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Early Opportunities to Strengthen Academic Readiness: Effects of Summer Learning on Mathematics Achievement

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Abstract

Students who come from low-income backgrounds tend to be underidentified and underserved in gifted education. Early interventions with learners of high potential from underserved groups, including exposure to challenging curriculum and summer opportunities, are important for nurturing these students' talents and preparing them for advanced learning opportunities in later school years. Project SPARK, based on the Young Scholars model, focuses on recognizing and responding to high-potential learners from underserved populations in the early grades. In this study, we examined the effects on mathematics achievement of participation in a summer program as part of Project SPARK in schools with substantial populations of students in poverty, as demonstrated by percentage of students eligible for free or reduced lunch. We examined summer program effects on achievement for the sample overall and specifically for students from low-income backgrounds. Students who participated in the summer program made moderately larger mathematics achievement gains than students who did not participate, with Cohen's *d*-type effect sizes of 0.92. Students who qualified for free or reduced lunch saw similar gains over the summer if they participated in the summer program, indicating that the summer program experience was supportive for students across a range of income backgrounds.

Keywords

hierarchical linear modeling, quantitative methodologies, mathematics, curriculum, early childhood, age/developmental stage, low income, special populations/underserved gifted

Students who come from backgrounds of poverty—who represent an increasing population in schools today—tend to be underidentified and, thus, underserved in gifted education (Hamilton et al., 2017). In a recent national survey, less than 20% of school districts reported close alignment between the percentage of students of poverty in the district overall and the percentage in gifted programs at the elementary level (Callahan, Moon, & Oh, 2014). Another recent report demonstrated the high degree to which policies at the state level across the country disadvantage students of high potential from low-income backgrounds (Plucker, Giancola, Healey, Arndt, & Wang, 2015). Student achievement patterns also demonstrate disadvantages for students of poverty. Wyner, Bridgeland, and DiIulio (2007) reported that students from low-income backgrounds who show high achievement in the early grades of school are less likely than their more economically advantaged peers to maintain their high achievement levels, even to the end of elementary school. Furthermore, students from low-income backgrounds are far less likely than students from higher income backgrounds to rise from low or average achievement levels to higher levels (Wyner et al., 2007).

Olszewski-Kubilius and Clarenbach (2012) highlighted several key barriers that may limit opportunity for learners of high-potential from low-income populations to participate in advanced programming. Among these challenges are misconceptions about low-income students and about what high potential may look like, as well as policies and programs that are not set up to support these learners. For example, barriers might include heightened focus on already-developed skills over evidence of potential in an identification process; programming in times and locations not accessible for many low-income families; and instruction from teachers with little or no background in responding to the needs of these learners. Efforts to address the disparities in identification, opportunity, and performance for high-potential students from low-income backgrounds

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include a variety of approaches to modifying identification practices, providing access to high-quality curriculum and programming, and ensuring supports beyond the classroom setting (e.g., Adams & Chandler, 2014; Card & Giuliano, 2015; Harradine, Coleman, & Winn, 2014; Horn, 2015; Lee, Olszewski-Kubilius, & Peternel, 2009; Olszewski-Kubilius & Clarenbach, 2012; VanTassel-Baska & Stambaugh, 2007).

In Project SPARK, a Javits-sponsored research initiative, we have combined aspects of each of these approaches in a replication of the Young Scholars model (Advanced Academic Programs Office, Instructional Services Department, 2013; Horn, 2015), with an eye to helping teachers recognize and respond to high potential in the early grades. Such early recognition and response may help students from traditionally underserved populations develop greater readiness for advanced academic experiences as they approach their districts' formal gifted program identification process.

The goals of Project SPARK include (a) promoting achievement and gifted program identification for high-potential students from underrepresented groups, including those from backgrounds of poverty; (b) increasing student readiness for gifted program participation through engagement in challenging curriculum; and (c) promoting professional practice that will support the identification and development of emergent talent. In this study, we examined the effects on achievement of student participation in a summer program focused on advanced learning in mathematics, with particular attention to how the summer program may have influenced achievement for students from low-income backgrounds.

Access to Gifted Programming

Students who come from backgrounds of poverty are substantially less likely than their more economically advantaged peers to be identified for gifted programs and therefore to have access to the kinds of advanced learning opportunities such programs may provide (Burney & Beilke, 2008; Olszewski-Kubilius & Clarenbach, 2012; VanTassel-Baska, 2017). In some cases, the limited access that students in poverty may have is compounded by issues of race and ethnicity, of language, and of other factors; there is substantial heterogeneity in the population of individuals living in poverty (Kitano, 2007), and multiple factors may contribute to students' limited opportunities for identification. Moreover, these students may also be less likely than students from higher income backgrounds—gifted or not—to have access to other kinds of extracurricular opportunities that might enhance their development and increase their chances of demonstrating high potential (Burney & Beilke, 2008). For example, researchers have demonstrated the long-term influences of access to summer learning opportunities on achievement gaps between students from lower income and higher income families (Alexander, Entwisle, & Olson, 2007).

