Prince George's County Public Schools

EVALUATION REPORT

The Impact of the Montessori Program on Achievement and College Readiness

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The Impact of the Montessori Program on Achievement and College Readiness

EXECUTIVE SUMMARY

Prince George's County School District (PGCPS) opened three Montessori programs in 1986 and in 2002, which established two dedicated Montessori sites at John Hanson Montessori and Robert Goddard Montessori. Having been an established program for quite some time now, PGCPS decision-makers are interested in the impact of attending a Montessori school. The district established a third Montessori school; however, the current study will focus on these two schools. Placement in a Montessori program is through a lottery process and students can only be placed in a Montessori school starting at 3 or 4 years old. The current study will focus on the impact of attending a Montessori school at Grade 3, Grade 5, Grade 8, and Grade 11. While examining the effect of Montessori education while students are enrolled in the program is important because it provides a better understanding on the added value of a child attending Montessori versus attending another type of school; examining the long-term effect of Montessori in Grade 11 will provide insight on whether the impact of Montessori sustains throughout high school.

The following research questions guided this study: 1) Do third, fifth, and eighth grade students who are enrolled in Montessori have better English Language Arts (ELA), math, and science scores compared to similar students with other schooling experiences?; 2) Are eleventh graders who completed Montessori education more likely to be ready for college and career than eleventh graders of the same high school who attended non-Montessori schools?; 2a) After accounting for academic achievement in elementary and middle grades, are eleventh graders who completed Montessori education more likely to be ready for college and career than eleventh graders of the same high school who attended non-Montessori schools?

To address the research questions, we used SY15-SY16 enrollment data to create the analytical samples and Montessori lottery participation data across several years, starting In SY05, as a proxy for parental motivation. The outcomes of interest for this study were ELA and math proficiency in Grades 3, 5, 8 and 11; whether a student takes advanced math in Grade 8; science proficiency in Grades 5 and 8; and whether a student is considered college ready in ELA and math in Grade 11. PARCC ELA and math data, MSA science data, and Maryland State's College and Career Readiness (CCR) report data were used for the outcomes. The samples were restricted to students who attended the same elementary schools (i.e. K-5 and K-3 for the Grade 3 analysis) and had available achievement data for the respective analysis. Each Montessori student in the sample was then matched with a demographically identical student. To estimate the impacts of Montessori experience on PARCC proficiency rate for each grade, we used the Average Treatment Effect on the Treated (ATET) model.

The Impact of Montessori Education in Elementary and Middle School

The findings from the Grade 3, Grade 5, and Grade 8 treatment effect analysis show a consistent pattern of impact of Montessori enrollment across grade levels in ELA, mathematics, and science. The results demonstrate that the size of the impact progressively increased as students moved though elementary and middle school. In ELA, impact estimates range from 15 percent in Grade 3 to about 24 percent in Grade 8. In mathematics, Montessori students outperform their peers by eight percent to 30 percent, depending on grade level, and in science, they outperform by 14 percent to 27 percent. Thus, the impact of Montessori generally increases by grade level. This is consistent with previous findings that found the achievement advantage for Montessori students increases with the number of years in Montessori education and concluded that the effect of Montessori education is cumulative, which is realized with sustained time in a Montessori classroom (Mallet and Schroeder, 2015). The study also explored the role of parental motivation in moderating the impact of Montessori. After controlling for parental motivation, findings further suggest that there were positive and statistically significant impacts in ELA, mathematics, and science at each observed grade level, but in mathematics for Grade 3.

Long-term Effect of Montessori Education in Grade 11

The findings from the treatment effect for Grade 11 analysis show that high school students who had attended Montessori program demonstrated higher rates of readiness for college and career in reading and they were as prepared as their peers for college and career in mathematics. That is, despite a very different educational experience through the 8th grade, Montessori students performed as well as their matched high school peers on PARCC ELA, Algebra II and CCR Math, and they were better prepared for college than their matched peers in CCR ELA. Moreover, the overall higher performance of students who attended Montessori schools on the 11th grade reading outcome is due primarily to the higher academic performance in reading they achieved during the elementary and middle grades. However, we cannot confidently say that there was a significant long-term effect of Montessori enrollment on achievement in math. Thus, the study confirmed that the impact of Montessori in reading sustained long after the students graduated from the program, but there is no evidence to suggest that was the case for mathematics. Nevertheless, Montessori educated students were as prepared in mathematics as their peers, and this is a sign that they adjusted very well to high school mathematics instruction in spite of the different instructional method in mathematics that they received until the 8th grade.

I.   INTRODUCTION

Montessori education is a child-centered educational approach designed to support the natural development of children. The Montessori Method of education, developed by Dr. Maria Montessori in 1907, was based on scientific observations of children and has been proven to be a successful method of education that benefits students both academically and socially. An essential component of the Montessori education is multiple groupings which involves younger children learning from older children. This also allows the older children to reinforce concepts they have already learned via teaching younger children. Other essential components include uninterrupted blocks of work time and guided choice of work activity. The Montessori classroom is supposed to be prepared by the teacher to encourage "independence, freedom within limits, and a sense of order,'' with Montessori learning materials arranged in a way that encourages the child to make use of the environment, interacting with the teacher when support is needed. These components are necessary for a program to be considered an authentic Montessori program.

