Letter-Word Identification, differences between groups tended to grow over time. By the end of grade 1, the Wave 1 treatment group scored more than 13 points higher than controls on the PPVT, compared to a baseline difference for Wave 1 of less than 5 points. The divergence between groups over time was similar on Applied Problems, with a grade 1 difference nearly 3 times the size found at baseline. The comparison of means shown in Table 2 was conducted using independent-sample *t* tests, without controlling for other variables. Adjusting for incidental group differences in family background characteristics diminishes baseline discrepancies, but does not eliminate them completely.

### *Growth Curve Analyses*

Growth curve analyses were conducted to determine whether students in the experimental group experienced a significantly different trajectory of achievement over time on the PPVT and five WJ-R subtests. The data were centered by converting age to a deviation score around the total group mean, and then a regression equation was created to examine growth as it occurred by month. Both linear and non-linear trends were examined.

As shown in Table 3, students who attended the treatment program showed a significantly higher rate of growth on four of six child outcome measures, and were favored on a fifth. Standard scores on the PPVT improved for all children at an average rate of .40 points per month. A significant time by treatment interaction ( $t^*x$ ) reveals that scores for students who received extended-day preschool education rose an additional .21 standard score points per month ( $p < .01$ ). This indicates that the “value added” by the extended-day program was to increase growth rates by 53%. Scores on the Picture Vocabulary subtest measuring expressive verbal ability also favored the experimental group, with added growth of .16 standard points per month. A similar pattern was found for measures of mathematic abilities. Children in the treatment group demonstrated twice the growth rate of controls on the Applied Problems subtest of the WJ-R (.35 additional standard points per month,  $p < .01$ ). No significant differences in trends were found for scores on the Letter/Word Identification WJ-R subtest.

**Table 3**  
**Regression Estimates of Treatment Effect on Growth in Child Standard Scores**

Test (Standard)	DF	t	x	t*x	t*t*x
PPVT-III	638	.40	3.77	.21*	.00
Picture Vocab.	637	.30	2.44	.15	.01
L/W Identification	637	.24	1.62	.05	.00
Applied Problems	637	.35	5.64	.35*	.02*

**Test (Raw)**

Passage Comp.	637	.12	.00	.06*	.01*
Calculation	637	.16	.24	.05*	.00

Dependent Variable: PPVT-III and WJ-R subtest standard scores

t represents within subject standard score growth per month across treatment groups

x represents an estimate of baseline differences between groups

t\*x represents a treatment effect in terms of additional growth per month for the experimental group

t\*t\*x represents an estimate of quadratic treatment effects on growth in standard scores per month

\*  $p < .05$

Analyses conducted on the Passage Comprehension and Calculation subtests are limited to Wave 1 because standard scores for younger children on these tests were not considered appropriate for analysis due to unreliable age-norms. Even the most basic skills required to provide accurate responses on these tests typically develop in kindergarten and beyond. A raw score of 0 corresponds to an age equivalent of 4 years 11 months on Calculation, and 5 years 6 months on Passage Comprehension. For the study sample, a restricted range of performance was observed for children prior to first grade, with over 90% of raw scores at kindergarten posttest falling between 0 and 4 for Passage Comprehension and between 0 and 5 for Calculation. By contrast, in Spring of grade 1, children had experienced considerable gains, with 95% of scores between 0 and 17 for Passage Comprehension, and 0 and 11 for Calculation. Growth analyses were conducted on raw scores to compare improvement between groups by the end of first grade. The growth curve model was appropriate for analyses of these scores due to the sensitivity of this approach to group differences regardless of the timing or nature of the difference. The extended-day program was found to significantly improve performance on both measures ( $p < .05$ ), though the estimated effect was less than one added raw score point per year. In Spring of grade 1, students assigned to the control group achieved mean raw scores of 8.85 on Passage Comprehension and 8.02 on Calculation, as compared to 11.84 and 9.72, respectively, for the experimental group.

### Regression Analyses Comparing Treatment and Control Groups

Ordinary least squares regression was used to estimate the effect of the extended-duration program on test scores at the end of the preschool, kindergarten, and first grade years. In addition to the treatment variable, regression equations included child age and gender, mother's education, mother's employment status, a dummy variable for Hispanic race, and a dummy variable for African-American race. To control for baseline differences in test performance between groups, all regression equations included baseline scores on the dependent measure. For reasons discussed earlier, analyses were conducted for passage comprehension and calculation at the end of first grade only.