One barrier to access to advanced programming for students from low-income backgrounds is the limited opportunity for such programming in schools at the primary grades. Despite long-standing and extensive recommendations around the importance of early intervention (e.g., Olszewski-Kubilius & Clarenbach, 2012; U.S. Department of Education, 1993), many school districts do not provide gifted services in the early elementary grades (National Association for Gifted Children & Council of State Directors of Programs for the Gifted, 2015). Yet the influence of early interventions should not be underestimated (Alexander et al., 2007; Payne, 2010).

Another barrier to advanced academic services for students from underserved populations is the background knowledge and perceptions of the classroom teacher. Teachers may have limited knowledge overall of behaviors that indicate high potential, and in particular of what high potential may look like in underserved groups (Neumeister, Adams, Pierce, Cassady, & Dixon, 2007). Yet in many school districts, teacher nomination is the key step for initial referral to a gifted program (McBee, Peters, & Miller, 2016). Thus, professional development and support for teachers around how to recognize and draw out high potential is critical (Harradine et al., 2014; McBee, 2006; McBee et al., 2016).

The Young Scholars model (Advanced Academic Programs Office, Instructional Services Department, 2013; Horn, 2015) was developed in response to patterns of underrepresentation in gifted programming in a large school district in Virginia. The model developers examined not only approaches to identification to increase diversity but also the opportunities available to students prior to the point of identification to begin to develop their potential. Furthermore, the model includes strong emphasis on providing teachers with professional development around recognizing and responding to high potential, to promote more referrals of students from underrepresented groups. In particular, teachers are encouraged to pay attention to particular patterns of behavior linked to learning, to observe and document behavior over time, and to avoid comparing students from substantially different demographic backgrounds with one another (Harradine et al., 2014). Rather, teachers are guided to reflect on student behaviors as compared with other students with similar backgrounds and opportunities (Lohman, 2005). In addition, the model focuses on supporting teachers in implementing the kinds of instructional activities likely to yield behaviors indicative of advanced potential, so that students have opportunities to show their strengths and talents (Payne, 2011; Worrell, 2007).

Beyond guiding teachers to recognize and respond to high potential in underserved groups, the Young Scholars model also includes emphasis on interventions through use of advanced curriculum, professional development, support for families, and opportunities for summer learning. The premise of the model is that affirmation of potential, access to advanced learning, and advocacy from professionals as well as parents will increase the likelihood that students from underserved groups will be identified at the "official" time of identification for gifted services and will be successful in advanced programs because of the efforts to develop their readiness. Horn (2015) reported that the Young Scholars model has yielded (a) higher rates of identification for gifted programs among minority students and (b) high participation in advanced coursework at the high school level after early participation in Young Scholars programming.

Learning Opportunities in Out-of-School Time

Summer learning programs and other opportunities for students to learn outside of the regular school day are often cited as possible remedies to address achievement gaps and the needs of students from low-income backgrounds (Alexander et al., 2007; Cooper, Charlton, Valentine, Muhlenbruck, & Borman, 2000). A recent study of the effects of summer learning programs for low-income urban youth demonstrated short-term gains in mathematics achievement for students who participated in a free, voluntary summer learning program as compared with similar students who did not participate (Augustine et al., 2016). Although the study did not include specific attention to outcomes for advanced learners, Augustine et al. (2016) did note that teachers in the study perceived that the curriculum in use was not sufficiently challenging for their advanced learners, which signals the importance of summer programming that does target the needs of advanced learners.

Gifted education has a long tradition of providing opportunities for students to engage in advanced learning experiences in out-of-school time (Olszewski-Kubilius, 2010). Enrichment programs provided on Saturdays or in the summer may allow students to access more advanced learning opportunities than what the regular school curriculum provides, or to enhance the school offerings; in such settings, students also have opportunities to be grouped with others of similar ability (Kaul, Johnsen, Witte, & Saxon, 2015). For students from underserved populations in particular, programs in out-of-school time may provide some of the value-added support they need to develop their potential (VanTassel-Baska, 2017)—particularly if supports for advanced learning are limited for these students in regular school settings (Lee et al., 2009). Ideally, these opportunities should start early and be provided on a consistent basis over multiple years, in combination with school-based approaches, to promote growth (Olszewski-Kubilius, 2007; VanTassel-Baska, Feng, & de Brux, 2007; VanTassel-Baska, Johnson, & Avery, 2002).

Programs for advanced and high-potential learners outside of the regular school setting have influenced several positive outcomes for learners, including achievement gains, social benefits, and access to further learning experiences (Kim, 2016). In several studies, researchers have demonstrated these types of benefits specifically for students from underserved populations. For example, Miller and Gentry (2010) found that students from lower and higher income backgrounds reported similarly positive academic and social benefits from an enrichment program in out-of-school time. Olszewski-Kubilius, Lee, Ngoi, and Ngoi (2004) found that after participating in an out-of-school time program through Project Excite, students from minority groups qualified for an advanced mathematics course at Grade 6 at a substantially higher rate than students who, in previous years, had not had the same out-of-school opportunity. Further work on Project Excite has continued to demonstrate the power of out-of-school time programming and partnerships between universities and school districts in closing achievement gaps for students from underserved populations (Cockrell, 2014).

In this study, we examined the effects on mathematics achievement of participation in a summer program as part of a larger implementation of the Young Scholars model in schools with substantial populations of students in poverty, as demonstrated by the percentage of students eligible for free or reduced lunch. Project SPARK, as noted, focuses on increasing teacher referral of students from underserved populations, with attention to evidence of advanced potential. Given that perspective, we focus here on overall effects of participation as well as examining specifically the effects for students from low-income backgrounds.

