Summer Program Effects on Geometry Achievement

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Abstract

We studied a summer learning program that provides access to advanced curriculum to support high-potential learners. Such programs may help reduce achievement gaps between students of diverse backgrounds by providing learning opportunities to underserved groups. We examined whether participation in the summer program resulted in higher achievement scores in the specific strand of mathematics (geometry) targeted by the curriculum. In the sample of 210 participants, nearly half of the students were eligible for free/reduced-price lunch, and over half identified as Black or Hispanic. Using hierarchical linear modeling, we found that students who participated in the summer program scored statistically significantly higher than students who did not attend the summer program, even after controlling for pretest geometry scores and demographic variables.

Summer learning opportunities may provide a context for advanced learners to access advanced curriculum, interact with learners similar to themselves, and experience academic challenges that may benefit their long-term learning. Particularly for learners with high potential from underserved populations, summer learning may provide important supports for their later academic achievement and identification for advanced programs – a critical consideration given evidence of early appearance of excellence gaps for these learners (Morgan, Farkas, Hillemeier, & Maczuga, 2016). The Young Scholars Model (Horn, 2015) emphasizes enrichment experiences with advanced curriculum during summer as well as the academic year to promote access, affirmation, and advocacy for learners with high potential from underserved populations.

Project SPARK is a scale-up of the Young Scholars Model. We worked with teachers at grades K-2 in 19 schools to refer students who showed evidence of advanced academic potential to the project, and students in the treatment group schools had access to a 3-week summer learning opportunity organized around challenging mathematics curriculum (Project M^2; Gavin, Casa, Adelson, & Firmender, 2013). In our prior research, we have demonstrated gains in mathematics achievement for students who participated in the summer program and dosage effects demonstrating achievement benefits for students who participated in more than one summer (Little et al., 2018a, 2018b).

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In the present study, we examined mathematics achievement in geometry, the specific goal area most relevant to the summer curriculum. The sample of 210 students included 90 who participated in the summer program and 120 who did not. We examined students' Fall 2017 scores in the geometry goal area on the NWEA Measures of Academic Progress for Primary Grades (MPG). Based on our own prior work and earlier study of the curriculum (Gavin et al., 2013); we hypothesized that students who participated in the summer program would have greater fall geometry achievement scores than their peers who did not participate, controlling for spring geometry scores, grade level, gender, underrepresented minority status, and eligibility for free/reduced lunch (FRL).

We used hierarchical linear modeling (HLM; Raudenbush & Bryk, 2002) to appropriately account for the clustering effect of students within schools (McCoach & Adelson, 2010). We estimated two-level models with students at Level 1 and schools at Level 2. Due to the relatively small number of schools, we used restricted likelihood estimation.

To control for student demographics, we included several variables at Level 1: whether a student identified as Hispanic or Black (White/Asian = 0, Hispanic or Black = 1), gender (female = 0, male = 1), eligibility for FRL (no FRL = 0, FRL = 1), and fall grade level (0 = first grade, 1 = second grade). Because prior achievement is the greatest predictor of future achievement and to control for any pre-existing differences in achievement, we also controlled for spring geometry achievement scores, grand-mean centered. To answer our research question, we included a dummy code indicating whether or not the student participated in the summer program in 2017 (0 = did not attend, 1 = attended).

First, we ran an unconditional, or null model, with fall geometry achievement scores as the outcome and no predictors included. Average fall geometry scores (γ_{00} = 178.72; t_{18} = 118.08, p < .001) varied across schools (τ_{00} = 16.90, χ^2_{18} = 31.39, p = .03). The intraclass correlation coefficient (ICC) was equal to .06, indicating that 6% of the total variability in fall geometry scores was between schools and 94% of the variability was between students within schools.

Next, we added our control variables. None of the covariate slopes randomly varied across schools, indicating that the relationship between the control variables and geometry achievement did not differ across schools. Therefore, we sequentially fixed each of these slopes. Together, pretest geometry scores, grade level, gender, underrepresented minority status, and FRL status explained 33% of the variability between students in fall geometry scores (level-1 variability) and 51% of the variability between schools in fall geometry scores (level-2 variability).