Research has shown that Montessori students out-perform students receiving traditional education in reading and math (Borman et al., 2003; Dorhrmann et al., 2007; Lopata, Wallace, & Finn, 2005). In addition, research suggested that Montessori students have more adaptive behavioral and social skills than other students (e.g., Lillard & Else-Quest, 2006). Montessori students have also reported more positive perceptions of their school environments and teachers compared to traditional students (Rathunde & Csikszentmihalyi, 2005). In the past few decades, Montessori schools have experienced a second wind of popularity in the United States.

Prince George's County School District (PGCPS) opened three Montessori programs in 1986 and in 2002 established two dedicated Montessori sites at John Hanson Montessori and Robert Goddard Montessori. The district established a third Montessori school; however, the current study will focus on these two schools. Placement in a Montessori program is through a lottery process and students can only be placed in a Montessori school starting at 3 or 4 years old. Older students may be placed in the program if they are transferring from another full-day Montessori School but this is not common.

Scope and Purpose of the Evaluation

Having been an established program for quite some time now, PGCPS decision-makers are interested in the impact of attending a Montessori school. The current focused on the impact of attending a Montessori school at Grade 3, Grade 5, Grade 8, and Grade 11. These

grades were chosen because they are considered critical points in a child's educational trajectory. Third grade is a pivotal year for students, particularly for reading, and is often considered a "make-or-break" period of academic success as this year is when students transition from learning to read to reading to learn. Third grade is also the first grade where students begin to take the required state assessment, currently the Partnership for Assessment of Readiness for College and Careers (PARCC) and previously the Maryland State Assessment (MSA). Fifth grade is considered a pivotal year as Grade 5 performance is a good indication for how prepared students are for middle school. Eighth grade is a critical time because it marks the end of Montessori education as well as the end of middle school. Finally, eleventh grade is considered a crucial year for preparing for college and/or career; therefore, Grade 11 achievement outcomes are often used to determine whether a student is college or career ready. Thus, the study focused on relatively short term effect of Montessori in elementary and middle school grades as well as the long-term effects of the Montessori program once students go through high school.

Research Questions

The study addresses the following research questions:

1. Do third, fifth, and eighth grade students who are enrolled in Montessori have better English Language Arts (ELA), math, and science scores compared to similar students with other schooling experiences?
2. Are eleventh graders who completed Montessori education more likely to be ready for college and career than eleventh graders of the same high school who attended non-Montessori schools?

    2a) After accounting for academic achievement in elementary and middle grades, are eleventh graders who completed Montessori education more likely to be ready for college and career than eleventh graders of the same high school who attended non-Montessori schools?

Organization of Report

This report is organized into four major sections. Following this introductory section, the second section describes the methods and procedures used in data collection and the analysis plan developed to answer the aforementioned research questions. Section III contains the findings by research question. A summary of the findings is contained in Section IV, which includes the conclusions that can be drawn from the findings.

II. METHODS

Table 1 outlines the sample, data, and analytic procedure used for this study. Below, we further explain the data, sampling, and method of analysis for each question.

Table 1: Study Questions, Data Sources, & Analysis Techniques

Evaluation Questions	Sample	Data	Analytic procedure
1. Do third, fifth, and eighth grade students who are enrolled in Montessori have better ELA, math, and science scores compared to similar students with other schooling experiences?	SY15 and SY16 Grade 3, Grade 5, and Grade 8 Montessori students and matched PGCPS students	PGCPS SY05-SY16 enrollment and demographic data; Montessori SY10-SY13, SY08-SY11, and SY05-SY08 lottery data; SY15 and SY16 end-of Grade 3, 5, and 8 PARCC data	Treatment effects analysis - Comparison of Montessori students vs. other demographically similar students
2. Are eleventh graders who completed Montessori education more likely to be ready for college and career than eleventh graders of the same high school who attended traditional K-8 schools?	SY15 and SY16 Grade 11 Montessori students and matched PGCPS students	PGCPS SY15 and SY16 enrollment and demographic data; Montessori SY02-SY05 lottery data; SY15 and SY16 end-of Grade 11 PARCC data	Treatment effects analysis - Comparison of Montessori students vs. other demographically similar students
2a) After accounting for academic achievement in elementary and middle grades, are eleventh graders who completed Montessori education more likely to be ready for college and career than eleventh graders of the same high school who attended non-Montessori schools?	SY15 and SY16 Grade 11 Montessori students and matched PGCPS students	PGCPS SY15 and SY16 enrollment and demographic data; Montessori SY02-SY05 lottery data; SY12 and SY13 (Grade 8), SY09 and SY10 (Grade 5), SY07 and SY08 (Grade 3) MSA math and English data;	The population-average logistic regression model Treatment effects analysis

Types of Data Used

Enrollment, demographic, and lottery data: To address the research questions, we used SY15-SY16 enrollment data to create the analytical samples and demographic data to use for controls in the analyses. We also used prior years' enrollment data to track the schools that students attend each year. Our primary interest was in the differences in achievement outcomes between Montessori and all other similar PGCPS students. However, we were also interested in how Montessori students compared to other students with similar parental motivation before the Montessori pre-kindergarten entry years. We used Montessori lottery participation data across several years, starting In SY02, as a proxy for parental motivation.