Research Questions

We examined several research questions related to student achievement in mathematics as linked to participation in a summer program intervention. First, we examined the broad effects of the summer program on students' mathematics achievement growth over the summer and during the academic year. We hypothesized that students who participated in the summer program would exhibit greater mathematics achievement growth between spring and fall testing than those who did not. However, we hypothesized that during the school year following the summer program there would not be a differential in achievement growth for those who had participated in the summer program and those who had not. In other words, we hypothesized the summer program would have an immediate effect, increasing their achievement over the summer; however, while they would retain that increase in achievement compared with their peers who did not attend the summer program, there would be no additional effect on growth during the school year.

Next, we examined whether summer programming effects differed for students from low-income backgrounds, for whom we used eligibility for free or reduced price lunch (FRL) as a rough proxy (Snyder & Musu-Gillette, 2015). We hypothesized that due to the focus on identifying students from underserved populations and on educating teachers about their needs, students who are FRL-eligible would see achievement gains similar to or greater than their peers who are not FRL-eligible. This is similar to findings of Xiang, Dahlin, Cronin, Theaker, and Durant (2011) that students who were high achieving within their grade and school and attended high-poverty schools do not grow academically at a rate different from high achieving students within their grade and school in low-poverty schools.

Study Context and Method

In this article, we present results from the first year of a larger, 5-year study conducted in a Northeastern state that provides no direct support from the state level for gifted programming even though state policy mandates identification. With a long-term project goal of increasing diversity in existing gifted programs, we targeted recruitment efforts primarily toward school districts that did provide some gifted programming and that had high populations of students from economically disadvantaged and/or minority backgrounds. In particular, we collaborated with districts whose leaders expressed interest in trying to increase their rates of identification for students from underserved populations.

Ten schools across two school districts participated in the study reported here on summer program effects, with eight schools in District A and two schools in District B. According to state school profile reports for 2014-2015 (the year the schools were recruited), the percentages of students eligible for FRL in the eight schools of District A ranged from 30.4% to 84.2% (district mean = 54.8%). In District B, the percentages of students eligible for FRL at the two schools were 48.9% and 57.1% (district mean = 43.8%). Across the state in the same year, 37.6% of students were FRL-eligible.

Treatment/Comparison Schools and Student Referrals

Within each district, schools were assigned to the treatment or comparison group for the project, reflecting the focus of the Young Scholars model as a school-wide approach. District A ensured that when assigning schools to treatment and comparison status, there were pairs of matching schools across conditions based on demographic and performance data. Both District B administrators agreed to participate in the project and were assigned at random (flip of a coin). In all schools (treatment and comparison), teachers in Grades K-2 participated in introductory professional development and follow-up meetings with project staff about patterns of behavior that might indicate advanced potential. These meetings were organized around the items on the Gifted Behaviors Rating Scale (GBRS; Shaklee, 1993, 2002), which includes indicators of behavior related to four larger categories: Exceptional Ability to Learn, Exceptional Application of Knowledge, Exceptional Creative/Productive Thinking, and Exceptional Motivation to Succeed. All teachers also had access to video and written material related to such behaviors. Teachers in both treatment and comparison schools referred to these materials in the process of referring students to the project.

In collaboration with the project team, teachers conducted referrals and invited students to participate in the project. For students and teachers in the comparison schools, participation beyond the point of referral consisted primarily of collection of assessment data (described further below). In the treatment schools, students were invited to participate in a summer program.

Summer Program Intervention

Instruction in the summer program focused on mathematics content and discourse; specifically, summer program teachers implemented a geometry unit developed under the NSF-funded Project M^2, "Mentoring Young Mathematicians" (Gavin, Casa, Chapin, & Sheffield, 2011). Project M^2 built on another initiative, the Javits-funded Project M^3 (Gavin et al., 2007), to bring a successful model of advanced mathematics curriculum to the primary grades. In Project M^2, the project team combined key research-based practices and standards from mathematics education, gifted education, and early childhood education to construct units on geometry and measurement for Grades K-2 (Gavin, Casa, Firmender, & Carroll, 2013). These units focus on engaging learners in thinking and acting like practicing mathematicians.

Specifically, the unit used in the summer program described here focuses on the study of two-dimensional shapes, with emphasis on composing and decomposing shapes; describing, sorting, and classifying shapes; and investigating congruence and symmetry of shapes (Gavin et al., 2011). The unit also includes a strong focus on mathematical reasoning and communication, with specific attention to strategies for mathematical discourse and written communication. The content of the unit is relevant to the content and practices standards of the Common Core State Standards, which the state adopted, but some of the specific content details and reasoning expectations are more advanced than the standard curriculum. For example, the strategies students use to sort and compare shapes include Venn diagrams, tree diagrams, and Carroll diagrams, each of which requires different types of thinking about attributes. Because these more advanced reasoning activities constituted most of the instructional time during the summer program, the unit may have built on school-year content but did not substantially overlap except in introductory stages. In addition, the unit includes guidelines to support differentiation for students who need further challenge or additional support (Gavin et al., 2013).

