MONTGOMERY COUNTY PUBLIC SCHOOLS

# Evaluation Brief

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## Impact of Full-day Head Start Prekindergarten Class Model on Student Academic Performance, Cognitive Skills, and Learning Behaviors by the End of Grade 2

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This brief describes the impact of the Montgomery County Public Schools (MCPS) 2007–2008 full-day Head Start prekindergarten (pre-K) class model on student academic performance, cognitive skills, and learning behaviors by the end of Grade 2. This is the fourth impact study of the MCPS full-day Head Start pre-K class model (Maina, 2011; Maina & Modarresi, 2010; Zhao & Modarresi, 2010; Zhao, Modarresi, & Liu, 2009).

### Summary of Major Findings

By the end of Grade 2 in 2010–2011, students who attended the full-day Head Start pre-K classes in 2007–2008—

- outperformed their half-day Head Start pre-K peers on TerraNova, second edition (TN/2) math computation;
- performed at the same level academically, cognitively, and behaviorally on all other outcome measures, compared to their peers who attended 2007–2008 half-day Head Start pre-K classes;
- performed at the same level academically, cognitively, and behaviorally on most outcome measures, compared to their peers who attended 2007–2008 MCPS partial-day pre-K classes;
- scored significantly lower on InView analogy and learning behaviors than their counterparts who attended MCPS partial-day pre-K classes; and
- performed at the same level academically, cognitively and behaviorally on all outcomes compared to their peers who entered the MCPS kindergarten in 2008–2009.

### Background

The goal of an early intervention such as the pre-K class model is to provide our youngest learners the support they need to offset the impact of socioeconomic factors before entering kindergarten. In MCPS, there are three types of pre-K class models—full-day Head Start, half-day Head Start, and MCPS partial-day—serving students who are eligible for Free and Reduced-price Meals System (FARMS) services. The level of intensity (full-day Head Start, half-day Head Start, and MCPS partial-day) is directly associated with a student's family income. By addressing the achievement gap at the starting point for a child's formal education, the momentum established is deliberate to keep pre-K program participants on par with their peers through kindergarten and beyond.

In 2007–2008, MCPS offered its Title I schools an opportunity to expand their existing half-day Head Start classes into full-day classes for children living at or below the federal poverty level. Thirteen half-day Head Start classes in 10 elementary schools chose to participate. The expansion was intended to provide additional instructional time to students most highly impacted by poverty, mobility, and limited English proficiency. In a school day, the full-day Head Start classes last 6 hours and 15 minutes and operate on the same full-day schedule as all other elementary students, while the half-day Head Start classes last 3 hours and 15 minutes, and MCPS partial-day pre-K classes last 2 hours and 30 minutes. A more detailed description of the MCPS pre-K class models is available from the study, *Impact of Full-day Prekindergarten Program on Student Academic Performance (*Zhao, Modarresi, & Liu, 2009*).*

### Methodology

*Study Questions*

This study addressed the following three questions:

1. At the end of Grade 2, did the students who attended the full-day Head Start pre-K classes differ in reading, mathematics, cognitive skills, and learning behaviors, compared with their

counterparts in the half-day Head Start pre-K classes?
2. At the end of Grade 2, did the students who attended the full-day Head Start pre-K classes differ in reading, mathematics, cognitive skills, and learning behaviors, compared with their counterparts in MCPS partial-day pre-K classes?
3. At the end of Grade 2, did the students who attended the full-day Head Start pre-K classes differ in reading, mathematics, cognitive skills, and learning behaviors, compared with their counterparts who entered MCPS in kindergarten?

*Original pre-K Cohort*

The original 2007–2008 pre-K cohort included 260 students in the full-day Head Start classes, 391 in the half-day Head Start classes, and 1,887 in MCPS partial-day classes (Appendix A, Table A1). Students in MCPS partial-day pre-K classes had higher family income than their full-day or half-day Head Start peers.

***Study Samples***. The analytical samples included one treatment and three comparison groups. The treatment group included Grade 2 students in 2010–2011 who attended the full-day Head Start pre-K classes in 2007–2008.

The three comparison groups included Grade 2 students in 2010–2011 who—

- attended half-day Head Start pre-K classes in 2007–2008;
- attended MCPS partial-day pre-K classes in 2007–2008; or
- entered MCPS kindergarten in 2008–2009 without MCPS pre-K experience.

After statistical control, the treatment group was similar to the comparison groups on important demographics, kindergarten to Grade 2 school attendance, and school readiness.

*Measures*

For the analyses in the study, outcome measures included MCPS Assessment Program in Primary Reading (AP-PR), TN/2, InView, and learning behaviors. The Maryland Model for School Readiness (MMSR) and school attendance rate were used as control variables.

***MCPS AP-PR*** is a research-based and locally developed assessment measuring important concepts and skills in MCPS pre-K–Grade 2 reading curriculum. The percentage of students meeting or exceeding the Grade 2 reading benchmark was an outcome measure.

***TN/2*** is a norm-referenced test assessing skills in reading, language arts, mathematics, language mechanics, and mathematics computation (CTB/McGraw-Hill, 2002a). The scale scores of TN/2 subtests were used as academic performance measures.

***InView*** is a norm-referenced test focusing on critical quantitative processes rather than learned mathematic skills (CTB/McGraw-Hill, 2002b). The analogy subtest is a nonverbal measure of a student's ability to differentiate relationships among pictures. The quantitative reasoning subtest measures the ability to think about numbers and to solve problems through the reasoning process, systematic logic, induction, and deduction. InView scale scores were used as measures of cognitive skills.

***Learning Behaviors***. A report card is available to every MCPS student for four marking periods in a school year. There are two different kinds of report cards—standards-based and traditional. Most elementary schools used the traditional report card in 2011. On the traditional report card, teachers rate a student's learning skills in areas such as homework, classwork, engaging in learning tasks, cooperation with others, following rules, and exercising self-control. Student rankings by teachers across four marking periods in 2010–2011 were computed as an outcome measure of learning behaviors (Appendix B).

***MMSR*** assesses seven developmental domains of Maryland kindergartners: personal and social development, language arts literacy, mathematical thinking, scientific thinking, social studies, the arts, and physical development (MSDE, 2009). The MMSR scores were used to control for school readiness at the beginning of kindergarten when the full-day pre-K students were compared to their peers who entered MCPS in kindergarten.

***Kindergarten to Grade 2 School Attendance*** refers to the total days a student attended school from kindergarten to Grade 2 (K–Grade 2). K–Grade 2 school attendance was used as a control variable.

*Study Design and Analytical Procedures*

A nonrandomized comparison design (Isaac & Michael, 1995) was used to assess the impact of the

full-day Head Start pre-K class model on student academic performance, cognitive skills, and learning behaviors by Grade 2.

***Covariate-Adjusted Model***. Prominent researchers (Campbell & Stanley, 1963) suggested that in order to observe the true treatment effects in nonrandomized design, analysis of covariance (ANCOVA) should be conducted. To address the first evaluation question, a covariate-adjusted model was used to compare the full-day and half-day Head Start pre-K class models.

ANCOVA procedures were utilized when outcome measures were continuous (Kirk, 1995), and binary logistic regression was used where the outcome variables were dichotomous (e.g., met Grade 2 reading benchmark or not). Based on demographic characteristics such as gender, race/ethnicity, family size, FARMS status, receipt of English for Speakers of Other Languages (ESOL) services or special education, and K–Grade 2 school attendance, propensity score was computed as a covariate using logistic regression models (Luellen, Shadish, & Clark, 2005). To balance the nonequivalent groups, the propensity scores were divided into five categories and used as covariates (Rosenbaum & Rubin, 1983, 1984, 1985). It must be noted that only students with information on all measures were included in the analyses. The covariate-adjusted model also was used to verify results for the second evaluation question.

Effect size was calculated with Cohen *d*.[1] An effect size of .2 is considered small, .5 is medium and .8 or greater is large (Cohen, 1988, Rosenthal & Rubin, 1984).

***Propensity Score Matching Model***. To answer the second and third evaluation questions, propensity score was generated to match the full-day pre-K students with students who attended the half-day pre-K or MCPS partial-day pre-K classes, based on gender; race/ethnicity; participation in ESOL, special education or FARMS services; and K–Grade 2 school attendance. The MMSR scores were added to propensity score models for Evaluation Question 3. Based on proximity of propensity scores, students in the treatment group were matched to their peers in MCPS partial-day pre-K, or their peers without MCPS pre-K experience. For a balanced design, the treatment and the comparison groups had the same number of students.

After matching, bivariate statistical analyses such as T-test, and chi-square were conducted when appropriate to detect academic, cognitive, and learning behavior differences between the treatment group and each comparison group. Effect size was calculated when significant differences were found.

