MONTGOMERY
COUNTY PUBLIC
SCHOOLS

Impact of Full-day Prekindergarten Program on Student Academic Performance

Office of Shared Accountability

February 2009

Huafang Zhao, Ph.D.
Shahpar Modarresi, Ph.D.
Shihching Liu

Montgomery County Public Schools

OFFICE OF SHARED ACCOUNTABILITY

Dr. Stacy L. Scott , Associate Superintendent
850 Hungerford Drive
Rockville, Maryland 20850
301-279-3925

Dr. Jerry D. Weast   **Dr. Frieda K. Lacey**
Superintendent of Schools   *Deputy Superintendent*
                                                               of Schools

Table of Contents

List of Tables

List of Figures

THIS PAGE IS LEFT BLANK INTENTIONALLY

Executive Summary

Montgomery County Public Schools (MCPS) prekindergarten (pre-K) and Head Start programs include locally funded pre-K classes and locally and federally funded Head Start classes. These classes provide an early learning experience for mostly 4-year-old children who meet Head Start and pre-K program income-eligibility guidelines. The pre-K and Head Start programs are integral parts of the MCPS Early Success Performance Plan, designed to provide necessary supports for all students to achieve at high levels and address the pervasive achievement gap among student groups.

There are three different types of pre-K classes—Head Start full-day, Head Start partial-day, and MCPS partial-day classes. In this report, Head Start and MCPS partial-day classes are referred to as half-day programs. These pre-K classes are modeled after effective and high-quality preschool programs, and provide early education services to children who are eligible for Free and Reduced-price Meals System (FARMS) services in the school district. All pre-K classes provide scientifically based and literacy-focused instruction five days a week, for approximately 180 days per year. Classes are taught by state-certified early childhood education teachers, with the support of para-educators. The class ratio is two adults per class of 20 children. The MCPS pre-K curriculum and instructional program is designed to promote children's cognitive, physical, social, and emotional development. Teaching teams use an interdisciplinary, whole-child approach, with emphasis on language, literacy, and mathematics. The MCPS pre-K and Head Start programs also provide children with lunch at no cost, health care, social services, and transportation.

In 2007–2008, MCPS offered its Title I schools the opportunity to expand their existing Head Start half-day classes into Head Start full-day classes. Ten elementary schools chose to participate and expanded their 13 Head Start half-day classes to full-day classes using Title I funding. The expansion was intended to provide more instructional time for non-English-speaking children as well as children highly impacted by poverty and mobility. Instructional time was extended as a strategy to close achievement gaps among socioeconomic and racial/ethnic groups. The increased instructional time allows students to experience a more integrated school day, with in-depth study of the MCPS pre-K curriculum. Added benefits include decreased child-care expenses, more convenient arrangements for many participating families, and a greater opportunity to foster the academic, social, and emotional growth of the children.

This study examined whether the increased instructional time resulted in greater student academic improvement in Head Start full-day classes, after controlling for differences in initial academic performance, demographic characteristics, and family background such as income and family size. Since students were not random assigned to different classes, multivariate statistical methods were used to control for potential selection bias. As part of a comprehensive pre-K program evaluation in MCPS, this study addressed the following questions:

1. Did increased instructional time contribute to higher reading and mathematics performance of pre-K students in the Head Start full-day classes compared with their peers in the Head Start half-day and MCPS half-day classes in the 2007–2008 school year?

2. Did program effect differ by student subgroups and schools?
3. What is the magnitude of the Head Start full-day program effects? What are the cost-benefit estimates of full-day and half-day classes?

Major Findings

The empirical evidence suggests the following:

- Increased instructional time in Head Start full-day pre-K classes has contributed to greater academic achievement.
- Students in the Head Start full-day classes made significantly larger gains in reading skills compared with their peers in the Head Start half-day classes. Significantly larger gains were found in mathematics for some subgroups in Head Start full-day classes.
- Students in the Head Start full-day classes made significantly larger gains in reading and mathematics skills compared with their peers in the MCPS half-day classes.
- Gains were significantly larger for female and Hispanic students, and students receiving English for Speakers of Other Languages (ESOL) services in the Head Start full-day classes.
- The full-day program effect was not the same for all schools. Students in some elementary schools such as Broad Acres, Twinbrook, and Viers Mill made much larger gains than others.
- Full-day program effects were sufficient enough to have practical educational significance.
- The full-day program effect is significantly large enough to justify its higher cost per student.

Recommendations for Improvement

- Expand Head Start half-day classes to Head Start full-day classes in Title I schools, if financially feasible.
- Make extra efforts to obtain complete assessment data for all future students in the pre-K classes.
- Examine and share best practices in schools with the greatest pre-K achievement growth.
- Revise pre-K reading and mathematics assessments and set proficiency benchmarks for these assessments.

Impact of Full-day Prekindergarten Program on Student Academic Performance

Huafang Zhao, Ph.D., Shahpar Modarresi, Ph.D.,
Shihching Liu

Background

Early Success Performance plan focuses on closing the achievement gap for most-impacted children and is a strategy of MCPS Goal 2 of *Our Call to Action: Pursuit of Excellence*—provide an effective instructional program.

Head Start, a U.S. government early childhood program was launched in 1965 as part of President Lyndon B. Johnson's War on Poverty. It provides low-income children, ages 3–5, and their parents with education, health, nutrition, and social services.

Montgomery County Public Schools (MCPS) prekindergarten (pre-K) and Head Start programs include locally funded pre-K classes and locally and federally funded Head Start classes. These classes provide an early learning experience for mostly 4-year-old children who meet Head Start and pre-K program income-eligibility guidelines. The pre-K and Head Start programs are integral parts of the MCPS Early Success Performance Plan, designed to provide necessary supports for all students to achieve at high levels and address the pervasive achievement gap among student groups.

There are three different types of pre-K classes—Head Start full-day, Head Start partial-day, and MCPS partial-day classes. In this report, Head Start and MCPS partial-day classes are referred to as half-day programs. These pre-K classes are modeled after effective and high-quality preschool programs, and provide early education services to children who are eligible for Free and Reduced-price Meals System (FARMS) services in the school district. All pre-K classes provide scientifically based and literacy-focused instruction five days a week, for approximately 180 days per year. Classes are taught by state-certified early childhood education teachers, with the support of para-educators. The class ratio is two adults per class of 20 children. The MCPS pre-K curriculum and instructional program is designed to promote children's cognitive, physical, social, and emotional development. Teaching teams use an interdisciplinary, whole-child approach, with

emphasis on language, literacy, and mathematics. The MCPS pre-K and Head Start programs also provide children with lunch at no cost, health care, social services, and transportation.

In 2007–2008, MCPS offered its Title I schools the opportunity to expand their existing Head Start half-day classes into Head Start full-day classes. Ten elementary schools chose to participate and expanded their 13 Head Start half-day classes to full-day classes using Title I funding. The expansion was intended to provide more instructional time for non-English-speaking children as well as children highly impacted by poverty and mobility. Instructional time was extended as a strategy to close achievement gaps among socioeconomic and racial/ethnic groups. The increased instructional time allows students to experience a more integrated school day, with in-depth study of the MCPS pre-K curriculum. Added benefits include decreased child-care expenses, more convenient arrangements for many participating families, and a greater opportunity to foster the academic, social, and emotional growth of the children.

Both full-day and half-day classes provide a high-quality educational experience to eligible pre-K children. However, full-day classes offer additional instruction in mathematics, literacy, the arts, music, physical education, social interaction, oral language, and vocabulary development. The Head Start full-day classes last 6 ¼ hours each day, while the Head Start half-day classes last 3¼ hours each day. The reading instructional time increases from 30 minutes per day in a half-day class to 60 minutes per day in a full-day class. Mathematics instructional time increases from 20 minutes daily in a half-day class to 50 minutes daily in a full-day class.

MCPS half-day classes serve disadvantaged students whose family incomes are slightly above the federal poverty guidelines. Vacancies are filled by students whose family incomes are above the eligibility criteria and who are impacted by at least one or more risk factors, such as having an Individualized Educational Program (IEP) or not speaking English. MCPS half-day classes last 2 ½ hours on a regular school day.

Literature about Early Education

There have been many studies since 1966 on Head Start's short- and long-term effects. Some studies suggest that early childhood is the most promising time to provide educational intervention for low-income children. Positive effects of high-quality early education have been found on cognitive, linguistic, social, and economic outcomes (Barnett, 1998; Barnett & Belfield, 2006). Programs targeted at the most disadvantaged students have documented significant gains in cognitive functioning and subsequent academic outcomes (Currie & Thomas, 1995). Gilliam and Ziegler (2001) conducted a meta-analysis of state-funded preschool classes in 13 states and found significant positive impacts; but only one of the programs credibly controlled for selection bias and students often differed in observable characteristics. Westat's Head Start national impact study provided evidence on short-term program effects with randomized experiment, but Westat's program effect results have been characterized as disappointingly small (Yoshikawa, 2005). Many studies show that parental education and family income are two of the most important factors that influence students' achievement (Drazen, 1992; Heller & Fantuzzo, 1993).

