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High School Outcomes for Students in a Public Montessori Program

Kathryn Rindskopf Dohrmann
Lake Forest College
Tracy K. Nishida
University of Virginia
Alan Gartner
National Center for Educational Restructuring and Inclusion (NCERI), The Graduate School and University Center, The City University of New York
Dorothy Kerzner Lipsky
National Center for Educational Restructuring and Inclusion (NCERI), The Graduate School and University Center, The City University of New York
Kevin J. Grimm
University of Virginia

Abstract. The study compares two groups of students who graduated from high school in the Milwaukee Public Schools (MPS) during 1997-2001. Students who had participated in MPS Montessori programs from preschool through 5th grade were matched to a comparison group on the basis of gender, SES, race/ethnicity, and high school attended. Data from the ACT and WKCE, as well as overall and subject specific high school grade point averages, were used in exploratory and confirmatory factor analyses. Once a model was established, the factors were regressed on the students' demographic characteristics and type of elementary education in a structural equation modeling framework. The Montessori group had significantly higher scores on tests associated with the math/science factor. There were no significant group differences for the factors associated with English/social studies and grade point average.

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A Montessori education is one of the more common alternatives to traditional schooling. In the United States, more than 5,000 Montessori schools are affiliated with national or international Montessori organizations, and many others operate independently. Montessori schools are typically characterized by multiage classrooms, unique didactic materials, self-pacing, self-chosen activities, and a virtual absence of homework, grades, and standardized tests.

In recent years, Montessori programs have expanded from private to public settings, and from preschool into elementary school and beyond. This growth of a system with decidedly different pedagogical practices,

coupled with the demand for assessment and scientifically supported teaching methods, has raised questions of accountability. The purpose of the current research, which assesses longitudinal outcomes for children who experienced eight to nine years of education in Montessori public schools, was to determine whether Montessori programs offer a viable educational alternative.

Outcomes of Montessori Education

Studies of Montessori schools span nearly a century and cover diverse topics. Researchers have explored relationships between Montessori education and various outcomes, ranging from private speech (Krafft & Berk, 1998) and drawing ability (Cox & Rowlands, 2000), to positive emotions, energy, and intrinsic motivation (Rathunde & Csikszentmihalyi, 2005). However, the majority of research on Montessori outcomes has focused on students' cognitive achievements.

The results from these studies are often difficult to interpret and generalize from because of methodological shortcomings, such as small sample size, attrition, lack of random assignment, and poor or unmeasured implementation of Montessori practices. In addition, such confounding factors as parental choice (Hill & Craft, 2003; Shumow, Vandell, & Kang, 1996) and the high-SES level of most Montessori students (Duax, 1989) have not always been taken into account. Although these problems render the results of such research inconclusive, the general picture that emerges is that Montessori students might outperform traditionally schooled peers.

In one of the more experimentally sound studies, Miller and Dyer (1975) assessed four different Head Start programs in Louisville by randomly assigning 214 children to one of 14 classes: 4 traditional, 4 Bereiter-Engelmann, 4 Darcee, and 2 Montessori. Because no qualified Montessori teachers could be found, the researchers recruited college graduates, who were then given eight weeks of summer Montessori training. Children were assessed through 2nd grade, and then again from 6th to 10th grade. Different measures were employed at different ages, but included Stanford Achievement tests, Stanford-Binet Intelligence Scales, the WISC-R, Raven's Progressive Matrices, and tests of self-esteem, creativity, aspirations, sex-role behavior, and persistence.

Over time, the performance of the children shifted, with initial gains followed by losses. The effects of these Head Start programs mirrored the "wash-out" seen in other early intervention studies (e.g., Lee, Brooks-Gunn, Schnur, & Liaw, 1990). The males in the Montessori program were an exception. They consistently outperformed all other experimental subgroups on IQ, and were the only group that was not relatively lower at the end of 10th grade than at the end of preschool (Miller & Bizell, 1983, 1984).

Unfortunately, the design of the Louisville study was compromised by attrition: at older ages, some groups had as few as six subjects. Another problem was the quality of the Montessori implementation, which consisted of a one-year exposure to teachers who were minimally trained and experienced. In a typical Montessori school, a child spends three years in one classroom, preferably with the same teacher, and with classmates of three different ages. Ideally, the child begins the program by age three. By studying children for less than one year, in a classroom that had only 4-year-olds, the experiment was evaluating a much compromised version of Montessori. Montessori consultants also confirmed these weaknesses.