Achievement data: The outcomes of interest for this study were ELA and math proficiency in Grades 3, 5, 8 and 11; whether a student takes advanced math in Grade 8; science proficiency in Grades 5 and 8; and whether a student is considered college ready in ELA and math in Grade 11. The outcome measures were extracted from PARCC ELA and math data (proficiency status), MSA science data (proficiency status), and Maryland State's College and Career Readiness (CCR) report data (being ready for college and career).

Analytic Procedures

Research Question 1 and 2: To answer research questions 1 and 2, we utilized reading and math proficiency at the end of Grades 3, 5, 8, and 11 (and science proficiency at the end of Grades 5 and 8) in SY15 and SY16 as measured by PARCC and MSA. The samples were restricted to students who attended the same elementary schools (i.e. K-5 and K-3 for the Grade 3 analysis) and had available achievement data for the respective analysis. In addition, students attending French Immersion schools were excluded. To estimate the impacts of Montessori experience on PARCC proficiency rate for each grade, we used the Average Treatment Effect on the Treated (ATET) model. In this framework, there is a potential outcome (i.e., PARCC proficiency) with treatment (i.e., Montessori enrollment) and the opposite potential outcome without treatment (e.g., enrollment in another school).

Treatment effects analysis allows us to estimate the counterfactual by using several observations in the non-treatment group who have similar observable characteristics. These observable characteristics of interest were used to control for differences in student characteristics and parental motivation. The control variables we included for all grades were: Free- or reduced-priced meals (FARMS) status, race/ethnicity, and gender. A second set of analyses also included parent participation in the Montessori lottery during the student's pre-kindergarten years to account for differences in parent motivation before attending

Montessori. For the Grade 11 analysis, we used nearest-neighbor matching to include an exact matching on the high school they attended. That is, a Montessori student is matched with a similar student who also attended the same high school.

The Grade 3, 5, and 8 Montessori samples consisted of 160, 150, and 139 students, respectively. As stated above, for each grade, we used gender, race/ethnicity, and FARMS status to match each Montessori student with a demographically identical peer student who attended a non-Montessori school. For the analysis of Grade 3 PARCC ELA and PARCC math, matching of the sample is conducted from a sampling frame of 10,108 and 10,109 students, respectively, who attended the same elementary school from Kindergarten to Grade 3 and took these assessments in SY15 and SY16. For the analysis of Grade 5 PARCC ELA, PARCC math, and MSA science, matching of the sample is conducted from a sampling frame of 6,984, 6,981, and 6,393 students, respectively, who attended the same elementary school from Kindergarten to Grade 5 and took these assessments in SY15 and SY16. For the analysis of Grade 8 PARCC ELA, PARCC math and advanced math indicator, and MSA science, matching of the sample is conducted from a sampling frame of 9,215, 9,452, and 8, 108 students, respectively, who attended the same elementary school from Kindergarten to Grade 5 and took these assessments in SY15 and SY16.

The 11th grade Montessori sample consisted of 87 students who had (a) begun their Montessori education at age three or four in the Robert Goddard or John Henson Montessori schools; (b) completed the 8th grade between 2012 and 2013; and (c) maintained active status within the PGCPS throughout high school. Of these 87 Montessori students, 59 (68 percent) attended 7 (out of 29 possible in 2013-2016) PGCPS high schools; each of these high schools had at least 5 former Montessori students. It should be noted that the three out of four of the high schools with the highest number of Montessori students (49.4 percent of the total) have highly selective specialty programs (Flowers, Roosevelt, Oxon Hill and Bowie). Using gender, race/ethnicity, and free/reduced-price lunch status, a demographically identical peer student was matched with a Montessori student at each high school.

For the analysis of Grade 11 PARCC reading the matching of the sample is conducted from a sampling frame of 1211 students who attended the same elementary school from Kindergarten to Grade 5, attend PGCPS high schools and took PARCC ELA assessment in SY15 and SY16 (i.e. 27 Montessori were matched with 27 non-Montessori students who attend the same High Schools). For the analysis of PARCC Algebra II the matching of the sample is conducted from a sampling frame of 1334 students who attended the same elementary school from Kindergarten to Grade 5, attend PGCPS high schools and took PARCC Algebra II assessment in SY15 and SY16 (39 Montessori students were matched with 39 non-Montessori students who attend the same High Schools). For the analysis that used the Maryland College

and Career Readiness Report (MD CCR) as the outcome, the matching of the sample is conducted from a sampling frame of 1473 students who attended the same elementary school from Kindergarten to Grade 5, attend PGCPS high schools and were included in the SY17 Maryland College and Career Readiness Report (i.e. 30 Montessori students were matched with 30 non-Montessori who attend the same High Schools).