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With a control model established, we added the dummy code indicating whether students attended the summer program. The slope for summer program attendance did not statistically significantly vary across schools (τ_{60} = 13.50, χ^2_{11} = 9.43, p > .500), so we fixed the variance for the slope.The final model was:

$$GEOMETRY_{ij} = \gamma_{00} + \gamma_{10}*GEOMETRYpretest_{ij} + \gamma_{20}*GRADE\_1_{ij} + \gamma_{30}*GENDER_{ij} + \gamma_{40}*HISPANICorBLACK_{ij} + \gamma_{50}*FRL_{ij} + \gamma_{60}*SUMMER_{ij} + u_{0j} + r_{ij}$$

where $GEOMETRY_{ij}$ is the fall geometry achievement score (posttest) for student *i* in school *j*. γ_{60} is the average difference in fall geometry achievement score for students who attended the summer program after controlling for spring geometry score (pretest), grade level, gender, identification as Hispanic or Black or not, and FRL status.

Students who participated in the summer program scored statistically significantly higher than students who did not attend the summer program (γ_{60} = 4.90, p = .02). Whether students attended the summer program explained an additional 34% of variability in geometry achievement scores between schools, beyond pretest scores, grade level, gender, minority status, and FRL status. Participating in the summer program had a moderate effect size (d = 0.29).

This study builds on a prior study examining overall mathematics achievement effects of a summer program implemented 2 years prior and represents a piece of a larger, long-term study that focuses on developing talent in students showing high potential in the early grades. We found that students who participated in the summer program had moderately greater fall geometry than those who did not. This provides evidence that the summer program not only provides overall mathematics improvement but also improves specific content knowledge and skills. The study results add to the existing literature on the value of advanced summer learning experiences for high-potential learners. Specifically, these findings strengthen the rationale for using advanced, targeted curriculum in out-of-school time programs with diverse, high-potential learners to provide access to challenging learning experiences and to support student growth in key academic areas.

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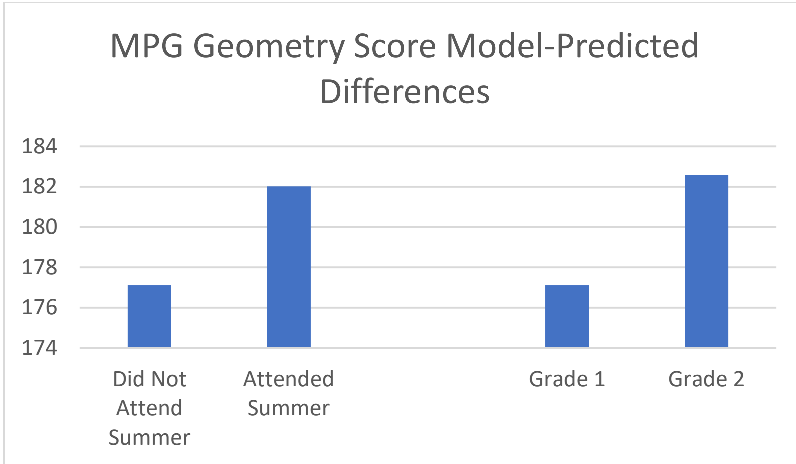

Figure 1. Model-predicted differences in Measurements of Academic Growth for Primary Grades (MPG) geometry subtest scores showing differences for attending the 3-week summer program and for an additional academic year of school.

Table 1

Effects of Summer Program Attendance on Fall Geometry Achievement

Fixed Effect	Coefficient	SE	*t*	*df*	*p*
Intercept, γ_{00}	177.11	2.39	74.26	18	< .001
GeometryPretest, γ_{10}	0.50	0.07	7.51	185	< .001
Grade_1, γ_{20}	5.46	2.24	2.44	185	.02
Gender, γ_{30}	-0.80	1.89	-0.42	185	.67
Minority, γ_{40}	-5.10	2.20	-2.32	185	.02
FRL, γ_{50}	-1.23	2.12	-0.58	185	.56
Summer, γ_{60}	**4.90**	**1.99**	**2.47**	**185**	**.02**

Random Effect	Variance	*df*	χ^2	*p*
Variance between schools in intercept (τ_{00})	2.64	18	17.06	> .500
Variance within students (σ^2)	181.33			

Note. The reference group for the summer program dummy code is students who did not attend the summer program. Grade_1 is student grade level dummy code with 0 = in first grade and 1 = in second grade. Gender is coded with 0 = female and 1 = male. Minority status indicates if a student identified as Black or Hispanic. Free or reduced lunch (FRL) is coded with 0 = does not receive FRL and 1 = does receive FRL. The geometry pretest was administered in the spring, and the score was grand-mean centered.

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