Most preschool program-evaluation efforts have focused on the achievement of kindergarten students. The limited research related to pre-K programs is far from definitive. Pre-K programs are expanding rapidly in the United States, but there is limited literature about the benefit of pre-K programs of different durations and levels of intensity. A recent study showed that the added hours of pre-K education were "substantially effective at closing the achievement gap between urban children and their more advanced peers" (Robin, Frede & Barnett, 2006).

Educational evaluators often use Cohen's (1988) effect size to judge the magnitude of program effectiveness. An effect size of 0.2 is considered as small, 0.5 as medium, and 0.8 or more as large. In evaluating program effects, researchers also need to consider benefits and costs. Harrison (2007) presented a cost-effectiveness framework, which suggested that any intervention producing increased test scores of 0.025 standard deviation per child per $1,000 spending should be considered large. Ludwig and Philips (2008) estimated the long-term effects of Head Start with cost-benefit analyses. They suggested that, with a cost of about $9,000 per child, Head Start did not need to yield a large, short-term program effect. They believed that program "effect size of 0.1 or 0.2 may be enough, and effects even smaller than this, perhaps much smaller, might be sufficient" (p.11).

Methodology

Evaluation Design

A critical issue in outcome evaluations is whether or not a program produces levels of effects above what would have occurred without the program (Rossi & Freeman, 1993). Because students were not randomly assigned to Head Start full-day classes in this study, a nonequivalent control group was used, which is a common quasi-experimental design. The stated design is the most appropriate evaluation design in assessing the effectiveness of any intervention program among the quasi-experimental designs (Shadish, Cook & Campbell, 2002). A problem with this design is that the two groups of students might differ in important ways that may influence outcomes. The advantage of this design is that statistical control can account for some pre-existing differences.

Evaluation Questions

This study examined whether more instructional time resulted in greater student academic improvement in the Head Start full-day classes, after controlling for pre-K students' initial academic performance, demographics, family background, and services received. The study addressed the following questions:

1. Did increased instructional time contribute to higher reading and mathematics performance of pre-K students in the Head Start full-day classes compared with their peers in the Head Start half-day and MCPS half-day classes in 2007–2008 school year?
2. Did program effect differ by student subgroups and schools?
3. What is the magnitude of the Head Start full-day program effects? What are the cost-benefit estimates of full-day and half-day classes?

Study Measures

Outcome measures are of critical importance when examining program effectiveness. MCPS pre-K reading and mathematics assessments are research-based, locally developed, and designed to measure important constructs and skills. These assessments are administered three times a year—fall, winter, and spring. Due to the young age of pre-K students, test practice effect is negligible. The assessment results provide valuable data about progress in student learning, and assist teachers in providing individualized instruction to meet students' needs.

Measures based on curriculum and instruction are more sensitive to students' learning than standardized tests. Students tend to do better on the content they have been taught (Walker & Schaffarzick, 1974). In this study, MCPS pre-K assessments were used as the outcome measures and total percent correct scores for reading and mathematics were calculated for analyses.

The pre-K reading assessment consists of five content clusters, with a total of 94 points. The five clusters are oral language, letter identification, identifying rhyming words, beginning sounds, and concepts about print. The reliability coefficient is a statistic that ranges from zero to 1, which quantifies the precision of test scores. The reliability of the reading assessment is 0.85, as measured by Cronbach's alpha which is considered high based on accepted criteria in research

(Nunnally, 1978). The correlation among five reading clusters and total scores ranges from 0.30 to 0.94 (see Table A1, Appendix A). The correlation between letter identification and total reading scores are the highest (0.94) followed by oral language (0.63).

The pre-K mathematic assessment consists of three content clusters. They are geometry, number representation, and number comparison, with a total of 18 score points. The test reliability in mathematics is 0.83, as measured by Cronbach's alpha. The correlation among geometry, number representation, number comparison, and total scores ranges from 0.25 to 0.97 (see Table A1, Appendix A). The number representation cluster has the highest correlation (0.97) with the total score.

Participants

By September 2007, 2,538 students were enrolled in all MCPS pre-K classes. Because the Head Start full-day and half-day classes required similar eligibility at the federal poverty level, students in the Head Start half-day classes served as a comparison group.

The majority of the participants (91%) were U.S. citizens and the rest were from 57 other countries. Approximately 68% of these students spoke a language other than English as their first language and a total of 67 different languages were represented.

As shown in Table 1, 391 of the pre-K students were enrolled in the Head Start half-day classes, 260 in the Head Start full-day classes, and 1,887 in MCPS half-day classes at the beginning of the school year. In the Head Start full-day classes, 34.6% of the students were African American, 50.4% were Hispanic, 9.2% received special education services, and 63.5% receiving English for Speakers of Other Languages (ESOL) services.

Table 1
Characteristics for 2007–2008 MCPS Students, by Prekindergarten Class (N=2,538)

	Head Start Half Day		Head Start Full Day		MCPS Half Day	
	N	*%*	*N*	*%*	*N*	*%*
Total	391		260		1,887	
Gender						
Male	184	47.1	140	53.8	949	50.3
Female	207	52.9	120	46.2	938	49.7
Race/Ethnicity						
African American	192	49.1	90	34.6	585	31.0
Asian American	28	7.2	23	8.8	235	12.5
Hispanic	138	35.3	131	50.4	972	51.5
White	33	8.4	15	5.8	94	5.0
Services Provided						
Special Education	30	7.7	24	9.2	78	4.1
ESOL	127	32.5	165	63.5	1,077	57.1

Note. American Indian students were included in the total but not reported separately.

Table 2 indicates that students in the three pre-K classes were very similar with regard to guardian's age, guardian's education, and family size. However, annual median family income and median income per person in a family were higher for students in MCPS half-day classes.

This suggests that students in MCPS half-day classes were financially better off than their peers in the Head Start classes, due to different program income-eligibility criteria.

Table 2
Family Background for 2007–2008 MCPS Students, by Prekindergarten Class
(*N*=2,538)

	Head Start Half Day		Head Start Full Day		MCPS Half Day	
	Mean	Median	Mean	Median	Mean	Median
Total Family Income	$13,872	$13,200	$15,944	$15,523	$28,638	$28,000
Income per Person	$3,616	$3,485	$4,153	$4,108	$7,452	$7,467
Female Guardian's Age	31	30	32	31	32	31
Male Guardian's Age	36	37	37	37	36	36
Female Years of Education	12	12	12	12	12	12
Male Years of Education	12	12	12	12	12	12
Family Size	4	4	4	4	4	4

Study Samples

The treatment group included students who attended the Head Start full-day classes in 2007–2008. The comparison groups included students in the Head Start half-day and MCPS half-day classes in the same school year. Only students with complete assessment results were included in the analyses.

Procedures for Analyses

Two statistical methods were used, namely Analysis of Covariance (ANCOVA) and repeated measure two-way Analyses of Covariance. Full-day program effects are shown with two important indicators. One is the significant treatment effect (or main effect) and the other is the significant interaction effect.

Analyses of Covariance (ANCOVA)

Since students were not assigned to each class type randomly, analysis of covariance was used to control for important background variables in order to reduce selection bias and observe the true treatment effects (Campbell & Stanley, 1963; Judd, Smith & Kidder, 1991). It is important to examine pre-existing differences among individual students in each pre-K class type.

After controlling for pre-existing differences, significant variations between students' mean scores on MCPS reading and mathematics tests were tested for those attending the Head Start full-day classes and those who had not. The four models of analysis contained the students' prior performance, demographics, family income per person, special education and ESOL services[1] (see Appendix B).

---

[1] To test for nonparallelism or interaction (homogeneity of regression slopes), the product term between the pretest scores and the group variable was included in the ANCOVA models.

Since spring assessment results in reading and mathematics were the outcome measures, all students in Head Start full-day and Head Start half-day classes with both fall and spring test results were included. Five hundred students in MCPS half-day classes were selected randomly to maintain a more balanced design for comparison. Among them, 333 students had complete data in reading and 331 had complete data in mathematics.

Repeated Measure Two-way Analyses of Covariance

This study also examined test results from three administrations for students in different pre-K classes. Repeated measure[2] is more sensitive to detect program effects and a natural design to measure performance over time (Stevens, 1992). Fall test results were used as a control for performance difference at the beginning of a school year. Academic outcome measures included reading and mathematics test results in winter and spring. Included in the analyses were all students in the three types of pre-K classes, with complete assessment data in fall, winter, and spring.

Effect Size and Cost-benefit Estimates

Effect size is a commonly used statistic to measure the magnitude of program effect (American Psychological Association, 2001). It was calculated to measure the standardized difference between two group means and to examine if the effect had any practical importance.

Two different kinds of effect sizes were calculated— program and seasonal effects[3]. Program effect size was calculated based on the mean score differences between the Head Start full-day classes and two half-day classes. Seasonal effect size was calculated based on the difference between the fall mean score and the spring mean scores for each pre-K class type.