To estimate the ATET, we calculated the average difference in the students' ELA and math proficiency rates for attending a Montessori school and for attending in another school. The difference in the average PARCC reading and math proficiency rates between treatment (attending Montessori schools) and non-treatment (attending traditional schools) scenarios for each analysis is the ATET. The ATET is equivalent to the impact of Montessori attendance for all treatment students. The analyses were conducted using Stata 14.

Research Question 2a: To answer research question 2a, we conducted a two-step analysis: 1) We started with the Grade 11 cohort data from SY15 and SY16 and merged in their achievement outcomes when they were in Grade 3, Grade 5 and Grade 8 and calculated probability of proficiency in reading and mathematics in each year of MSA assessment during the elementary and middle school years; and 2) determined if this probability of being proficient in reading and mathematics influenced college and career readiness of the students in the sample. The first step of the analysis was conducted by estimating the predicted probability of being consistently proficient in Grades 3, 5 and 8 controlling for Montessori status, gender, race/ethnicity and FARMS status. These probabilities were calculated from a Population-Averaged Logistic Regression Model using the Generalized Estimating Equations (GEE) method in Stata 14. See the appendix for more on the Population-averaged model. In the second step, the probability of being proficient was used as a covariate in Grade 11 Average Treatment Effect on the Treated (ATET) model estimated to answer research question 2. This ATT is equivalent to the long-term impact of Montessori education (i.e. impact in high school) if the matched comparison group had the same proficiency rate in each year of MSA assessment as the Montessori students.

II.   FINDINGS

One goal of this study is to examine whether Montessori students have better achievement compared to non-Montessori students at the end of critical grades during the elementary and middle school years. Examining the effect of Montessori education while students are enrolled in the program is important because it provides a better understanding on the added value of a child attending Montessori versus attending another type of school. Another goal of the study is to determine the post-Montessori impact by examining whether students who completed Montessori are better prepared for college compared to other students. Examining the long-term effect of Montessori in Grade 11 will provide insight on whether the impact of Montessori sustains throughout high school.

Descriptive Statistics from the Grade 3, Grade 5, and Grade 8 Analyses

Research Question 1: Do third, fifth, and eighth grade students who are enrolled in Montessori have better ELA, math, and science scores compared to similar students with other schooling experiences?

Table 2 displays the descriptive statistics for the achievement outcomes for the Grade 3, Grade 5, and Grade 8 Montessori samples. The table also includes the overall achievement for non-Montessori (not including French Immersion students) students. It is important to note that the data presented in Table 2 are purely descriptive and do not account for differences in student characteristics. In addition, the students used in the analysis attended the same school in elementary from kindergarten through Grade 5 (and Grade 3 for the Grade 3 sample).

According to Table 2, Montessori students had higher achievement outcomes compared to non-Montessori students throughout elementary and middle school regardless subject. In addition, the proficiency rates for Montessori students increase for the higher grades for each subject, with the exception of math proficiency being slightly lower in Grade 5 compared to Grade 3. As displayed, between 42 and 57 percent of Montessori were proficient in English across the grades compared to between 22 and 28 percent of non-Montessori students. Between 34 and 47 percent of Montessori students (versus between 18 and 22 percent of other students) were proficient in math throughout elementary and middle school. About 47 percent of Montessori students were taking an advanced math course in Grade 8 compared to 13 percent of other students. Between 73 and 83 percent of Montessori students were proficient in science in elementary and middle school, while between 54 and 50 percent of other students were proficient in science.

Table 2: Descriptive Statistics for Grade 3, Grade 5, and Grade 8 Samples

Achievement Outcomes	Montessori Students		All Other Students	
	Total # Tested	% Proficient	Total # Tested	% Proficient
Grade 3				
PARCC ELA Proficient	146	41.78%	9,962	21.57%
PARCC Math Proficient	146	34.25%	9,963	22.18%
Grade 5				
PARCC ELA Proficient	139	41.73%	6,845	24.89%
PARCC Math Proficient	139	33.81%	6,842	18.09%
MSA Science Proficient	128	73.44%	6,265	54.01%
Grade 8				
PARCC ELA Proficient	125	56.80%	9,090	28.34%
PARCC Math Proficient	125	47.20%	9,327	16.36%
Taking Advanced Math	125	47.20%	9,327	13.37%
MSA Science Proficient	93	82.80%	8,015	49.69%

We cannot simply attribute the difference in proficiency and advance math taking rates to Montessori enrollment without considering the socio-demographic characteristics of students. As discussed in the methods section, we estimated proficiency rates that take into account these observed differences to establish whether Montessori students vs. non-Montessori students performed differently in math, ELA, and science. The results are discussed in the following section.