In prior research on this unit in an academic-year setting, students participating in the unit received scores on the Iowa Tests of Basic Skills (ITBS) similar to those of other students in similar classes who were not participating, even though the unit reduced the time treatment group students spent on the content most prevalent in the achievement test. In addition, students in the treatment group outperformed students in the comparison group on an open-response assessment of geometry content (Gavin et al., 2013).

The summer program lasted for 3 weeks in District B and 4 weeks in District A (schedule determined by district calendars), and students attended 5 days a week for 3 to 3.25 hours. The schools within each district provided the program at no cost to families. The program provided transportation, snacks,

Table 1. Demographics of Analytical Sample.

	Full sample			Free/reduced only		
	Summer attendance			Summer attendance		
	Total (N = 220), n (%)	Yes (n = 85), n (%)	No[a] (n = 135), n (%)	Total (N = 84), n (%)	Yes (n = 36), n (%)	No (n = 48), n (%)
Sex						
Female	117 (53.2)	48 (56.5)	69 (51.1)	41 (48.8)	18 (50.0)	23 (47.9)
Male	103 (46.8)	37 (43.5)	66 (48.9)	43 (51.2)	18 (50.0)	25 (52.1)
Grade (in spring 2015)						
Kindergarten	71 (32.3)	28 (32.9)	76 (31.9)	27 (32.1)	11 (30.6)	16 (33.3)
First	95 (43.2)	36 (42.4)	59 (43.7)	35 (41.7)	18 (50.0)	17 (35.4)
Second	54 (24.5)	21 (24.7)	33 (24.4)	22 (26.2)	7 (19.4)	15 (31.3)
English language learner						
Yes	24 (10.9)	6 (7.1)	18 (13.3)	15 (17.9)	4 (11.1)	11 (22.9)
No	195 (88.6)	79 (92.9)	116 (85.9)	69 (82.1)	32 (88.9)	37 (77.1)
Ethnicity						
Black or Hispanic	30 (13.6)	9 (10.6)	21 (15.6)	6 (7.1)	1 (2.7)	5 (10.4)
Other	190 (86.4)	76 (89.4)	114 (84.4)	78 (92.9)	35 (97.2)	43 (89.6)
Special education						
Yes	3 (1.4)	1 (1.2)	2 (1.5)	1 (1.2)	0 (0.0)	1 (2.1)
No	217 (98.6)	84 (98.8)	133 (98.5)	83 (98.8)	36 (100.0)	47 (97.9)
Free/reduced lunch						
Yes	84 (38.2)	36 (32.4)	48 (29.1)			
No	136 (61.8)	49 (44.1)	87 (52.7)			
Intervention						
Treatment school	112 (50.9)	84 (98.8)	28 (20.7)	50 (59.5)	36 (100)	14 (29.2)
Comparison school	108 (49.1)	1 (1.2)[b]	107 (79.3)	34 (40.5)	0 (0)	34 (70.8)

[a]Note that students who did not attend the summer program included all students referred from comparison schools and students from treatment schools who were unable or chose not to attend the summer program. [b]One student was in a treatment school in 2014-2015 and thus was eligible for the summer program. This student participated in the summer program and then transferred to a comparison school for 2015-2016.

and all program materials. Summer program participation was voluntary for students from treatment schools.

Summer program teachers, who included teachers from the participating school districts, participated in professional development in preparation for implementation of the program. The summer program included a full-day professional development workshop, conducted by a member of the project staff with prior experience with Project M^2 and M^3 on the specific unit employed in the summer program. Project staff conducted observations in every classroom at least three times during the program, using (a) the Classroom Observation Scales–Revised (VanTassel-Baska et al., 2003) to document strategies supporting critical and creative thinking and (b) the mathematics portion of the Instructional Quality Assessment (Boston & Wolf, 2006) to document the mathematical rigor and use of discourse strategies. In most observations, teachers received scores of at least 2 (somewhat effective) and in more instances 3 (effective) on all items that were observed using the Classroom Observation Scales–Revised, although many items were rated "not observed" because they did not match the context of the observed lesson and therefore could not be evaluated. On the Instructional Quality Assessment, most teachers received scores of 3 or 4 on the 4-point scale on items related to implementing the curriculum with fidelity, asking questions, and encouraging participation, although other aspects of the discourse interactions (e.g., student use of linking strategies) were less frequently observed. Overall, based on results of the two forms, teachers demonstrated satisfactory fidelity and use of strategies as indicated in both instruments.

Sample

As noted previously, participants in the study were students from 10 schools across 2 school districts in the Northeastern United States. There were 220 students in the full analytical sample,[1] as detailed in Table 1, including 71 students who were in kindergarten in the spring 2015, 95 students in first grade, and 54 students in second grade. About 11% of the participants were English language learners, and 1.4% participated in special education programming. Slightly more than 13% of the participants identified as Black or Hispanic. Approximately 38% of the students were eligible for FRL, which is similar to the overall percentage for the state

(37.6%). Of the 220 students, treatment schools referred 112 were referred and comparison groups schools referred 108. Of the 112 treatment school students, 85 (76%) attended the summer program. Because this article specifically focuses on the summer program, from this point the 85 students who participated in the summer constitute the treatment group, while the remaining 135 students who did not participate constitute the comparison group.

