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October 16, 2024 **Efficacy Research**

Comparing 2024 TNReady! Elementary Math Achievement for STEMscopes and Non-STEMscopes Schools in Tennessee

Background

The current study examined the efficacy of the STEMscopes Math 4th grade curriculum. We used a post-facto quasi-experimental design (QED) with a matched control group to evaluate the potential association between STEMscopes Math and Math achievement on the 2024 Tennessee Ready! Math Assessment (TNReady!). **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.** Since standardized math assessments are given in each grade, we first evaluated within school change in student passing rates. We used the 2023 3rd grade passing rate as a baseline measure. Students then received STEMscopes Math across the 4th grade year, and the 2024 TNReady passing rate was used as a post-measure to evaluate the impact of STEMscopes Math on elementary school passing rates as children transition from 3rd through 4th grade. We then considered group differences in the 4th grade passing rate between STEMscopes Math schools and non-STEMscopes Math schools that used different curricular resources.

For both analyses (within and across schools), we considered school level math achievement in several student groups. This helps us understand what students may be most benefiting/ most taking advantage of the 5E model offered within the STEMscopes Math curriculum. Past STEMscopes reports suggest that STEMscopes Math may have a stronger association with standardized math test outcomes among minorities (particularly Black/African American students and Latino/Hispanic students) and English language learners.

Thus, within the current report we consider: 1) potential within school changes in math achievement as indexed by school passing rates year over year with STEMscopes Math, and 2) group differences in math achievement for STEMscopes Math versus non-STEMscopes schools. Overall, we hypothesize that even with the more stringent matched control group QED design, schools that purchased and used STEMscopes Math during the 2023-2024 school year will achieve higher math passing rates on the 2024 TNReady! math test relative to previous school passing rates in 2023 as well as compared to 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 2024 relative to 2023 in STEMscopes schools. We also tested if STEMscopes Math schools had higher 2024 passing rates versus non-STEMscopes schools. Finally, we tested and expected significant associations between STEMscopes Science and school TNReady! outcomes among subgroups of students.

Results

To evaluate changes within STEMscopes Math schools' passing rates, we initially ran paired t-tests with STEMscopes schools' 2024 4th grade TNReady! Math passing rates (i.e., the percent of students that met and exceeded state level benchmarks) as the outcomes and 2023 3rd grade passing rates as the predictor. This allows us to test potential changes across the year that STEMscopes Math was used as the 4th grade curriculum, but only includes complete data within the analysis. After the t-tests, we used multiple regression within a structural equation model framework to evaluate a more stringent growth model that includes covariates (see methods) and

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utilized full information maximum likelihood to account for missing data. Models were run for all 4th grade students in a school and several groups of students (e.g., economically disadvantaged). Results indicated positive significant growth in STEMscope's schools passing rates between 2023 and 2024 (See Table 1 and Figure 1). Specifically, using the more stringent SEM models, there was an estimated 14.76 percentage point increase in 4th grade TNReady! passing rates relative to the prior years' 3rd grade passing rates (b = 14.76, $p < .05$, ES = 0.73). All student group analyses yielded positive significant change ranging between 5.20-16.72 percentage point increases (ES: 0.41 – 0.79) in student 4th grade passing rates. As can be seen in the last two columns of Table 1, the analysis with complete cases yielded similar findings. Thus, there is evidence of positive, significant growth in math achievement (as indexed by passing rates) across the 4th grade year with use if the STEMscopes Math Curriculum.

Table 1: STEMscopes is Positively Related to within School Increases in TNReady! 4th Grade Math Passing Rates

Outcome populations	TNReady 2023	TNReady 2024	Estimate (SE)	p	g	Complete cases t-value (DF)	p
All Students	34.11%	48.87%	14.76 (2.09)	<.01	0.72	4.18 (67)	<.01
Females	29.92%	37.94%	8.02 (2.15)	<.01	0.38	1.89 (65)	0.06
Males	38.36%	54.92%	16.56 (2.10)	<.01	0.79	4.98 (65)	<.01
African American/Black	24.78%	32.05%	7.27 (1.55)	<.01	0.64	5.05 (51)	<.01
Hispanic / Latinx	29.18%	34.38%	5.20 (2.35)	0.03	0.41	3.16 (39)	<.01
White/Caucasian	50.57%	67.29%	16.72 (2.17)	<.01	0.79	4.82 (39)	<.01
Economically Disadvantaged	21.74%	28.66%	6.93 (1.63)	<.01	0.62	3.96 (54)	<.01