## Findings

The findings are presented in the order of the evaluation questions. First, demographic characteristics are presented, followed by student performance.

*Compare Full-day Head Start and Half-day Head Start*

**Evaluation Question 1: At the end of Grade 2, did the students who attended the full-day Head Start pre-K classes differ in reading, mathematics, cognitive skills, and learning behaviors, compared with their counterparts in the half-day Head Start pre-K classes?**

Table 1 presents the characteristics of Grade 2 students who attended the full-day Head Start or half-day Head Start pre-K classes and stayed in MCPS for Grade 2.

Table 1
Characteristics of MCPS 2010–2011 Grade 2 Students Who Attended 2007–2008 Full-day or Half-day Head Start pre-K Classes

| | Full-day Head Start | | Half-day Head Start | |
|---|---|---|---|---|
| | *N* | *%* | *N* | *%* |
| All Students | 214 | | 242 | |
| Gender | | | | |
| Female | 97 | 45.3 | 127 | 52.5 |
| Male | 117 | 54.7 | 115 | 47.5 |
| Race | | | | |
| Asian | 17 | 7.9 | 22 | 9.1 |
| Black or AfAm | 74 | 34.6 | 116 | 47.9 |
| Hispanic/Latino | 113 | 52.8 | 85 | 35.1 |
| White | 10 | 4.7 | 19 | 7.9 |
| Services | | | | |
| Ever ESOL | 159 | 74.3 | 124 | 51.2 |
| Ever FARMS | 207 | 96.7 | 237 | 97.9 |
| Sped | 26 | 12.1 | 21 | 8.7 |

*Note.* Ever ESOL = Received English for Speakers of Other Languages services in MCPS by Grade 2; Ever FARMS = Received Free and Reduced-price Meals System services in MCPS by Grade 2; Sped = Received special education in Grade 2.

[1] The formula for Cohen $d = (M_t - M_c)/SD$.

The majority of the two groups were Black or African American or Hispanic/Latino students. The full-day Head Start pre-K classes had a higher percentage of Hispanic/Latino students (52.8%) and a lower percentage of Black or African American students (34.6%) when compared with their half-day Head Start pre-K counterparts (35.1% and 47.9%, respectively). The full-day Head Start pre-K classes had a higher percentage of students who received ESOL services in MCPS by the end of Grade 2 (74.3%), when compared to their half-day pre-K counterparts (51.2%).

As shown in Table 2, 67.3% of the full-day Head Start pre-K students and 63.6% of the half-day Head Start pre-K students met the Grade 2 reading benchmark in 2010–2011. However, the difference of 3.7 percentage points was not statistically significant (*p = .62).* This shows the two groups performed at the same level in meeting the Grade 2 reading benchmark as measured by the AP-PR.

Table 2
Grade 2 Students Who Attended 2007–2008 Full-day Head Start pre-K or Half-day Head Start pre-K Classes and Met Grade 2 Reading Benchmark in 2010–2011

| | *N* | *N* Met | % | *p value** |
|---|---|---|---|---|
| Full-day HS | 214 | 144 | 67.3 | .62 |
| Half-day HS | 242 | 154 | 63.6 | |

*Note.* Degree of freedom = 1 for chi-square tests.
* Statistically significant *p* value ≤ .05.

Table 3 shows that the adjusted mean scores for the two groups were not significantly different in TN/2 reading, language arts, and math, and InView analogy and reasoning, and learning behaviors. This indicates that the two groups performed at the same level academically, cognitively, and behaviorally by the end of Grade 2. More information can be found in Appendix C.

Table 3
Adjusted Mean Scores on TN/2, InView and Learning Behaviors for MCPS 2010–2011 Grade 2 Students Who Attended 2007–2008 Full-day Or Half-day Head Start pre-K Classes

| | *N* | Adj. Mean | DIF | SE | *p value* |
|---|---|---|---|---|---|
| **TN/2 Reading** | | | | | |
| Full-day HS | 214 | 608 | 2.32 | 2.77 | .40 |
| Half-day HS | 242 | 605 | | | |
| **TN/2 Language Arts** | | | | | |
| Full-day HS | 214 | 606 | .30 | 3.90 | .94 |
| Half-day HS | 242 | 606 | | | |
| **TN/2 Math** | | | | | |
| Full-day HS | 214 | 566 | 1.78 | 4.02 | .66 |
| Half-day HS | 241 | 564 | | | |
| **InView Analogy** | | | | | |
| Full-day HS | 214 | 364 | -5.19 | 5.97 | .39 |
| Half-day HS | 239 | 369 | | | |
| **InView Reasoning** | | | | | |
| Full-day HS | 209 | 381 | -.04 | 5.60 | .99 |
| Half-day HS | 241 | 381 | | | |
| **Learning Behaviors** | | | | | |
| Full-day HS | 182 | 81 | -.26 | 1.62 | .87 |
| Half-day HS | 192 | 81 | | | |

*Note.* Adj. Mean = adjusted means. DIF = difference between the adjusted means. SE = standard error.
* Statistically significant *p* value ≤ .05.

In summary, the full-day Head Start group performed significantly higher on math computation than the half-day Head Start group. On eight out of nine other academic, cognitive, and learning behavior measures, the full-day and half-day Head Start groups performed at the same level.

*Compare Full-day Head Start and MCPS Partial-day*

**Evaluation Question 2: At the end of Grade 2, did the students who attended the full-day Head Start pre-K classes differ in reading, mathematics, cognitive skills, and learning behaviors, compared with their counterparts in the MCPS partial-day pre-K classes?**

Table 4 presents the characteristics of the matched samples of Grade 2 students who attended full-day Head Start pre-K or MCPS partial-day pre-K classes. The majority of the two groups were Black or African American or Hispanic/Latino students. The full-day Head Start pre-K classes had a slightly higher percentage of Black or African American students (34.6%) and a slightly lower percentage of Hispanic/Latino students (52.8%) when compared with their half-day Head Start pre-K counterparts

(29.4% and 57.9%, respectively). Across two groups, over 70% of them received ESOL services and over 95% received FARMS services by the end of Grade 2.

Overall, the two groups were relatively close in demographic characteristics. Most of the students served in the full-day and half-day Head Start classes received ESOL or FARMS services.

Table 4
Characteristics of MCPS 2010–2011 Grade 2 Students Who Attended 2007–2008 Full-day Head Start pre-K or MCPS Partial-day pre-K Classes

| | Full-day Head Start | | MCPS Partial-day | |
|---|---|---|---|---|
| | *N* | *%* | *N* | *%* |
| All Students | 214 | | 214 | |
| Gender | | | | |
| Female | 97 | 45.3 | 95 | 44.4 |
| Male | 117 | 54.7 | 119 | 55.6 |
| Race | | | | |
| Asian | 17 | 7.9 | 18 | 8.4 |
| Black or AfAm | 74 | 34.6 | 63 | 29.4 |
| Hispanic/Latino | 113 | 52.8 | 124 | 57.9 |
| White | 10 | 4.7 | 9 | 4.2 |
| Services | | | | |
| Ever ESOL | 159 | 74.3 | 176 | 82.2 |
| Ever FARMS | 207 | 96.7 | 207 | 96.7 |
| Sped | 26 | 12.1 | 20 | 9.3 |

*Note.* Ever ESOL = Received English for Speakers of Other Languages services in MCPS by Grade 2; Ever FARMS = Received Free and Reduced-price Meals System services in MCPS by Grade 2; Sped = Received special education in Grade 2.

As shown in Table 5, bivariate analyses found no significant differences between the full-day Head Start pre-K group and their peers in the MCPS partial-day pre-K group in meeting Grade 2 reading benchmark (*p value* =.84). A difference of 1.4 percentage points was not significant. This suggests that the two groups performed at the same level in meeting the Grade 2 reading benchmark.

Table 5
Grade 2 Students Who Attended 2007–2008 Full-day Head Start pre-K or MCPS Partial-day pre-K Classes and Met Grade 2 Reading Benchmark in 2010–2011

| | *N* | *N Met* | *%* | *p value* |
|---|---|---|---|---|
| Full-day HS | 214 | 144 | 67.3 | .84 |
| Partial-day pre-K | 214 | 141 | 65.9 | |

*Note.* Degree of freedom = 1 for chi-square tests.
* Statistically significant *p* value ≤ .05.

As shown in Table 6, mean scores for the full-day Head Start and MCPS partial-day pre-K groups were not significantly different on TN/2 reading, language arts and math, as well as InView reasoning (*p values* > .05). This indicates that the two groups performed at the same level on TN/2 reading, language arts, and math, as well as on InView reasoning.