The cost-benefit estimation for the full-day program effect is to determine if the Head Start full-day program effect is sufficient enough to justify its cost. In addition, seasonal effect sizes, as computed by class type, were used to estimate relative program cost and benefits.

---

[2]In order to yield unbiased results, the Huynh-Feldt correction method was applied when sphericity assumption was violated in repeated measure. Partial eta squared values were computed to estimate program effect. If significant differences were found, the Bonferroni method was used to compare performance among groups.

[3]The following formula was used to calculate the effect size in this evaluation: effect size = $(M_t - M_c)/SD$. The M_t and M_c are adjusted group means for students who participated in Head Start full-day classes and those who attended the two half-day classes, respectively, and *SD* is the standard deviation of the pooled outcome scores.

Results

Results are displayed in several steps. First, descriptive statistics are presented for students with complete reading or mathematics results. Second, ANCOVA results are shown with the associated effect sizes to estimate the overall full-day class effect, followed by results of repeated measure analyses for subgroups and schools. Finally, the effect sizes from repeated measure analyses and cost-benefit estimates are illustrated.

Prekindergarten Students with Complete Reading or Mathematics Results

Of the pre-K students enrolled in fall 2007, 808 had incomplete assessment data in reading, and 794 had incomplete data in mathematics. Demographic characteristics of students with incomplete test results are displayed in Table A2 and Table A3 (see Appendix A). Only 1,827 students had complete test results either in reading or mathematics. Among them, 202 were in Head Start half-day classes, 177 in Head Start full-day classes, and 1,448 in MCPS pre-K classes (Table 3).

Table 3 shows demographic characteristics and family background for the 1,827 students. There were more Hispanic students (46.9%) in the Head Start full-day class compared with the Head Start half-day class (35.1%). There were also more ESOL (71.2%) students in the Head Start full-day class than both Head Start half-day (44.6%) and MCPS half-day (62%) classes. More students in the Head Start full-day (11.3%) and Head Start half-day (11.4%) classes received special education services, compared with MCPS half-day (4.6%) classes.

Family income for students in the MCPS half-day classes was higher than family income for students in the Head Start classes (Table 4). Overall, students with the complete test results are similar to the original cohort by pre-K class type, as shown in Tables 1 and 2.

Table 3
Characteristics for 2007–2008 MCPS Students with Complete Reading or Mathematics
Test Results for Fall, Winter, and Spring Test Administrations,
by Prekindergarten Class (*N*=1,827)

	Head Start Half Day		Head Start Full Day		MCPS Half Day	
	N	*%*	*N*	*%*	*N*	*%*
Total	202		177		1,448	
Gender						
Male	88	43.6	103	58.2	714	49.3
Female	114	56.4	74	41.8	734	50.7
Race/Ethnicity						
African American	103	51.0	65	36.7	442	30.5
Asian American	15	7.4	19	10.7	175	12.1
Hispanic	71	35.1	83	46.9	763	52.7
White	13	6.4	9	5.1	68	4.7
Services Provided						
Special Education	23	11.4	20	11.3	66	4.6
ESOL	90	44.6	126	71.2	898	62.0

Table 4
Family Background for 2007–2008 MCPS Students with Complete Reading or
Mathematics Test Results for Fall, Winter, and Spring Test Administrations,
by Prekindergarten Class (*N*=1,827)

	Head Start Half Day		Head Start Full Day		MCPS Half Day	
	Mean	Median	Mean	Median	Mean	Median
Total Family Income	$14,351	$13,547	$16,280	$16,155	$28,717	$28,393
Income per Person	$3,758	$3,568	$4,181	$4,128	$7,433	$7,494
Female Guardian's Age	31	30	32	31	32	32
Male Guardian's Age	36	37	37	38	36	36
Female Years of Education	12	12	12	12	12	12
Male Years of Education	13	12	12	12	12	12
Family Size	4	4	4	4	4	4

Tables A2–A3 (Appendix A) show demographic characteristics and family background for 1,098 students who did not have complete reading or mathematics test results for the test administrations. Students without complete data were similar in background characteristics to those with complete test results.

Impact of Instruction Time on Academic Performance

Head Start Full-day vs. Head Start Half-day Classes

Only students with both fall and spring assessment results were included in the analyses. The results showed that the main effect of the Head Start full-day class in reading was significant, after controlling for demographics, income per person in the family, special education services, ESOL services, gender, and prior academic performance (Table 5). This suggests, on average, students in the Head Start full-day class scored significantly higher than their peers on reading and math assessments in the Head Start half-day class. The effect size of 0.2 indicated that students attending the Head Start full-day class outperformed their peers in the Head Start half-day class and the observed higher performance is meaningful in an educational setting.

In mathematics, the analyses revealed that Head Start full-day students performed as well as those in the Head Start half-day class in spring, after factoring out the effects of students' pre-test scores, demographics, and receipt measures services.

Table 5
Adjusted Means, Mean Difference, and Effect Size for the 2007–2008 Spring Reading and
Mathematics Scores for Students in Head Start Full-day and Head Start Half-day Classes

	Adjusted Means				Treatment Effects	
	Head Start Full Day		Head Start Half Day			
Spring Assessment	*N*	Mean	*N*	Mean	Mean Difference	Effect Size
Reading	157	82.8	157	79.3	3.54*	0.20
Mathematics	156	87.8	202	87.3	0.50	0.03

Note. *=statistically significant.
    Reading: t=3.2; standard error=3.4; p=0.001.
    Mathematics: t=3.1; standard error=3.6; p=0.75.

Head Start Full-day vs. MCPS Half-day Classes

The analyses also showed that, on average, Head Start full-day students significantly outperformed their peers in MCPS half-day classes on reading in spring 2008, after adjusting for students' fall performance, demographics, and family background (Table 6). The effect of the program was large enough to be meaningful in an educational setting.

Similarly, when students' initial abilities, demographic characteristics, and services receipt measures were accounted for, the effect of the Head Start full-day class was statistically significant for mathematics. This suggests that, on average, students attending the Head Start full-day performed significantly higher than their peers in MCPS half-day class on spring mathematics assessment. The calculated effect size of 0.23 showed that the magnitude of the program effect was large enough to be of practical significance to educators.

Table 6
Adjusted Means, Mean Difference, and Effect Size for the 2007–2008 Spring Reading and
Mathematics Scores for Students in Head Start Full-day and MCPS Half-day Classes

| | Adjusted Means | | | | Treatment Effects | |
| | Head Start Full Day | | MCPS Half Day | | | |
Spring Assessment	N	Mean	N	Mean	Mean Difference	Effect Size
Reading	157	85.1	333	79.0	6.08*	0.30
Mathematics	156	88.7	331	84.6	4.13*	0.23

Note. *=statistically significant.
    Reading: t=4.5; standard error=2.99; p=0.000.
    Mathematics: t=2.3; standard error=3.3; p=0.024.

Repeated Measure Results

Different from analysis of covariance, only students with complete test results in fall, winter, and spring were included in the repeated measure analyses, which was intended to validate the significant program effect and to investigate differences for student groups and schools.

Overall results estimated with repeated measure are presented first, followed by findings for student subgroups and schools. Because students participated only in one of the three pre-K class types, comparisons were made across schools by class type. The main effects for season (winter to spring) and the interaction between season and pre-K class type were examined.

As shown in Table A4 (Appendix A), there were significant main effects for season (*p* value=0.00 for both reading and mathematics). The seasonal effect[4] accounted for about half (54.6% and 46%) of the score variance in reading and mathematics. The significant seasonal effect indicated that all pre-K students significantly improved their scores in reading and mathematics from fall to spring in 2007–2008, regardless of their pre-K class types.

---

[4] Partial eta squared values were computed to estimate seasonal effect.

Because we were interested in finding out if the improved performance varied by pre-K class type, we studied interaction between season and pre-K. The interaction was significant for reading (p=0.00), but not for mathematics (p=0.103), as shown in Table A4 (Appendix A). The significant interaction suggested that students in different pre-K classes performed differently in winter and spring, even when their fall reading scores were controlled.

Table 7 shows the estimated marginal means and standard deviations for reading and mathematics by pre-K class. Estimated marginal means are referred to as adjusted means in ANCOVA results. In fall, students in the Head Start full-day class had a slightly lower mean score in reading (40.5), compared with those in the Head Start and MCPS half-day classes (41.9 and 42.2, respectively).

By spring, students' mean score in reading improved significantly in the Head Start full-day class, from 40.5 to 86.2, with a 45.7-point increase. The increases for the Head Start half-day and the MCPS half-day students were 40.6 and 40.7, respectively. Students in the Head Start full-day class also had a much smaller standard deviation (15.6 in spring) compared with their peers in Head Start and MCPS half-day classes (19.6 in spring). This shows that students in the full-day classes had a significantly greater improvement in reading, and their reading ability became more homogenous in spring compared with their peers in the Head Start and MCPS half-day classes.