**Table 4**  
**Regression Results at Spring Preschool Testing**

	PPVT	Picture Vocab.	L/W Identification	Applied Problems
Total <i>df</i>	255	255	255	254
Adj. <i>R</i> <sup>2</sup>	.647	.387	.322	.489

#### Standardized regression coefficients

Baseline test score	.696*	.481*	.482*	.654*
Mother's education	.112*	.117*	.103 <sup>+</sup>	.098*
Mother employed	-.005	.067	.033	.094*
Child male	.036	-.157*	-.055	.017
Child Latino	-.094 <sup>+</sup>	-.128 <sup>+</sup>	-.112	-.013
Child African-American	-.009	.039	.003	.016
Treatment/Control	.123*	.037	.159*	.078 <sup>+</sup>

\*  $p < .05$

<sup>+</sup>  $p < .10$

Results for regressions performed on Spring preschool test scores are presented in Table 4. The regression model is significant ( $p < .01$ ) for all four outcome measures, explaining between one-third (for Letter-Word Identification) and two-thirds (for PPVT) of the variance of Spring preschool scores. Children who had attended extended-day preschool significantly outperformed children in the control group on two of the four measures analyzed ( $p < .05$ ). Group differences were found for the PPVT and Letter-Word Identification.

**Table 5**  
**Regression Results at Spring Kindergarten Testing**

	PPVT	Picture Vocab.	L/W Identification	Applied Problems
Total <i>df</i>	232	229	229	228
Adj. R <sup>2</sup>	.496	.344	.123	.417

**Standardized regression coefficients**

Baseline test score	.532*	.434*	.320*	.564*
Mother's education	.054	.119*	.094	.045
Mother employed	.045	.008	-.004	.151*
Child male	-.008	-.237*	.019	.024
Child Latino	-.220*	-.139 <sup>+</sup>	-.162 <sup>+</sup>	-.081
Child African-American	-.128 <sup>+</sup>	.004	-.119	.013
Treatment/Control	.235*	.087	.045	.196*

\*  $p < .05$

<sup>+</sup>  $p < .10$

Scores obtained at the beginning of the kindergarten year were almost identical to the results from Spring preschool assessments. Summer break did not seem to affect the advantages demonstrated by children who had attended extended-day preschool. Regression results for child test scores at the end of the kindergarten year are shown in Table 5. The model continued to predict test scores well, with adjusted R<sup>2</sup> values above .33 for all analyses except Letter-Word Identification scores. Statistically significant effects ( $p < .01$ ) were found for PPVT and Applied Problems scores. Compared to the end of preschool results, regression coefficients rose from .16 to .24 on the PPVT, and from .09 to .20 on Applied Problems. No effect on Letter-Word Identification scores was evident at Spring of the kindergarten year. However, a trend favored students in the extended-duration program on WJ-R Picture Vocabulary scores ( $p < .10$ ).

The strength of the association between maternal education and child test scores appeared to weaken over time, remaining significant at Spring kindergarten only for Picture Vocabulary scores. As found at the end of the preschool year, Spring kindergarten scores showed significantly greater achievement on Applied Problems for children with working mothers compared to students whose mothers did not work. Latino children scored significantly lower than peers on the PPVT, and may have performed slightly more poorly on both Picture Vocabulary and Letter-Word Identification.

Two considerations distinguish analyses of treatment effect at Spring grade 1 from previous analyses. These scores only include children in Wave 1 ( $N = 132$ ), and analyses could be conducted on two additional measures, the WJ-R Passage Comprehension and Calculation subtests. Regression results for Spring grade 1 scores are presented in Table 6. Children attending extended-day preschool scored significantly higher than the control group on five of the six measures analyzed ( $p < .05$ ). Performance did not differ between groups on Letter-Word Identification.



With one exception, family background characteristics did not significantly impact Spring grade 1 test scores. Achievement of Latino children no longer differed significantly on any measure compared to peers. In addition, no significant results were found related to maternal education or employment. However, consistent with all previous assessments, girls performed significantly better than boys on Picture Vocabulary ( $p < .05$ ).

**Table 6**  
**Regression Results at Spring Grade 1 Testing (Wave 1 Only)**

	PPVT	Picture Vocab.	L/W Ident.	Passage Comp.	Calculation	Applied Problems
Total <i>df</i>	131	130	130	130	130	129
Adj. R <sup>2</sup>	.446	.261	.080	.059	.086	.320

**Standardized regression coefficients**

Baseline test score	.553*	.386*	.346*	.093	.218*	.415*
Mother's education	.103	.146 <sup>+</sup>	.040	.123	.137	.052
Mother employed	-.060	.023	-.029	-.103	-.132	-.130 <sup>+</sup>
Child male	-.070	-.179*	-.109	-.075	-.107	-.139 <sup>+</sup>
Child Latino	-.089	-.108	-.026	-.012	.100	.049
Child African-American	-.054	-.009	-.070	.091	.141	.052
Treatment/Control	.270*	.179*	.041	.187*	.210*	.343*

\*  $p < .05$

<sup>+</sup>  $p < .10$

*Regression Analyses Comparing Treatment and Half-day Programs Only*

Because 31 children assigned to the control group either enrolled in full-day private childcare or stayed home at baseline assessment, regressions were conducted comparing the treatment group to children in half-day public programs only. These analyses were intended to focus group differences on duration alone, and to test the hypothesis that the treatment effect could in part be explained by poor test performance of children in private care. The estimated impact of treatment was generally the same as found in analyses that included the entire control group. The treatment group advantage at Spring grade 1 on Picture Vocabulary was no longer statistically significant, though scores for children in the treatment program were still higher ( $p < .10$ ), and the effect size was essentially unchanged (.17 compared to .18). Scores on the Calculation subtest no longer significantly differed between groups at Spring grade 1. These results seem likely to be due to reduced power with the smaller Wave 1 sample.