Other researchers used a similar experimental design to assess different preschool curricula, including Montessori. Their results replicated some of the positive findings of Miller and colleagues (e.g., Montessori children were less likely to drop out of school or to repeat a grade), but shared the same methodological issues of attrition and implementation (Karnes, Schwedel, & Williams, 1983; Karnes, Teska, & Hodgins, 1970).

More recently, Lillard and Else-Quest (2006) studied children from a low-income population who, at ages 2-3, had won or lost a public Montessori school lottery in a major U.S. city. The Montessori program was

recognized by AMI-USA, which required it to meet a high standard of Montessori implementation. Children in the experimental group had won the lottery and had been in Montessori continually since age 3; those who lost the lottery were the control group. This unique design accounted for differences in parental motivation, because all parents had enrolled their children in the lottery. The children were tested at ages 5 or 12 on a variety of social and academic outcomes. The control children were at a variety of schools, mostly public, and in the same neighborhood as the public Montessori.

Several differences were noted between the 5-year-old Montessori students and their peers in the control group. The Montessori 5-year-olds performed better on standardized achievement tests (Woodcock-Johnson Letter-Word identification, Word Attack, and Applied Math sub-tests) and other cognitive measures (false belief task, dimensional card sort). No differences were found on tests of Picture Vocabulary, Understanding Directions, Spatial Reasoning, and Concept Formation, or on a delay of gratification test. The researchers also found differences in social outcomes: on a social problem-solving task, the Montessori children were more likely to make references to justice or fairness, and they were more likely to be involved in shared peer play and less likely to engage in rough and tumble play at recess.

The Montessori 12-year-olds wrote essays that were rated higher for creativity and more sophisticated sentence structures. In comparison to the control group, Montessori 12-year-olds reported that they felt a greater sense of community at school and they were more likely to choose positive assertive responses to conflicts presented in a social problem-solving questionnaire. The two groups performed equally well on the Woodcock-Johnson tests at age 12. One problem with this study is that, although the effect sizes were respectable for education research, the samples were small (25-30 per group).

Not all researchers have found an advantage for Montessori students. Lopata, Wallace, and Finn (2005) compared 4th- and 8th-graders in three magnet schools—Montessori, "back to basics," and "open classroom"—and in a traditional neighborhood school, employing mathematics and language scales of standard achievement tests (New York State Exams and the Terra Nova). The results were mixed and varied by grade levels, with most tests showing no differences. Although asserting that their study did not find support for Montessori education, the authors note the limitations of their findings. Despite the fact that a large number of children were studied (543 in total), only one school of each type was tested and information on quality of program implementation was not available. Furthermore, there were no data concerning age of entry or length of time enrollment in any of the schools. Finally, children were not randomly assigned to programs, and it is unclear how parental backgrounds might have varied across the different schools.

In sum, a limited number of studies have assessed the outcomes of Montessori education. Most of these are compromised by undocumented or poor Montessori quality, small sample sizes, or lack of random assignment. In addition, few studies have assessed the impact of Montessori education on high school achievement; those that have done so also have been hampered by small samples and biased by attrition. In this era of evidence-based education, there is a need for up-to-date, carefully constructed studies of the outcomes of Montessori programs. The current research addresses previous methodological concerns by utilizing a retrospective longitudinal design to examine various high school achievement outcomes.

Method

Overview of Design

This study assessed high school outcomes of children who had previously attended two different public Montessori programs from preschool through the 5th grade. A valid control group is a substantial issue in a study of this nature. Although admission to the Montessori schools was by lottery, no

records of lottery participants remained. Consequently, the authors, in consultation with the Milwaukee Public Schools district (hereafter MPS), focused statistical control on the high school years by establishing a comparison group of students who attended and graduated from the same high schools as the Montessori students. The purpose of this comparison group (the Peer Control group) was to control, insofar as possible, for other life experiences, especially educational experiences after 5th grade.

The research plan was as follows: 1) identify the students who had completed the 5th grade at two public Milwaukee Montessori schools (MacDowell and Greenfield) in the academic years 1990-1994; 2) ascertain the high school destinations of these students; 3) establish a comparison group of graduates at each high school that Montessori students attended; and 4) compare Montessori and non-Montessori students on academic outcomes that could be obtained from high school records and transcripts.