Table 7

Estimated Marginal Mean Score and Standard Deviation of Reading and Mathematics for Students with Complete Test Results for Fall, Winter, and Spring Test Administrations, by Prekindergarten Class

	Head Start Half Day			Head Start Full Day			MCPS Half Day		
	N	Mean	*SD*	*N*	Mean	*SD*	*N*	Mean	*SD*
Reading (*N*=1,523)									
Fall	152	41.9	23.5	141	40.5	24.3	1,230	42.2	25.7
Winter	152	64.1	23.7	141	71.2	22.0	1,230	67.3	25.1
Spring	152	82.5	19.6	141	86.2	15.6	1,230	82.9	19.6
Seasonal Gain		40.6*			45.7*			40.7*	
Mathematics (*N*=1,537)									
Fall	177	53.7	26.9	152	47.9	25.8	1,208	51.5	26.3
Winter	177	75.9	21.4	152	72.5	20.9	1,208	73.5	23.0
Spring	177	88.7	16.1	152	86.9	17.5	1,208	86.1	16.9
Seasonal Gain		35.0*			39.0*			34.6*	

Note. *=statistically significant with alpha at 0.05 level.

In mathematics, the increase for Head Start full day is also the largest, 39 points from fall to spring compared with 35.0 and 34.6 for Head Start and MCPS half-day students, respectively. However, the mathematics gain is not significantly different among students in the three different types of pre-K classes. The analyses validated the overall larger positive effect for reading in the Head Start full-day program found in ANCOVA presented previously.

Differences Across Student Groups

Tables A5–A6 (Appendix A) provide tests of within-subject and between-subject effects by student groups. The findings reveal significant main effects and interaction for pre-K classes by gender, race/ethnicity, and ESOL status (Table A5). This suggests that academic gains varied by pre-K classes and by student groups. Tables A7–A8 (Appendix A) show estimated marginal means and standard deviations in reading and mathematics for the three types of pre-K classes, by subgroup, from fall to spring.

Figure 1. Estimated marginal means in reading and mathematics for MCPS students, by gender and prekindergarten classes in 2007–2008.

Figure 1 shows estimated marginal means in reading and mathematics for students by gender. Male and female students in the Head Start full-day classes scored lower or similar on reading in fall and approached or surpassed their Head Start and MCPS half-day counterparts in spring.

The narrowing of the achievement gap is most obvious for female students in the Head Start full-day class. In fall, females in the Head Start full-day class scored lower than their peers in the

other two class types, but they scored highest in spring. From fall to spring, female students in the Head Start full-day class increased 50.4 points in reading compared with 40.7 and 41.3 points for their female peers in the Head Start half-day class and MCPS half-day class. In mathematics, score increase for females was 42.9 points for Head Start full-day and 32.4 points for the Head Start half-day and 33.4 points for MCPS half-day classes, respectively.

Figure 2. Estimated marginal means in reading for MCPS students, by race/ethnicity and prekindergarten classes in 2007–2008.

As shown in Figure 2, Hispanic, Asian American, and White students in the Head Start full-day class made greater gains in reading than students in Head Start half-day and MCPS half-day classes. Due to the smaller number of Asian American and White students, results should be interpreted with caution. Hispanic students in the full-day class scored lower in fall, but scored significantly higher on reading in spring. The reading score gain was the largest for Hispanic students in Head Start full-day classes (55.6 points) compared with their counterparts in Head Start half-day (49.5 points) and MCPS half-day (47.3 points) classes.
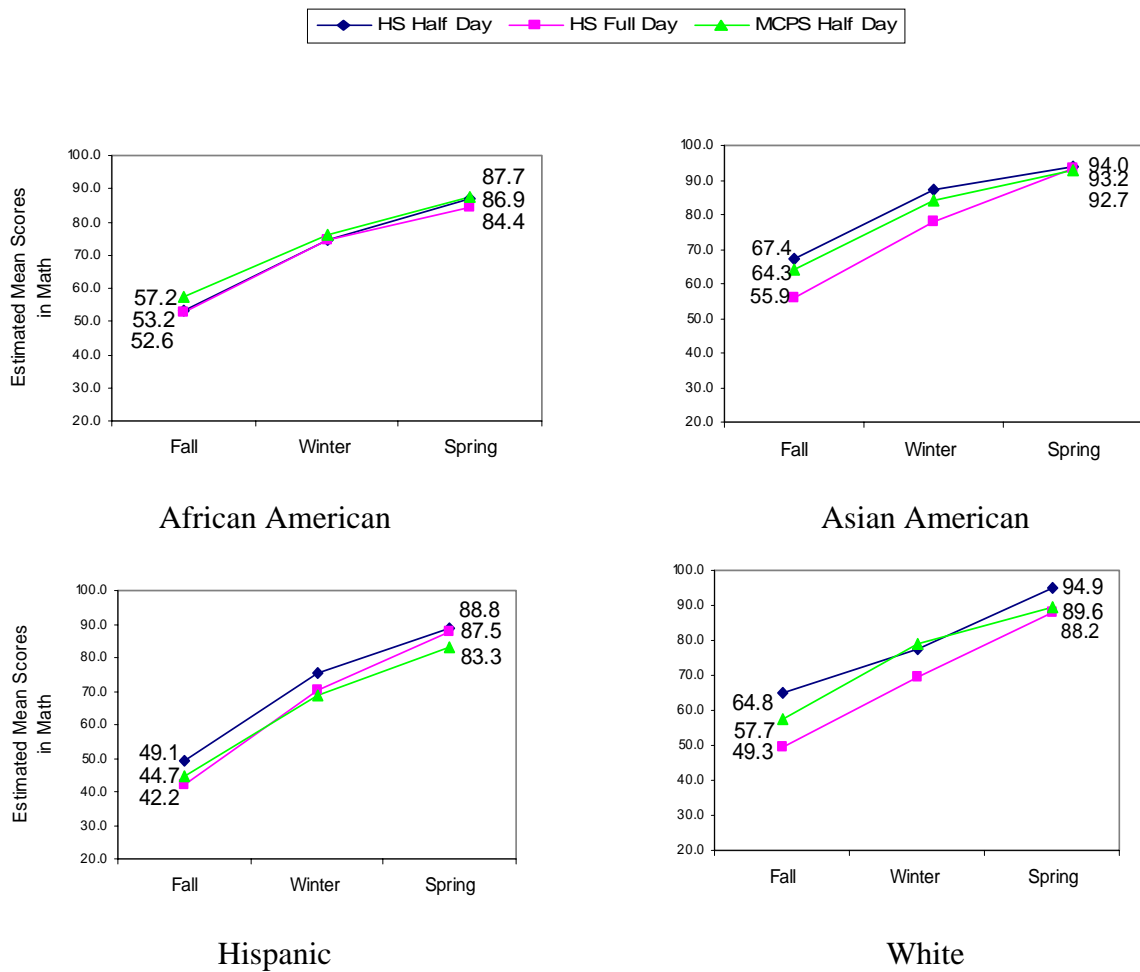
Figure 3. Estimated marginal means in mathematics for MCPS students, by race/ethnicity and prekindergarten classes in 2007–2008.

