Abstract Title Page

Title:

"STEMming" the Swell of Absenteeism in Urban Middle Grade Schools: Impacts of a Summer Robotics Program

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Abstract Body

Problem / Background / Context:

Attendance is probably the most fundamental behavioral indicator of student engagement with school. Though many students fall off-track to success for the first time in ninth grade, poor attendance patterns often begin increasing in middle school and become worse in high school. Recent studies indicate higher rates of chronic absenteeism in grade 8 than in earlier middle grades in such states as Oregon and Nebraska (Balfanz & Byrnes, 2012) and alarming rates of middle grades absenteeism in urban districts such as New York City and Baltimore (e.g., Balfanz & Byrnes, 2013; Mac Iver et al., 2008). Rigorous research on interventions to improve student attendance remains in the early stages. Evaluation studies of out-of-school time (OST) programs, both summer school and after school, have found mixed results regarding program impacts on school attendance (Dynarski et al., 2004; Gottfredson et al.,2010; Lauver,2002). Cooper et al. (2000, p. 102) specifically advocate the need for summer program evaluations to investigate such outcomes as attendance.

Missing school during the secondary grades can often be traced to low levels of motivation. As Eccles (2008) has so aptly summarized the crux of the motivation issue, it often boils down to two main questions in students' minds about what happens in school: "Can I do the task?" And "Do I want to do the task?" (Eccles & Midgely, 1989; Meece, 2003). Recent discussions of noncognitive factors affecting academic performance have emphasized the importance of developing an academic mindset to influence academic behaviors such as attendance and exerting effort in class and homework assignments (Farrington et al., 2013). The process of helping students to internalize these beliefs can occur not only in the core academic classroom, but also in elective activities like robotics that build a sense of competence and value in academic pursuits. A number of studies have begun to investigate the impacts of one such hands-on activity, robotics, but the research evidence remains rather thin. Benitti's (2012) literature review identified just ten articles that included quantitative measurement of student learning. The reviewed studies reported some positive effects on learning of science concepts and some positive effects on mathematics learning for some subgroups, but did not address noncogitive outcomes such as attendance as a measure of school engagement.

Purpose / Objective / Research Question / Focus of Research:

Given the salience of attendance as a predictor of student achievement outcomes, additional research on effective means of increasing attendance for at-risk students is particularly important. In this paper we focus primarily on the following research question: Did the five week STEM robotics summer learning program (described below) have a positive impact on the following year's attendance rate of middle school students (compared to a matched sample of students who did not receive any of the district's summer programs)?

Improvement Initiative / Intervention / Program / Practice:

The focus of this study is a STEM Robotics Summer Learning Program funded by the U.S. Department of Education's Investing in Innovation (i3) program in a development award. The primary goal of this five-week summer program implemented by the school district was to provide additional out of school time focused on mathematics instruction and robotics so that enrolled students could increase their mathematics grade-level aptitude by the end of the program and develop interest in technology and STEM college majors and careers. The robotics component was expected to increase student engagement (including attendance) and perception of the relevance of mathematics, leading to increased student effort and math achievement.

Setting:

The program was developed and conducted in 8 school sites citywide by an urban school district with 85% of students eligible for free/reduced price lunch and 92% African-American or Hispanic.

Population / Participants / Subjects:.

All district students in grades 5 to 7 (rising 6^{th}-8^{th} graders) were eligible to enroll in the program. The program specifically targeted students who were low-performers in mathematics on the previous year's state assessment. In Summer 2012, a total of 193 students within the specified grade levels were enrolled in the summer robotics program in eight different sites throughout the city. A total 166 students were enrolled in 2012-13 in grades 6 to 8 in the district, had not been retained in grade, and had both a 2013 and 2013 mathematics score. Table 1 summarizes the significant demographic and behavioral differences between the students who attended the summer school robotics program from the full group of students who did not attend summer school (as evidenced especially in their attendance rates during the regular school year and the large majority of males as program participants), as well as differences between the prior characteristics of their post-program schools.