Participants and Procedures

At the outset, MPS staff hand-searched archived files and constructed a list of students who had completed 5th grade between 1990 and 1994 at the MacDowell and Greenfield schools. Of the initial list of 396 students, 75 represented duplicate names or students for whom no further data could be found (most likely meaning that they had unofficially left MPS for another school system); 69 others had formally transferred out of the MPS system. Twenty-nine students were officially classified as dropouts, 11 had received an alternative high school diploma, and 11 were still in school. Thus, a net of 201 students who had graduated after maintaining active status within MPS were eligible for the study. The identities of the students were known only to relevant MPS staff.

Of these 201 students, 144 (72 percent) had attended 7 (out of 18 possible in 1999-2000) different MPS high schools; each of these high schools had at least 10 former Montessori students. The remaining 57 students graduated from a variety of other MPS high schools with 9 or fewer total Montessori graduates.

It should be noted that the four high schools with the highest number of Montessori graduates (51.8 percent of the total) were quite selective. One is the largest of four International Baccalaureate (IB) programs in the state, and in 2000—based on the number of IB and AP exams given—it was the top-ranked Wisconsin high school; another is a city-wide arts specialty program, with admittance based upon audition; the third, a technical school, emphasizes the integration of academic disciplines with technology, based upon national, state and industrial norms; the fourth is a rigorous university preparatory program (Milwaukee Public Schools, 2000).

One approach to construction of the peer control group would be to sample randomly within each of the high schools attended by the Montessori students. However, evaluation of the demographics of the Montessori group and their high school peers revealed this approach to be unsound. First, the percentage of Montessori students taking advantage of the MPS free/reduced lunch program (a surrogate for SES) was small (about 5 percent) compared to the MPS high school average (58 percent in 1999-2000), as well as to the average (48.25 percent in 1999-2000) at the four high schools (described above) that they were most likely to attend. Second, the percentage of Montessori high school students who were classified as minority (59.2 percent) was somewhat lower than either the MPS average (82.4 percent in 1999-2000) or the average for the four most frequently attended high schools (71 percent).

With these facts in mind, we constructed a modified peer control group. Using the criteria of gender, race/ethnicity, and free/reduced-price lunch status, a demographically identical peer group was generated at each high school with 10 or more Montessori-origin graduates. The schools with nine or fewer Montessori graduates were treated as a single school and (correspondingly) a demographically identical peer group was generated from their pooled populations.

The Montessori and Peer Controls were each composed of 54.7 percent females and 45.3 percent males. In each group, 10 students (about 5 percent) had qualified for free or reduced-price lunch status. The groups were identical in terms of overall race/ethnicity, with 59.2 percent of each group classified as non-white minority and 40.8 percent classified as white. Variations emerged within the Montessori and Peer Control groups in the specific percentages of race/ethnicity classifications (see Table 1), but these were not significantly different, χ^2 (4, N= 402) = 5.69, $p > .20$. The two groups did not significantly differ in terms of the high schools they had attended, $\chi^2 = (17, N = 398) = 6.46, p > .95$).

Dependent Measures

All dependent variables used in this study were based upon data from MPS records. Missing data were the result of incomplete or illegible older records. Intercorrelations for the dependent measures are available upon request from the first author.

The Wisconsin Knowledge and Concepts Examination (WKCE) is a nationally standardized achievement test given to all MPS 10th-grade students. (Published by CTB-McGraw-Hill, the test is known elsewhere as the Terra Nova.) The WKCE consists of 5 scales: Reading, Language Arts, Mathematics, Science, and Social Studies. Students' national percentile scores from these scales were included as dependent measures.

The ACT is the standardized test generally taken by college-bound MPS seniors. It provides achievement data in English, Mathematics, Reading, and Science Reasoning, as well as a composite score. For the 1997 through 1999 graduates, ACT scores were found on the high school transcripts. By 2000 and 2001, a change in MPS student privacy policies meant that these scores were no longer included on transcripts.