However, there were significant differences between the two group on InView analogy and learning behaviors in favor of the partial-day pre-K group (Appendix D). In InView analogy (Table D4, Appendix D), the mean score was 370 for the full-day Head Start group and 388 for the MCPS partial-day pre-K group. The difference of 18 points on InView analogy was significant (*p value* = .00). The effect size was -.29, which was large enough to be educationally significant.

The difference in learning behaviors also was significant in favor of the partial-day pre-K group (*p value* = .01) with an effect size of -.22 (Table D5). The effect sizes were large enough to have practical importance.

Table 6
Mean Scores on TN/2, InView and Learning Behaviors for MCPS 2010–2011 Grade 2 Students Who Attended 2007–2008 Full-day Head Start pre-K or MCPS Partial-day pre-K Classes

| | *N* | Mean | SD | *p value* |
|---|---|---|---|---|
| **TN/2 Reading** | | | | |
| Full-day HS | 214 | 609 | 28.4 | .37 |
| Partial-day pre-K | 212 | 611 | 25.8 | |
| **TN/2 Language Arts** | | | | |
| Full-day HS | 214 | 607 | 43.9 | .47 |
| Partial-day pre-K | 212 | 610 | 37.3 | |
| **TN/2 Math** | | | | |
| Full-day HS | 214 | 569 | 44.2 | .38 |
| Partial-day pre-K | 213 | 573 | 39.9 | |
| **InView Analogy** | | | | |
| Full-day HS | 214 | 370 | 65.7 | .00* |
| Partial-day pre-K | 214 | 388 | 57.8 | |
| **InView Reasoning** | | | | |
| Full-day HS | 209 | 384 | 55.9 | .88 |
| Partial-day pre-K | 213 | 384 | 56.0 | |
| **Learning Behaviors** | | | | |
| Full-day HS | 182 | 82 | 15.0 | .01* |
| Partial-day pre-K | 169 | 85 | 12.1 | |

*Note.* SD = standard deviation.
* Statistically significant *p* value ≤ .05.

Further subgroup analyses showed that significant differences were found in InView analogy in favor of Male, Hispanic/Latino, FARMS, or special education students of the partial-day group. The *p* values ranged

from .00 to .03 (Appendix D, Table D4). The effect sizes were -.33 for Males, -.29 for Hispanic/Latino, -.31 for FARMS, and -.71 for special education students. This means that the Male, Hispanic/Latino, FARMS, and special education students who attended the full-day pre-K performed lower than their counterparts in the partial-day pre-K. The effect sizes were large enough to be practically significant. However, the large effect size for special education students needs to be interpreted with caution due to the small number of students.

The mean score difference of four points in learning behavior also was significant in favor of FARMS students in the partial-day pre-K group (Appendix D, Table D5). The effect size was -.30, large enough to be educationally significant.

To sum up, the full-day Head Start students performed at the same level on most of the outcome measures but scored significantly lower on InView analogy and learning behaviors, when compared to their partial-day pre-K peers. On InView analogy, Male, Hispanic/Latino, FARMS, or special education students in the full-day Head Start pre-K performed significantly lower than their peers in the MCPS partial-day pre-K. The full-day Head Start pre-K students who received FARMS services in Grade 2 scored significantly lower in learning behaviors than their partial-day pre-K counterparts.

*Verification Results with Covariate-adjusted Model*

The covariate-adjusted model also was used to verify results for the second evaluation question (Appendix D, Tables D6–D9). There were no significant differences between the full-day Head Start and MCPS partial-day pre-K classes on all outcome measures. This suggests that the full-day and partial-day pre-K groups performed at similar levels on all outcome measures by the end of Grade 2. However, the mean difference was 8.8 on InView Analogy in favor of the partial-day pre-K classes (Appendix D, Table D8). The effect size was -.15 close to being educationally significant. The results provide further evidence of the gap in cognitive skills between the full-day pre-K and MCPS partial-day pre-K groups.

*Compare Full-day Head Start and MCPS Kindergartners Without MCPS pre-K*

**Evaluation Question 3: At the end of Grade 2, did the students who attended the full-day Head Start pre-K classes differ in reading, mathematics, cognitive skills, and learning behaviors, compared with their counterparts who entered MCPS in kindergarten?**

Table 7 presents characteristics of the full-day Head Start pre-K students and their matched peers who entered MCPS in kindergarten. Across the two groups, about one third of students were Black or African American and more than half were Hispanic/Latino. Over 70% of them received ESOL services, and over 95% received FARMS services by the end of Grade 2. The two groups were relatively close in demographic characteristics.

To ensure the full-day Head Start pre-K group and the group with no MCPS pre-K were similar on the school readiness at the beginning of kindergarten, their mean MMSR scores were examined. The MMSR mean scores for the two groups were very close (about 76 for both groups (Appendix E, Table E1). This indicates that the two groups were also similar on school readiness at the beginning of kindergarten in 2008–2009.

Table 7
Characteristics of MCPS 2010–2011 Grade 2 Students Who Attended 2007–2008 Full-day Head Start pre-K Classes or Had No MCPS pre-K Experience

| | Full-day Head Start | | No MCPS pre-K | |
|---|---|---|---|---|
| | *N* | % | *N* | % |
| All Students | 214 | | 214 | |
| Gender | | | | |
| Female | 97 | 45.3 | 102 | 47.7 |
| Male | 117 | 54.7 | 112 | 52.3 |
| Race | | | | |
| Asian | 17 | 7.9 | 11 | 5.1 |
| Black or AfAm | 74 | 34.6 | 77 | 36.0 |
| Hispanic/Latino | 113 | 52.8 | 117 | 54.7 |
| White | 10 | 4.7 | 9 | 4.2 |
| Services | | | | |
| Ever ESOL | 159 | 74.3 | 156 | 72.9 |
| Ever FARMS | 207 | 96.7 | 207 | 96.7 |
| Sped | 26 | 12.1 | 22 | 10.3 |

*Note.* Ever ESOL = Received English for Speakers of Other Languages services in MCPS by Grade 2; Ever FARMS = Received Free and Reduced-price Meals System services in MCPS by Grade 2; Sped = received special education in Grade 2.

Even though a higher percentage of students (67.3%) in the full-day Head Start pre-K group met the Grade 2 reading benchmark than their peers without MCPS pre-K experience (62.1%), the difference was not statistically significant (*p value* = .31) as measured by the AP-PR (Table 8). This shows that

the two groups performed at the same level in meeting the Grade 2 reading benchmark.

Table 8
Grade 2 Students Who Attended 2007–2008 Full-day Head Start pre-K or Had No MCPS pre-K Experience and Met Grade 2 Reading Benchmark in 2010–2011

| | *N* | *N* Met | % | *p value** |
|---|---|---|---|---|
| Full-day HS | 214 | 144 | 67.3 | .31 |
| No MCPS pre-K | 214 | 133 | 62.1 | |

*Note.* Degree of freedom = 1 for chi-square tests.
* Statistically significant *p* value ≤ .05.

Further subgroup analyses (Appendix E, Table E2) showed that a significantly higher percentage of ESOL students in the full-day Head Start pre-K group met the Grade 2 reading benchmark (65.3%), compared with their ESOL peers without MCPS pre-K experience (51.9%). ESOL students in the full-day Head Start pre-K group were 28% more likely to meet the Grade 2 reading benchmark than their ESOL peers without MCPS pre-K experience (*p value* = .04; odds ratio = 1.28).

Table 9
Mean Scores on TN/2, InView, and Learning Behaviors for MCPS 2010–2011 Grade 2 Students Who Attended 2007–2008 Full-day Head Start pre-K Classes or Had No MCPS pre-K Experience

| | *N* | Mean | SD | *p value** |
|---|---|---|---|---|
| **TN2 Reading** | | | | |
| Full-day HS | 214 | 609 | 28.4 | .88 |
| No MCPS pre-K | 214 | 608 | 26.3 | |
| **TN2 Language Arts** | | | | |
| Full-day HS | 214 | 607 | 43.9 | .57 |
| No MCPS pre-K | 214 | 610 | 38.5 | |
| **TN2 Math** | | | | |
| Full-day HS | 214 | 569 | 44.2 | .53 |
| No MCPS pre-K | 214 | 567 | 33.8 | |
| **InView Analogy** | | | | |
| Full-day HS | 214 | 370 | 65.7 | .13 |
| No MCPS pre-K | 213 | 379 | 65.3 | |
| **InView Reasoning** | | | | |
| Full-day HS | 209 | 384 | 55.9 | .72 |
| No MCPS pre-K | 213 | 382 | 52.6 | |
| **Learning Behaviors** | | | | |
| Full-day HS | 182 | 82 | 15.0 | .37 |
| No MCPS pre-K | 174 | 83 | 13.0 | |

*Note.* SD = standard deviation.
* Statistically significant *p* value ≤ .05.