Research Design:

Program pre-enrollment and district policy did not permit random assignment of students to the summer program treatment condition. The research design was quasi-experimental, with program students matched to comparison students who did not attend summer school using propensity score and Mahalanobis metric matching. Only potential control students who did not attend summer school and who did have data on the prognostic covariates (prior year's attendance and prior year's state mathematics z-score) as well as the outcome variables were included in the matching analyses. In this two-step method, all control subjects meeting these requirements who were within ± .2 of the estimated propensity score of each treated subject were identified as potential matches. Then, Mahalanobis metric matching on the two prognostic covariates was used to make a final selection of up to three matches for each treated student. Within each prior grade level (fifth, sixth, and seventh), we selected a comparison group subsample from among our larger sample of potential control subjects (so that the comparison group subsample had similar covariate values to the treatment sample on 15 covariates, including on the 2 key "prognostic" covariates). All of the matching was performed using nearest-remaining-neighbor matching, beginning with the most difficult to match treated subject (the one with the highest propensity score) and proceeding to the subject with the lowest propensity score. The propensity scores were estimated using logistic regression with linear terms for each covariate.

Data Collection and Analysis:

The district shared program record data and student administrative data with the research team. The primary outcome variable for this study was yearly attendance rate (percent of days attended), calculated for all students from district administrative records on attendance in the year following the summer program treatment. Mathematics achievement in the spring following the summer program intervention was another outcome variable for the overall study.

The treatment variable indicates for each student whether he or she was in the Robotics enrichment during summer school group (coded 1) or the matched comparison group with no summer school (coded 0). All covariates were grand mean centered in the impact models. Students were nested in the summer treatment sites, not the post-treatment schools, so in addition to their individual characteristics we estimated as level 1 variables the value of school level characteristics (measured the year prior to intervention) of the school attended the year following the intervention. All covariates were pre-specified and included in the final model, regardless of their statistical significance (see list in Table 4).

We used a two-level fixed effects model with covariates that assumed homogeneity of the treatment effects across sites. The treatment students were nested in eight summer treatment sites, and control students were nested together in a ninth site (no treatment). This follows the constant block effect model described by Dong and Maynard (in press).

Level 1 describes the relationship between students' outcomes, student-level characteristics, and their treatment status. The level 1 model is

$$Y_{iJ} = \beta_{0j} + \beta_{1J}T_i + \Sigma\beta_{2s}X_{sij} + e_{ij},$$

where

Y_{iJ} is an outcome for student $_I$ in site $_j$;

T_i is 1 if the student is the treatment group and 0 otherwise;

X_{ij} is a set of S student-level covariates (described above) for student $_I$ in site $_j$, measured in the year prior to treatment exposure and centered on the grand mean in the sample; and

e_{ij} is a random error term for student $_I$ from site $_j$, assumed to be independently and identically distributed across students within sites (i.e., the "within-site" residual).

Level 2: Sites

$$\beta_{0j} = \gamma_{00} + u_0$$

$$\beta_{1J} = \gamma_{10}$$

$$\beta_{2s} = \gamma_{2S} \textit{ (and so on for each covariate)}$$

where

γ_{00} *is the grand mean*

γ_{10} is the main effect of treatment

The set of γ_{2S} regression coefficients represent the relationships between students' outcomes and the covariates, with each coefficient assumed to be constant across sites, U_{0j} J=1,…,J are fixed effects associated with each site effect, and are constrained to have a mean of zero. All available covariates described earlier were included in the final model, regardless of their statistical significance. To test for baseline equivalence between the treatment and control students on attendance, we estimated a hierarchical linear model in the form specified above in which prior year's attendance was predicted by treatment status (controlling for grade level dummy variables).

Findings / Outcomes:

Baseline equivalence between the treatment and control group was achieved (Table 3). As shown in Table 4, the adjusted mean attendance rate of the treatment students was 1.4 percentage points higher than control students. This impact was both statistically significant ($t(631) = 3.52$, $p = .001$), and large enough to be educationally meaningful, Glass's $\Delta = .34$ Another way of stating the impact is that treatment students attended about 2.5 days more of the 180-day school year on average. Parallel analyses were conducted on the subgroup of low-achieving students (60 treatment students who scored Basic on the math pre-test and their 167 matches from the comparison group). Baseline equivalence was again achieved. As shown in Table 4, the adjusted mean attendance rate of the treatment students in the subsample was 2.6 percentage points higher. This impact was both statistically significant ($t (206) = 2.865$, $p = .005$), and large enough to be educationally meaningful, Glass's $\Delta = .33$. Another way of stating the impact is that treatment students in the subsample attended, on average, about a week more of school than did the control students in the subsample (i.e., attended 4.7 days more during the course of the 180-day school year.)