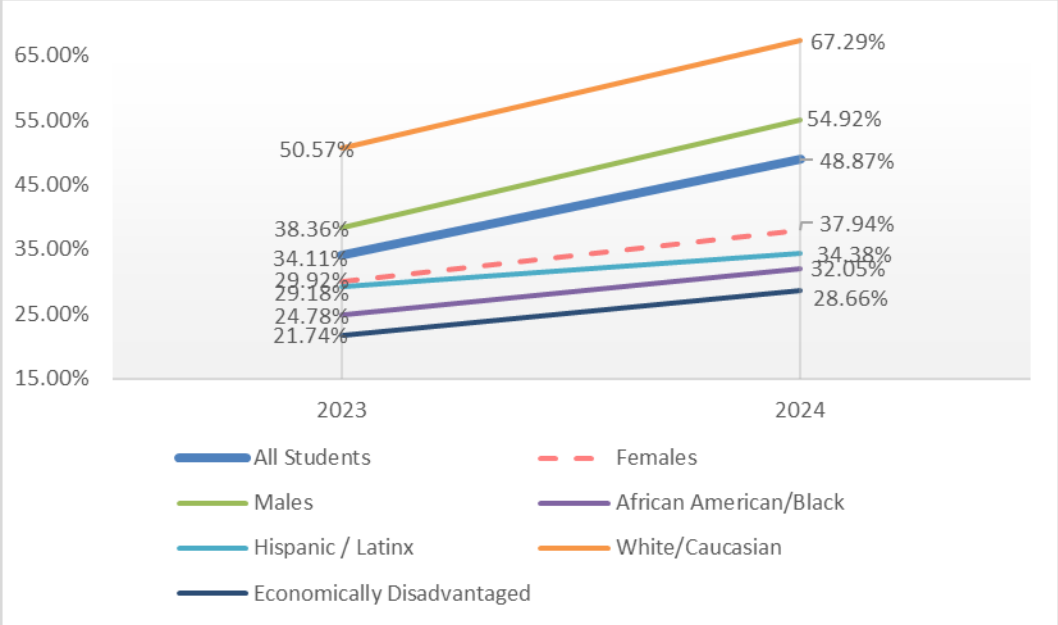

Figure 1. STEMscopes is Positively Related to within School Increases in TNReady! Passing Rates

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Next, we evaluated the effect of STEMscopes Math on schools' 2024 TNReady! 4th grade passing rates *relative* to schools that did not use STEMscopes Math as their curricular resource (Non-STEMscopes schools). As part of this analysis, we matched STEMscopes schools to non-STEMscopes schools across key school demographics to ensure that schools were comparable. We then used multiple regression with STEMscopes Math performance use as the main predictor, controlling for several covariates (see methods).

Results indicated that there was a significant positive effect of using the STEMscopes Math program in 4th grade, b = 5.10, $p < .01$; see Table 2. Of interest, this model is specified such that we can parse the unique effect of STEMscopes relative to potential passing rate increases without STEMscopes. Specifically, as can be seen in Table 2: the estimate associated with "2023 3rd grade TNReady!": 13.62 represents the estimated increase in the percent of 4th grade students that passed the TNReady! in 2024 in *non-STEMscopes* schools (that is, when STEMscopes Math program use = 0). This increase is relative to our estimated 3rd grade average passing rate: 30.36, and suggests that for non-STEMscopes Math schools, the estimated 2024 passing rate would equal (30.36 + 13.62) or 43.98. This is interesting and suggests that for the matched sample of Tennessee 4th grades, there was a robust increase in passing rates regardless of program. However, when we consider the STEMscopes Math estimate (b = 5.10, p < .001, ES = 0.42, this represents an additive effect such that schools with STEMscopes Math increased 5.10 percentage points above and beyond the non-STEMscopes schools' growth rate (30.36 + 13.62 + 5.10) or a 2024 TNReady! 4th grade passing rate of 49.08. As a follow-up, we added an interaction term to the analysis to test whether the effect of STEMscopes Math (as specified) in the previous model is uniform across various 3rd grade passing rates. That is, we tested whether schools that started with higher or lower passing rates in 3rd grade were differentially impacted by STEMscopes. This model yielded a non-significant interaction effect (b = 0.49, p = 0.78), indicating that the additive effect of STEMscopes Math was uniform across schools with different 3rd grade passing rates; thus, all schools increased similarly. When we consider the regular non-STEMscopes increase of 13.62 in school passing rates, the additive effect of STEMscopes (5.10) represents an ~37% increase above and beyond the increase in passing rates we saw in other schools.

