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The Effect of Desmos Math Curriculum on Middle School Mathematics Achievement in Nine States

A Matched-Comparison Study

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Executive Summary

Using a matched comparison design with almost 900 schools from 9 states, schools that used Desmos Math Curriculum in the 2021-22 school year for 6th, 7th, and 8th grade math instruction had significantly higher math achievement compared to similar schools who did not use Desmos Math Curriculum.

Introduction

Many educators and policymakers are interested in interventions that have been shown to improve math learning. This interest is driven, in part, by lackluster U.S. student performance on domestic and international math assessments in recent decades. Disruptions in schooling from COVID-19 have increased the urgency for interventions with strong evidence of improving math teaching and learning, particularly so for schools in underserved communities (Barnum, 2022).

Providing educators with high-quality curricular materials, and training and support for teachers to implement those materials as intended, is hypothesized to be a promising type of reform (e.g., see Lynch et al., 2019). And there are a growing number of K-12 math curricula that have been deemed high-quality by external reviewers in terms of coherence, rigor, and usability (e.g., see EdReports, 2023). Many of these high-quality programs utilize technology to support conceptual understanding and formative assessment, both of which have been shown to be effective in improving math learning in certain types of technology products (e.g., see Irving et al., 2016; Pane et al., 2014; Roschelle et al., 2010; 2016).

The current study is designed to contribute to the limited research base on effective math curricular programs. Specifically, it evaluates the impact of a program that includes a highly-rated core curriculum, *Illustrative Mathematics (IM) 6-8*, that has been enhanced with interactive, evidenced-based technology features developed by Desmos.

The Study

Desmos Math Curriculum is a core math curriculum, adapted from the open source *IM 6-8* curriculum. WestEd conducted a quasi-experimental study using genetic matching to estimate

the effect of using the widely available Desmos Math Curriculum on math achievement in middle school grades in nine states. The research team investigated schools that use Desmos Math Curriculum in 6th, 7th, or 8th grade classrooms. Schools' mean state math assessment scores were compared for schools that used the Desmos Math Curriculum versus comparable schools in the same states using other math curricula.

Study Design

To estimate the effect of using Desmos Math Curriculum (described below) we conducted a retrospective quasi-experimental study with genetic matching. We used this approach to compare schools where middle grade (6th, 7th, and 8th) math teachers used Desmos Math Curriculum in at least one of grades 6-8 to schools that are similar on several key baseline characteristics (See Table 1). We identified intervention schools as those in which at least half of the middle grade math teachers in the school used the Desmos Math Curriculum at a minimum level of engagement (described below) in the 2021-22 school year. We then identified a pool of eligible comparison schools comprising all schools which had non-missing baseline matching and outcome data and that never used Desmos Math Curriculum. For each intervention school we used genetic matching (Diamond & Sekhon, 2005) to find five schools with comparable baseline characteristics as the intervention school. These matches were pooled together to create a matched comparison group to compare to the group of intervention schools. A linear regression model was then used to estimate the effect of using Desmos Math Curriculum in middle grade math on mean middle grade achievement on state

Matching

In order to estimate the effect of a school-based educational intervention, the outcome when using the intervention must be compared to the outcome in the absence of the intervention. However, for each school that uses the intervention the desired counterfactual – the very same school without the intervention – does not exist. In randomized control trials (RCTs) the intervention is randomly assigned to a group of schools who implement the intervention while the remaining comparison schools continue with business-as-usual instruction. Randomization at the outset of the study creates two groups that are, on average, the same and are thus balanced on important characteristics that might influence their outcome under the intervention and in its absence. In creating these balanced groups, the analysis at the end of the study comparing the outcomes of the two groups is an unbiased estimate of the effect of the intervention. In the absence of an RCT, which tend to be expensive and time-consuming, matching can be used to create intervention and comparison groups that are balanced on important baseline characteristics that are related to the outcome of interest. Another alternative is to compare the schools receiving the intervention to all other eligible schools. This approach does not account for baseline differences in schools using the intervention and schools that do not. Rather than simply comparing schools that received the intervention to all schools that did not receive the intervention, matching protocols allow researchers to reduce the bias in their estimates by comparing schools that are similar and thus likely to perform similarly under the intervention and comparison conditions.

standardized math assessments, controlling for the baseline variables that were used in the matching procedure.