As shown in Table 9, there were no significant differences between the full-day Head Start pre-K group and their peers without any MCPS pre-K experience on TN/2 reading, language arts, and math, InView analogy and reasoning, and learning behaviors. This suggests that the two groups performed at the same level academically, cognitively, and behaviorally by Grade 2.

Additional analyses showed that a significant difference in InView analogy existed for FARMS students. FARMS students in the full-day pre-K classes scored 13 points lower than their peers who entered MCPS in kindergarten (*p value* = .04, Appendix E, Table E4). The effect size was -.20 in favor of students with no MCPS pre-K experience. The effect size was large enough to be practically significant. This indicates that the full-day pre-K FARMS students scored significantly lower on InView analogy, compared to their peers who entered MCPS in kindergarten.

## Discussion

By Grade 2, students who attended the full-day Head Start pre-K classes in 2007–2008 significantly outperformed their half-day Head Start pre-K peers on TN/2 math computation. The full-day students performed at the same level as their comparison groups on most other outcome measures. As intended by the pre-K class model, the full-day Head Start students either performed higher or at the same level in content areas covered in MCPS curriculum.

A higher percentage of ESOL students in the full-day Head Start group met the Grade 2 reading benchmark compared to their ESOL peers who entered MCPS in kindergarten. Even though the two groups were similar in school readiness at the beginning of kindergarten, the full-day Head Start impact on ESOL students remained positive. However, the larger positive impact of the full-day Head Start class model discovered in pre-K and kindergarten seem to have faded out by Grade 2.

Despite higher or similar academic performance, the full-day Head Start students did not fare as well in areas of critical quantitative processes and learning behaviors as measured by InView analogy and learning behaviors, when compared with their peers in MCPS partial-day pre-K group. It is worth noting that students in the MCPS partial-day group had higher family income when they were in pre-K (Zhao, Modarresi, & Liu, 2009).

InView analogy measures critical quantitative processes instead of learned mathematic skills (CTB/McGraw-Hill, 2002b). Learning behaviors measure skills related to homework, classwork, engaging in learning tasks, cooperation with others, following rules, and exercising self-control.

Despite similar or higher performance in academic areas, the significantly lower performance of the full-day Head Start pre-K students on analogy and learning behaviors indicates cognitive and behavior gaps exist between the full-day Head Start students and their MCPS partial-day peers whose family income was higher. Students from higher income families may have other resources to help them develop critical thinking skills and learning behaviors in environments other than school. Even though students who entered MCPS in kindergarten did not have MCPS pre-K experience, they still may have had other pre-K experience.

The lower performance of the full-day Head Start group on cognitive skills and leaning behavior may signal the beginning of a gap in critical thinking and behaviors conducive to learning by the end of Grade 2 for students most impacted by poverty and limited English proficiency. The importance of critical thinking is emphasized in MCPS Curriculum 2.0. MCPS Curriculum 2.0 is built around developing students' critical and creative thinking skills and essential academic success skills so students are well prepared for a lifetime of learning. As a result, it is crucial to address the development of critical thinking skills in early childhood education.

## Recommendations

Based on the findings of this study and feedback from the program staff, the following recommendations are suggested:

- Examine the pre-K curriculum to ensure that critical thinking skills are included.
- Focus on instruction of critical thinking skills in pre-K through subsequent grades.
- Explore and develop strategies to improve student's learning skills through collaboration with teachers and parents.
- Continue to monitor the progress of students who received pre-K services in MCPS, and provide support when appropriate to sustain their academic gains as students transition to Grade 1 and beyond.

## Limitations

Despite rigorous statistical control, this study employed a quasi-experimental design. The study group and two comparison groups may have some preexisting differences on non-measured factors. If so, this may consequently threaten the internal validity of the findings (Gay & Airasian, 2000; Shadish, Cook, & Campbell, 2002).

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# Appendix A
## Original pre-K Cohort in 2007–2008

Table A1
Students' Characteristics for the Original 2007–2008 MCPS Cohort
by pre-K Class Model (N = 2,538)

| | Half-day Head Start | | Full-day Head Start | | MCPS Partial-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 | | | | | | |
| Black or AfAm | 192 | 49.1 | 90 | 34.6 | 585 | 31.0 |
| Asian | 28 | 7.2 | 23 | 8.8 | 235 | 12.5 |
| Hispanic/Latino | 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 or Alaskan Native students were included in the total but not reported separately.

Table A2
Family Background for the Original 2007–2008 MCPS
Cohort by pre-K Class Model *(N = 2,538)*

| | Half-day Head Start | | Full-day Head Start | | MCPS Partial-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 guardian's education (yrs.) | 12 | 12 | 12 | 12 | 12 | 12 |
| Male guardian's education (yrs.) | 12 | 12 | 12 | 12 | 12 | 12 |
| Family size | 4 | 4 | 4 | 4 | 4 | 4 |

# Appendix B

## Construction of Overall Learning Skill Score Based on 2010–2011 Traditional Report Cards

MCPS parents receive four report cards in a school year. Most schools use a traditional report card, while a few schools use a standards-based report card. Since the two types of report cards are different, only the traditional report card was used to construct a composite learning skill score. On the traditional report card, there is a section for learning skills (nonacademic indicators) consisting of the eight items below:

1. Completion of homework
2. Completion of classwork
3. Engagement in learning tasks
4. Use of feedback to improve learning
5. Cooperation with others towards a common goal
6. Showing consideration for others
7. Following oral and written directions
8. Exercising self-control

Teachers rated students on each of the above skills with letters I, L, F, R, and NI in 2010–2011. The researchers assigned 1–4 points to each skill.

| | |
|---|---|
| I = independent | (4 points) |
| L = limited prompting | (3 points) |
| F = frequent prompting | (2 points) |
| R = rarely | (1 point) |
| NI = not enough information | |

On Learning Skills 4 and 6 (use of feedback to improve learning and showing consideration for others), most teachers indicated that they did not have enough information to judge their students. To construct a composite learning skill score for a school year, the researchers summed up all the points for each skill across four marking periods, excluding Learning Skills 4 and 6 due to lack of sufficient information. As a result, the overall learning behavior score is based on six out of eight learning skills. It is the sum of the points for the six items across four marking periods, with a maximum score of 96.

The reliability of the learning behavior score is .89 as measured by Cronbach's alpha. It is considered high based on accepted criteria in research (Nunnally, 1978).

# Appendix C

## Covariate-Adjusted Model and Findings

The Levene's test of the equality of error variances between the two groups of students for each of the comparisons (full-day vs. half-day Head Start pre-K; and full-day Head Start vs. MCPS partial–day pre-K) and its associated *p value* were reported for each of the ANCOVA models. The ANCOVA findings were supplemented with the computation of effect size measures. One of the most common effect size measures is the standardized mean difference, Cohen's *d*. Therefore, the effect size (ES) for each outcome measure was estimated using Cohen's *d* convention by which an ES of 0.2 is considered small, an ES of at least 0.5 is considered medium, and an ES of 0.8 or greater is considered large (Cohen, 1988). The following formula was used to calculate the effect size from odds ratio (Rosenthal & Rubin, 1984): $\text{logit}\ \ d = \frac{\ln(OR)}{pi\ /\ \sqrt{3}}$.

## Comparing Full-day Head Start pre-K and Half-day Head Start pre-K Class Model with ANCOVA

**TN/2**. The scale scores of TN/2 reading, language arts, language mechanic, mathematics, and math computation are compared in Table C1. After controlling for demographics such as gender; race; services in special education, ESOL, FARMS; family size; and K–Grade 2 school attendance, there were no statistically significant differences between the academic performance of the two groups of Grade 2 students who attended the 2007–2008 full-day or half-day Head Start pre-K class models in MCPS, as measured by TN/2 reading,[2] language arts,[3] and language mechanics.[4] The adjusted mean score differences between the two groups of students calculated by ANCOVA procedures ranged from 0.30 (for language arts) to 2.56 (for language mechanics). The observed mean differences were not practically significant as well. The negligible effect sizes (ranging from .01 to .08) support the ANCOVA findings (Table C1).

[2] Levene's Test for reading: p = .02

[3] Levene's Test for Language Arts: p = .37

[4] Levene's Test for Language Mechanics: p = .32

Table C1
Comparison of TN/2 Reading, Language Arts, and Language Mechanics in Grade 2 Between Students Who Attended the Full-day and Half-day Head Start pre-K Classes

| | Adjusted Means | | | | Treatment Effect | | |
|---|---|---|---|---|---|---|---|
| | Full-day Head Start | | Half-day Head Start | | | | |
| Outcome Measures | Mean | N | Mean | N | Mean Difference | Standard Error | Effect Size |
| TN/2 Reading | 607.79 | 214 | 605.48 | 242 | 2.32* | 2.77 | .08 |
| TN/2 Language Arts | 605.85 | 214 | 605.55 | 242 | 0.30* | 3.90 | .01 |
| TN/2 Language Mechanics | 604.24 | 214 | 601.68 | 242 | 2.56* | 3.78 | .07 |

Reading: F = .70; $p$ = .40
Language Arts: F = .006, $p$ = .94
Language Mechanics: F = .46, $p$ = .50
* Statistically significant $p$ value ≤ .05.