Impact of Montessori Enrollment during Elementary and Middle School

We ran two sets of analyses to address the first research question. These models estimated the effects of Montessori enrollment on Grade 3, Grade 5, and Grade 8 achievement using the treatment effect function in Stata (as explained in the Analysis section above). In both sets of analyses, we examined the impact of Montessori enrollment on achievement for Grade 3, Grade 5, and Grade 8 students while matching Montessori students with non-Montessori students on gender, FARMS, and race/ethnicity. However, the second set of the analyses also controlled for parental participation in the Montessori lottery. This lottery participation variable was used as a proxy for parental motivation during their child's pre-school years. In other words, the first set of analyses examines differences in proficiency rates between Montessori

students and other students regardless of parental motivation, while the second set of analyses captures these differences while accounting for differences in parental motivation. Thus, each analysis addresses the research question differently. The first examines Montessori students' achievement compared to similar non-Montessori students; the second examines Montessori students' achievement compared to non-Montessori students with similarly motivated parents. Table 3 displays the results from the analyses.

Table 3: Impact of Montessori Enrollment in Grades 3, 5, and 8

	ATET Analyses			ATET Analyses adjusting for Parental Motivation		
	Estimated Proficiency Rates			Estimated Proficiency Rates		
	Montessori Students (A)	Non-Montessori Students (B)	Impact of Montessori (A-B)	Montessori Students (C)	Non-Montessori Students (D)	Impact of Montessori (C-D)
Grade 3						
ELA	41.78%	27.00%	**14.78%***	41.78%	34.10%	**7.68%†**
Math	34.24%	26.23%	**8.01%***	34.24%	31.69%	**2.56%**
Grade 5						
ELA	41.72%	29.82%	**11.90%***	41.72%	31.37%	**10.36%***
Math	33.81%	20.50%	**13.31%***	33.81%	22.67%	**11.14%***
Science	73.44%	59.62%	**13.82%***	73.44%	60.40%	**13.04%***
Grade 8						
ELA	56.80%	33.08%	**23.72%***	56.80%	37.42%	**19.38%***
Math	47.20%	17.28%	**29.92%***	47.20%	24.56%	**22.64%***
Advanced Math	47.20%	16.26%	**30.94%***	47.20%	20.30%	**25.90%***
Science	82.80%	55.87%	**26.93%***	82.80%	62.84%	**19.96%***

Note. Match Variables: Gender, Race/Ethnicity, FARMS status. Significance levels: *†p < .10; * p < .05; **p < .01; *** p < .001*

Overall, the results indicate that there is a significant impact, as measured by differential in estimated proficiency rates, of Montessori enrollment on achievement for each grade and subject. This means that Montessori students, regardless of grade, would have higher ELA, math, and science proficiency rates because they attended a Montessori school. Not surprisingly, accounting for lottery participation (i.e., parent motivation) decreases the impact of Montessori enrollment. However, the impact remains significant in most cases. In addition, the positive impact of Montessori generally increases by grade level, being the highest for

Grade 8 students. For example, while the impact for Grade 3 ELA achievement is significant at 15 percent higher than non-Montessori students (becoming marginally significant when controlling for lottery participation), the estimated proficiency rate for Grade 8 Montessori ELA achievement is close to two times higher. The Grade 8 Montessori student ELA proficiency rate was 24 percentage points higher than the non-Montessori student ELA proficiency rate. In addition, the Grade 8 Montessori student estimated rates for math proficiency, taking advanced math, and science proficiency was 30, 31, and 27 percentage-points higher, respectively, than for non-Montessori students. This indicates that attending a Montessori school from kindergarten to Grade 8 has a very meaningful impact on student achievement.

Descriptive Statistics from the Grade 11 Analyses

Research Question 2: Are eleventh graders who completed Montessori education more likely to be ready for college and career than eleventh graders of the same high school who attended non-Montessori schools?

Table 4 displays the descriptive statistics for the achievement outcomes for the Grade 11 sampling frame. It is important to note that the rates presented in Table 4 are purely descriptive and do not account for differences in student characteristics. The estimated rates, which do control for student characteristics, are discussed in the next section.