Conclusions:

It is important to point out the limitations of this study. Although the propensity score matching yielded a comparison group with baseline equivalence on prior attendance, and the analysis also controlled for all covariates, the study's quasi-experimental design, like all such designs, was subject to potential unmeasured bias in the self-selection of summer program participants. It is possible that even though matched comparison groups students were equivalent to program students on prior school attendance rates, as well as on all the other matching variables, they differed in some unmeasured way that would explain their higher school attendance in the year following the program. At the same time, while random assignment of students to the summer school program or control condition would have been a stronger design, such a design would have been subject to non-compliance among the students assigned to summer school treatment and to differential attrition that could undermine internal validity.

Despite its limitations, the findings of this study emphasize the importance of investigating the potential impact of out-of –school programs on school-focused engagement. As Lawson and Lawson (2013) argue, research on school engagement needs to move beyond the traditional classroom and school to include out-of-school and community-focused activities. Activities outside of the regular school schedule can potentially build developmental competencies -- particularly feelings of confidence, competence, and connection -- that can keep students attached enough to school through attendance to increase their likelihood of success after leaving high school. Further research on the impact of similar programs on student engagement measures (in addition to academic achievement measures) will be a useful investment.

"Motivating the academically unmotivated " is one of the critical issues of the 21st century, as Hidi and Harackiewicz (2000, p. 151) have argued. Finding ways to stir up student interest in pursuing learning activities to maintain even the crudest indicator of engagement, simple school attendance, remains a challenge for most high-poverty secondary schools. Prior research has noted that attendance (together with behavior and course grades) is much more important than test scores as a predictor of high school graduation (e.g., Balfanz, Herzog, & Mac Iver, 2007; Allensworth & Easton, 2007). While test scores may become more important as states continue to institute graduation testing requirements, and certainly predict the need for remediation as students transition to college, it is important not to ignore the impact of improving attendance on students' college and career readiness. Attending class in college and showing up to work every day are critical determinants of college and career success. Increasing attendance in middle and high school is the first step to getting urban students ready for college and career.
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Appendices

Appendix A. References (from full paper)

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Appendix B. Tables and Figures

TABLE 1

Differences in Group Means between Robotics Summer Program Students and Non-Program Students Before Propensity Score Matching, By Prior Grade Level