Figure 3 displays mathematics performance by race/ethnicity. Again, Hispanic students in the full-day class had a significantly larger score increase (45.3 points) compared with their peers in the other two half-day class types (39.7 and 38.6 points, respectively).
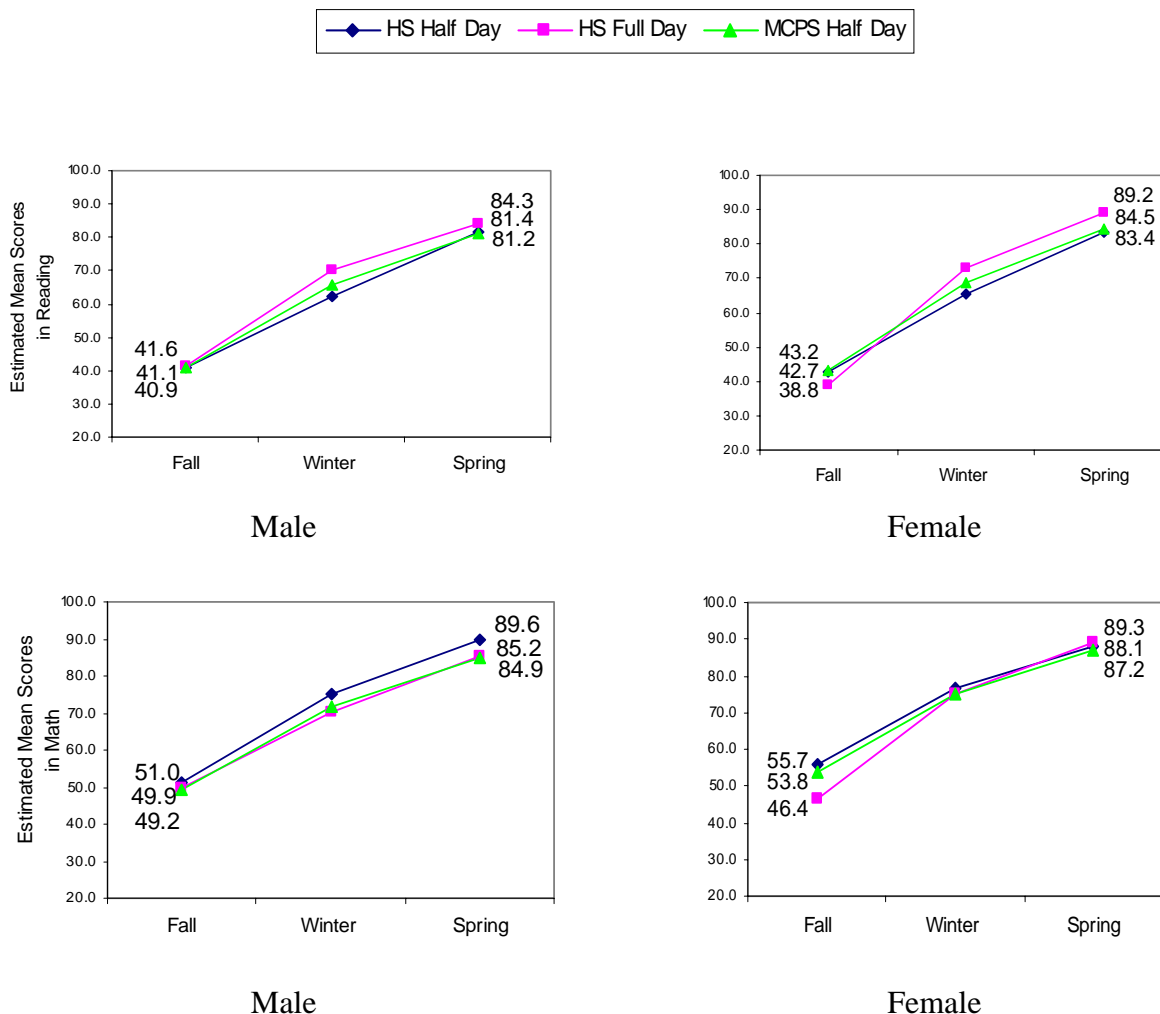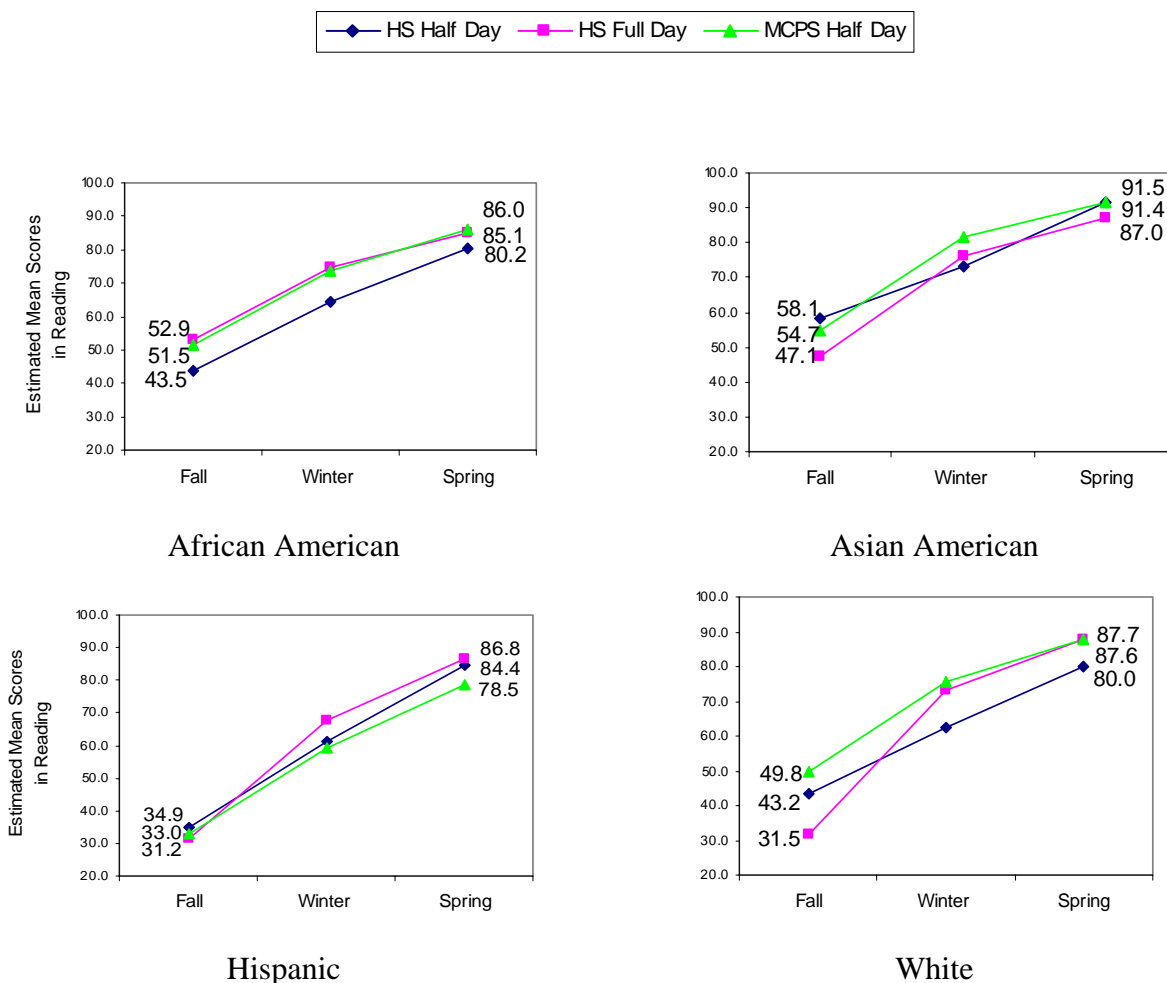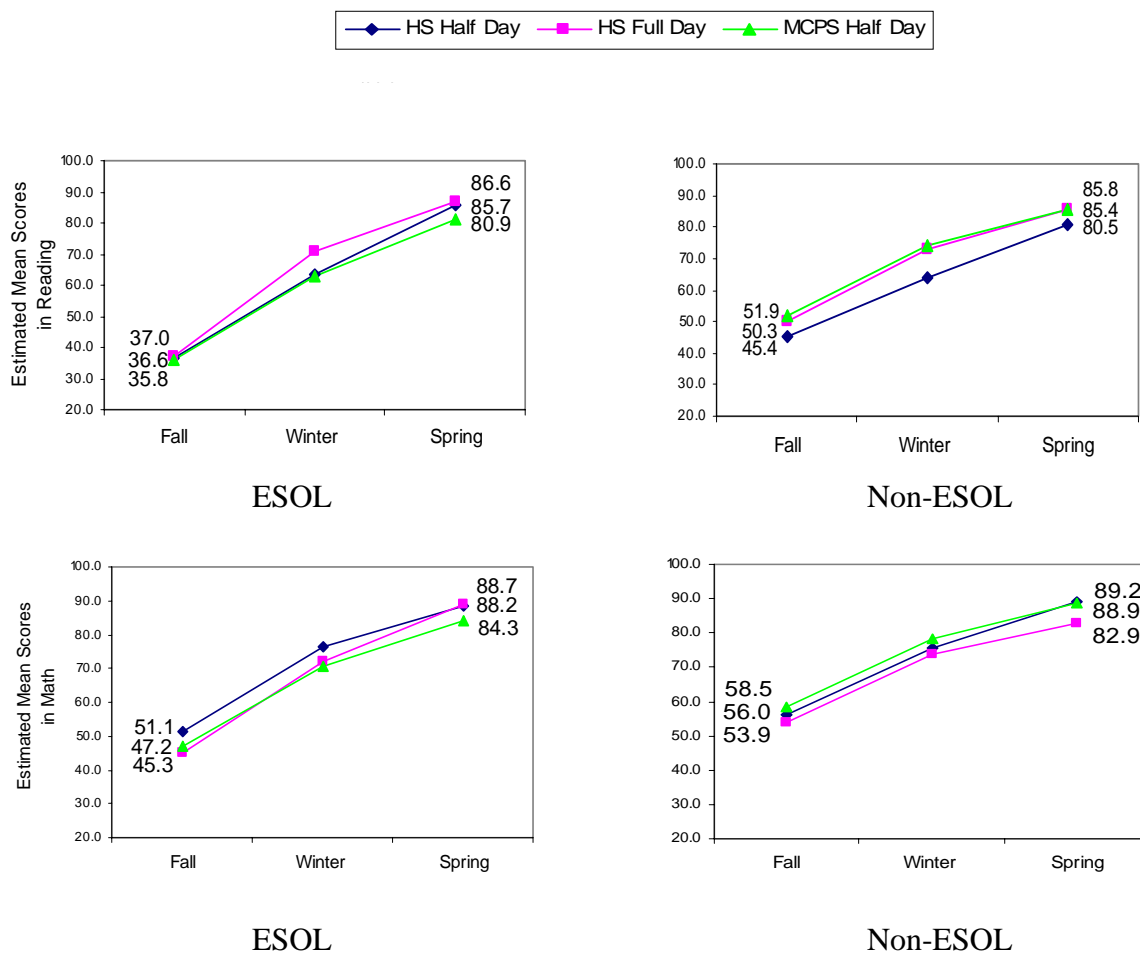
Figure 4. Estimated marginal means in reading and mathematics for MCPS students, by ESOL status and prekindergarten classes in 2007–2008.