Table 4: Descriptive Statistics for Grade 11 Samples

Achievement Outcomes	Montessori Students		All Other Students in the Sampling Frame	
	Total # Tested	% Proficient	Total # Tested	% Proficient
PARCC ELA 11	27	48.14%	1184	34.96%
PARCC Algebra II	39	10.25%	1295	4.01%
MD CCR ELA	30	73.33%	1443	51.62%
MD CCR Math	30	46.66%	1443	25.23%

Overall, high school students who had attended Montessori schools had higher achievement outcomes compared to those who did not attend Montessori schools. As reported in Table 4, 48 percent and 10 percent of the Montessori students in the sample demonstrated PARCC proficiency in PARCC ELA and Algebra II, compared to proficiency rates of 35 and 4 percent for the non-Montessori students. Similarly, 73 percent and 47 percent of

Montessori students were designated as college and career ready on the MD CCR report, respectively, in ELA and math compared to the college and career readiness rates of 52 and 25 percent for the non-Montessori students. These rates indicate that Montessori students had higher level of college readiness compared to non-Montessori students. However, we cannot simply attribute the difference to enrollment in the Montessori program without considering the socio-demographic characteristics of students and the effect of enrollment in a particular high school. As discussed in the methods section, we estimated proficiency rates that take into account these observed differences and the results are discussed in the following section.

Impact of Montessori Enrollment during High School

As in the analyses for the impact of attending Montessori schools on Grades 3, 5 and 8, we ran two sets of analyses to assess the impact of Montessori during high school. The treatment effect models for Grade 11 matched each Montessori student with a student of similar gender, race/ethnic and economic background who attended the same high school. Table 5 displays the results from the analyses.

The results indicate there were not significant differences between Montessori and non-Montessori students on achievement in 11th grade, with one exception. There were not statistically significant differences on PARCC ELA, PARCC Algebra II and CCR math (see Table 5). However, the Montessori students were significantly better prepared for college and career in CCR ELA (+20 percentage points) than the matched traditional students.

Table 5: Impact of Montessori Enrollment during High School

	ATET Analyses			ATET Analyses adjusting for Parental Motivation		
	Estimated Proficiency Rates			Estimated Proficiency Rates		
	Montessori Students (A)	Montessori Students (B)	Impact of Montessori (A-B)	Montessori Students (C)	Non-Montessori Students (D)	Impact of Montessori (C-D)
Grade 11						
PARCC ELA	48.14%	29.95%	**18.19%†**	48.14%	29.95%	**18.19%***
PARCC Algebra II	10.25%	1.84%	**8.41%†**	10.25%	1.84%	**8.41%†**
CCR ELA	73.33%	52.98%	**20.34%***	73.33%	52.98%	**20.34%****
CCR Math	46.66%	32.37%	**14.29%**	46.66%	32.54%	**14.13%**

Note. Match Variables: Gender, Race/Ethnicity & FARMS status. Exact matched on high school attended.
Significance levels: †p < .10; * p < .05; **p < .01; *** p < .001

The results of the analysis for the impact of Montessori education while adjusting for differences in parental motivation are also reported in Table 5. As presented in Table 5, there is still a significant impact of Montessori enrollment on achievement on key indicators in 11th grade after adjusting for differences in parental motivation. For all pairs of comparisons but one, accounting for differences in parental motivation did not substantially change the estimated impacts. Adjusting for parental motivation resulted in the impact for PARCC ELA reading being statistically significance (p<.05). That is, if the comparison was between students whose parental had applied to the Montessori program during their pre-school years, Montessori students would still perform as good as their matched peers in math and they would be better prepared than their peers in ELA.

Research Question 2a: After accounting for academic achievement in elementary and middle grades, are eleventh graders who completed Montessori education more likely to be ready for college and career than eleventh graders of the same high school who attended non-Montessori schools?

The Grade 11 results in question 2a are interpreted as the average differences in readiness for college between demographically similar students who differ on whether they attended Montessori program or not. This estimated impact, however, occurred several years after students have graduated from the Montessori schools. It is important to demonstrate that the observed impact is indeed a result of the gains in reading and mathematics the Montessori students made during their elementary and middle school. Thus, we ran additional analyses that adjusted for the academic performance of the sample during elementary and middle school. These analyses used MSA assessment data when these students were in Grades 3, 5, and 8. For each student in the sample, based on longitudinal models, a probability of being proficient in each year of MSA assessment (Grades 3, 5 and 8) was calculated controlling for Montessori status, gender, race/ethnicity and FARMS status. See the appendix for more on the longitudinal models. Table 6 displays the average predicted probability rates of consistently being proficient for the sample.

Overall, 87 percent of the Montessori students in the sample were consistently proficient in MSA reading in elementary and middle grades compared to 80 percent for the non- Montessori sample. On MSA math, 79 percent of the Montessori sample was 79 percent proficient in MSA math compared to 73 percent for the sample who had attended non-Montessori schools. The differences in the estimated probability of being consistently proficient for Montessori and non- Montessori students were found to be statistically significant. Thus, it is clear that these former Montessori students in the sample were better prepared academically before high school. Next, we explored if this observed better academic

preparation in elementary and middle school explains the Grade 11 estimated impact of Montessori enrollment presented in question number 2.

