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April 30, 2024 **Efficacy Research**

Comparing 2023 MCAS 5th and 8th Grade Science Achievement for STEMscopes and Non-STEMscopes Schools in Massachusetts

Background

The present study examines the efficacy of the STEMscopes Science 5th grade curriculum. Employing a post-facto quasi-experimental design (QED) with a matched control group, we the potential association between STEMscopes Science and science outcomes on the 2023 Next Generation Massachusetts Comprehensive Assessment System (MCAS). **QED efficacy studies with matching meet the requirements for ESSA Tier 2 evidence and the What Works Clearinghouse (WWC) 5.0 Group Design Standards with reservations.**

We also consider school-level science achievement in several student sub-populations. Specifically, previous results in the field (Morgan, Farkas, Hillemeier, & Maczuga, 2016) suggest there is a need for science curriculums that can engage students with diverse experiences and backgrounds and give then opportunities based on where they currently are in their science learning trajectory. Past STEMscopes reports suggest that STEMscopes may have a stronger association with standardized science test outcomes among minorities (particularly black/African American students and Latino/Hispanic students) as well as students considered low-income and students who receive special education services.

Thus, within the current report we consider: 1) potential group differences in science achievement for STEMscopes versus non-STEMscopes schools. Overall, we hypothesize that even with the more stringent matched control group QED design, schools that purchased and used STEMscopes during the 2022-2023 school year will achieve higher science outcomes on the 2023 MCAS science test than schools that did not purchase STEMscopes (i.e., "non-STEMscopes schools"). Specifically, we tested whether a higher percentage of students "passed" (met or exceeded state set benchmarks) in STEMscopes versus non-STEMscopes schools, whether STEMScopes schools had significantly high average scale scores on the MCAS as well as higher school percentile ranks relative to matched non-STEMscopes schools. 2) We also anticipate significant associations between STEMscopes Science and school 5th grade MCAS science outcomes among subgroups of students.

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Results

To examine our hypothesis that STEMscopes Science schools will have higher 5th grade science outcomes on the MCAS, we conducted multiple regression analyses with 234 matched Massachusetts schools. Our first set of analyses focused on predicting 2023 MCAS 5th grade school "passes" grade level expectation rates (includes students who either met or exceeded grade level) as well 5th grade school level average scale score and school percentile rank. We created a binary variable to indicate if a school was a STEMscopes school or non-STEMscopes school, and we include several covariates (see methods). Results indicated a significant and positive increase in the school average scale score ($b = 1.68$, $p < .05$, ES = 0.12) and school percentile rank ($b = 3.67$, $p<.05$, ES = 0.14) for the STEMscopes schools versus the non-STEMscopes schools, see Table 1. There was also a trend level finding ($p < .10$) indicating a potential positive effect of STEMscopes on school passing rates (meets and exceeds) relative to non-STEMscopes schools ($b=2.10$, $p = .09$, ES = 0.08, see Table 1 and Figure 1.

In addition, the sub-group analyses indicated positive effects for all tested sub-groups. Statistically significant positive curricular effects were found such that average school-level scale scores were higher among males ($b=1.94$, $p < .05$, ES = 0.16) and students with disabilities ($b=2.56$, $p < .05$, ES = 0.09) in STEMscopes schools versus non-STEMscopes schools (see Figure 2). Although not significant at the $p = 0.05$ level, there were trend-level findings ($p < .10$) such that average schools scale scores were higher among Hispanic students ($b = 1.90$, $p = .09$, ES = 0.11) and low-income students ($b=1.57$, $p = .08$, ES = 0.19) in STEMscopes versus non-STEMscopes schools.