Figure 4 shows the mean reading and mathematics scores for students receiving ESOL services. ESOL students in Head Start full-day class had significantly larger performance increase (49.6 points in reading and 43.4 points in mathematics) compared with non-ESOL students (35.1 points in reading and 29.0 points in mathematics) in the same class type.

ESOL students in full-day class had significantly higher score increases in mathematics from fall to spring compared with ESOL students in half-day classes. ESOL students in Head Start full-day gained 43.4 points in mathematics compared with 37.1 points for ESOL students in the other two half-day class types.

Differences Among Schools with Head Start Full-day Classes

Additional analyses showed that full-day class effects also varied significantly by school (*p*=0.000). Table 8 presents the mean scores and standardized deviations in reading and mathematics only for students in the full-day class by school.

Table 8
Estimated Marginal Mean and Standard Deviation of Reading for Students in Head Start
Full-day Class, with Test Results in Fall, Winter, and Spring, by School

	N	Fall		Winter		Spring		Fall-Spring change
		Mean	SD	Mean	SD	Mean	SD	
Reading	141							
Broad Acres	15	33.8	25.4	77.3	21.6	95.0	6.9	61.2
Georgian Forest	20	39.5	22.5	61.1	22.0	75.6	19.9	36.2
Montgomery Knolls	15	44.9	28.8	68.2	27.5	85.7	20.9	40.8
New Hampshire	52	46.0	24.3	68.4	20.8	83.2	15.0	37.2
Twinbrook	20	27.3	17.3	81.5	14.3	94.1	4.7	66.9
Viers Mill	19	42.4	24.3	76.7	23.6	91.3	11.6	48.8
Math	152							
Broad Acres	16	46.5	27.5	80.9	20.1	96.5	5.7	50.0
Georgian Forest	14	47.2	27.2	72.2	17.0	95.6	3.9	48.4
Montgomery Knolls	18	40.1	25.4	60.2	21.8	67.0	19.8	26.9
New Hampshire	53	53.5	25.7	70.9	22.6	83.3	18.7	29.9
Twinbrook	36	47.8	25.6	75.3	18.1	93.4	12.8	45.5
Viers Mill	15	40.0	24.1	77.8	20.1	90.4	14.9	50.4

Note. Data include only schools with students who had complete test results for three test administrations.

In reading, Twinbrook Elementary School full-day classes witnessed the largest fall-to-spring score increase (66.9), followed by Broad Acres Elementary School (61.2). Broad Acres Elementary School decreased its standard deviation in reading from 25.4 in fall to 6.9 in spring, followed by Twinbrook Elementary School, which decreased its reading standard deviation from 17.3 in fall to 4.7 in spring. The shrinking standard deviation indicates that students used to be very different in their reading ability in fall and became more homogeneous in spring.

In mathematics, Viers Mill Elementary School had the largest mean increase (50.4) from fall to spring, followed by Broad Acres Elementary School (50.0). In Broad Acres Elementary School, the standard deviation dropped from 27.5 in fall to 5.7 in spring.

Effect Sizes

Table 9 shows program effect sizes associated with mean score differences between the Head Start full-day classes and Head Start and MCPS half-day classes. For all students, the effect sizes were 0.20 in reading and 0.03 in mathematics, between Head Start full-day class and Head Start half-day class, and 0.33 in reading and 0.23 in mathematics between Head Start full-day class and MCPS half-day class. Program effect size is larger in reading than in mathematics.

According to the repeated measure results, the effect sizes varied by student groups. For example, the effect size is 0.40 between Hispanic students in the full-day class and their peers in MCPS half-day class. Since the repeated measure controlled only for fall academic performance, not family background, the yielded effect sizes are conservative estimates. This indicates that female, Hispanic, and ESOL students who attended the Head Start full-day classes had made larger academic gains, regardless of their family backgrounds.

Table 9
Effect Size Between Head Start Full Day and Comparison
Groups in Reading and Mathematics, by Subgroup

	Comparison Class	
	Head Start Half Day	MCPS Half Day
Head Start Full Day		
Reading		
All Students [a]	0.20	0.33
Female	0.33	0.25
Hispanic	0.16	0.40
ESOL	0.05	0.28
Math		
All Students [a]	0.03	0.23
Female	0.08	0.12
Hispanic	0.09	0.23
ESOL	0.03	0.24

Note. Due to their small numbers, results for Asian American and White students were not shown here, despite significant improvement for those in the full-day class.

[a] Effect size was calculated by ANCOVA. All other effect sizes were computed with repeated measure results.

Cost-benefit Estimates

Since the program effect sizes for the full-day class were 0.20 and 0.33 in reading and 0.03 and 0.23 in mathematics compared with the Head Start and MCPS half-day classes, the cost-benefit estimates for the full-day class ranged from 0.019 to 0.031 per child per $1,000 in reading, and 0.003 to 0.022 per child per $1,000 in mathematics. The sufficient effect sizes seem to justify the full-day class cost (Harrison, 2007; Ludwig & Philips, 2008).

Table 10 illustrates the cost-benefit estimates for the three MCPS pre-K class types in 2007–2008, based on the seasonal effect size. The Head Start full-day class had the largest seasonal effect in both reading (2.24) and mathematics (1.77). This suggests that students in full-day class had the largest score increase from fall to spring in 2007–2008. On the other hand, due to more instruction and staff time, the cost is also the highest for Head Start full-day classes, followed by Head Start half-day and MCPS half-day classes.

Table 10
Cost-benefit Estimates Based on Seasonal Effects for MCPS
Prekindergarten Classes, 2007–2008

	Cost Per child ($)	Seasonal Effect Size in Reading	Seasonal Effect Size in Math
Head Start Full Day	10,509	2.24	1.77
Head Start Half Day	7,856	1.87	1.58
MCPS Half Day	4,673	1.78	1.57

Even though the Head Start full-day class costs more to operate, it yielded the largest academic improvement. With more instruction time, students of low socioeconomic status were able to catch up with or even outperform their peers of higher socioeconomic status in academic performance. Based on the cost-benefit estimates, the Head Start full-day class type seems to have yielded the largest academic improvement and its program effect size is sufficiently large enough to justify its higher cost.

Discussion

After exposure to a rigorous curriculum, students of low socioeconomic status attending all pre-K classes in MCPS made significant academic gains in reading and mathematics during a school year. Students' performance significantly increased from fall to spring in all pre-K classes.

When instruction is of high quality, additional instructional time can further improve student performance (Robin, Frede & Barnett, 2006). Students who attended Head Start full-day classes obtained significantly greater gains in reading scores compared with their peers in Head Start half-day classes and their peers of higher SES in MCPS half-day classes. Increased instructional time produced better academic performance because it has provided teachers with the opportunity to work individually with students and spend disproportionately less time on routines (Robin, Frede & Barnett, 2006). Since Head Start full-day and Head Start half-day classes are very similar, except for instructional time, the performance improvement can be attributed to longer instruction time. In mathematics, certain student groups in Head Start full-day classes gained significant improvement compared with their peers in the Head Start half day.

Longer instructional time in Head Start full-day classes seems to have made a difference in narrowing achievement gaps among socioeconomic and racial subgroups. The full-day program effect is not the same for all subgroups. The gains are the largest for female, Hispanic, and ESOL students. At the school level, the full-day classes in some schools have generated greater improvement than others. These most-improved schools started with students performing at the lowest level in the fall, but their students outperformed their peers in other schools in the spring. The magnitude of the Head Start full-day program effect differed across schools.

The cost for the Head Start full-day class is higher than the Head Start and MCPS half-day classes, due to extended instructional time. High-quality instruction appears to have closed achievement gaps in pre-K. The academic performance improvement of students from the lowest SES and sufficient program effects may justify the Head Start full-day program costs.

Only students with complete test scores were included in the analyses. However, students without complete test scores were similar to those with complete test results with regard to important family background variables. The large number of students without complete test results may be related to attrition, mobility, or absence during testing windows.

The academic improvement is better in reading than in mathematics. Smaller mathematics gains may have resulted from the fact that the pre-K mathematics test does not have enough items to sufficiently measure the pre-K curriculum and to reflect academic improvement.

Recommendations

- Due to the sufficiently large Head Start full-day program effect, the Head Start half-day classes should be expanded into Head Start full-day classes in the Title I schools, if financially feasible. It is important to follow up with these students to examine long-term pre-K program impact.
- At the same time, schools should make extra efforts to obtain complete assessment data for future students in the classes.