Analytical Sample of Students Eligible for FRL. Because we were interested in whether there was a differential effect for students eligible for FRL compared with those who were not eligible, we also describe here that subsample. There were 84 students eligible for FRL. This subgroup included slightly more males than females. The distribution of students across the three grade levels mirrored that of the full sample—32.1% in kindergarten, 41.7% in first grade, and 26.2% in second grade. The percentage of students participating in special education programming was also similar to the full sample at 1.2%. Only 7.1% of this subgroup identified as Black or Hispanic, which was less than the percentage in the full sample, but the percentage of English language learners (17.9%) was greater than in the full sample. Within this subgroup of students eligible for FRL, 36 students (42.9%) attended the summer program.

Instruments

Baseline Measures. We collected two pretest measures for each student referred to the project that allowed us to compare students from the different groups for similarity at baseline. First, we collected GBRS scores from the referring teacher. Then, we administered the Naglieri Nonverbal Ability Test–Second Edition (NNAT-2; Naglieri, 2011).

As noted above, teachers used the GBRS to refer students to the project. The scale lists sample behaviors in four major categories (Exceptional Ability to Learn, Exceptional Application of Knowledge, Exceptional Creative/Productive Thinking, and Exceptional Motivation to Succeed), on which teachers rate students on a scale of 1 to 4 to indicate the frequency with which students demonstrate relevant behaviors. For reporting purposes, the overall score summed these scores. With no minimum score established for the referral of students to the project, project staff, and teachers worked together to decide which students to refer based on observed behaviors.

The NNAT-2 is a measure of general intelligence that does not require a child to produce any language-related responses. Each task on the NNAT-2 asks children to view a visual representation of a pattern or matrix and then to choose the correct piece to complete the image. Nonverbal tests of this nature often are postulated to yield scores more likely to support gifted program identification for students from underserved populations (Horn, 2014; Naglieri & Ford, 2003). Internal consistency reliability coefficients for the NNAT-2 are between .84 and .92 (Naglieri, 2011). Multiple studies have established the validity of the NNAT-2 across samples as well as its correlations with other tests of general intelligence (Giessman, Gambrell, & Stebbins, 2013). Converted NNAT-2 raw scores have standardized ability scores with a mean of 100 and a standard deviation of 15. Student scores on the NNAT-2 were collected for all referred students whose parents provided permission; there was no minimum score designated for participation in the study.

Comparison of Students Participating in the Summer Program and Students Not Participating. We conducted preliminary analyses comparing students on the NNAT-2 and the GBRS, examining whether there were differences between the group participating in the summer program and those who were not participating. Students who participated in the summer program had an average NNAT-2 score of 108.18 (SD = 13.55) and an average GBRS score of 13.17 (SD = 1.74), and students who did not participate in the summer program had an average NNAT-2 score of 110.30 (SD = 11.80) and an average GBRS score of 13.55 (SD = 1.90). The average scores on both measures were not statistically significantly different between the groups (p = .34 and .14, respectively).

Achievement Measure: Measures of Academic Progress (MAP)—Mathematics. The Northwest Evaluation Association (NWEA) produces two similar tests designed to measure student achievement in mathematics: MAP for Primary Grades (MPG) and MAP. MPG was designed specifically for students in kindergarten through the second grade, while MAP is intended for use with students in second grade and beyond. The two tests measure mathematics achievement on a continuous scale, the RIT scale, which uses Rasch units that are equal interval so that the difference between scores is the same regardless of where a student is on the scale. The use of the RIT scale allows for the study of student growth over time as well as the comparison of student achievement across grade level. Because they are computer adaptive tests, MAP and MPG exhibit minimal ceiling effects (McCall, Kingsbury, & Olson, 2004). Early elementary students can take either MPG or MAP, and within a particular score range, either test has been demonstrated to measure student achievement similarly. In this study, all students began with MPG with the spring 2015 testing and then transitioned to MAP when they, either, reached the third grade or they achieved a score of 200 on MPG, as recommended by NWEA (2014). We tested students in spring 2015 (pretest), fall 2015 (post-summer program), winter 2016, and spring 2016.

One would expect scores across the MPG to MAP transition point to continue to show growth, as students continue to gain new mathematics abilities over time during a school year. However, this transition is not always as smooth as projected (NWEA, 2014), particularly for the highest achieving students, and we documented a scale score drop when students transitioned from the MPG to the MAP. NWEA adjusted students' MPG scores to align with their MAP equivalents because of the misalignment in test scores for many students in this data set. The procedure NWEA used included data from their large national sample ranging from fall of kindergarten to spring of fifth grade (totaling 12,593 participants with 107,300 observations). They used a mixed-effect modeling approach with validation to correct the vertical shift in the study's MPG scores "while preserving critical features of . . . the data trend for MAP" (NWEA Psychometric Services, 2016, p. 1). This statistical adjustment was necessary, because the large national sample and not our study sample determined the strength, to vertically equate the scores to examine growth over time. The means of the MAP scores for students in this study were stable over the summer (spring 2015 = 180.79, fall 2015 = 180.59) and grew during the academic year (winter 2016 = 185.33, spring 2016 = 191.45), with strong correlations of adjacent time periods (from .85 to .90), indicating a stability in the rank order of students based on scores.