The Cumulative Unweighted Grade Point Average (GPA) was the measure of overall high school achievement; per MPS practice, the GPA gave no extra weight to honors courses and failing grades were included. Almost all GPAs were found on the high school transcripts; if not, they were manually computed by summing the number of units attempted times grade value and dividing by the number of units attempted. Unweighted grade point averages also were manually computed for the specific subjects of Social Studies, Mathematics, Science, Foreign Language, and English.

Treatment

The independent variable was previous exposure to Montessori education. The two Montessori elementary schools included in this study were well-established and considered to have good Montessori implementation. Teachers were rigorously trained in Montessori education and classrooms were composed of multiage groupings of students. After enrolling at either age 3 or 4, the

Table 1
Racial/Ethnic Classifications of the Participants

	Montessori Group		Peer Control Group	
	Frequency	Percentage	Frequency	Percentage
Black	107	53.2	95	47.3
White	82	40.8	82	40.8
Hispanic	7	3.5	18	9.0
Asian/Pacific Islander	3	1.5	4	2.0
Native American	2	1.0	2	1.0

children in this study received 8 to 9 years of Montessori education before graduating from these schools. For an extended discussion of the Montessori implementation at the schools, see the comprehensive history by Butz and Miller (1988).

Overview of Statistical Analyses

The differences between Montessori-educated high school students and their matched controls were examined for several academic variables: composite and subtest scores for the ACT and WKCE, as well as overall and subject-specific high school grade point averages. Due to the large number of dependent variables in our data set, factor analysis was used to determine the number of underlying dimensions of the dependent variables, and to identify the subset of variables that corresponded to each of these dimensions. A series of confirmatory and exploratory factor models were fit in order to determine the factor structure that best represented the data. The effects of gender, race/ethnicity, SES, and Montessori education were then modeled at the factor level.

Muthen and Muthen's Mplus program (www.statmodel.com), with the missing data algorithm, was used. The factor models were fit in a confirmatory set-up using all available data, but exploratory models were based on the 53 participants with complete data.

Results

Exploratory Factor Analysis

Exploratory factor models were fit to the 53 participants with complete data, with Promax Rotation. The exploratory models indicated that three factors existed in the data. The first factor, GPA, had substantial loadings on the six GPA variables. The second and third factors represented general content areas of the ACT and WKCE. The second factor, Math/Science, had high loadings by the seven math and science tests and the composite score of the ACT. The third factor, English/Social Studies, had high loadings by the nine English and social studies tests, the two science tests, and the ACT composite.

Confirmatory Factor Analysis

Five factor models were compared using confirmatory factor analysis. Two of the models were based on the results of the exploratory factor analysis and three were previously described in the Method section. The first model based on the exploratory factor analysis (EFA), Exploratory A, has a relatively simple structure, as only the ACT composite score has a dual loading on the Math/Science and the English/Social Studies factors. The second factor model based on the results of the EFA, Exploratory B, has a slightly more complex factor structure as the two science tests, ACT Science Reasoning and WKCE-Science, have dual loadings as well as the ACT composite score. This second model more closely mirrors the results from the EFA. The path diagram for this model is shown in Figure 1.

The fit statistics for the five confirmatory factor models are contained in Table 2. The confirmatory model, Exploratory B, best fits

Table 2
Fit Statistics for Confirmatory Factor Models

Model	df	χ^2	RMSEA
One Factor	230	2203	0.15
Two Subject Factors	227	2056	0.14
Three Area Factors	227	1232	0.11
Exploratory A	226	1073	0.10
Exploratory B	224	974	0.09

the data (χ^2 = 974, *df* = 224, RMSEA= 0.09). The dual loadings of the science tests in Exploratory B were a significant improvement over Exploratory A ($\Delta\chi^2$ = 99, Δdf = 2), indicating that the science tests measure both reading ability and mathematics/science ability. The factor intercorrelations and standardized factor loadings for the best fitting model are contained in Tables 3 and 4, respectively.

Structural Equation Modeling Analysis

Once the factor structure was established, the factors were regressed on gender (-0.5 = female, 0.5 = male), ethnicity (-0.5 = majority, 0.5 = minority), social economic status (-0.5 = not eligible for free lunch, 0.5 = eligible for free lunch), and type of elementary education (-0.5 = traditional, 0.5 = Montessori) of the subjects. Because all of the variables were effect coded (-0.5, 0.5) and the factor variances were set to unity, the effects are standardized and represent the exact difference between groups. There were several significant results (see Table 5). Attending a Montessori elementary school had a significant positive effect on the Math/Science factor (0.30). Children who received a Montessori education outperformed children who attended traditional elementary schools on the Math/Science factor by approximately one-third of a standard deviation.