- Since full-day program effects vary by school, it is important to examine best practices in schools with the greatest improvement. Such practices can be shared in order to further improve program quality and student achievement.
- The pre-K assessments were originally designed to measure the half-day curriculum. It is now necessary to reexamine the curriculum and assessments for full-day classes. If the assessments measure the key concepts in the curriculum, the results are more likely to reflect program impact.
- It is also important to establish reading and mathematics proficiency benchmark criteria for the assessments, so teachers and parents know the expected performance by the end of a school year.

Limitations

Babbie (1992) notes that only a classical experiment with random assignment of subjects to different levels of treatment guard against each of the sources of internal invalidity in a study (e.g., selection bias, maturation, history, mortality). Due to lack of randomization, the current evaluation used a quasi-experimental design to investigate the impacts of the Head Start full-day class on the pre-K students' reading and mathematics achievement. Randomized evaluations often are not feasible in educational settings because of ethical, practical, and logistic concerns. As a result, educational evaluators are being challenged to develop procedures to determine the impacts of their intervention on student achievement within a typical educational setting (Modarresi & Connolly, 2007).

A major issue with employing quasi-experimental design is that students in the treatment (full-day class) and comparison groups (half-day classes) may have important preexisting differences that may influence their achievement after exposure to an intervention. If so, this will consequently threaten the internal validity of the evaluation findings (Gay & Airasian, 2000; Shadish, Cook, & Campbell, 2002). In this evaluation study, causal conclusions about the impacts of Head Start full-day class on student reading and mathematics achievement may not be definitively inferred from the study results. However, our use of covariates in the statistical models and comparison groups in the current evaluation greatly improved the internal validity of the study.

References

American Psychological Association. (2001). *Publication manual of the American Psychological Association*. Washington, DC: Author.

Babbie, Earl. (1992). *The practice of social research* (6th ed.). Belmont, CA: Wadsworth Publishing Company.

Barnett, W. S. (1998). Long-term effects on cognitive development and school success. In. W. S. Barnett & S. S. Boocock (Eds.), *Early care and education for children in poverty: Promises, classes and long term results*. Albany, NY: SUNY Press.

Barnett, W. S. & Belfield, C. R. (2006). *Early childhood development and social mobility*. Retrieved April 30, 2008 from www.futureofchildren.org

Campbell, D. T., & Stanley, J. C. (1963). *Experimental and quasi-experimental designs for research*. Chicago, IL: Rand McNally College Publishing.

Cohen, J. (1988). *Statistical power analysis for the behavioral science* (2nd ed.). Hillsdale, NJ: Lawrence Earlbaum Associates.

Currie, J., & Thomas, D. (1995). Does Head Start make a difference? *American Economic Review 85*(3): 341–364.

Drazen, S. (1992). *Student achievement and family and community poverty: Twenty years of education reform.* ERIC. No. 346234.

Gay, L. R., & Airasian, P. W. (2000). *Educational research: Competencies for analysis and application* (6th ed.). Englewood Cliffs, NJ: Prentice Hall.

Gilliam, W. S., & Ziegler, E. (2001). A critical meta-analysis of all evaluation of state-funded preschool from 1977 to 1998: Implication for policy, service delivery and class evaluation. *Early Childhood Research Quarterly, 15,* 441–473.

Harrison, D. N. (2007). *New benchmarks for interpreting effect sizes: Combining effects with cost*. Working paper at University of Wisconsin at Madison.

Heller, L. R., & Fantuzzo, J. W. (1993). Reciprocal peer tutoring and parent partnership: Does parent involvement make a difference? *School Psychology Review, 22*(3), 517–534.

Judd, C. M., Smith, E. R., & Kidder, L.H. (1991). *Research methods in social relations* (p.72). San Francisco, CA: Holt, Rinehart and Winston Inc.

Ludwig, J., & Philips, D. A. (2008). *Long-term effects of Head Start on low-income children*. Presented at 2008 Annual New York Academy of Science.

Modarresi S., & Connolly, F. (2007). *Applying quasi-experimental design to the impact evaluation of a teacher professional development class: Design issues & methodological challenges*. Presented at the annual meeting of the American Educational Research Association, Chicago, IL.

Nunnally, J. C. (1978). *Psychometric theory*. New York, NY: McGraw Hill Publishing Company.

Philips, D., Voran, M., Kisker, E., Howes, C., & Whitebook, M. (1994). Child care for children in poverty: Opportunity of inequality? *Child Development 65*, 472–492.

Robin, K. B., Frede, E. C., & Barnett, W. S. (2006). *Is it better? The effects of full-day vs. half-day preschool on early school achievement*. New Brunswick, NJ: National Institute of Early Education Research.

Rossi. P. & Freeman, H. E. (1993). *Evaluation: A systematic approach*. Newbury Park, CA: Sage Publications.

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference.* Boston, MA: Houghton Mifflin Company.

Stevens, J. (1992). *Applied multivariate statistics for the social sciences*. Hillsdate, NJ: Lawrence Erlbaum Associates, Inc., Publishers.

Walker, D. G., & Schaffarzick, J. (1974). Comparing curricula. *Review of Educational Research, 74,* 83–111.

Yoshikawa, H. (2005). *Placing the first-year findings of the national Head Start impact Students in context*. Brief prepared for the Society for Research in Child Development. Retrieved April 15 from http://srcd.org/documents/policy/Impactstudy.pdf

Appendix A

Table A1

Pearson Correlation Coefficients among Cluster Scores and Total Scores for MCPS
Prekindergarten Reading and Mathematics Assessments

	Read Total	Oral Lang.	Letter Identi.	Rhyming Word	Begin. Sound
Reading Total					
Oral Lang.	0.63				
Letter Identi.	0.94	0.38			
Rhyming Word	0.47	0.36	0.30		
Begin. Sound	0.59	0.39	0.44	0.51	
Concept Print	0.53	0.46	0.36	0.36	0.39

	Math Total	Geometry	Num. Compare.		
Math Total					
Geometry	0.45				
Num. Compare.	0.75	0.25			
Num. Represent.	0.97	0.29	0.66		

Table A2

Characteristics for 2007–2008 MCPS Students Without Complete Reading or
Mathematics Test Results for Fall, Winter, and Spring Test Administrations,
by Prekindergarten Class (N=1,098)

	Head Start Half Day		Head Start Full Day		MCPS Full Day	
	N	*%*	*N*	*%*	*N*	*%*
Total	167		122		809	
Gender						
Male	79	47.3	58	47.5	409	50.6
Female	88	52.7	64	52.5	400	49.4
Race/Ethnicity						
African American	82	49.1	44	36.1	257	31.8
Asian American	10	6.0	14	11.5	94	11.6
Hispanic	60	35.9	54	44.3	420	51.9
White	15	9.0	9	7.4	38	4.7
Services Provided						
Special Education	13	7.8	6	4.9	35	4.3
ESOL	75	44.9	81	66.4	487	60.2

Note. American Indian students were included in the total but not reported separately.

Table A3

Family Background for 2007–2008 MCPS Students Without Complete Reading or
Mathematics Test Results for Fall, Winter, and Spring Test Administrations,
by Prekindergarten Class (N=1,098)

	Head Start Half Day		Head Start Full Day		MCPS Full Day	
	Mean	Median	Mean	Median	Mean	Median
Total Family Income	$12,984	$13,000	$17,160	$15,640	$27,949	$26,973
Income per Person	$3,378	$3,293	$4,525	$4,193	$7,339	$7,203
Female Guardian's Age	31	30	32	31	32	31
Male Guardian's Age	36	36	36	37	36	36
Female Years of Education	12	12	12	12	12	12
Male Years of Education	13	13	11	12	11	12
Family Size	4	4	4	4	4	4

Table A4

Tests of Within-subject and Between-subject Effects for All MCPS Students' Performance on
Reading and Mathematics from Fall to Spring, by Prekindergarten Class, 2007–2008

	Reading				Math			
Source	DF	F	p value	Partial Eta squared	DF	F	p value	Partial Eta squared
Within-Subject								
Season	1.61	1828.9	**0.000**	0.546	1.66	1387.7	**0.000**	0.462
Season x Pre-K	3.2	5.514	**0.000**	0.007	3.3	2.015	0.103	0.003
Between-Subject								
Pre-K	2	0.838	0.433	0.001	2	1.615	0.199	0.002

Note. Bolded *p* values are statistically significant.