Shape of the Growth Trajectory

Based on prior research on reading achievement (McCoach, O'Connell, Reis, & Levitt, 2006; Rambo-Hernandez & McCoach, 2015), we expected that students would make less achievement growth in the summer (May to October) than during the academic year (October through May), and thus, we anticipated that the growth trajectory would not be linear across the entire period. We began by examining the growth plots for individuals and overall, and the shape of the achievement growth trajectory did match our hypothesis that there would be one slope for summer growth (May to October) and a different slope for academic year growth (October through May). Therefore, we used a piecewise two-level hierarchical linear model of student mathematics achievement growth over the first year of the project, modeling the two separate growth slopes.

Statistical Analyses

Using restricted maximum likelihood estimation, we estimated a two-level model with measurement occasions (time) being Level 1 and students being Level 2. Because we only had 10 schools, we planned to account for school differences by including nine weighted effect codes, which took into account the different sample sizes in the different schools. We estimated pretest mathematics score (intercept) and two growth slopes (summer and academic year), using months since pretest as our measure of time. Because we administered the assessment at similar intervals at each school, we included the same data collection schedule for all students, with the administration from fall to spring (across the summer) being 5 months, from fall to winter being 3 months, and from winter to spring being 4 months. At the student level, the control variables considered were whether students were eligible for FRL (0 = no, 1 = yes), the school weighted effect codes, and two grade-level dummy codes for Kindergarten and Grade 2 (with Grade 1 as the reference group). For the first research question, the main effects of the summer program, our variable of interest was whether students participated in the summer program (0 = no, 1 = yes). To examine whether that effect differed for students who were eligible for FRL, we added an interaction variable indicating whether they were in the summer program *and* were FRL-eligible (0 = no, 1 = yes).

Results

An unconditional growth model, with the summer and academic year growth slopes added to the model, indicated that while pretest mathematics scores and academic year growth varied across students, the change in scores over the summer did not vary across students ($\tau_{11} = 0.36$, $\chi^2_{190} = 201.26$, $p = .27$); thus, we fixed the summer growth slope for subsequent analyses. Given that prior research has indicated individual differences in student learning, an effort to explain such differences as a function of student factors was warranted, so we continued with our research question examining the relationship, as supported by Raudenbush and Bryk (2002).

Unfortunately, due to sample size limitations and the small amount of variability in the summer slope, we were underpowered to add the nine school weighted effect codes, two grade-level dummy codes, an indicator of FRL eligibility, an indicator of summer program participation, and the interaction between FRL eligibility and summer program participation. Therefore, we ran our model two ways to examine robustness of the results. First, we only added the school weighted effect codes to the randomly varying intercept and slope. Adding the school weighted effect codes as predictors explained about 3% of the variance in the intercept and none of the variance in the randomly varying growth slope. Second, we ran a model without the school weighted effect codes. The parameter estimates were similar in both models, with no decisions to reject the null for our parameters of interest differing between the two models. To determine which model to report, we ran both these models as well as a third with the school weighted effect codes predicting the intercept and both slopes and examined the model fit, as recommended by McCoach and Black (2008). The Akaike information criterion (AIC) indicated the model with the least amount of misfit was the model without the school weighted effect codes ($\Delta AIC_{full} = 9.14$, $\Delta AIC_{random\text{-}only} = 10.58$), and the Bayesian Information Criterion (BIC) supported that conclusion ($\Delta BIC_{full} = 100.77$, $\Delta BIC_{random\text{-}only} = 71.67$). According to Raftery (1995), this provides "very strong" evidence favoring the model without the school weighted effect codes. Therefore, we report that model in the remainder of the article.

Main Effects of Summer Program Participation

We first examined the broad effects of the summer program by adding an indicator of summer program participation as a predictor of the intercept, summer growth slope, and

Table 2. Effects of Summer Program on Mathematics Achievement for Full Sample.

Fixed effect	Coefficient	*SE*	*t*	*df*	*p*
For pretest mathematics score, π_0					
Intercept, β_{00}	186.57	1.51	123.19	215	<.001
Summer program, β_{01}	−.073	1.68	−0.43	215	.67
Grade K, β_{02}	−22.54	1.91	−11.80	215	<.001
Grade 2, β_{03}	18.39	2.07	8.90	215	<.001
FRL, β_{04}	−8.00	1.71	−4.70	215	<.001
For summer growth slope, π_1					
Intercept, β_{10}	0.10	0.20	0.49	390	.63
Summer program, β_{11}	0.55	0.23	2.43	390	.02
Grade K, β_{12}	0.19	0.26	0.75	390	.46
Grade 2, β_{13}	−1.34	0.28	−4.76	390	<.001
FRL, β_{14}	0.10	0.23	0.45	390	.65
For academic year growth slope, π_2					
Intercept, β_{20}	1.25	0.21	6.05	215	<.001
Summer program, β_{21}	0.14	0.23	0.58	215	.56
Grade K, β_{22}	0.42	0.26	1.63	215	.11
Grade 2, β_{23}	0.06	0.29	0.22	215	.83
FRL, β_{24}	0.14	0.23	0.59	215	.55

Random effect	Variance	*df*	χ^2	*p*
Variance between students in intercept (τ_{00})	107.28	212	1631.34	<.001
Variance between students in academic year slope (τ_{22})	1.32	212	470.41	<.001
Variance within students (σ^2)	33.87			