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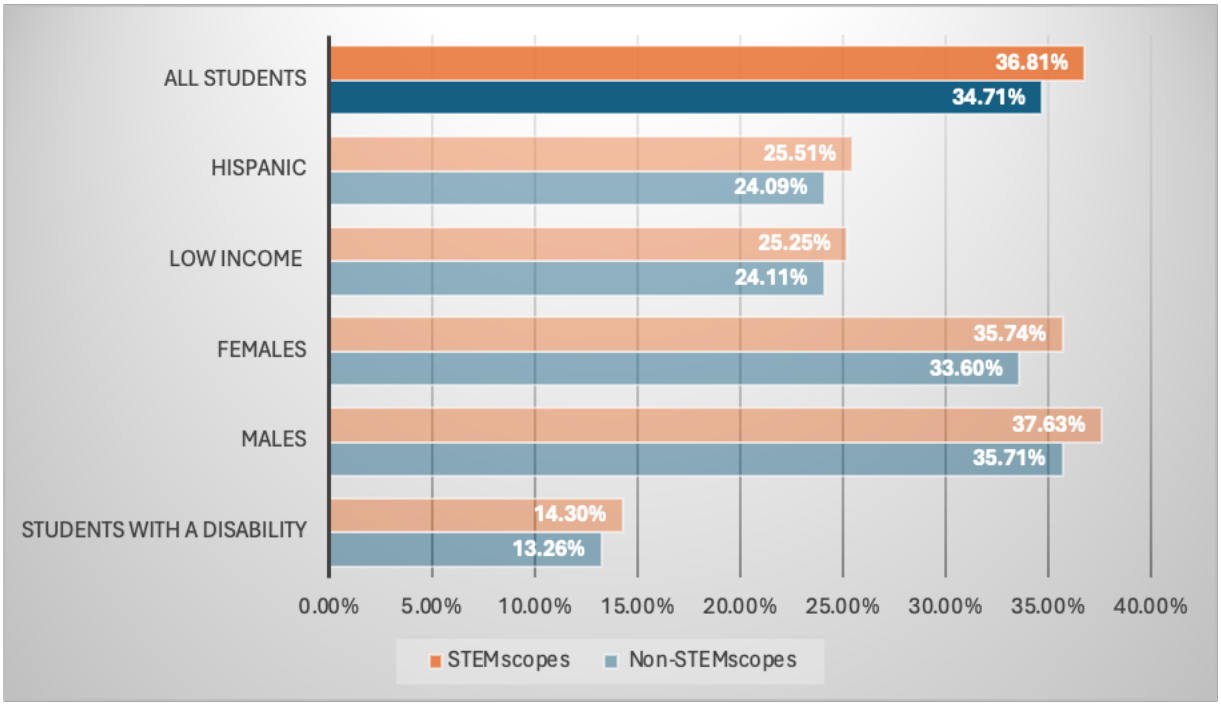

Figure 1. STEMscopes is Positively Related to MCAS School Passing Rates After Controlling Covariates

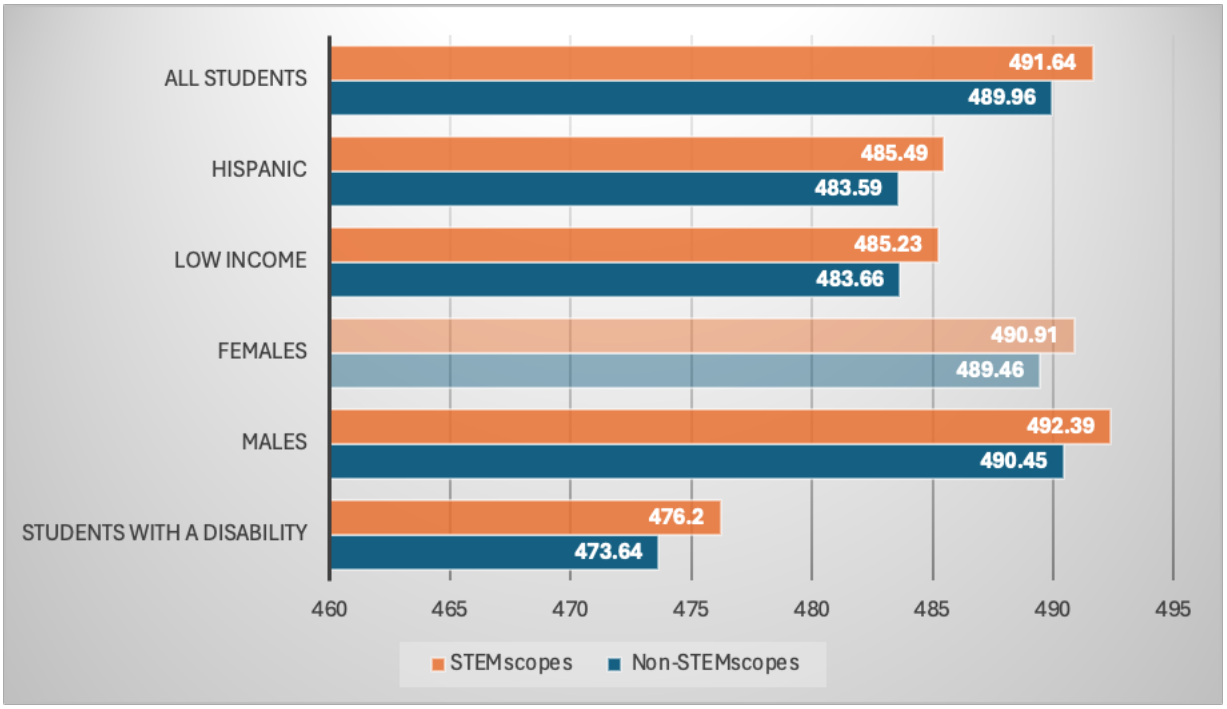

Figure 2. STEMscopes is Positively Related to MCAS School Average Scale Scores After Controlling Covariates