Table 6: Average Probability of being Consistently Proficient in MSA Assessments in Grades 3-8, 11th Grade Class of 2015 and 2016

		Montessori Students		All Other Students in the Sampling Frame	
		Total #	Prob.	Total #	Prob.
PARCC sample	**MSA ELA ***	27	.873	1184	.804
	MSA Math *	27	.794	1184	.731
CCR sample	**MSA ELA ***	30	.869	1443	.808
	MSA Math *	30	.792	1443	.736

Note. Significance levels: * *p* < .05; **p < .01; *** p < .001

Table 7 displays impact of Montessori Enrollment in high school if the matched comparison students had the same rate of being consistently proficient on MSA assessment during elementary and middle grades as the Montessori students. The results from Table 6 showed that Montessori students had higher rates of being consistently proficient on the MSA compared to demographically similar non-Montessori students. The analyses for research question 2a adjusted for the probability of being consistently proficient on MSA in elementary and middle school and therefore assume that both groups (i.e., Montessori and non-Montessori) in the sample had the same probability of MSA proficiency. In other words, the analyses assume that non-Montessori students were as high achieving as Montessori students when both groups were in elementary and middle school. If the estimated impacts reported for research question 2 do not significantly change (i.e., in size and statistical significance) under this assumption, we cannot confidently conclude that the estimated impact in Grade 11 is associated with Montessori education up to Grade 8. If the estimated impact changes, we can interpret the difference between the adjusted and unadjusted impacts as the long-term impact of Montessori education.

The results from the PARCC ELA model without adjusting for student academic performance during elementary and middle grades show that the estimated impact of Montessori at the end 11th grade was 18 percentage points (i.e. 48% for Montessori and 30% for non-Montessori students) and approaching significance but the impact was reduced to 11 percentage points (i.e. 48% for Montessori and 37% for non- Montessori students) and was not statistically significant under the assumption of equal rate of being consistently proficient in MSA reading for the sample. That is, if it were not for the higher academic performance of

Montessori students in reading prior to high school, their 11th grade PARCC reading proficiency would have only been higher by 11 percentage points but not statistically significant. We can conclude that a 7 percentage point advantage (the difference between the two impact estimates) in readiness in reading is associated with the higher academic performance achieved in elementary and middle grades as a result of enrollment in Montessori program. The results from the PARCC Algebra II show that the advantage for former Montessori students was 8 percentage points (i.e. 10% for Montessori and 2% for non-Montessori students) and approaching significance but the impact increases to 10 percentage points (i.e. 10% for Montessori and -.04% for non- Montessori students) and was statistically significant under the assumption of equal rate of being consistently proficient in MSA reading for the sample. The analyses from the models that used the Maryland CCR ELA as outcome show similar results to the PARCC ELA impact, as the non-Montessori Immersion students would have performed better if they had the same rate of MSA proficiency during their elementary and middle grades as the Montessori students. The results of the analysis from the model that used the Maryland CCR math as an outcome are different from the analysis for algebra; non- Montessori students would have higher levels of readings for college in math achievement if both groups had the same rate of MSA proficiency during their elementary and middle grades.

Table 7: Impact of Montessori Enrollment without Adjusting and Adjusting for pre-high school achievement trajectory

	ATET Analyses			ATET Analyses adjusting for Gr 3-8 Achievement Trajectory		
	Estimated Proficiency Rates			Estimated Proficiency Rates		
	Montessori Students (A)	Montessori Students (B)	Impact of Montessori (A-B)	Montessori Students (C)	Non-Montessori Students (D)	Impact of Montessori (C-D)
Grade 11						
PARCC ELA	48.14%	29.95%	**18.19%†**	48.14%	37.24%	**10.90%**
PARCC Algebra II	10.25%	1.84%	**8.41%†**	10.25%	-0.035%	**10.29%***
CCR ELA	73.33%	52.98%	**20.34%***	73.33%	55.21%	**18.12%†**
CCR Math	46.66%	32.37%	**14.29%**	46.66%	39.79%	**6.86%**

Note. Match Variables: Gender, Race/Ethnicity & FARMS status. Exact matched on High School attended.
Significance levels: †*p* < .10; * *p* < .05; ***p* < .01; *** p < .001

In sum, students who had attended Montessori schools performed as well as their matched high school peers on the PARCC ELA, Algebra II and CCR math and they were better

prepared for college than their matched peers in CCR ELA. Moreover, the overall higher performance of students who attended Montessori schools on the 11th grade reading outcomes is due primarily to the higher academic performance in reading they achieved during the elementary and middle grades. As shown in the findings reported earlier in research question 2a, this higher academic performance during the elementary and middle grades is a result of attending Montessori schools during these grades. However, we cannot confidently say that there was a significant long-term effect of Montessori enrollment on achievement in math; there is no evidence to indicate that the Montessori students would have been worse in math compared to their matched peers if they did not have higher math performance during the elementary and middle grades.