Similar analyses for the students' scale scores on Grade 2 TN/2 math,[5] and math computation,[6] (Table C2) revealed neither a statistical nor a practical significant difference ($p$ < .05; ES = .04) between the two groups of students on TN/2 math. However, a significant adjusted mean difference ($p$ < .05) was found between the same two groups of students as measured by TN/2 math computation scale scores. The effect size associated with the mean difference also was practically significant (ES = .20). This means that the full-day group performed significantly higher on TN/2 math computation, compared to their half-day Head Start counterparts.

Table C2
Comparison of Scale Score on TN/2 Math and Math Computation in Grade 2 Between Students Who Attended the Full-day and Half-day Head Start pre-K Classes

| | Adjusted Means | | | | Treatment Effect | | |
|---|---|---|---|---|---|---|---|
| | Full-day Head Start | | Half-day Head Start | | | | |
| Outcome Measures | Mean | N | Mean | N | Mean Difference | Standard Error | Effect Size |
| TN/2 Math | 565.80 | 214 | 564.01 | 241 | 1.78* | 4.02 | .04 |
| TN/2 Math Computation | 552.19 | 213 | 542.38 | 241 | 9.81* | 4.76 | .20 |

Math: F = .197; $p$ = .66;
Math Computation: F = 4.25, $p$ = .04
* Statistically significant $p$ value ≤ .05.

**InView**. The two comparisons (Table C3) made between the two groups of students on InView analogy[7] and quantitative reasoning[8] found no statistically or practically significant differences ($p$ >.05); ES = -.10 and -.00, respectively). The group of students who attended the full-day Head Start pre-K classes performed as well as those who attended the half-day Head Start pre-K classes as measured by InView in Grade 2.

[5] Levene's Test for Math: p = .02

[6] Levene's Test for Math Computation: p = .37

[7] Levene's Test for InView Analogy: p = .04

[8] Levene's Test for InView Quantitative Reasoning: p = .64

**Learning Behaviors**. The same analytical procedures did not show any statistical or practical significant difference ($p > .05$; ES = -.07) between the two groups of students on the learning behavior measures[9] (Table C3).

Table C3
Comparison of Scale Scores on InView Analogy, Quantitative Reasoning, and Learning Behaviors in Grade 2 Between Students Who Attended the Full-day and Half-day Head Start pre-K Classes

| | Adjusted Means | | | | Treatment Effect | | |
|---|---|---|---|---|---|---|---|
| | Full-day Head Start | | Half-day Head Start | | Mean Difference | Standard Error | Effect Size |
| Outcome Measures | Mean | N | Mean | N | | | |
| InView Analogy | 363.73 | 214 | 368.93 | 239 | -5.19* | 5.97 | -.10 |
| InView Quantitative Reasoning | 380.73 | 209 | 380.78 | 241 | -0.04* | 5.60 | -.00 |
| Learning Behaviors | 80.51 | 182 | 80.77 | 192 | -.26* | 1.62 | -.07 |

InView Analogy: F = .76; $p$ = .39
InView Quantitative Reasoning: F = .00; $p$ =.99
Learning Behaviors Scores: F = .02; $p$ = .87
* Statistically significant $p$ value $\leq$ .05.

**Grade 2 AP-PR Reading**. The results from the logistic regression analysis indicate that the probability (or chance) of meeting end of Grade 2 reading benchmarks on the MCPS AP-PR for those students who attended the full-day Head Start pre-K was the same as those who attended the half-day Head Start pre-K ($p > .05$). This finding indicates that Grade 2 students who attended the full-day Head Start Pre-K had a statistically equal chance (odds ratio = 1.11) to meet the benchmark compared to their peers who attended the half-day Head Start pre-K. The calculated effect size (ES = .06) further supports the findings from the logistic regression (Table C4).

Table C4
Odds of Meeting the Grade 2 Reading Benchmark in 2010–2011 by Students Who Attended 2007–2008 pre-K Classes

| pre-K Classes | N | Odds Ratio | $p$ value | Effect Size |
|---|---|---|---|---|
| Full-day Head Start | 214 | 1.11 | .62 | .06 |
| Half-day Head Start | 242 | | | |

* Statistically significant $p$ value $\leq$ .05.

[9]Levene's Test for Learning Behaviors: p = .01

# Appendix D

## Comparing Full-day Head Start pre-K and MCPS Partial-day pre-K Classes With Propensity Score Matching

Table D1
MMSR Mean Scores for MCPS 2010–2011 Grade 2 Students Who Attended 2007–2008 Full-day Head Start pre-K Classes or MCPS Partial-day pre-K Classes After Propensity Score Matching

| | *N* | *Mean* | *SD* |
|---|---|---|---|
| Full-day Head Start pre-K | 214 | 75.7 | 11.0 |
| Partial-day pre-K | 214 | 75.9 | 11.9 |

*Note.* SD = standard deviation.

Table D2
Grade 2 Students Who Attended 2007–2008 Full-day Head Start pre-K or MCPS Partial-day pre-K Classes and Met Grade 2 Reading Benchmark in 2010–2011[10]

| | Full-day Head Start | | Partial-day pre-K | | | |
|---|---|---|---|---|---|---|
| | *N* | *%* | *N* | *%* | $x^2$ | *p value** |
| **Met Grade 2 Reading Benchmark** | | | | | | |
| All Students | 214 | 67.3 | 214 | 65.9 | .10 | .84 |
| Female | 97 | 71.1 | 95 | 69.5 | .06 | .88 |
| Male | 117 | 64.1 | 119 | 63.0 | .03 | .89 |
| Asian | 17 | 88.2 | 18 | 83.3 | .17 | 1.00 |
| Black or AfAm | 74 | 63.5 | 63 | 74.6 | 1.94 | .20 |
| Hispanic/Latino | 113 | 66.4 | 124 | 56.5 | 2.45 | .14 |
| White | 10 | 70.0 | 9 | 100.0 | 3.21 | .21 |
| ESOL | 121 | 65.3 | 116 | 53.4 | 3.45 | .07 |
| FARMS | 190 | 66.8 | 176 | 65.3 | .09 | .83 |
| Sped | 26 | 23.1 | 20 | 35.0 | .79 | .51 |

*Note.* ESOL = English for Speakers of Other Languages in Grade 2; FARMS = Free and Reduced-price Meals System in Grade 2; Sped = Special Education in Grade 2. Degree of freedom = 1 for chi-square tests.

* Statistically significant $p$ value $\leq .05$. Effect size is calculated only when the difference is significant ($p$ value $\leq .05$).

[10] Chi-square test was used to examine difference in proportion meeting Grade 2 reading benchmark between students of the full-day Head Start pre-K and MCPS partial-day pre-K classes.

Table D3

Mean Scale Scores of TN/2 Reading, Language Arts, and Mathematics for MCPS 2010–2011 Grade 2 Students Who Attended 2007–2008 Full-day Head Start pre-K or MCPS Partial-day pre-K by Subgroup After Propensity Score Matching[11]

