Success in Algebra 1: Significantly Higher NWEA MAP Scores for Courseware Students

Edmentum Efficacy Research & Learning Engineering

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Introduction

Students who pass core academic courses during the first years of high school are more likely to graduate than students who do not (Allensworth & Easton, 2005; 2007; Phillips, 2019; Rumberger, 2011). More students fail courses in ninth grade than in any other grade, and a disproportionate number of these students subsequently drop out (Freeman & Simonson, 2015; Herlihy, 2007; Rumberger, 2011). In response to the call for higher graduation standards by the National Governors Association and others (Conklin & Curran, 2005), many states have adopted rigorous course requirements in high school. Of particular interest is introductory Algebra, which is oft considered a critical "gatekeeper" for advanced high school math classes and for college-readiness (National Mathematics Advisory Panel, 2008). In fact, Algebra is so strongly associated with positive outcomes such as college entrance exams, college enrollment, and graduation that it has led policymakers to mandate double-dose algebra and other intensive math interventions in many states and districts (Cortes, Goodman, & Nomi, 2013; Rickles et al., 2018; Heppen et al., 2017). Consequently, Algebra I is usually a mandated requirement for all students in ninth grade (Nomi, 2012). Thus, it is a focus of credit recovery since many students must pass the course to graduate.

However, districts face challenges in providing quality access to core instruction. Teacher shortages in content areas such as math and science, cost cutting in summer school, and uneven quality of instruction across schools has led to districts looking to online courses as a solution for offering credit recovery and original credit instruction in core content (Hart et al., 2019; Heppen et al., 2017; Rickles et al., 2018). However, the evidence of efficacy of online instruction is mixed. Some research indicates that offering virtual instruction in core areas such as Algebra is a viable option for policymakers, suggesting there little to no difference between traditional in person courses and online options (Cavalluzzo, 2012; Rickles et al., 2018). Other research shows a positive effect of online course-taking. In an eight-year longitudinal study of high school virtual enrollment, Heinrich & Darling-Aduana (2021) found positive associations between online course-taking, credits earned, and high school graduation. Similarly, Chingos & Schwerdt (2014) discovered that students had null or slightly positive results as compared with their peers on standardized tests when student and school characteristics were controlled. Hart et al. (2019 noticed differences between first-time credit seekers versus credit recovery students, with first-time credit seekers reporting more successful long-term outcomes. But the Hart et al. (2019) study used an expanded sample of courses, looking beyond the core curriculum required for graduation.

Given that online course-taking is prevalent and likely to stay as a policy in many districts, it is critical to keep the research lens focused on its use and outcomes. This study adds to the body of research about online Mathematics instruction by examining outcomes of ninth-grade Algebra course-taking in a large, urban, district in the south Midwest region of the United States. Using a quasi-experimental design, it studies first-time credit seekers—students who enrolled in Algebra 1 for the first time in ninth grade during 2020-2021 school year. It compared NWEA Measures of Academic Progress (MAP) Mathematics assessment (Meyer, 2019) for students participating in an online virtual instruction program to students receiving in-person instruction in traditional school settings. The sample included all students enrolled in Algebra 1 in the district across 14 schools in the district.

The results of this study showed that participation in the online Mathematics course was positively associated with student achievement test scores. The results were statistically significant for the ninth graders who enrolled in an Algebra 1 online course as compared to students who took Algebra 1 in an in-person setting. The increase in Mathematics achievement equates to an effect size of 0.13, suggesting that Courseware Algebra I is an effective option for high school students. These findings point to the importance of quality virtual instruction and refutes the trope (Loeb, 2020) that virtual learning is poor quality and insufficient to raise test scores and other positive outcomes.

Methods

Research Questions

The study examines associations between participation in Courseware Algebra 1 (Edmentum, 2024) and student achievement outcomes. The specific research question driving this analysis was:

Do student outcomes on the NWEA MAP Mathematics assessment differ from those who took Algebra 1 in an in-person setting compared to those who used Courseware Algebra 1 A/B (Edmentum, 2024) virtually?

Data

This study used student-level data from two sources. Student demographic characteristics, school and class enrollment information, and test scores in school years 2020-2021 and 2021-2022 were provided by a large, urban public school district in the Midwest region of the United States.[1] These data were linked to Edmentum's internal data systems, which included detailed information on students' online courses in the Courseware instructional system, as well as measures of their course progress, completion and online course grades. Both sets of data were matched to create the analytic sample.