	Grade 5			Grade 6			Grade 7		
	Program Students (n=57)	Non-program Students (n=4527)	Std. Mean Diff.	Program Students (n=63)	Non-Program Students (n=4388)	Std. Mean Diff.	Program Students (n=46)	Non-Program Students (n=4406)	Std. Mean Diff.
Male	0.72 (.45)	0.48 (.50)	0.53	0.70 (.46)	0.48 (.50)	0.50	0.76 (.43)	0.49 (.50)	0.00
FRL	0.86 (.35)	0.89 (.32)	-0.07	0.87 (.34)	0.88 (.32)	-0.01	0.80 (.40)	0.86 (.34)	-0.17
Minority	0.91 (.29)	0.87 (.34)	0.17	0.97 (.18)	0.88 (.33)	0.53	0.96 (.21)	0.88 (.33)	0.41
Spec. Ed	0.12 (.33)	0.15 (.36)	-0.10	0.22 (.42)	0.15 (.35)	0.16	0.20 (.40)	0.14 (.35)	0.17
Overage	0.11 (.45)	0.21 (.41)	-0.37	0.27 (.45)	0.21 (.41)	0.15	0.20 (.40)	0.22 (.41)	-0.08
Changed schools	0.02 (.13)	0.07 (.25)	-0.38	0.06 (.25)	0.08 (.27)	-0.08	0.04 (.21)	0.07 (.25)	-0.12
Suspended	0.07 (.26)	0.08 (.27)	0.03	0.10 (.30)	0.12 (.32)	-0.09	0.09 (.29)	0.12 (.33)	-0.15
Summer School prior year	0.46 (.50)	0.23 (.42)	0.46	0.27 (.45)	0.14 (.35)	0.33	0.52 (.51)	0.12 (.33)	0.84
Prior Math z-score	0.02 (1.13)	-0.03 (.99)	0.02	0.35 (.82)	0.38 (.92)	0.01	-0.12 (1.01)	0.06 (1.0)	-0.11
Prior attendance	96.9 (4.39)	95.0 (5.38)	0.42	95.96 (5.6)	94.84 (5.74)	0.18	97.07 (2.56)	94.35 (6.72)	1.11
Prior Year Characteristics of Students Post-Intervention School									
Enrollment	232 (141)	220 (135)	0.07	271 (146)	221 (136)	0.38	300 (161)	226 (138)	0.52
%FRL	81.2 (13.8)	84.9 (12.5)	-0.30	82.3 (14.5)	85.0 (12.5)	-0.21	82.6 (13.1)	85.3 (11.9)	-0.29
Charter	0.19 (.40)	0.19 (.39)	0.00	0.13 (.34)	0.18 (.39)	-0.18	0.07 (.25)	0.17 (.38)	-0.45
Middle School	0.28 (.45)	0.25 (.43)	0.06	0.30 (.46)	0.25 (.43)	0.09	0.22 (.42)	0.27 (.44)	-0.15
Middle High	0.16 (.37)	0.13 (.34)	0.06	0.22 (.42)	0.13 (.33)	0.25	0.22 (.42)	0.13 (.34)	0.18
Avg. Math z-score	0.04 (.51)	0.02 (.49)	0.05	-0.05 (.46)	0.03 (.48)	-0.14	0.05 (.46)	0.02 (.49)	0.14

(Standard deviations in parentheses)

TABLE 2
Results for Differences in Group Means between Robotics Summer Program Students and Comparison Students after Propensity Score Matching, By Prior Grade Level

	Grade 5			Grade 6			Grade 7		
	Program Students (n=57)	Comparison Students (n=169)	Std. Mean Diff.	Program Students (n=63)	Comparison Students (n=189)	Std. Mean Diff.	Program Students (n=46)	Comparison Students (n=128)	Std. Mean Diff.
Male	0.72 (.45)	0.73 (.44)	-0.03	0.70 (.46)	0.70 (.46)	0.00	0.76 (.43)	0.76 (.43)	0.00
FRL	0.86 (.35)	0.89 (.32)	-0.08	0.87 (.34)	0.89 (.31)	-0.06	0.80 (.40)	0.80 (.40)	0.01
Minority	0.91 (.29)	0.92 (.27)	-0.04	0.97 (.18)	0.97 (.16)	-0.03	0.96 (.21)	0.96 (.19)	-0.04
Spec. Ed	0.12 (.33)	0.09 (.29)	0.09	0.22 (.42)	0.18 (.39)	0.10	0.20 (.40)	0.20 (.40)	-0.02
Overage	0.11 (.45)	0.12 (.33)	-0.06	0.27 (.45)	0.25 (.43)	0.05	0.20 (.40)	0.21 (.40)	-0.04
Changed schools	0.02 (.13)	0.02 (.13)	0.00	0.06 (.25)	0.05 (.21)	0.07	0.04 (.21)	0.06 (.24)	-0.09
Suspended	0.07 (.26)	0.07 (.26)	0.00	0.10 (.30)	0.06 (.24)	0.11	0.09 (.29)	0.12 (.32)	-0.10
Summer School prior year	0.46 (.50)	0.47 (.50)	-0.03	0.27 (.45)	0.25 (.43)	0.05	0.52 (.51)	0.46 (.50)	0.13
Prior Math z-score	0.02 (1.13)	0.04 (1.10)	-0.02	0.35 (.82)	0.37 (.80)	-0.02	-0.12 (1.01)	-0.12 (.93)	0.00
Prior attendance	96.9 (4.39)	96.8 (4.1)	0.02	95.96 (5.6)	96.39 (4.77)	-0.08	97.07 (2.56)	97.50 (2.39)	-0.17
Prior Year Characteristics of Students Post-Intervention School									
Enrollment	232 (141)	245 (164)	-0.09	271(146)	274 (161)	- 0.02	300 (161)	310 (157.1)	-0.06
%FRL	81.2 (13.8)	81.6 (17.8)	-0.03	82.3 (14.5)	82.0 (16.1)	0.02	82.6 (13.1)	83.6 (14.9)	-0.06
Charter	0.19 (.40)	0.19 (.39)	0.03	0.13 (.34)	0.17 (.38)	-0.14	0.07 (.25)	0.14 (.35)	-0.30
Middle School	0.28 (.45)	0.23 (.42)	0.10	0.30 (.46)	0.34 (.48)	-0.09	0.22 (.42)	0.31 (.46)	-0.22
Middle High	0.16 (.37)	0.12 (.32)	0.11	0.22 (.42)	0.19 (.39)	0.07	0.22 (.42)	0.24 (.43)	-0.06
Avg. Math z-score	0.04 (.51)	0.07 (.53)	-0.06	-0.05 (.46)	-0.03 (.53)	-0.02	0.05 (.46)	-0.06 (.54)	0.21