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Table 1. *Science Outcomes and Estimated Effects of STEMscopes Science (n=234)*

Outcome	Non-STEMscopes M (SE)	STEMscopes M (SE)	STEMscopes vs. Non-STEMscopes difference (b)	Effect size (Cohen's D)
School level percent "Passed" MCAS (all students)	**34.71 (0.87)**	**36.81 (1.23)**	**2.10[t]**	**0.08**
School Average Scale Score (all students)	**489.96 (0.54)**	**491.64 (0.76)**	**1.68***	**0.12**
School Percentile Ranking (all students)	**40.37 (1.21)**	**44.04 (1.71)**	**3.67***	**0.14**
Male "Passed" MCAS	35.71 (1.03)	37.63 (1.44)	1.92	0.03
Male Average Scale Score	**490.45 (0.62)**	**492.39 (0.93)**	**1.94***	**0.16**
Female "Passed" MCAS	33.60 (1.11)	35.74 (1.54)	2.14	0.11
Female Average Scale Score	489.46 (0.67)	490.91 (0.93)	1.44	0.11
Low income "Passed" MCAS	24.11 (0.94)	25.25 (1.29)	1.13	0.10
Low-income Average Scale Score	**483.66 (0.64)**	**485.23 (0.89)**	**1.57[t]**	**0.19**
Hispanic "Passed" MCAS	24.09 (1.30)	25.51 (1.59)	1.42	0.11
Hispanic Average Scale Score	**483.59 (0.92)**	**485.49 (1.14)**	**1.90[t]**	**0.20**
Students with a Disability "Passed" MCAS	13.26 (1.07)	14.30 (1.48)	1.04	0.07
Students with a Disability Average Scale Score	**473.64 (0.82)**	**476.20 (1.14)**	**2.56***	**0.09**

*= p < .05; **= p<.01; [t]=p<.10.

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Methods

In this section we provide details about study procedures including the data sources, variables used, and participating schools.

Data sources

Data for this study came from two sources. We identify schools that purchased and used STEMscopes for 5th grade in the 2022 - 2023 school year through the STEMscopes analytics and Sales Force systems. Within the analytics reports, we used the number of 5th grade scopes accessed as a metric of use and then confirmed usage with our internal Sales Force reports (to rule out schools that had free trial usage). We defined a school as using the curriculum if the teacher accessed at least 3 of the available science units (called scopes) for 5th grade during the period from Aug 1 – May 15. We use this criterion to help rule out when other grade levels may have accessed a 5th grade unit (e.g., sometimes a 4th grade teacher will access a 5th grade unit).

Second, school demographic data and school performance on the MCAS were accessed through the Massachusetts Department of Education website. We used the 2021 - 2022 MCAS school achievement reports for 4th grade and focused on the school level "meets and exceeds" on the MCAS mathematics test as a baseline measure of academic achievement. Specifically, the state of Massachusetts creates proficiency benchmarks in all academic content and identifies students as not meeting grade level expectations, partially meeting grade-level expectations, meeting grade-level expectations, and exceeding grade-level expectations. The state of Massachusetts focuses on the combined "meets and/or exceeds grade level expectation" as the state passing rate. We use the MCAS math as baseline as the science test is not administered in 4th grade. We wanted to ensure it was (approximately) the same students contributing scores to a school's passing rate, noting that math and science on the MCAS correlate highly (e.g., $r = 0.89$ in 2021-2022 8th grade).

We downloaded 2022-2023 school enrollment data by race/ethnicity. This provided complete race/ethnicity percentage data by school. We also used the selected populations report that included complete percentages by school of sub-populations of students including English language learners (ELL), students with disabilities, and low-income students. We used these variables to match STEMscopes and non-STEMscopes schools (details are included in the participants section below). Once matching was complete, and

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baseline analyses were conducted (see baseline equivalence), we downloaded the 2023 MCAS school achievement reports for 5th grade for all students and for student sub-populations. We analyzed school-level data across the combined "meets and exceeds" grade-level expectations. We also ran analyses with "Average Scale Score" by school and "school percentile rank." relative to other schools.

Missing data

For the Massachusetts data there was no missingness in the background demographic data and limited missingness in outcomes. Specifically, 10% of data was missing for the 4th grade math baseline achievement variable. The 2023 outcome data had more missingness. This was because certain sub-populations were not present in many schools. We handled missing data in two ways. For any covariate variable used to match schools, we used multiple imputation by chained equations via R-studio's "MICE" package with the "CART" imputation method (see Van Buuren and Groothuis-Oudshoorn, 2011). We use MICE procedures during this step to ensure complete data for matching procedures via R-Studio's "Match-it" package. Once data were matched, in all final analyses, we used R-Studio's "Lavaan" package, which uses full information maximum likelihood procedures to handle missing outcome data.