Table 2

Model parameters	B (SE)	p-value
Intercept	30.36 (1.23)	<.001
2023 3rd grade TNReady!	13.62 (1.44)	<.001
STEMscopes	5.10 (1.61)	.002
Economic disadvantage	-4.46 (1.77)	.012
%Hispanic/Latinx students	-2.82 (0.98)	.004
%Students with disabilities	-2.09 (3.14)	.505
School size	2.68 (1.31)	.041

We also tested the additive effect of STEMscopes Math across different student groups (see Table 3 and Figure 2) using the same predictors but different student groups' passing rates as the outcome. In all cases, we saw a positive effect with estimated parameters between 2.57 - 8.99, however effects were significant for females, males, and White/ Caucasian students.

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Overall, findings suggest that STEMscopes Math positively influences schools' 4th grade math passing rates on TNReady! And that this effect is robust across student groups.

Table 3 The Estimated effect of STEMscopes on student groups school passing rates

Student group	Estimated effect of STEMscopes (SE)	p-value
Females	5.68 (1.88)	.003
Males	6.13 (1.75)	<.001
African American/Black	2.57 (2.34)	.271
Hispanic/Latinx	4.89 (3.37)	.147
White/Caucasian	8.99 (2.34)	<.001
Economically disadvantaged	2.85 (2.57)	.268

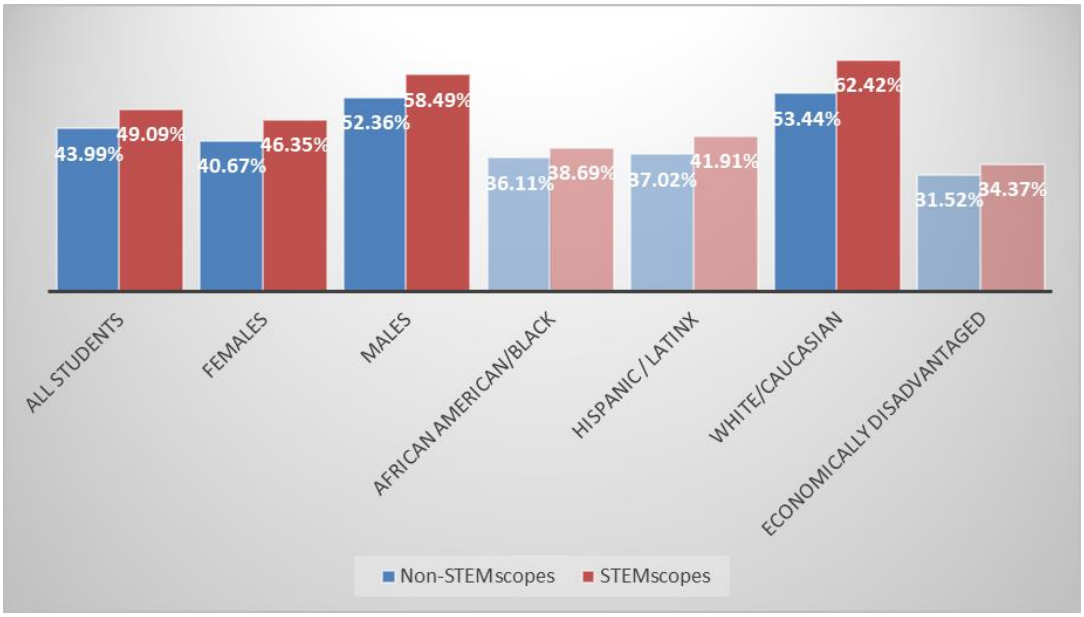

Figure 2. Comparing the effect of STEMscopes on student groups' school passing rates

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 identified schools that purchased and used STEMscopes in 4th grade during the 2023 - 2024 school year through the STEMscopes analytics and Sales Force systems. Within the analytics reports, we used the number of 4th grade scopes accessed as a metric of use, and then confirmed usage with our internal Sales Force reports.

Second, school demographic data and school performance on the TNReady! were accessed through the Tennessee.gov website. We used the 2022 - 2023 TNReady! school achievement reports for 3rd grade and focused on the school level "meets and exceeds" on the

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TNReady! mathematics test as a baseline measure of academic achievement. Specifically, the state of Tennessee creates proficiency benchmarks in all academic content and identifies students as below grade level expectations, approaching grade-level expectations, meeting grade-level expectation, and exceeding grade-level expectations. The state of Tennessee focuses on the combined "meets and/or exceeds grade level expectation" as the state passing rate. We use the TNREady! math as a baseline achievement measure to ensure it was (approximately) the same students contributing scores to a school's passing rate, making it possible to evaluate within and across school passing rate increases year over year for a specific set of students.