Additionally, females had higher GPAs than males (0.46) and non-minority students outperformed minority students on the GPA (0.88), Math/Science (1.26), and English/Social Studies (1.21) factors. The measure used for socioeconomic status, eligibility for the free lunch program, also had a significant effect on GPA. Economically disadvantaged students had a lower GPA factor than students who were not eligible for the free lunch program by almost one standard deviation (0.88).

In sum, the results of the structural equation analyses indicate that children who attended Montessori elementary schools scored higher on high school standardized math and science tests than their peers who attended traditional schools.

Figure 1
Path Diagram of Exploratory Model B

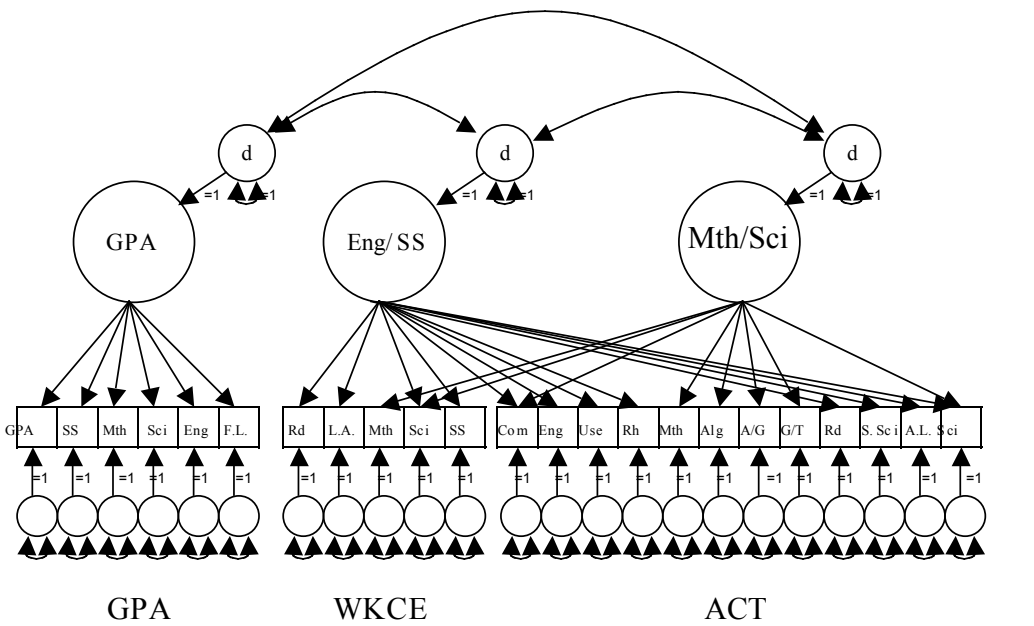

Table 3
Factor Intercorrelations

	GPA	Math/Science	English/Social Studies
GPA	1.00		
Math/Science	0.73	1.00	
English/Social Studies	0.71	0.86	1.00

Table 4
Standardized Loadings for the Chosen Factor Model

	Factor		
	GPA	Math/Science	English/Social Studies
Overall GPA	0.97	--	--
Social Studies GPA	0.88	--	--
Math GPA	0.85	--	--
Science GPA	0.88	--	--
English GPA	0.89	--	--
Foreign Language GPA	0.79	--	--
ACT Composite	--	0.26	0.75
ACT English Total	--	--	0.95
ACT English Use/Mechanics	--	--	0.93
ACT Rhetoric	--	--	0.91
ACT Math Total	--	0.99	--
ACT Elementary/Algebra	--	0.94	--
ACT Algebra/Geometry	--	0.85	--
ACT Geometry/Trigonometry	--	0.91	--
ACT Reading	--	--	0.94
ACT Social Science	--	--	0.92
ACT Arts & Literature	--	--	0.87
ACT Science Reasoning	--	0.31	0.63
WKCE-Reading	--	--	0.85
WKCE-Language Arts	--	--	0.88
WKCE-Math	--	0.83	--
WKCE-Science	--	0.43	0.41
WKCE-Social Studies	--	--	0.57

There were no significant differences between Montessori and non-Montessori students on GPA and standardized tests of English and Social studies.