| | Full-day Head Start | | | Partial-day pre-K | | | | |
|---|---|---|---|---|---|---|---|---|
| | *N* | *Mean* | *SD* | *N* | *Mean* | *SD* | *t* | *p value** |
| **TN/2 Reading** | | | | | | | | |
| All Students | 214 | 609 | 28.4 | 212 | 611 | 25.8 | -.89 | .37 |
| Female | 97 | 612 | 27.7 | 94 | 611 | 25.8 | .25 | .80 |
| Male | 117 | 605 | 28.6 | 118 | 610 | 26.0 | -1.43 | .15 |
| Asian | 17 | 623 | 23.8 | 18 | 624 | 26.7 | -.06 | .95 |
| Black or AfAm | 74 | 610 | 32.9 | 61 | 611 | 29.0 | -.20 | .84 |
| Hispanic/Latino | 113 | 605 | 24.2 | 124 | 609 | 24.3 | -1.19 | .24 |
| White | 10 | 613 | 37.2 | 9 | 613 | 14.4 | -.03 | .98 |
| ESOL | 121 | 604 | 23.4 | 116 | 607 | 25.3 | -1.01 | .31 |
| FARMS | 190 | 608 | 28.4 | 174 | 611 | 26.4 | -1.07 | .29 |
| Sped | 26 | 589 | 28.4 | 20 | 593 | 17.8 | -.65 | .52 |
| **TN/2 Language Arts** | | | | | | | | |
| All Students | 214 | 607 | 43.9 | 212 | 610 | 37.3 | -.72 | .47 |
| Female | 97 | 611 | 42.0 | 94 | 616 | 36.6 | -.80 | .43 |
| Male | 117 | 604 | 45.3 | 118 | 605 | 37.3 | -.30 | .76 |
| Asian | 17 | 627 | 32.8 | 18 | 640 | 36.5 | -1.12 | .27 |
| Black or AfAm | 74 | 613 | 39.3 | 61 | 613 | 31.5 | .08 | .93 |
| Hispanic/Latino | 113 | 600 | 43.3 | 124 | 602 | 37.2 | -.44 | .66 |
| White | 10 | 610 | 78.6 | 9 | 638 | 34.0 | -1.01 | .33 |
| ESOL | 121 | 599 | 40.0 | 116 | 602 | 36.4 | -.54 | .59 |
| FARMS | 190 | 606 | 44.3 | 174 | 608 | 36.2 | -.46 | .64 |
| Sped | 26 | 565 | 42.4 | 20 | 570 | 45.6 | -.45 | .66 |
| **TN/2 Mathematics** | | | | | | | | |
| All Students | 214 | 569 | 44.2 | 213 | 573 | 39.9 | -.87 | .38 |
| Female | 97 | 564 | 43.2 | 95 | 571 | 40.4 | -1.23 | .22 |
| Male | 117 | 574 | 44.7 | 118 | 574 | 39.6 | -.06 | .96 |
| Asian | 17 | 600 | 47.0 | 18 | 617 | 53.7 | -.97 | .34 |
| Black or AfAm | 74 | 572 | 42.8 | 62 | 569 | 33.4 | .46 | .65 |
| Hispanic/Latino | 113 | 560 | 34.8 | 124 | 566 | 34.6 | -1.19 | .24 |
| White | 10 | 590 | 95.5 | 9 | 602 | 54.1 | -.33 | .74 |
| ESOL | 121 | 562 | 36.7 | 116 | 567 | 35.5 | -.87 | .39 |
| FARMS | 190 | 566 | 42.5 | 175 | 572 | 38.0 | -1.20 | .23 |
| Sped | 26 | 531 | 43.6 | 20 | 543 | 29.7 | -1.07 | .29 |

*Note.* ESOL = English for Speakers of Other Languages in Grade 2; FARMS = Free and Reduced-price Meals System in Grade 2; Sped = Special Education in Grade 2. * Statistically significant $p$ value ≤ .05. Effect size is calculated only when the difference is significant ($p$ value ≤ .05).

[11] T-test was used to examine mean difference between students of the full-day Head Start pre-K and MCPS partial-day pre-K classes.

Table D4
Mean Scale Scores of InView Analogy and Quantitative Reasoning for MCPS 2010–2011 Grade 2 Students Who Attended 2007–2008 Full-day Head Start pre-K Classes or MCPS Partial-day pre-K Classes by Subgroup After Propensity Score Matching[12]

| | Full-day Head Start | | | Partial-day pre-K | | | | | *Effect* |
|---|---|---|---|---|---|---|---|---|---|
| | *N* | *Mean* | *SD* | *N* | *Mean* | *SD* | *T* | *p value** | *Size* |
| **InView Analogy** | | | | | | | | | |
| All Students | 214 | 370 | 65.7 | 214 | 388 | 57.8 | -3.00 | .00* | -.29 |
| Female | 97 | 370 | 63.7 | 95 | 385 | 60.6 | -1.67 | .10 | |
| Male | 117 | 369 | 67.6 | 119 | 389 | 55.6 | -2.52 | .01* | -.33 |
| Asian | 17 | 427 | 58.6 | 18 | 433 | 58.9 | -.32 | .75 | |
| Black or AfAm | 74 | 362 | 67.7 | 63 | 380 | 50.2 | -1.74 | .09 | |
| Hispanic/Latino | 113 | 368 | 58.9 | 124 | 385 | 59.0 | -2.18 | .03* | -.29 |
| White | 10 | 350 | 92.6 | 9 | 391 | 56.5 | -1.16 | .26 | |
| ESOL | 121 | 369 | 59.4 | 116 | 383 | 55.1 | -1.85 | .07 | |
| FARMS | 190 | 369 | 66.2 | 176 | 388 | 57.5 | -2.95 | .00* | -.31 |
| Sped | 26 | 324 | 77.4 | 20 | 368 | 41.0 | -2.27 | .03* | -.71 |
| **InView Quantitative Reasoning** | | | | | | | | | |
| All Students | 209 | 384 | 55.9 | 213 | 384 | 56.0 | -.16 | .88 | |
| Female | 95 | 375 | 57.3 | 94 | 375 | 54.1 | -.05 | .96 | |
| Male | 114 | 391 | 53.9 | 119 | 392 | 56.5 | -.11 | .91 | |
| Asian | 17 | 437 | 50.6 | 18 | 443 | 49.6 | -.33 | .75 | |
| Black or AfAm | 70 | 385 | 51.6 | 62 | 376 | 51.0 | .95 | .35 | |
| Hispanic/Latino | 112 | 374 | 53.7 | 124 | 378 | 54.8 | -.57 | .57 | |
| White | 10 | 394 | 71.5 | 9 | 414 | 45.0 | -.75 | .46 | |
| ESOL | 121 | 377 | 51.4 | 116 | 380 | 53.6 | -.40 | .69 | |
| FARMS | 186 | 382 | 55.1 | 175 | 383 | 57.5 | -.11 | .91 | |
| Sped | 26 | 348 | 48.4 | 20 | 346 | 55.0 | .10 | .92 | |

*Note.* ESOL = English for Speakers of Other Languages in Grade 2; FARMS = Free and Reduced-price Meals System in Grade 2; Sped = Special Education in Grade 2.

* Statistically significant $p$ value $\leq .05$. Effect size is calculated only when the difference is significant ($p$ value $\leq .05$).

[12] T-test was used to examine mean differences between students who attended the full-day Head Start pre-K and MCPS partial-day pre-K classes.

Table D5
Mean Scores of Learning Behaviors Based on Traditional Report Card for MCPS 2010–2011 Grade 2 Students Who Attended 2007–2008 Full-day Head Start pre-K Classes or MCPS Partial-day pre-K Classes by Subgroup After Propensity Score Matching[13]

| | Full-day HS | | | Partial-day pre-K | | | | | *Effect* |
|---|---|---|---|---|---|---|---|---|---|
| | *N* | *Mean* | *SD* | *N* | *Mean* | *SD* | *T* | *p value** | *Size* |
| **Learning Behaviors** | | | | | | | | | |
| All Students | 182 | 82 | 15.0 | 169 | 85 | 12.1 | -2.57 | .01* | -.22 |
| Female | 80 | 85 | 14.0 | 78 | 89 | 8.1 | -1.90 | .06 | |
| Male | 102 | 78 | 15.1 | 91 | 82 | 14.0 | -1.77 | .08 | |
| Asian | 14 | 90 | 7.9 | 11 | 92 | 5.7 | -.51 | .62 | |
| Black or AfAm | 58 | 80 | 17.4 | 52 | 84 | 13.0 | -1.27 | .21 | |
| Hispanic/Latino | 101 | 82 | 13.4 | 99 | 85 | 12.2 | -1.92 | .06 | |
| White | 9 | 77 | 20.8 | 7 | 90 | 7.9 | -1.52 | .15 | |
| ESOL | 112 | 83 | 12.9 | 91 | 85 | 12.2 | -.90 | .37 | |
| FARMS | 163 | 81 | 15.4 | 141 | 85 | 11.4 | -2.54 | .01* | -.30 |
| Sped | 24 | 72 | 18.7 | 17 | 82 | 16.0 | -1.75 | .09 | |

*Note.* ESOL = English for Speakers of Other Languages in Grade 2; FARMS = Free and Reduced-price Meals System in Grade 2; Sped = Special Education in Grade 2.

* Statistically significant $p$ value ≤ .05. Effect size is calculated only when the difference is significant ($p$ value ≤ .05).

### *Verification Results with Covariate-adjusted Model*

Five hundred students in MCPS partial-day pre-K classes were selected randomly to maintain a balanced design for the achievement comparisons between the full-day pre-K and MCPS partial-day pre-K students. Only students with complete data on all the measures were included in the analyses.