We also downloaded "school profile data" that included school total enrollment numbers as well as enrollment data disaggregated by gender, race/ethnicity, and several other student group categories. We used these variables to match STEMscopes and non-STEMscopes schools (details are included in the participants section below). Once matching was complete and baseline analyses were conducted (see baseline equivalence), we downloaded the 2024 TNReady! school achievement reports for all students and student groups. We analyzed school level data across the combined "meets and exceeds" grade level expectations.

Missing data

For the Tennessee data there was missingness in school background demographics. Specifically, 18% of data were missing for the 2023 3rd grade math baseline achievement variable. In relation to school demographic variables for matching, we used: percent economically disadvantaged, percent of Hispanic/Latinx students, total number of enrolled students, and percent of students with a disability. The missingness on these variables ranged from 2 – 25%. 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, with outcomes that had less than 50% missing considered.

Participants

In the 2023-2024 school year, the Nashville area public schools purchased STEMscopes Math district wide (n = 71 schools). To match schools based on the data available from the Tennessee.gov website we used R-Studio's "Match-it" package with the Mahalanobis Distance matching method. Mahalanobis Distance is designed to consider the multivariate space between numerous covariates when matching and can be very useful in smaller sample sizes (such as the current study). Specifically, rather than propensity scores, Mahalanobis Distance (Gu & Rosenbaum, 1993) is used as the distance metric, and it is considered both more robust to multiple covariate usage and to correlated covariates. Finally, using Mahalanobis distance in

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Match-it has the added benefit wherein one can prespecify an allowable multivariate distance between matched school pairs. Matching resulted in a final sample of 142 schools[1].

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 4). However, the What Works Clearinghouse (WWC) standards require that baseline 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 in the final analyses as a complementary approach to matching, and a more stringent test of effects.

[1] Due to the fact that all STEMscopes schools were in one district, we performed an additional analysis where STEMscopes schools were matched to non-STEMscopes schools in Shelby county- the largest district in Tennessee instead of schools across the state to ensure that results were similar when non-STEMscopes schools were also blocked within a single district. We used a 0.65 caliper to try and match as many schools as possible and were able to match 54/71 STEMscopes Math schools for a total sample of 108. All analyses were run with both the present full state matched sample and this district-to-district matched sample. The district sample provided a similar pattern of results. Thus, we present the larger sample, but the sensitivity analysis is available upon request.

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Table 4: Baseline comparison of matched STEMscopes and non-STEMscopes schools

Variables	Matched Sample Total	Non-STEMscopes	STEMscopes	t-value	p-value	Effect Size
Baseline variables						
Baseline school 3rd grade Math passing rate 2023	29.61%	30.39%	28.82%	0.48	.63	0.08
School size	438 students	449 students	426 students	0.88	.38	0.15
Percent low-income students	41.14%	40.90%	41.38%	0.15	.88	0.03
Percent Latino/Hispanic students	28.31%	26.41%	30.21%	1.06	.29	0.18
Percent of students with disabilities	16%	16.39%	15.61%	0.48	.63	0.08

Planned analyses

Analyses were conducted with R-studio. We initially ran paired t-tests in base R, and then used the Lavaan structural equation modeling package to run all regression analyses 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 2024 4th grade math outcomes on the TNReady!. In addition to the main outcome analyses, we ran follow-up regression to evaluate TNReady! outcomes for males, females, low income, Hispanic, African American/Black and White/Caucasian student groups. 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 Math 4th grade curriculum. Specifically, positive significant effects were found and provide evidence that STEMscopes Math increases school passing rates from year to year, with an average within school level increase of nearly 15 percentage points. Compared to schools that did not use STEMscopes, the additive effect of STEMscope Math results in an ~37% higher increase in 2024's TNReady! Passing rates relative to 2023. Findings also indicated gains among student groups (between 2.85- 8.99 percentage points). The effect sizes indicated medium program effects. This is very promising as 2024 represented the first year of program implementation for all STEMScopes Math schools; implementation can take years to be fully integrated with routine practice and may suggest that there is room for more improvement over time (Rangel, Bell, Monroy, & Whitaker, 2015; Sanetti & Collier-Meek, 2019). 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 math 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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