Method

Context

Schools. Analysis was restricted to states with schools that used Desmos Math Curriculum and had publicly-available middle school state standardized grade-level mean math achievement data. These restrictions resulted in nine focal states—California, Colorado, Connecticut, Massachusetts, Minnesota, Missouri, North Carolina, New York, and Texas. For each school that used Desmos, each math teacher was defined as a core curriculum user if the teacher used at least 20 core curriculum activities in a single classroom in the 2021-22 school year. Their usage was defined as engaged if they used the "pacing" tool described below in at least 20% of those activities. This is not to suggest that the use of the pacing tool is, on its own, indicative of high-quality use. Rather it indicates that teachers are engaged in using the curriculum enough that we would expect an impact on student achievement.

Each teacher who used Desmos during the 2021-22 school year was coded for core curriculum and engaged usage. We then calculated the percentage of engaged core curriculum users among the middle grade math teachers in each school. Schools in which at least 50% of their middle grade teachers were engaged core curriculum users were included in the eligible intervention group for matching and analysis. Desmos identified 154 such schools within the nine states.

Intervention: Desmos Math Curriculum. Desmos Math Curriculum is a core math curriculum, adapted from the open source *Illustrative Mathematics (IM)* curriculum. The curriculum preserves the core scope and sequence of *IM* while integrating particular digital media affordances into the source material. Those affordances include digital feedback where interactive illustrations respond to student thinking; student connections where one student sees the thinking of another student; teacher facilitation tools which allow teachers to pace students to different parts of the activity, pause the computer work for discussion, snapshot student work for display, and give written feedback to students. The core curriculum comprises roughly 20% paper-based activities and 80% digital activities. Desmos was first available for adoption in the 2018-19 school year.

Comparison: Business-as-Usual. Comparison schools were matched to the intervention schools based on publicly available data about those schools, which did not include the type of math curriculum used in grades 6-8 (other than that they have never used Desmos Math Curriculum).

Thus, the comparison condition is schools implementing business-as-usual grade 6-8 math curriculum.

Measures

School Characteristics. Data from the nine focal states (California, Colorado, Connecticut, Massachusetts, Minnesota, Missouri, North Carolina, New York, and Texas) was retrieved from the National Center for Education Statistics Common Core of Data (CCD; NCES, 2023) and state education websites. The following baseline school characteristics were determined from the 2021-22 CCD files for all schools in the nine focal states: school type (regular and alternative); charter school status (non-charter and charter); level (elementary, middle, high, other); Title I schoolwide program eligibility; Title I targeted program eligibility; the number of students in grades 6-8; and the student-to-teacher ratio.

School type, charter school status, level, number of students, and student-to-teacher ratio provide information about the educational context for each school. School type was dummy-coded as two variables. Charter school status was similarly dummy-coded. For example, the regular school dummy variable is equal to one when a school is a regular school and otherwise is equal to zero. While most schools indicated as elementary or high school served a grade range that did not include the middle grades, many, including some intervention schools, served at least one of the middle grades. Schools indicated as "other" served grades spanning elementary, middle, and high school grade levels. School level was coded as four dummy variables, one for each school level. The total number of students in the middle grades in a school was calculated by summing the number of students, if any, in each of grades 6-8 for each school.

Title I eligibility provides information about the socioeconomic status of the students served by each school. The Title I program provides additional federal funding for districts serving a high proportion of students from low-income families. Within districts that receive Title I funding, schools in which at least 40 percent of students come from low-income families are eligible for a schoolwide Title I program, which provides funding for all students in the school. Schools in the same districts which are not eligible for a schoolwide program but who serve students from low-income families are eligible for a targeted assistance program. A targeted program provides funding for schools to target support to students with the greatest need for support. Two dummy variables were created, one to indicate if a school was eligible for a Title I schoolwide program or not and the other to indicate if a school was eligible for Title I schoolwide program.

Prior Achievement. Desmos Math Curriculum has been available for schools to adopt since the 2018-19 school year. As a result, many schools have been influenced by Desmos Math Curriculum in that time. In order to match schools on math achievement prior to any possible influence from Desmos Math Curriculum, we used math achievement scores from the 2017-18 school year. In each focal state, we retrieved state files that contained the grade-level mean

score on the statewide standardized math assessment and the number of students who took the assessment for grades 6-8 for each school in the state.

To create a mean math achievement score that is comparable across grades and states, we standardized the mean score for each school in each grade in each state so that the mean and standard deviation of the mean math achievement score in each grade level in each state was 0 and 1, respectively. We then generated a mean middle grades math achievement score of the available standardized grade six, seven, and eight mean math achievement scores, weighted by the number of students who took the assessment in each grade level for each school. North Carolina does not release grade eight math assessment mean scores for each school, so for schools in North Carolina, the mean reflects grades 6 and 7 scores for available schools. We then merged all of the state achievement data together and standardized the weighted means for the entire sample of all nine state's middle grades math achievement scores. The result is a baseline math achievement score for each school in each state that reflects the distance, in standard deviations, from the mean middle grades math achievement in the state for all schools that serve at least one of grades 6-8.