**TN/2**. The analyses of TN/2 performance between Grade 2 students who attended the full-day Head Start and MCPS partial-day pre-K classes in 2007-2008 indicated that the two groups performed at the same level (Table D6). On average, no significant differences were found between the performances of the two groups of students on the Grade 2 TN/2 outcome measures (Reading,[14] Language Arts,[15] and Language Mechanics[16]).

[13] T-test was used to examine mean difference between students who attended the full-day Head Start pre-K and MCPS partial-day pre-K classes.

[14] Levene's Test for reading: p = .57

[15] Levene's Test for Language Arts: p = .09

[16] Levene's Test for Language Mechanics: p = .65

Table D6
Comparison of Scale Scores on TN/2 Reading, Language Arts, and Language Mechanics in Grade 2 Between Students Who Attended the Full-day Head Start and MCPS Partial-day pre-K Classes in 2007–2008

| Outcome Measures | Adjusted Means | | | | Treatment Effect | | |
|---|---|---|---|---|---|---|---|
| | Full-day Head Start | | MCPS Partial-day Head Start | | Mean Difference | Standard Error | Effect Size |
| | Mean | N | Mean | N | | | |
| TN/2 Reading | 609.43 | 214 | 612.41 | 498 | -2.98* | 2.34 | -.10 |
| TN/2 Language Arts | 608.47 | 214 | 613.61 | 498 | -5.14* | 3.21 | -.13 |
| TN/2 Language Mechanics | 606.91 | 214 | 609.22 | 495 | -2.31* | 3.07 | -.06 |

Reading: F = 1.62, $p$ = .20
Language Arts: F = 2.58, $p$ = .11
Language Mechanics: F = .57, $p$ = .45
* Statistically significant $p$ value ≤ .05.

Parallel to those observed above, the analyses for the students' scale scores on Grade 2 TN/2 math,[17] and math computation[18] (Table D7) revealed a non-significant difference between the two groups ($p$ > .05). The negligible effect sizes (ES = .00) supported the findings from the ANCOVA analytical procedures.

Table D7
Comparison of Scale Scores TN/2 Math and Math Computation in Grade 2 Between Students Who Attended the Full-day Head Start and MCPS Partial-day pre-K Classes in 2007–2008

| Outcome Measures | Adjusted Means | | | | Treatment Effect | | |
|---|---|---|---|---|---|---|---|
| | Full-day Head Start | | MCPS Partial-day Head Start | | Mean Difference | Standard Error | Effect Size |
| | Mean | N | Mean | N | | | |
| TN/2 Math | 571.07 | 214 | 571.02 | 498 | .05* | 3.24 | .00 |
| TN/2 Math Computation | 556.34 | 213 | 556.77 | 495 | -.43* | 3.78 | -.00 |

Math: F = .00, $p$ = .99
Math Computation: F = .01, $p$ = .91
* Statistically significant $p$ value ≤ .05.

**InView**. Employing the ANCOVA analytical procedures, the results revealed that on average, there was not a statistically significant difference ($p$ > .05) on the InView analogy[19] and In View quantitative reasoning[20] between the two groups of students (full-day Head Start pre-K vs. MCPS partial-day pre-K). The effect sizes associated with both comparisons ranged from -.02 to .15 and was not large enough to be practically significant (Table D8).

[17] Levene's Test for Math: p =.39

[18] Levene's Test for Math Computation: p = .62

[19] Levene's Test for InView Analogy: p = .61

[20] Levene's Test for InView Quantitative Reasoning: p = .44

**Learning Behaviors**. The same analytical procedures did not show a statistical ($p$ >.05) or practical significant difference ($p$ >.05; ES = -.15) between the two groups of students on the learning behavior measure[21] (Table D8).

Table D8
Comparison of InView Analogy, Quantitative Reasoning, and Learning Behaviors
in Grade 2 Between Students Who Attended the Full-day Head Start
and MCPS Partial-day pre-K Classes in 2007–2008

| | Adjusted Means | | | | Treatment Effect | | |
|---|---|---|---|---|---|---|---|
| | Full-day Head Start | | MCPS Partial-day Head Start | | Mean Difference | Standard Error | Effect Size |
| Outcome Measures | Mean | N | Mean | N | | | |
| InView Analogy | 371.26 | 214 | 380.06 | 498 | -8.80* | 4.93 | -.15 |
| InView Quantitative Reasoning | 386.19 | 209 | 387.11 | 497 | -.92* | 4.53 | -.02 |
| Learning Behaviors | 82.04 | 182 | 84.13 | 403 | -2.09* | 1.22 | -.15 |

InView Analogy: F = 3.18, $p$ = .08
InView Quantitative Reasoning: F = .04, $p$ = .84
Learning Behaviors Total Scores: F = 2.92, $p$ = .09
* Statistically significant $p$ value ≤ .05.

**Grade 2 AP-PR Reading**. Table D9 revealed that the probability (or chance) of meeting the Grade 2 reading benchmarks on the MCPS AP-PR for those students who attended the full-day Head Start pre-K was statistically the same as those who attended MCPS partial-day pre-K (odds ratio = .99; $p$ > .05). The negligible effect size (-.01) supports the findings from the logistic regression.

Table D9
Odds of Meeting the Grade 2 Reading Benchmark in 2010–2011
by pre-K Classes in 2007–2008

| pre-K Classes | N | Odds Ratio | $p$ value* | Effect Size |
|---|---|---|---|---|
| Full-Day Head Start | 214 | .99 | .95 | -.01 |
| MCPS Partial-day | 500 | | | |

* Statistically significant $p$ value ≤ .05.

[21] Levene's Test for Learning Behaviors: p = .00

# Appendix E

## Comparing Full-day Head Start pre-K Classes and Students Who Had No MCPS pre-K Experience After Propensity Score Matching

Table E1
MMSR Mean Scores for Students Who Attended 2007–2008 Full-day Head Start pre-K Classes or Had No MCPS pre-K Experience After Propensity Score Matching

| | *N* | *Mean* | *SD* |
|---|---|---|---|
| Full-day Head Start pre-K | 214 | 75.7 | 11.0 |
| No MCPS pre-K | 214 | 75.9 | 12.0 |

*Note.* SD = standard deviation

Table E2
Grade 2 Students Who Attended 2007–2008 Full-day Head Start pre-K or Had No MCPS pre-K Experience and Met Grade 2 Reading Benchmark in 2010–2011[22]

| | Full-day HS | | No MCPS pre-K | | | | |
|---|---|---|---|---|---|---|---|
| | *N* | *%* | *N* | *%* | $x^2$ | *p value* | *Odds Ratio* |
| **Met Grade 2 Reading Benchmark** | | | | | | | |
| All Students | 214 | 67.3 | 214 | 62.1 | 1.24 | .31 | |
| Female | 97 | 71.1 | 102 | 63.7 | 1.24 | .29 | |
| Male | 117 | 64.1 | 112 | 60.7 | .28 | .68 | |
| Asian | 17 | 88.2 | 11 | 90.9 | .05 | 1.00 | |
| Black or AfAm | 74 | 63.5 | 77 | 68.8 | .48 | .50 | |
| Hispanic/Latino | 113 | 66.4 | 117 | 53.8 | 3.76 | .06 | |
| White | 10 | 70.0 | 9 | 77.8 | .15 | 1.00 | |
| ESOL | 121 | 65.3 | 108 | 51.9 | 4.26 | .04* | 1.28 |
| FARMS | 190 | 66.8 | 186 | 61.8 | 1.03 | .33 | |
| Sped | 26 | 23.1 | 22 | 27.3 | .11 | .75 | |

*Note.* ESOL = English for Speakers of Other Languages in Grade 2; FARMS = Free and Reduced-price Meals System in Grade 2; Sped = Special Education in Grade 2. Degree of freedom = 1 for chi-square tests.
* Statistically significant *p* value ≤ .05. Odds ratio is calculated only when the difference is significant (*p* value ≤ .05).

[22] Chi-square test was used to examine difference in proportion meeting Grade 2 reading benchmark between students of the full-day Head Start pre-K and MCPS partial-day pre-K classes.