Note. SE = standard error; *df* = degrees of freedom; FRL = free or reduced price lunch. Summer program was coded 0 = participated, 1 = did not participate. FRL was coded 0 = not eligible for FRL, 1 = was eligible for FRL. Growth slopes are per month, with summer growth occurring from May to October (5 months), and academic year growth occurring October to May (7 months).

academic year growth slope. We included the grade-level dummy codes and the indicator of FRL eligibility as control variables on each equation:

Level 1 Model:

$$MATH\_RIT_{ti} = \pi_{0i} + \pi_{1i} * \left(P1SUMMER_{ti}\right) + \pi_{2i} * \left(P2SCHOOL_{ti}\right) + e_{ti}$$

Level 2 Model:

$$\pi_{0i} = \beta_{00} + \beta_{01} * \left(SUMMER_i\right) + \beta_{02} * \left(GRADEK_i\right) + \beta_{03} * \left(GRADE2_i\right) + \beta_{04} * \left(FRL_i\right) + r_{0i}$$

$$\pi_{1i} = \beta_{10} + \beta_{11} * \left(SUMMER_i\right) + \beta_{12} * \left(GRADEK_i\right) + \beta_{13} * \left(GRADE2_i\right) + \beta_{14} * \left(FRL_i\right)$$

$$\pi_{2i} = \beta_{20} + \beta_{21} * \left(SUMMER_i\right) + \beta_{22} * \left(GRADEK_i\right) + \beta_{23} * \left(GRADE2_i\right) + \beta_{24} * \left(FRL_i\right) + r_{2i}$$

where $MATH\_RIT_{ti}$ is the mathematics achievement score for student *i* at time *t*, β_{01} is the differential in initial achievement for students in the summer program, π_{1i} is the monthly summer growth slope, β_{11} is the differential per month in summer achievement growth for students in the summer program, π_{2i} is the monthly academic year growth slope, and β_{21} is the differential per month in academic year achievement growth for students in the summer program.

As shown in Table 2, students who did not participate in the summer program did not see any gains in their mathematics scores over the summer ($\beta_{10} = 0.10$, $p = .63$), controlling for grade and FRL eligibility. However, the students who did participate in the summer program had statistically significantly greater gains over the summer ($\beta_{11} = 0.55$, $p = .02$), averaging over the time period between testing occasions 2.77 points higher than students who did not participate in the summer program. We calculated a Cohen's *d*-type effect size for a linear trend (Feingold 2009). This is a moderately large effect size, $d = 0.92$. During the academic year, students who had not participated in the summer program exhibited average gains of 1.25 points per month ($\beta_{20} = 1.25$, $p < .001$), controlling for grade and FRL eligibility. The differential in the academic year growth slope for students who participated in the summer program was not statistically significant ($\beta_{21} = 0.16$, $p = .56$), and the difference was a small effect, $d = 0.14$, resulting in a model-predicted average growth of 1.39 points per month for summer program students.

Differential in Summer Program Effects for Students Eligible for FRL

Given the moderately large, statistically significant effect we found for the summer program, we examined whether there was a difference in the summer effect for students who were eligible for FRL and we added an interaction between summer program participation and FRL eligibility as a predictor to the intercept and both slopes.

Controlling for grade level, the difference in the monthly mathematics achievement growth during the summer for a student who participated in the summer program and was eligible for FRL was 0.03 (t_{389} = 0.06, p = .95), and the difference in the monthly mathematics achievement growth during the academic year for a student who participated in the summer program and was eligible for FRL was 0.14 (t_{214} = 0.30, p = .77).

Discussion

In this study, we examined the effects on achievement of a summer program that engaged students in mathematics learning with curriculum designed to respond to the needs of advanced learners at the primary level. This study of summer program effects represents a piece of a larger, long-term study intended to focus on supporting young students showing signs of high potential in their academic development through the early grades of school.

In our analyses, we found that students who participated in the summer program made moderately larger gains (d = 0.92) from spring testing to fall testing in their mathematics achievement as compared with those students who did not participate. Poverty status, as reflected in eligibility for FRL, did not moderate those summer program effects, indicating similar gains for summer participants who were eligible for FRL as compared with their more economically advantaged peers. This is important evidence to suggest that although this group may have had fewer opportunities for such learning experiences prior to this program, they were able to make gains similar to those of other students in their districts who may have greater economic resources.

Our results echo many other studies demonstrating the positive influence on achievement for advanced and high-potential learners who engage in out-of-school time programs designed to address their needs (Cockrell, 2014; Olszewski-Kubilius, 2010; Olszewski-Kubilius et al., 2004), as well as studies in general education demonstrating positive influences of summer programming on achievement (Augustine et al., 2016). The specific mechanism by which the summer program may have supported participating students' achievement score gains is difficult to document. The summer program offered a curriculum unit with more advanced content and greater instructional emphasis on discourse and writing than the standard curriculum offered for the academic year. The program also represented increased instructional time and focus on mathematics content in general, as well as possibly providing social and emotional benefits by bringing students together with other children similarly showing advanced potential. Any or all of these factors may have been influential in supporting achievement.