Math Outcome. The outcome of interest in this study was mean middle grades math achievement in the 2021-22 school year. A similar procedure as that described for creating the baseline math achievement scores was used for similar data from each state for the 2021-22 school year.

Intervention Schools. The list of 154 schools with engaged use of Desmos Math Curriculum was merged with the state and federal data described above. Six schools did not have math achievement data for both the 2017-18 and 2021-22 school years and were removed from the intervention schools for matching and analysis, resulting in an analytic set of 148 intervention schools.

Comparison Schools. A single data set containing each school that serves at least one middle grade was constructed by merging the CCD and state data described above. Starting with the 16,013 schools in this data, we constructed a pool of eligible comparison schools. We excluded any school or district that had used Desmos Math Curriculum based on a comprehensive list of accounts in these states supplied by Desmos. The pool was further narrowed by removing any school that did not have any available mean math achievement score for grades 6-8. We matched each of these accounts to a record in the CCD or confirmed that it was an institution that did not appear in the public school CCD data (e.g., a private school or summer camp). Any record that was matched to a CCD record was added to an exclusion list. In many cases, the account was an entire district. In these instances, we did not have information about which school or schools in the district used Desmos Math Curriculum, so we added the entire district to the exclusion list. The exclusion list was then used to remove any school or district ID on the

exclusion list from the pool of eligible schools. The exclusions resulted in a final pool of 10,083 schools eligible to be selected as a comparison school.

Matching. Genetic matching was conducted to find schools similar to the schools in the intervention group using the MatchIt package (Ho, et al., 2011) in the R statistical programming software platform (R Core Team, 2021). Each intervention school was matched to five schools in the pool of eligible comparison schools based on each school's state, 2017-18 middle-grade math achievement, school type, charter status, school level, Title I eligibility, number of students, and student-to-teacher ratio. Exact matching was implemented for each intervention school's state and Title I eligibility. For the remaining matching variables—2017-18 mean math achievement, school type, school level, number of students, and student-to-teacher ratio—the genetic matching algorithm uses a genetic search algorithm to find a weight for each variable that improves balance of the intervention and matched comparison samples. A data set of the intervention and matched comparison schools was created for analysis.

Analysis and Results

Ordinary least square (OLS) regression was used to estimate the effect of Desmos Math Curriculum on middle-grade mean math achievement using the lm function in the R statistical programming platform. The final model included middle-grade math achievement in 2021-22 as the outcome predicted by membership in the intervention group, middle-grade math achievement in 2017-18, number of middle grade students, student-to-teacher ratio, state, school type, school level, charter status, and Title I eligibility as predictors. While the matching procedure reduces bias related to the matching variables, including them as covariates in regression further reduces bias due to any remaining imbalance in the matching variables. For each categorical variable, a reference group was selected for the regression analysis to avoid perfect collinearity among any set of variables. Reference groups were chosen to be California, regular school, elementary school, non-charter, and not eligible for Title I for the analysis, though their choice does not impact the estimated effect of Desmos Math Curriculum.

Baseline Balance. Table 1 shows the baseline balance of the intervention group and the eligible pool of comparison schools (columns 1 and 2). Before matching, the intervention group of schools had large and meaningful differences in several baseline measures, including much higher middle-grade math achievement in 2017-18 and a much lower proportion of schools eligible for a schoolwide Title I program, which is the level of eligibility that reflects the greatest level of need within a school. After matching, the observed differences were greatly reduced (Table 1, columns 2 and 3). Whereas before matching the difference in middle grade math achievement was 0.30 standard deviations, after matching the difference was 0.03 standard

deviations. After exact matching, there were no differences in Title I eligibility between intervention and comparison schools.