(Standard deviations in parentheses)

TABLE 3
Results from HLM Models Predicting Baseline Student Level Attendance Rates (Year Prior to Intervention) for Full Sample and for Sub-Sample of Low-Performing Students in Mathematics

	Full Sample (n=652)		Low-Performing Students (n=227)	
	Coefficient	Std. Error	Coefficient	Std. Error
Intercept	96.84***	(0.65)	95.86***	(0.95)
Treatment	-0.31	(0.76)	-0.42	(1.23)
Sixth grade prior year	-0.58	(0.38)	-0.61	(0.88)
Seventh grade prior year	0.55	(0.42)	1.72	(0.91)

*p<.05 ** P < .01 *** P<.001

Grade level dummy variables were grand-mean centered.

TABLE 4
Results from HLM Models Predicting Student Level Attendance Rates in the Year Following Intervention for Full Sample and for Sub-Sample of Low-Performing Students in Mathematics

	Full Sample (n=652)		Low-Performing Students (n=227)	
	Coefficient	Std. Error	Coefficient	Std. Error
Intercept	95.61***	(.20)	93.82***	(0.46)
Treatment	1.38**	(.39)	2.58**	(0.90)
Male	0.13	(.39)	0.18	(1.04)
FRL	-0.71	(.54)	-0.87	(1.28)
Minority	-0.26	(.83)	-0.78	(2.25)
Special Ed	-0.46	(.48)	-0.53	(0.87)
Overage for grade	-0.03	(.45)	0.98	(0.86)
Changed schools	-0.15	(.87)	-1.27	(1.89)
Suspended	-0.82	(.65)	-2.01	(1.41)
Summer school prior year	0.92*	(.36)	1.12	(0.85)
Prior attendance	0.65***	(.05)	0.70***	(0.08)
Prior Math z-score	0.75**	(.21)	0.52	(0.86)
Sixth grade prior year	-0.13	(.42)	0.31	(1.31)
Seventh grade prior year	0.64	(.46)	2.12	(1.14)
Prior Year Characteristics of Students' Post-Intervention School				
Enrollment	0.00	(.00)	-0.01	(0.00)
%FRL	0.01	(.02)	0.03	(0.05)
Charter	0.05	(.56)	-0.51	(1.38)
Middle School[1]	0.93*	(.46)	1.62	(1.02)
Middle High	1.45**	(.55)	1.96	(1.20)
Avg. Math z-score	-.0.43	(.59)	0.40	(1.47)
Avg. Attendance	0.10	(.07)	0.10	(0.14)

*p<.05 ** P < .01 *** P<.001

[1] Reference groups are Grade 5 in prior year, K8 schools, did not change schools during prior year, etc. All covariates are grand-mean centered.