In earlier research on the same curriculum unit used in this study, Gavin et al. (2013) found that students participating in the unit during the academic year saw higher performance gains than a comparison group on an open-response assessment tied to the unit and similar gain scores to the comparison group on a standardized achievement test (ITBS). The researchers argued that because the unit content represented only a small percentage of the ITBS items, they did not expect their intervention group to outperform a comparison group. Furthermore, they argued that the similar results between groups spoke to the strength of the curriculum, because the instructional time required by the curriculum was longer than the time normally devoted to the unit topics, and therefore, treatment group students spent *less* time than the comparison groups on the content more broadly represented on the ITBS.

Because we conducted our intervention with the curriculum unit in the context of a summer program, there was clearly increased instructional time on the geometry content. As in Gavin et al.'s (2013) study, the standardized achievement measure used did not just focus on content related to the intervention, however, but addressed a much wider range of mathematics content. Therefore, the growth of summer program students' achievement between spring and fall testing, compared with previous results on the same curriculum (Gavin et al., 2013), indicates positive influence of specially designed curriculum for high-potential learners in a variety of settings (VanTassel-Baska & Stambaugh, 2008) and supports the implementation in a summer program context.

Beyond the initial postsummer testing, students who participated in the summer program did not differ from those who did not participate, suggesting that although the summer program may have provided an initial boost to achievement, there was no additional boost that carried the students even further in the following year than students who did not participate. This suggests the need for further professional development efforts to support teachers in responding to the needs of these learners in the regular classroom setting. It also raises the question as to how the "dosage" of out-of-school time support matters for student achievement; would participation in a longer program or one that was sustained across multiple years support higher achievement for learners?

Future Research and Practice

Our findings have practical implications for school districts, including using summer programming as a value-added intervention for students showing behaviors indicating high potential. Furthermore, the gains summer students showed on the achievement assessments indicate the value of using strong curriculum in such a summer program. Although the effects of the curriculum itself versus the instructional methods versus just a summer experience cannot be separated here, the results echo those of school-year studies of the same curricular materials (Gavin et al., 2013). Thus, this study adds to the evidence supporting the use of the Project M^2 materials with high-potential learners. Furthermore, the study provides support for using high-level curriculum as an intervention with high-potential learners in a summer program context.

Future work in Project SPARK will include analysis of the effects of multiple years of program participation on student achievement. In one recent study, researchers found that although a summer program showed effects on mathematics achievement after one summer for a general education population, there were no further effects on student achievement after a second summer (Augustine et al., 2016). Yet previous work in gifted education has indicated the value of multiple years of participation in out-of-school time (Lee et al., 2009), as well as the value of multiple years of participation in specially designed curriculum to support advanced learning (Feng, VanTassel-Baska, Quek, Bai, & O'Neill, 2005). Thus, we will closely examine effects of multiple years of participation and work to determine key variables of influence. Furthermore, we examined students' likelihood of being identified for their districts' gifted programs at the grade levels at which those programs begin, as linked to their prior participation. Finally, additional schools began participation in Year 2 of the project, so we will examine the degree to which similar effects occur across districts with varied demographics.

Limitations

Limitations of this study include the use of a broad-range achievement test in mathematics rather than one that focuses directly on the areas of mathematics content addressed in the summer program; this limits the degree to which student growth gains may be examined closely with reference to the specific curriculum in which they engaged. In addition, the study uses a guided, supported process of teacher referral to bring students into the project; despite the emphasis on teacher guidance, we also acknowledge the potential bias in teacher referrals and the evidence suggesting the likelihood of false negatives in such a process (McBee et al., 2016). Nevertheless, in the study context, which does not allow for universal screening, the guided process forms an important and carefully monitored portion of the project.

A further limitation involves the use of FRL eligibility as a proxy for indicating a background of poverty. Despite common use of this metric as an indicator of proxy in educational research, concerns over its use include the broader definition of FRL eligibility beyond the federal poverty line, the issue that families who choose not to participate are not captured in the statistics, and recent Community Eligibility guidelines that allow more access for all students in a district (Chingos, 2016; Snyder & Musu-Gillette, 2015). Nevertheless, FRL eligibility remains the closest approximation available to us to indicate students' poverty status, and thus, it employed here with recognition of its limitations.

Finally, the study only includes data on those students who were referred and whose parents agreed for them to participate; in each school, some students were referred but not given permission, and we have no access to any data on those students.

Conclusion

Supporting students from low-income backgrounds in maintaining and increasing high levels of achievement requires sustained, long-term efforts to offset some of the contextual challenges they face (Alexander et al., 2007; Wyner et al., 2007). In this study, we demonstrated positive evidence of the influence of summer program participation on the mathematics achievement of young students, including specific evidence that students eligible for FRL benefitted from the program to a degree similar to their peers not eligible for FRL. This study is part of an effort to determine how much support and what types are needed to sustain high-level achievement for students from low-income backgrounds and to increase their likelihood of identification for and success in advanced learning programs throughout their schooling. Such efforts to demonstrate the development of student potential are critical in ensuring that talents are nurtured and supported in and out of schools.

Declaration of Conflicting Interests

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Note

1. The analytical sample did not include students who only participated in the pretests in spring 2015 but did not return to a project school in fall 2015, including some students who participated in the summer program, as there was nonrandom attrition.

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