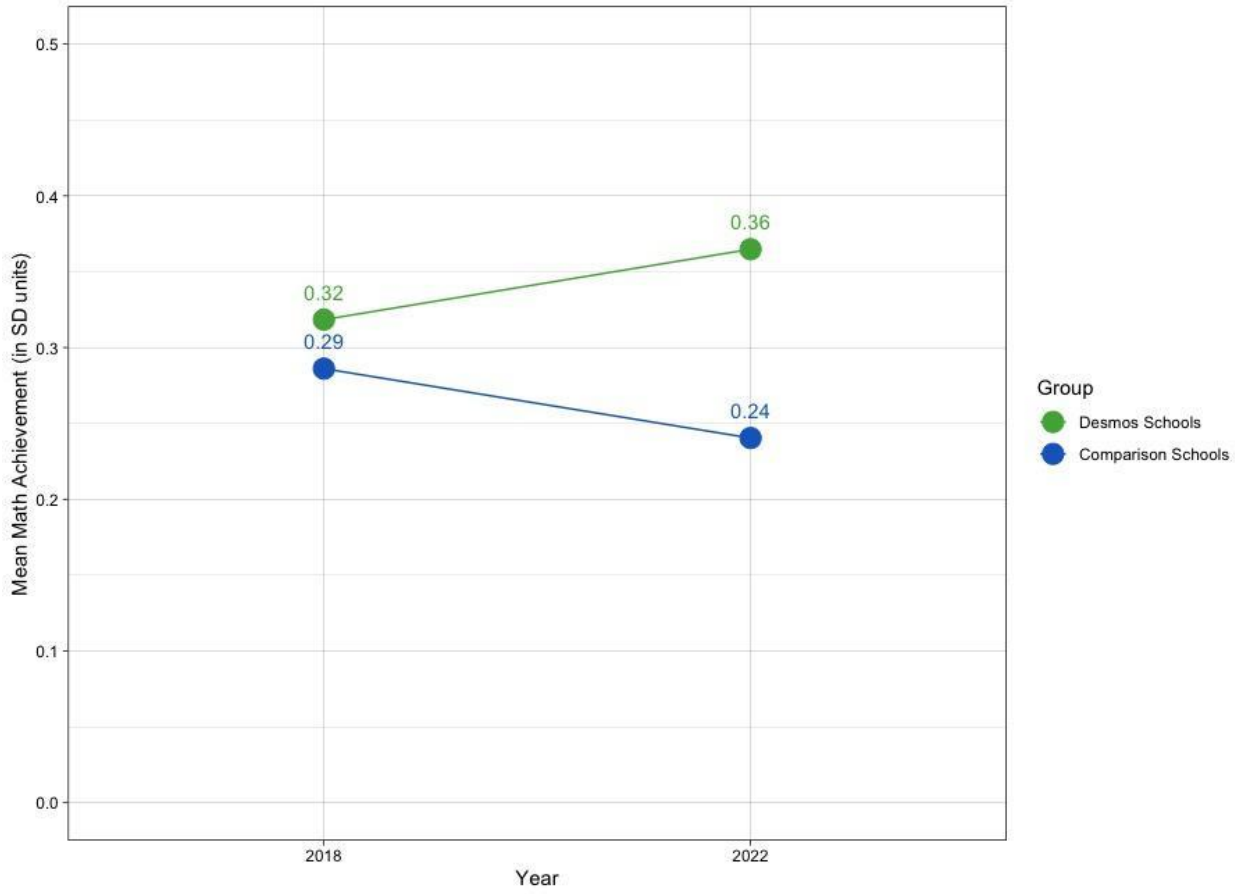
Table 1. Baseline Balance Before and After Matching

Suspension Rate Trajectory	Comparison-Eligible Schools	Desmos Schools	Matched Comparison Schools
n	10,083	148	740
	Mean (SD)	Mean (SD)	Mean (SD)
Mean Math 2017-18	0.02 (0.93)	0.32 (1.04)	0.29 (0.99)
# of Students	310.09 (324.64)	488.14 (319.69)	460.24 (309.12)
Student:Teacher	16.81 (77.58)	16.24 (7.35)	16.75 (5.65)
State	n (%)	n (%)	n (%)
California	3,228 (32.0)	64 (43.2)	320 (43.2)
Colorado	371 (3.7)	5 (3.4)	25 (3.4)
Connecticut	279 (2.8)	10 (6.8)	50 (6.8)
Massachusetts	451 (4.5)	26 (17.6)	130 (17.6)
Minnesota	621 (6.2)	3 (2.0)	15 (2.0)
Missouri	803 (8.0)	18 (12.2)	90 (12.2)
North Carolina	579 (5.7)	5 (3.4)	25 (3.4)
New York	1584 (15.7)	15 (10.1)	75 (10.1)
Texas	2167 (21.5)	2 (1.4)	10 (1.4)
School Type			
Regular	9,917 (98.4)	147 (99.3)	738 (99.7)
Alternative	166 (1.6)	1 (0.7)	2 (0.3)
Charter			
Non-Charter	8,629 (85.6)	140 (94.6)	700 (94.6)
Charter	1,454 (14.4)	8 (5.4)	40 (5.4)
School Level			
Elementary	3974 (39.4)	41 (27.7)	194 (26.2)
Middle	4291 (42.6)	100 (67.6)	512 (69.2)
High	1129 (11.2)	6 (4.1)	29 (3.9)
Other	689 (6.8)	1 (0.7)	5 (0.7)
Title I Eligibility			
Schoolwide Program	4730 (46.9)	28 (18.9)	140 (18.9)
Targeted Program	1021 (10.1)	22 (14.9)	110 (14.9)