Discussion

Despite a very different educational experience through 5th grade, students who had attended Montessori schools performed as well as their matched high school peers on most measurements, and even better on the Math/Science composite. The results suggest two related questions. First, why were there significant differences in favor of Montessori students on standardized tests of mathematics and science? Second, why were there no significant group differences for the Montessori students on standardized tests of English/Social Studies and on school grades?

Standardized Tests

Maria Montessori developed didactic materials and methods for all major areas of academic growth (Montessori, 1912/1988). Perhaps best known are Montessori's unique sensorial mathematics materials. They are manufactured to a set standard, presented to the child in the same sequence, and used in the same manner across all children at authentic Montessori schools. A Montessori mathematics education tends to be distinctive and highly consistent. From age 3 on, Montessori children work with abstract mathematical concepts in a concrete form. (The science materials, which take the form of stories called Great Lesson and are initially less sensorial, become concrete in the elementary levels as children work with laboratory experiments.) There are also specially designed Montessori language arts materials—the foundations for skills used in English and social studies—that follow the same principles of learning embodied in the Montessori science and mathematics curriculum. The pertinent issue is why differences appeared in math and science, but not in English and social studies.

The pattern of significant and non-significant group differences on standardized tests found in this study may reflect a number of factors. One perspective on this issue might be inferred from the results of a large-scale study of classroom instruction (Pianta, Belsky, Houts, Morrison, & NICHD Early Child Care Research Network, 2007). This study suggests that traditional schools spend much more time on language arts than they do on mathematics and science. For example, in the 1st and 3rd grades, more than 50 percent of instruction was in literacy and less than 10 percent was in math. In Montessori schools, children are expected to spend as much time working on mathematics and science as they do on language arts. Thus, long-term differences between the Montessori and Peer Control students may be influenced by differential amounts

Table 5
Regression Coefficients With Standard Errors

	Factor		
Predictor	GPA	Math/Science	English/Soc.Studies
Montessori	0.19 (0.10)	0.30 (0.12)*	-0.04 (0.11)
Gender	-0.46 (0.11)*	0.21 (0.12)	-0.13 (0.11)
Ethnicity	-0.86 (0.11)*	-1.26 (0.13)*	-1.21 (0.12)*
Free Lunch	-0.88 (0.24)*	-0.29 (0.27)	-0.33 (0.26)

Note. * indicates a significant parameter, $p < 0.05$

of exposure to these learning domains.

Differential exposure also may be occurring at home. Families seem to be generally better at facilitating the cognitive skills of language arts (through books, conversation, and opportunities for enrichment) than they are at stimulating the cognitive skills of mathematics and science. For example, research suggests that parents are likely to engage children in reading-related activities (Christenson, Rounds, & Gorney, 1992). Furthermore, parents seem to have less information and confidence about how to promote early math skills (Hill & Craft, 2003), and they have less sense of their children's actual mathematical competence (Pezdek, Berry, & Renno, 2002).

Long-term differences on standardized tests may simply mean that Montessori children may be receiving more exposure to mathematics and science. This phenomenon may reflect not only absolute exposure, but also timing: as noted, in Montessori schools, the use of mathematics materials begins relatively early. The nature of the materials themselves also may be important. Montessori mathematics materials embody abstract ideas in a concrete form, incorporating movement, concentration, and control of error (among other things). The impact of these materials on cognitive development is a promising topic for research.

Grade Point Averages

The Montessori and Peer Control groups did not significantly differ on the GPA factor, although in raw terms, both general and subject-specific grade point averages favored the Montessori group. It is important to consider that the Montessori and Peer Control students evidenced strong school performance relative to their counterparts in the MPS: their overall grade point averages were 2.72 and 2.59, respectively, while the general MPS overall grade point average in 1999-2000, for example, was 1.69. For MPS students with 90 percent or better attendance, the 1999-2000 GPA was 2.52 (Milwaukee Public Schools, 2000).

The interpretation of findings concerning grades is complex. Grades are likely to reflect a variety of influences, some of which are non-cognitive (Messick, 1979). These can include such variables as family background characteristics and educational values, school attendance, and class participation. Grade point average also can depend upon the ease or difficulty of curricula, and on differences in grading and teaching styles among instructors (Noble, Davenport, Schiel, & Pommerick, 1999a, 1999b; Noble & McNabb, 1989). By matching on demographic characteristics and, more importantly in this regard, on high school of graduation, we hoped to reduce the impact of some noncognitive factors.