Analytic Sample

The analytic sample included ninth graders who enrolled in Algebra 1 in 2020-2021. Our sample included 1,205 ninth graders in 14 secondary schools across the district. Table 1 shows descriptive statistics for the sample. Of students in the sample, 48% were female, 16% identified as White, 20% had a disability, 80% identified as low-income, and 30% were English learners. Additionally, students in the sample, on average, were suspended 2.45 days of school during the school year scored a 213.1 RIT scale scores on their eight-grade Spring MAP Mathematics assessment.

Table 1. Descriptive statistics of analytic sample of 2020-2021 Algebra 1 students (*N*=1,205).

Characteristic	N	%	Mean	SD
Female	581	0.48		

[1] The district provided data through a data-sharing agreement and agreed to participate anonymously in this study.

Black	303	0.25		
Hispanic/Latino	503	0.42		
White	193	0.16		
Disability status	238	0.20		
ELL	356	0.30		
Economic Disadvantage	968	0.80		
Days suspended			2.45	4.70
8th grade Spring MAP			213.07	15.01

Research Design

A quasi-experimental design was implemented to explore the research questions. Students were assigned to one of two groups in alignment with an intent-to-treat design. Within an intent-to-treat framework, any students exposed to an educational intervention are analyzed as if they received the intervention, regardless of the extent to which they actually received it. In this study, Algebra 1 is a year-long course that runs during the 2021-2022 school year. In a traditional classroom setting, students take semester A of Algebra 1 followed by semester B of the course. In virtual settings, students are assigned to each course and expected to take them sequentially. An instructor of record is assigned to monitor participation, but the student takes the courses asynchronously based on their individual schedules. The range of implementation and dosage fits an intent to treat design (Shadish et al., 2002). As such, students were assigned to Algebra 1 treatment if they spent any time doing an Algebra 1 Courseware lesson between August 16, 2021, and May 26, 2022.

Measures

Outcome Measure

Student achievement was captured by the MAP Mathematics assessment. MAP is a vertically scaled, computer adaptive assessment that provides educators with a precise and accurate measure of student achievement in Reading, Mathematics, Language Arts activity, as well as in General Science (Meyer, 2019). Roughly one in four public schools across the United States use the MAP assessment (Thum & Kuhfeld, 2020). We examined MAP Mathematics scores from the Spring 2021-2022 testing window.

Treatment Variable

Our primary predictor is a binary indicator of whether students took an Algebra 1 Course online. All online students were enrolled in Courseware since that was the district program in place at the time of the study. Students in the comparison group took Algebra 1 in an in-person instructional setting using the business-as-usual curricula.

Covariates

Covariates in this study included student-level demographics such as gender, race or ethnicity, disability status, economically disadvantaged status, English Language Learner status, suspensions, and prior-year test scores in Mathematics and Reading. See Table 1 for information. We used regression imputation to address missing covariate values following recommendations from What Works Clearinghouse (2022) for acceptable approaches for addressing missing data.[2] We did not impute outcome values.

Analysis Plan

We used propensity score matching to account for the difference between Courseware students and in-person enrollment students. Propensity score matching provides unbiased estimates as long as taking Courseware enrollment courses was determined by covariates included in the analysis (Rosenbaum & Rubin, 1983). Instead of doing one-to-one matching, we elected to use a full matching approach (Hansen, 2004) by forming matched sets, where each match set contains one Courseware student and one or more comparison students. Full matching is similar to optimal matching in terms of minimizing a weighted average of the estimated distance measure between each intervention student and each comparison subject within each matched set (Hansen, 2004). We matched ninth-grade Algebra 1 using the set of covariates as described. We used the *MatchIt* package in R (Ho et al., 2011). Table 2 presents baseline characteristics of ninth grades in the Courseware and comparison groups after matching. As the tables show, all differences between the two groups were 0.20 standard deviations or smaller in both subject areas, which meets standards for baseline equivalence (What Works Clearinghouse, 2022). We inspected balance plots for the amount of overlap in the covariate distribution between the intervention and treatment groups throughout the matching process (Austin, 2011).