Table A5
Tests of Within-subject Effect for 2007–2008 MCPS Prekindergarten Students' Performance on
Reading and Mathematics from Fall to Spring, by Subgroup

Source		Reading				Math		
	DF	F	p value	Partial Eta Squared	DF	F	P value	Partial Eta Squared
Gender								
Season	1	2420.6	**0.000**	0.615	1	1860.3	**0.000**	0.549
Pre-K	2	4.599	**0.010**	0.006	2	3.423	**0.033**	0.004
Season x Pre-K	1	3.021	0.082	0.002	1	0.125	0.724	0.000
Season x Pre-K x Gender	2	1.545	0.214	0.002	2	3.587	**0.028**	0.005
Race/Ethnicity								
Season	1	1054.3	**0.000**	0.411	1	131.0	**0.000**	0.074
Pre-K	2	3.395	**0.035**	0.004	2	2.471	0.085	0.003
Season x Pre-K	3	26.57	**0.000**	0.050	4	7.419	**0.000**	0.022
Season x Pre-K x Race	6	2.218	**0.039**	0.009	6	0.626	0.709	0.002
ESOL								
Season	1	2148.5	**0.000**	0.586	1	1625.0	**0.000**	0.510
Pre-K	2	1.754	0.174	0.002	2	0.959	0.383	0.001
Season x Pre-K	1	55.06	**0.000**	0.035	1	22.68	**0.000**	0.015
Season x Pre-K x ESOL	2	0.579	0.561	0.001	2	2.275	0.103	0.003

Note. Bolded *p* values are statistically significant.

Table A6
Tests of Between-subjects Effect for 2007–2008 MCPS Prekindergarten Students' Performance on
Reading and Mathematics from Fall to Spring, by Subgroup

Source		Reading				Math		
	DF	F	p value	Partial Eta squared	DF	F	p value	Partial Eta squared
Gender								
Pre-K	2	0.981	0.375	**0.001**	2	1.424	0.241	0.002
Gender	1	1.844	0.175	**0.001**	1	2.383	0.123	0.002
Gender x Pre-K	2	0.046	0.955	**0.000**	2	0.218	0.804	0.000
Race/Ethnicity								
Pre-K	2	1.191	0.304	**0.002**	2	1.780	0.169	0.002
Race	3	11.56	0.000	**0.022**	4	5.759	**0.000**	0.015
Race x Pre-K	6	2.166	0.044	**0.009**	6	1.179	0.315	0.005
ESOL								
Pre-K	2	1.538	0.215	**0.002**	2	1.087	0.337	0.001
ESOL	1	9.718	0.002	**0.006**	1	5.713	**0.017**	0.004
ESOL x Pre-K	2	4.035	0.018	**0.005**	2	3.008	**0.050**	0.004

Note. Bolded *p* values are statistically significant.

Table A7
Means and Standard Deviation of Reading for Students in MCPS Prekindergarten Classes,
by Season and Subgroup

	Fall		Winter		Spring	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
Gender						
Male						
Head Start Half Day	40.9	24.4	62.1	23.5	81.4	20.6
Head Start Full Day	41.6	23.6	70.0	21.4	84.3	16.1
MCPS Half Day	41.1	25.2	65.8	25.4	81.2	20.2
Female						
Head Start Half Day	42.7	22.8	65.6	23.8	83.4	18.9
Head Start Full Day	38.8	25.4	73.0	23.0	89.2	14.4
MCPS Half Day	43.2	26.1	68.8	25.1	84.5	18.9
Race/Ethnicity						
African American						
Head Start Half Day	43.5	21.9	64.4	23.8	80.2	22.0
Head Start Full Day	52.9	23.7	74.9	23.0	85.1	17.8
MCPS Half Day	51.5	24.3	73.5	22.7	86.0	17.5
Asian American						
Head Start Half Day	58.1	29.7	73.3	23.3	91.4	13.0
Head Start Full Day	47.1	26.0	76.0	24.3	87.0	21.7
MCPS Half Day	54.7	27.6	81.8	18.9	91.5	12.7
Hispanic						
Head Start Half Day	34.9	21.8	61.1	23.5	84.4	16.1
Head Start Full Day	31.2	20.4	67.6	21.3	86.8	13.1
MCPS Half Day	33.0	22.6	59.4	25.4	78.5	21.3
White						
Head Start Half Day	43.2	26.9	62.4	24.7	80.0	19.9
Head Start Full Day	31.5	20.1	73.0	10.7	87.7	7.7
MCPS Half Day	49.8	23.8	75.5	20.4	87.6	15.3
ESOL						
Head Start Half Day	36.6	23.7	63.7	23.7	85.7	16.1
Head Start Full Day	37.0	24.1	70.7	22.2	86.6	14.9
MCPS Half Day	35.8	24.3	63.0	25.6	80.9	20.5

Table A8
Means and Standard Deviation of Mathematics for Students in MCPS Prekindergarten
Classes, by Season and Subgroup

	Fall		Winter		Spring	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
Gender						
Male						
Head Start Half Day	51.0	26.9	75.2	21.7	89.6	17.3
Head Start Full Day	49.9	25.4	70.4	21.0	85.2	18.9
MCPS Half Day	49.2	26.2	71.8	23.4	84.9	17.2
Female						
Head Start Half Day	55.7	26.9	76.5	21.2	88.1	15.2
Head Start Full Day	46.4	26.5	75.3	20.6	89.3	15.2
MCPS Half Day	53.8	26.2	75.0	22.4	87.2	17.2
Race/Ethnicity						
African American						
Head Start Half Day	53.2	26.8	74.3	21.8	86.9	18.3
Head Start Full Day	52.6	22.2	74.8	18.9	84.4	19.7
MCPS Half Day	57.2	25.4	76.1	21.2	87.7	15.5
Asian American						
Head Start Half Day	67.4	29.9	87.3	14.0	94.0	12.2
Head Start Full Day	55.9	32.6	78.1	17.6	93.2	9.03
MCPS Half Day	64.3	23.4	84.3	17.2	92.7	11.3
Hispanic						
Head Start Half Day	49.1	26.0	75.4	21.6	88.8	14.4
Head Start Full Day	42.2	26.1	70.1	23.0	87.5	17.1
MCPS Half Day	44.7	25.5	68.8	24.2	83.3	18.5
White						
Head Start Half Day	64.8	23.3	77.3	22.6	94.9	7.2
Head Start Full Day	49.3	29.7	69.7	21.5	88.2	15.3
MCPS Half Day	57.7	26.3	79.1	19.9	89.6	13.8
ESOL						
Head Start Half Day	51.0	26.0	76.4	19.6	88.2	14.0
Head Start Full Day	45.3	25.5	71.9	21.5	88.7	15.5
MCPS Half Day	47.2	25.9	70.6	23.8	84.3	18.2

Appendix B

<div align="center">ANCOVA Model Description</div>

Model 1 (Head Start full-day vs. Head Start half-day in reading)

The dependent variable or outcome measure for this model was the spring 2008 MCPS pre-K reading test scores. The independent variable was a dummy variable created to represent the status of the students' experience. The control variables or covariates included race/ethnicity; income per person in the family; special education status; ESOL services; and gender. The pretests for this cohort were the fall 2007 MCPS pre-K reading test scores. The correlation coefficient of the fall pre-K reading scores reading scores with spring pre-K reading test scores was significant ($r=0.496$; $p<0.05$). The sample for the analysis included 313 students who had both fall and spring MCPS pre-K reading scores during the 2007–2008 school year.

Model 2 (Head Start full-day vs. Head Start half-day in mathematics)

The dependent variable for this model was the spring 2008 MCPS pre-K mathematics scores. The independent variable was a dummy variable created to represent the status of the students' experience. The control variables or covariates included race/ethnicity; income per person in the family; special education; ESOL services; and gender. The pretests for this cohort were the fall 2007 MCPS pre-K mathematics scores. The correlation coefficient of the fall 2007 MCPS pre-K mathematics scores with the spring ones was significant ($r=0.493$; $p<0.05$). The sample for the mathematic analyses included 358 students who had both fall and spring MCPS pre-K mathematics scores during the 2007–2008 school year.

Model 3 (Head Start full-day vs. MCPS half-day in reading)

The dependent variable for this model was the spring 2008 MCPS pre-K reading test scores. The independent variable was a dummy variable created to represent the status of the students' experience (Head Start full-day vs. MCPS half day). The control variables or covariates included race/ethnicity; income per person in the family; special education; ESOL services; and gender. The pretests for this cohort were the fall 2007 MCPS pre-K reading test scores. The correlation coefficient of the fall 2007 pre-K reading scores reading scores with spring 2008 pre-K reading test scores was significant ($r=0.57$; $p<0.05$). The sample for the analysis included 490 students who had both fall and spring MCPS pre-K reading scores during the 2007–2008 school year.

Model 4 (Head Start full-day vs. MCPS half-day in mathematics)

The dependent variable for this model was the spring 2008 MCPS pre-K mathematics scores. The independent variable was a dummy variable created to represent the status of the students' experience (Head Start full-day vs. MCPS half day). The control variables or covariates included race/ethnicity; income per person in the family; special education status; ESOL services; and gender. The pretests for this cohort were the fall 2007 MCPS mathematics scores. The correlation coefficient of the fall 2007 MCPS mathematics

scores with the spring mathematics was significant ($r=0.53$; $p<0.05$). The sample for the mathematic analyses included 487 students who had both fall and spring MCPS pre-K mathematics scores during the 2007–2008 school year.