Many of the students in this sample—both Montessori and Peer Control—attended the most rigorous of the MPS high schools, where expectations and support for school achievement would have been high. Their school attendance patterns, as found on the transcripts, were virtually identical. It is also possible that the Montessori students were taking higher level math and science courses (something suggested by their higher standardized test scores), but because GPA was unweighted, the impact of more challenging classes is not reflected in the GPA variable.

Limitations

One limitation of this research is lack of control for certain parent variables. Despite the fact that selection for the Montessori programs was made via lottery, children in this study were not randomly assigned to Montessori or non-Montessori schools; their parents probably chose these schools. One cannot determine how parental motivation (Shumow et al., 1996), involvement in school (Hill & Craft, 2003), or attitudes toward education (Glenn, 1993) might have systematically influenced outcomes across the two groups.

These limits are mitigated in part by the study's design. The construction of a comparison group based on equivalent high school experience allows control for a substantial portion of subsequent educational

experience, as well as some of the factors that vary with it (Noble, Davenport, Schiel, & Pommerick, 1999a, 1999b). Ideally, in public school systems that use lotteries for admission to their Montessori programs, those who were not admitted (the "lottery losers") can be identified and used as a control group, as was done in the study by Lillard and Else-Quest (2006).

Another limitation of this research lies in not knowing the prior educational experiences of the Peer Control group. At the time the children in this study were in elementary school, MPS had a wide variety of school choices, including language immersion, creative arts, and gifted and talented. Knowing the preschool and elementary school history of children in the comparison group (in addition to the specific 6th- through 8th-grade histories of both groups) might help us to better understand the academic similarities and differences between Montessori and Peer Control students.

As public school records become increasingly centralized and systematized, future researchers—especially if they design prospective studies—will be better able to document the nature and realities of educational history.

Implications

The results reported here are for students attending traditional MPS high schools, assessed five to seven years after they had participated in a preschool through elementary Montessori program. The measures were not particular to Montessori, but rather to the standard achievement tests and academic records of a public school system. The peer control group established common high school experience for both groups, and in demographic characteristics (such as gender, race, and eligibility for free lunch) the two groups were nearly identical.

With the qualification that the experience is that of a single school system, this study indicates that a program such as Montessori, with a rigorous set of principles and practices, can be implemented by a major urban school system with a high degree of fidelity to these standards and can achieve equal or better outcomes than are achieved by a conglomerate of other school programs. Many people have expressed concern that Montessori programs ill-prepare students for the competitive environments they face in high school. These results provide compelling evidence that this is not the case. Despite having spent the first five years of elementary school in a non-traditional school environment, without tests, grades, homework, or standard lectures, the Montessori students were doing as well or better than the control group that presumably had those traditional features.

Another notable finding is the better performance on mathematics and science standardized tests shown by the Montessori graduates. In an era when we are particularly concerned with STEM (Science, Technology, Education, Mathematics) education and with U.S. students lagging behind in these disciplines, this result is key. The difference (1/3 of a standard deviation) is not enormous, but the students had been enrolled in the same math and science programs for the 5 to 7 years leading up to the tests that constituted the dependent measures here. That early exposure to a different mathematics/science program could have such a difference after several subsequent years of exposure to the same education is remarkable. This begs the question of whether Montessori math/science education beyond 5th grade might further accentuate the differences.

This study supports the hypothesis that Montessori education has a positive long-term impact on student achievement. Additionally, it provides strong evidence that students can successfully move from Montessori programs to traditional schools.

References

Butz, M., & Miller, J. (1988, April). *A history of Montessori in the Milwaukee Public Schools.* Paper presented at the Annual Meeting of the Association Montessori Internationale, Amsterdam.

Christenson, S. L., Rounds, T., & Gorney, D. (1992). Family factors and student achieve-

ment: An avenue to increase students' success. *School Psychology Quarterly, 7*, 178-206.

Cox, M. V., & Rowlands, A. (2000). The effect of three different educational approaches on children's drawing ability: Steiner, Montessori and traditional. *British Journal of Educational Psychology, 70, 485-503*.