Participants

In the 2022-2023 school year, the overall number of regular public Massachusetts elementary schools that purchased and used STEMscopes (in any capacity) for 5th grade was 162 out of 868 elementary schools with state report data (~19%). Of the STEMscopes schools, 117 (72%) met the criterion of schoolwide usage of at least three science units (scopes) and were eligible for the study.

To match schools based on the data available from the Massachusetts DOE website we used R-Studio's "Match-it" package with one-to-one matching with optimal pair matching. We used 5th grade total enrollment (as an indicator of school size), school level race ethnicity percentages, baseline achievement, as well as percentages of ELL, low-income, and students with a disability to match schools.

Baseline Equivalence

For all covariate variables (the variables used for matching), including baseline academic achievement, there were no significant differences between matched groups (see Table 2). However, the What Works Clearinghouse (WWC) standards require that baseline

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differences for a single variable with a standard mean difference greater than 0.05 must be controlled for statistically. Following the advice of Stuart, 2010, we include all covariates that were not collinear in the final analyses as a complementary approach to matching and a more stringent test of effects. Several race/ethnicity variables were correlated above -/+0.70. Specifically, in both grades, the percentage of students who were Hispanic/Latinx was highly positively correlated with the percent of students who reported being English language learners and low-income students, as well as highly negatively correlated with the percent of students who were White/Caucasian. Likewise, White/Caucasian was also highly negatively correlated with low income. With this in mind, we present models where the percentage of Hispanic is included but White/Caucasian, percentage of low-income students, and percentage of ELL are excluded. We ran sensitivity analyses where these variables were separately included (but the percent Hispanic was excluded) and a collinear model with all variables. The results of the sensitivity analyses all followed the same patterns. The inclusion of these covariates satisfies the WWC standard, as several variables had standard mean differences greater than or equal to 0.05.

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Table 2: Baseline comparison of matched STEMscopes and non-STEMscopes schools

Variables	State Total	Matched Sample Total	Non-STEMscopes	STEMscopes	t-value	p-value	Effect Size
5th grade baseline variables							
Baseline school 4th grade Math passing rate 2022	42%	36.1%	35.1%	37.0%	0.70	0.48	0.09
Grade 5 enrollment	75.2	84.9	89.7	80.1	1.15	0.25	0.15
Percent low-income students	42.3%	54.6%	54.7%	54.5%	0.06	0.95	0.01
Percent Black/African American students	9.4%	8.8%	8.9%	8.7%	0.13	0.90	0.02
Percent Latino/Hispanic students	24.2%	35.5%	34.6%	36.4%	0.49	0.62	0.06
Percent Asian students	7.3%	4.6%	4.5%	4.7%	0.16	0.87	0.02
Percent White/Caucasian students	54.4%	46.9%	47.8%	45.9%	0.46	0.64	0.06
Percent Multi-racial students	4.4%	3.9%	3.8%	4.0%	0.59	0.56	0.07
Percent of English Language Learners (ELLs)	12.1%	13.7%	14.3%	13.0%	0.73	0.46	0.10
Percent of special education students	19.4%	21.7%	21.5%	21.9%	0.33	0.74	0.04

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Planned analyses

Analyses were conducted with R-studio's Lavaan structural equation modeling package because this package includes estimation with full information maximum likelihood (FIML) to handle missing data. FIML procedures to handle missing data estimation ensure that in the final analyses the estimation is not biased. Our main variables of interest were the 2023 5th grade science outcomes on the Next Generation MCAS. In addition to the main outcome analyses, we ran follow-up regression to evaluate MCAS outcomes for males, females, low income, Hispanic, and students with disabilities student sub-populations. All other sub-population variables included too much missingness to be considered (e.g., greater than 50% missing).

Conclusion

The current study provides efficacy evidence for the STEMscopes Science 5th grade curriculum. Specifically, positive significant effects were found and provide evidence that STEMscopes Science increases schools' overall average scale scores on the MCAS and the schools' percentile rank relative to non-STEMscopes schools. Among sub-groups, analyses indicated that school-level average scale scores for the studied student sub-populations were also impacted by STEMscopes. The effect sizes indicated small program effects that are consistent with early program usage for many schools and regardless of promising efficacy findings, implementation can take years to be fully integrated with routine practice (Rangel, Bell, Monroy, & Whitaker, 2015; Sanetti & Collier-Meek, 2019). The findings also indicate that the average scale score is a more sensitive measure of change than the percentage of students meeting a given benchmark. One of the limitations of the current study is that it focuses on school-level change, which is less nuanced to program effects than considering individual student changes in science knowledge and skills. Nevertheless, this study provides a stringent test of effects using a quasi-experimental design that meets the What Works Clearinghouse (WWC) 5.0 standards with reservations What Works Clearinghouse, 2022) and ESSA Tier 2 evidence.

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