Impact Results. To visualize the impact of the Desmos Math Curriculum, the raw mean of the intervention and comparison group's middle grade mean math achievement in 2017-18 and in 2021-22 was plotted in Figure 1. As can be seen, in 2017-18, before Desmos Math Curriculum was available for adoption, the schools in the two groups had similar mean math achievement and, as demonstrated in Table 1, were also similar on a number of other key school characteristics. Four years later, in the 2021-22 school year, the schools with teachers who exhibited engaged use of Desmos Math Curriculum had mean middle grade mean math achievement that was 0.12 standard deviations higher than the comparison group. Moreover,

in that time span the comparison schools' mean middle grade mean math achievement decreased while the intervention schools' increased.

Figure 1. Mean Math Achievement for Desmos Schools and Matched Comparison Schools in 2018 and 2022.



Regression Results. Results of the OLS regression indicated that schools in the intervention group had significantly higher ($p < 0.01$) mean middle grade math achievement compared to the comparison group, controlling for mean middle grade math achievement in 2017-18, number of middle grades students, student-to-teacher ratio, state, school type, school level, charter status, and Title I eligibility. The mean difference in middle grade mean math achievement was estimated to be 0.10 standard deviations, which is similar in magnitude to the 0.12 standard deviations when comparing the raw means in Figure 1. This means that schools in the intervention group that used Desmos Math Curriculum had mean middle grade math

achievement in 2021-22 that was 0.10 standard deviations higher, on average, than similar schools in the comparison group.

Implications

The results of this study show that there is a positive effect of engaged use of Desmos Math Curriculum in increasing middle-grade-wide math achievement as compared to business-as-usual math curriculum. It is worth noting that this impact was seen coming out of the COVID-19 pandemic in which the similar schools matched to the Desmos schools saw their middle grade mean math achievement decrease. In a time when learning loss from the pandemic is top-of-mind for parents, caregivers, educators, and administrators, the schools in this study that were using Desmos Math Curriculum had higher middle grade math achievement relative to their state mean while the students in the matched comparison schools had lower middle grade mean math achievement relative to their state mean.

The full impact of Desmos Math Curriculum may yet be higher than the effect estimated in this study. The schools in this study were not enrolled in a study in which their fidelity of implementation would be monitored. Rather they are schools from nine states who adopted Desmos Math Curriculum and used it to varying levels. The metric used to determine membership in the intervention group was based on a minimum level of engagement with the curriculum that indicates teachers used the curriculum. It did not necessarily reflect a full implementation with high fidelity to the intended curriculum. Furthermore, in order to include sufficient schools for the study, the threshold for inclusion was set to at least 50% of teachers meeting the minimum level of engagement for a school to be included. Finally, the study did not account for the level of training and support teachers received to implement the curriculum with intended fidelity. All of these factors may have reduced the average impact of the curriculum across all of the intervention schools.

Limitations

The gold standard in education for demonstrating an effect of an educational intervention is a randomized control trial (RCT). This study is not an RCT. However, by matching on baseline variables that are predictive of future middle grade math achievement, we were able to mimic some of the conditions of an RCT. This includes demonstrating balance of those key predictors between intervention and comparison groups. Nonetheless, the results of this study are not immune to bias due to unobserved variables that are related to a school adopting Desmos Math Curriculum and a school's middle grade math achievement above and beyond their relation to the variables controlled for in our model. Additionally, the schools in the intervention group had, on average, higher achievement than schools in their state. Care should

be taken in generalizing these results to schools that are markedly different from the schools included in this study.

Future Directions

The results of this study demonstrated a positive impact of Desmos Math Curriculum on middle grade mean math achievement. Despite the COVID-19 pandemic, schools using Desmos Math Curriculum emerged with higher math achievement than before the pandemic while similar schools that did not use the curriculum saw their math achievement decrease over the same time period. While the estimated effect is robust to the observed variables included in the matching and regression analysis, a randomized controlled trial (RCT) designed to measure fidelity and impact would provide more robust evidence on the full potential of Desmos Math Curriculum to improve student math learning. Future studies should also attempt to create a sample with a larger diversity of schools than in the current study, which would potentially extend these results to a more representative sample of schools.

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