Duax, T. (1989). Preliminary report on the educational effectiveness of a Montessori school in the public sector. *NAMTA Journal, 14,* 56-62.

Glenn, C. M. (1993). Market research at a Montessori school. Reasons for choosing, leaving and staying. *Montessori Life, 5,* 13-14.

Hill, N. E., & Craft, S. A. (2003). Parent-school involvement and school performance: Mediated pathways among socioeconomically comparable African-American and Euro-American families. *Journal of Educational Psychology, 95,* 74-83.

Karnes, M., Schwedel, A., & Williams, B. (1983). A comparison of five approaches for educating young children from low-income homes. In The Consortium for Longitudinal Studies (Eds.), *As the twig is bent: Lasting effects of preschool* (pp. 133-170). Hillsdale, NJ: Lawrence Erlbaum.

Karnes, M., Teska, J., & Hodgins, A. S. (1970). The effects of four programs of classroom intervention on the intellectual and language development of 4-year-old disadvantaged children. *American Journal of Orthopsychiatry, 40,* 58-76.

Krafft, K. C., & Berk, L. (1998). Private speech in two preschools: Significance of open-ended activities and make-believe play for verbal self-regulation. *Early Childhood Research Quarterly, 13,* 637-658.

Lee, V. E., Brooks-Gunn, J., Schnur, E., & Liaw, F. (1990). Are Head Start effects sustained? A longitudinal follow-up comparison of disadvantaged children attending Head Start, no preschool, and other preschool programs. *Child Development, 61,* 495-507.

Lillard, A., & Else-Quest, N. (2006). Evaluating Montessori education. *Science, 313,* 1893-1894.

Lopata, C., Wallace, N., & Finn, K. (2005). Comparison of academic achievement between Montessori and traditional education programs. *Journal of Research in Childhood Education, 20,* 5-13.

Messick, S. (1979). Potential uses of noncognitive measures in education. *Journal of Educational Psychology, 71*, 281-292.

Miller, L., & Bizzell, R. (1983). Long term effects of four preschool programs: Sixth, seventh, and eighth grades. *Child Development, 54*, 727-741.

Miller, L., & Bizzell, R. (1984). Long-term effects of four pre-school programs: Ninth- and tenth-grade results. *Child Development, 55*, 1570-1587.

Miller, L., & Dyer, J. (1975). Four preschool programs: Their dimensions and effects. *Monographs of the Society for Research in Child Development, 40,* 5-6.

Milwaukee Public Schools. (2000). *1999-2000 accountability report.* Milwaukee, WI: MPS Office of Research and Assessment.

Montessori, M. (1988). *The discovery of the child: Vol. 2. The Clio Montessori Series.* Oxford, England: Clio Press. (Reprinted from *The Montessori method,* 1912)

Noble, J., Davenport, M., Schiel, J., & Pommerick, M. (1999a). *High school academic and noncognitive variables related to the ACT scores of racial/ethnic and gender groups.* Iowa City, IA: ACT, Inc. (ACT Research Report No. 99-6).

Noble, J., Davenport, M., Schiel, J., & Pommerick, M. (1999b). *Relationships between the noncognitive characteristics, high school course work and grades, and test scores for ACT-Tested students.* Iowa City, IA: ACT, Inc. (ACT Research Report No. 99-4).

Noble, J., & McNabb, T. (1989). *Differential course work and grades in high school: Implications for performance on the ACT Assessment.* Iowa City, IA: ACT, Inc. (ACT Research Report No. 89-5).

Pezdek, K., Berry, T., & Renno, P. (2002). Children's mathematics achievement: The role of parents' perceptions and their involvement in homework. *Journal of Educational Psychology, 94,* 771-777.

Pianta, R., Belsky, J., Houts, R., Morrison, F., & NICHD Early Child Care Research Network (2007). Opportunities to learn in America's elementary classrooms. *Science, 315*, 1795-1796.

Rathunde, K., & Csikszentmihalyi, M. (2005). Middle school students' motivation and quality of experience: A comparison of Montessori and traditional school environments. *American Journal of Education, 111,* 341-371.

Shumow, L., Vandell, D. L., & Kang, K. (1996). School choice, family characteristics, and home-school relations: Contributors to school achievement? *Journal of Educational Psychology, 88,* 451-460.