Table E3

Mean Scale Scores of TN/2 Reading, Language Arts, and Mathematics for MCPS 2010–2011 Grade 2 Students Who Attended 2007–2008 Full-day Head Start pre-K Classes or Who Had No MCPS pre-K Experience by Subgroup After Matching[23]

| | Full-day HS | | | No MCPS pre-K | | | | |
|---|---|---|---|---|---|---|---|---|
| | *N* | *Mean* | *SD* | *N* | *Mean* | *SD* | *t* | *p value* |
| **TN/2 Reading** | | | | | | | | |
| All Students | 214 | 609 | 28.4 | 214 | 608 | 26.3 | .16 | .88 |
| Female | 97 | 612 | 27.7 | 102 | 610 | 26.4 | .57 | .57 |
| Male | 117 | 605 | 28.6 | 112 | 606 | 26.2 | -.24 | .81 |
| Asian | 17 | 623 | 23.8 | 11 | 637 | 22.2 | -1.54 | .14 |
| Black or AfAm | 74 | 610 | 32.9 | 77 | 609 | 29.6 | .17 | .87 |
| Hispanic/Latino | 113 | 605 | 24.2 | 117 | 605 | 22.9 | .05 | .96 |
| White | 10 | 613 | 37.2 | 9 | 607 | 23.4 | .40 | .69 |
| ESOL | 121 | 604 | 23.4 | 108 | 602 | 22.2 | .50 | .62 |
| FARMS | 190 | 608 | 28.4 | 186 | 607 | 26.5 | .23 | .82 |
| Sped | 26 | 589 | 28.4 | 22 | 594 | 24.0 | -.77 | .45 |
| **TN/2 Language Arts** | | | | | | | | |
| All Students | 214 | 607 | 43.9 | 214 | 610 | 38.5 | -.57 | .57 |
| Female | 97 | 611 | 42.0 | 102 | 614 | 36.0 | -.53 | .60 |
| Male | 117 | 604 | 45.3 | 112 | 605 | 40.2 | -.24 | .81 |
| Asian | 17 | 627 | 32.8 | 11 | 639 | 41.0 | -.85 | .40 |
| Black or AfAm | 74 | 613 | 39.3 | 77 | 615 | 37.1 | -.22 | .83 |
| Hispanic/Latino | 113 | 600 | 43.3 | 117 | 603 | 38.2 | -.58 | .56 |
| White | 10 | 610 | 78.6 | 9 | 612 | 31.6 | -.08 | .94 |
| ESOL | 121 | 599 | 40.0 | 108 | 601 | 36.8 | -.36 | .72 |
| FARMS | 190 | 606 | 44.3 | 186 | 609 | 38.9 | -.75 | .45 |
| Sped | 26 | 565 | 42.4 | 22 | 579 | 35.9 | -1.22 | .23 |
| **TN/2 Mathematics** | | | | | | | | |
| All Students | 214 | 569 | 44.2 | 214 | 567 | 33.8 | .63 | .53 |
| Female | 97 | 564 | 43.2 | 102 | 565 | 33.0 | -.32 | .75 |
| Male | 117 | 574 | 44.7 | 112 | 568 | 34.5 | 1.08 | .28 |
| Asian | 17 | 600 | 47.0 | 11 | 594 | 44.0 | .34 | .74 |
| Black or AfAm | 74 | 572 | 42.8 | 77 | 565 | 34.1 | 1.12 | .27 |
| Hispanic/Latino | 113 | 560 | 34.8 | 117 | 564 | 31.5 | -.86 | .39 |
| White | 10 | 590 | 95.5 | 9 | 578 | 34.0 | .38 | .71 |
| ESOL | 121 | 562 | 36.7 | 108 | 561 | 32.5 | .40 | .69 |
| FARMS | 190 | 566 | 42.5 | 186 | 566 | 33.0 | .12 | .91 |
| Sped | 26 | 531 | 43.6 | 22 | 537 | 33.7 | -.55 | .59 |

*Note.* ESOL = English for Speakers of Other Languages in Grade 2; FARMS = Free and Reduced-price Meals System in Grade 2; Sped = Special Education in Grade 2. * Statistically significant $p$ value $\leq .05$. Effect size is calculated only when the difference is significant ($p$ value $\leq .05$).

[23] T-test was used to examine mean difference between students who attended the full-day Head Start pre-K and those without MCPS pre-K experience.

Table E4
Mean Scale Scores of InView Analogy and Quantitative Reasoning for MCPS 2010–2011 Grade 2 Students Who Attended 2007–2008 Full-day Head Start pre-K Classes or Who Had No MCPS pre-K Experience by Subgroup After Matching[24]

| | Full-day HS | | | No MCPS pre-K | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *N* | *Mean* | *SD* | *N* | *Mean* | *SD* | *t* | *p value* | *Effect Size* |
| **InView Analogy** | | | | | | | | | |
| All Students | 214 | 370 | 65.7 | 213 | 379 | 65.3 | -1.51 | .13 | |
| Female | 97 | 370 | 63.7 | 101 | 377 | 60.6 | -.73 | .47 | |
| Male | 117 | 369 | 67.6 | 112 | 381 | 69.4 | -1.36 | .18 | |
| Asian | 17 | 427 | 58.6 | 11 | 418 | 65.7 | .35 | .73 | |
| Black or AfAm | 74 | 362 | 67.7 | 77 | 370 | 70.4 | -.69 | .49 | |
| Hispanic/Latino | 113 | 368 | 58.9 | 116 | 382 | 58.2 | -1.87 | .06 | |
| White | 10 | 350 | 92.6 | 9 | 373 | 93.5 | -.54 | .60 | |
| ESOL | 121 | 369 | 59.4 | 108 | 378 | 59.5 | -1.13 | .26 | |
| FARMS | 190 | 369 | 66.2 | 185 | 382 | 62.6 | -2.07 | .04* | -.20 |
| Sped | 26 | 324 | 77.4 | 22 | 362 | 57.2 | -1.90 | .06 | |
| **InView Quantitative Reasoning** | | | | | | | | | |
| All Students | 209 | 384 | 55.9 | 213 | 382 | 52.6 | .36 | .72 | |
| Female | 95 | 375 | 57.3 | 101 | 374 | 53.2 | .05 | .96 | |
| Male | 114 | 391 | 53.9 | 112 | 388 | 51.4 | .39 | .70 | |
| Asian | 17 | 437 | 50.6 | 11 | 425 | 58.5 | .59 | .56 | |
| Black or AfAm | 70 | 385 | 51.6 | 76 | 379 | 58.7 | .56 | .58 | |
| Hispanic/Latino | 112 | 374 | 53.7 | 117 | 378 | 47.3 | -.62 | .54 | |
| White | 10 | 394 | 71.5 | 9 | 394 | 37.9 | -.02 | .99 | |
| ESOL | 121 | 377 | 51.4 | 108 | 374 | 53.7 | .44 | .66 | |
| FARMS | 186 | 382 | 55.1 | 186 | 380 | 52.7 | .33 | .74 | |
| Sped | 26 | 348 | 48.4 | 22 | 360 | 64.5 | -.72 | .48 | |

*Note.* ESOL = English for Speakers of Other Languages in Grade 2; FARMS = Free and Reduced-price Meals System in Grade 2; Sped = Special Education in Grade 2.
* Statistically significant $p$ value ≤ .05. Effect size is calculated only when the difference is significant ($p$ value ≤ .05).

[24] T-test was used to examine mean difference between students who attended the full-day Head Start pre-K and those without MCPS pre-K experience.

Table E5
Mean Scores of Learning Behaviors Based on Traditional Report Card for MCPS 2010–2011 Grade 2 Students Who Attended 2007–2008 Full-day Head Start pre-K Classes or Who Had No MCPS pre-K Experience by Subgroup After Matching[25]

| | Full-day HS | | | No MCPS pre-K | | | | |
|---|---|---|---|---|---|---|---|---|
| | *N* | *Mean* | *SD* | *N* | *Mean* | *SD* | *t* | *p value* |
| **Learning Behaviors** | | | | | | | | |
| All Students | 182 | 82 | 15.0 | 174 | 83 | 13.0 | -.89 | .37 |
| Female | 80 | 85 | 14.0 | 86 | 86 | 11.3 | -.48 | .64 |
| Male | 102 | 78 | 15.1 | 88 | 79 | 13.8 | -.46 | .65 |
| Asian | 14 | 90 | 7.9 | 9 | 88 | 9.5 | .66 | .52 |
| Black or AfAm | 58 | 80 | 17.4 | 64 | 83 | 13.3 | -1.07 | .29 |
| Hispanic/Latino | 101 | 82 | 13.4 | 94 | 82 | 13.4 | -.35 | .73 |
| White | 9 | 77 | 20.8 | 7 | 84 | 11.1 | -.75 | .47 |
| ESOL | 112 | 83 | 12.9 | 96 | 81 | 12.7 | .88 | .38 |
| FARMS | 163 | 81 | 15.4 | 151 | 83 | 12.7 | -.96 | .34 |
| Sped | 24 | 72 | 18.7 | 18 | 78 | 13.4 | -1.23 | .22 |

*Note.* ESOL = English for Speakers of Other Languages in Grade 2; FARMS = Free and Reduced-price Meals System in Grade 2; Sped = Special Education in Grade 2. Effect size is calculated only when the difference is significant ($p$ value $\leq .05$).

[25] T-test was used to examine mean difference between students who attended the full-day Head Start pre-K and those without MCPS pre-K experience.