## Discussion

Children who attended an extended-day, extended-year preschool program experienced greater improvement in test scores compared to peers who attended half-day programs. The difference in performance gains over time was evident for measures of both verbal and mathematic abilities. These results indicate that duration is an important consideration for the effectiveness of preschool education. Common sense and other research suggests that increased time in the classroom yields better results because it provides greater opportunity for teachers to work individually with students and allows for a more relaxing atmosphere with less time proportionately spent on routines such as meals, tying shoelaces and hand washing.

The average classroom quality score on the ECERS-R was just under 5 which is higher than scores found for the rest of the Abbott preschool program during that time period (Barnett, Tarr, Esposito-Lamy, & Frede, 2001) and higher than typical results from other programs (Espinosa, 2002), but roughly equal to scores of Head Start classrooms reported in the 2000 Family and Child Experiences Survey (U.S. Department of Health and Human Services, 2003). The magnitude of treatment effect found in this study may be dependent on program quality. Effects of increased duration could be even larger with higher quality programs. Conversely, the effect of increased duration could be reduced, eliminated, or even reversed if program quality is low. If disparities in child growth rates occurred independent of classroom quality, then benefits experienced by children in extended-day preschool were not caused by exposure to something generally better, but rather by increased exposure to an equally advantageous environment. However, different assessment of the classroom practices would be required to fully understand the extent to which the proportion of time spent in various activities may have differed with duration of day.

Results of this study indicate that students in a high-poverty district who are far behind at entry to preschool can develop vocabulary, math, and literacy skills that approach national norms if provided with extended-duration preschool that maintains reasonable quality standards. At Spring kindergarten assessment, children in the extended-duration program had improved more than 10 standard points on two measures (from 85 to 96 on the PPVT, and from 89 to 101 on Applied Problems), though they remained somewhat behind national norms on all measures except Applied Problems. Scores of children in control programs also improved, but not to the degree demonstrated by their treatment group peers. From baseline to Spring kindergarten, the average standard score for the control group rose from 81 to 87 on the PPVT, and from 85 to 92 on Applied Problems. Due to their accelerated rate of improvement, children in the treatment group were within .3 standard deviations of the national mean on two of four valid outcome measures and had achieved the national mean on a third. The control group remained approximately a full standard deviation behind the national mean on two measures and was not within .3 standard deviations on any measure.

The impact of family and child background characteristics on learning was weaker at the end of first grade than at earlier assessments. The apparent fade-out of the influence of such background characteristics as ethnicity and maternal education over the course of the study may be evidence that quality early education compensates somewhat for disadvantaged circumstances. If so, then preschool education is an effective tool for enhancing equality of opportunity as well as increasing achievement generally.

One interpretation of baseline discrepancies in test scores between groups is that pre-testing was not conducted early enough in the academic year to avoid early impacts of treatment. Scores for the experimental group may have been boosted during the first two months of attendance at the extended duration preschool. The existence of such an immediate impact could only be fully examined using a different methodology than was employed for this research. Another possibility is that the treatment group began with some advantages despite random assignment, and started the program with accelerated scores. There is no evidence that the randomization procedure was somehow faulty, but baseline differences could have occurred by chance. No difference at baseline was statistically significant at ( $p < .01$ ) and given that these factors tend to fade in their power to predict child progress, confidence can be placed in the statistical procedures controlling for the initial differences.

The difference in duration of program continued into kindergarten. The treatment group continued to receive 8 hours of service daily in kindergarten, while the control group moved to a 6-hour daily kindergarten schedule. Given the research design of this study, it is not possible to analyze how much later gains by the treatment group were due to the 5-hour advantage in preschool duration or the 2-hour advantage in kindergarten day. A proportional allocation of the benefits would attribute the majority of the gains to the preschool program, and the magnitude of difference in gains between groups was larger at the end of preschool and beginning of kindergarten than at the end of kindergarten. However, this is another question that calls for further empirical research.

Although further research is needed to augment this single study of half-day vs. extended-day preschool, the results clearly indicate that duration and intensity matter. Extended-day preschool seems to have dramatic and lasting effects when it is high quality. All teachers in the study classrooms were certified, public school employees paid on union scale. A comprehensive curriculum was implemented with strong supervisory support offered to classroom staff. Classrooms were also well supplied, and both children and families received support services. Given the evident need of many families for full-day care for their 4 year olds and the evidence presented here that full-day preschool has important benefits for child learning, policy makers should strongly consider implementation of full-day preschool.

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