IV. SUMMARY AND CONCLUSIONS

The present study identifies a consistent pattern of impact of Montessori enrollment across grade levels in reading, mathematics, and science. The results demonstrate that the size of the impact (measured in differentials in percent proficient) progressively increased as students moved though elementary and middle school. In reading, estimates range from 15 percentage points in Grade 3 to about 24 percentage points in Grade 8. In mathematics, Montessori students outperform their peers by eight percent to 30 percentage points, depending on grade level, and in science, they outperform by 14 percentage points to 27 percentage points. The impact of Montessori generally increases by grade level. This is consistent with previous findings that found the achievement advantage for Montessori students increases with the number of years in Montessori education and concluded that the effect of Montessori education is cumulative, which is achieved with sustained time in a Montessori classroom (Mallet and Schroeder, 2015).

High school students who had attended Montessori were better prepared for college and career in ELA but not in mathematics. Montessori education resulted in long-term reading impact of between 18 and 20 percent of readiness for college and career in Grade 11. Despite a very different educational experience through 8th grade, students who had attended Montessori schools performed as well as their matched high school peers on PARCC ELA, Algebra II and CCR Math and performed better than their peers on the CCR ELA. These findings of the current study contrast with studies that examined the long term impact of Montessori education. Dohrmann and colleagues (2007) study of the long term impacts of Montessori program in Milwaukee Public Schools found that students who had attended the Montessori schools from the approximate ages of 3 to 11 significantly outperformed their peers in mathematics but found no differences in English.

The study also explored the role of parental motivation in moderating the impact of Montessori. This was an important variable to consider as entry into the program required application into a lottery and enrollment as early as three and four year old. Parents' motivation may have lasting effect on the academic achievement of students. If parents of those who enrolled in the Montessori program were more motivated than other parents, then the estimated impact represent the upper bound of the estimated impact and the adjustment for parental motivation shows the effect of education in the Montessori model irrespective of parental factors. After controlling for parental motivation, we also found positive and statistically significant impacts in reading, mathematics, and science at each observed grade level but not for mathematics in Grade 3 and Grade 11.

Finally, the study conducted additional analyses to ascertain that the observed advantage for former Montessori students at the end of Grade 11 is the result of their enrollment in the Montessori program from prekindergarten through Grade 8. Even though Montessori students have been shown to post higher rates of readiness for college and career in reading and they were as prepared as their peers for college and career in mathematics, it was necessary to determine if this similar or higher readiness rates were associated with factors other than the higher academic performance Montessori students attained during the elementary and middle grades. We were able to test this by matching each Montessori student with a demographically identical student in the same high school and by controlling for each student's probability of being consistently proficient on Maryland State assessments in elementary and middle grades. The analysis of being consistently proficient in each year of MSA assessment indicates that Montessori students were between 6 to 7 percentage points more likely to consistently be proficient in reading and mathematics in grades 3 through 8. In addition, the analysis showed that the higher rate of being consistently proficient (i.e., higher academic performance during the elementary and middle grades) was primarily responsible for the observed higher rate of readiness for college and career in reading but in not in mathematics. Thus, the study confirmed that the impact of Montessori in reading sustained long after the students graduated from the program but there is no evidence to suggest that was the case for mathematics. Nevertheless, Montessori educated students were as prepared in mathematics as their peers and this is a sign that they adjusted very well to high school mathematics instruction in spite of the different math instructional method they received until the 8th grade.

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Appendix

Panel Data Analysis for Grade 11 Cohorts:

Dependent Variable: Whether or not a Student was proficient on MSA state assessment on Math and Reading in Grades 3, 5 and 8.

Treatment Variable: Attendance in Montessori school through eighth grade vs. eight graders who attendance the same elementary school kindergarten through Grade 5 and participated in MSA state assessments.

Control Variables: Gender, Race/Ethnicity and FARM status (time-Varying).

Time/Panel: Grades 3, 5 and 8

Regression Model: The population-average logistic regression model. The Population-averaged model is estimated using generalized estimating equations (GEE) method and allows us to make inference on average for the entire population accounting for between subject correlations in the dependent variable. The odds-ratio, $\exp(B_1)$, is interpreted as the odds of proficiency in the average Montessori students compared with the average non-Montessori student.

Result: The longitudinal models demonstrate that, on average, Montessori students were more likely to stay proficient in reading (58% higher) but the not in math during their elementary and middle school enrollment.

Table 8: Results from the G-11 GEE Population- averaged model on MSA proficiency Grades 3 to 8

	Odds-ratio	P-Value
MSA Reading (n=2958)		
Montessori Enrolled	1.58†	.090
Male	.48***	.000
Black	.46***	.000
Hispanic	.48***	.000
White	1.35	.305
FARMS	.79***	.001
Constant	13.6***	.000
MSA Math (n=2958)		
Montessori Enrolled	1.34	.34

Male	.79***	.000
Black	.38***	.000
Hispanic	.48***	.000
White	1.47	.131
FARMS	.74***	.000
Constant	8.18***	.000

The reference group for Race/Ethnicity is 'Other'

Note. †$p < .10$; * $p < .05$; **$p < .01$; *** $p < .001$