Table 2. Balance check after matching (*N*=1,205)

Variable	**Courseware**	**Comparison**	**Std. Mean Difference**
Female	0.46	0.48	-0.030
Black	0.17	0.25	-0.017
Hispanic	0.46	0.42	0.085
White	0.20	0.16	0.107
Disability status	0.20	0.20	-0.008
ELL	0.30	0.30	-0.009
Economic Disadvantage	0.82	0.80	0.032
Days suspended	3.05	2.47	0.126
Grade 8 Spring MAP	215.86	213.02	0.196

Note. Standard deviation in parentheses. Estimates of standardized mean difference are calculated using the difference in means of a variable across intervention and comparison groups, divided by the standard deviation in the intervention group (Austin, 2011).

Subsequently, propensity score-based weights were used to weight the following model to estimate the difference between Courseware students and in-person students:

$$Y_i = \beta_0 + \beta_1 Treatment_i + \boldsymbol{X_i}\beta_2 + \varepsilon_i,$$

[2] We tested the sensitivity of our results to the exclusion of students for whom we imputed covariates by repeating our analysis without students with missing data (i.e., complete cases). Impact estimates were similar in direction and magnitude to our main results.

where Y_i is the achievement outcome for student i, $Treatment_i$ is participation status of student i in the Courseware course; $\boldsymbol{X_i}$ is the vector of student demographic and achievement covariates listed above; and ε_i is the model residual. By controlling for all variables that were used in the estimation of propensity scores as covariates, this model is considered doubly robust (Bang & Robins, 2005).

Results

Table 3 presents the results of the models estimating the effects of Courseware participation on achievement outcomes using the MAP Mathematics assessment. Columns 2-4 show the means and standard deviations for the Courseware and comparison groups, as well as the respective sample size for each group. Comparison group means and standard deviations are weighted using the propensity score weighting procedures described above. We found that on average ninth graders who took an Algebra 1 Courseware course gained 2.98 RIT points ($p < 0.05$) in Mathematics achievement as compared to their peers who enrolled in an in-person course. This difference equates to an effect size of 0.13 for ninth-grade Algebra 1 students.

Table 3. Results of Courseware Algebra 1 Course-taking, MAP Outcomes (*N*=1,205)

	Courseware		Comparison				
	Mean	**SD**	**Mean**	**SD**	**Effect Size**	***p*-value**	**Improvement Index**
Algebra 1 Grade 9 Spring MAP	217.2	11.1	214.2	23.5	0.13	< 0.05	+5

Notes. Comparison group means and standard deviations are weighted; effect sizes are calculated as the ratio of the impact estimate to the pooled (weighted) standard error.

In terms of practical significance, these results translate into an improvement index of +5, suggesting that the average comparison student could accelerate learning for a gain of up to 5 percentile points in Mathematics if the student had received the treatment. For example, on average, a ninth-grade Algebra I student in the comparison group, who scored at the 50th percentile would be expected to have scored at the 55th percentile had she received the intervention. The findings indicate that implementation of Courseware offers educators and administrators an impactful strategy to meet the needs of their diverse students and boost academic achievement.

In addition, we checked the robustness of the matching procedures by performing a placebo test (Austin, 2011) where we estimated the impact of Algebra 1 Courseware participation on student achievement in Reading. The results of the placebo test were not significant ($\beta = -0.07$, $t(626) = -0.81$, $p = 0.4180$).

Limitations

This study has some limitations. First, the students who enrolled in the online course either chose to take the course as a virtual option or were assigned to do so by their administrators, possibly due to schedule conflicts or class size limitations. We have to assume there is selection bias in the study and without a randomized design we must also suppose there are unobserved variables in the study that influence the results. Second, the study included only one school district in the Midwest region of the United States;

generalizing beyond that region should be done cautiously. Third, the study only had sufficient data to examine student achievement outcomes for one year and the design could not explore how taking an online course affects longer-term outcomes such as college and career readiness and graduation. Last but not least, it is probable the COVID-19 pandemic impacted the learning trajectories of students, it also may have affected the enrollment of students in online settings, and it prevented our team from obtaining standardized assessment data for the 2019-2020 school year.

Discussion and Conclusion

The results of this study show that participation in Edmentum's Courseware online Algebra 1 course was positively associated with student achievement in mathematics, as measured by the NWEA MAP assessment. Growth in mathematics as measured by the NWEA was statistically significant. We believe our research adds to the extant literature by using a widely used external measure of achievement—the NWEA MAP. Instead of focusing on course credits (which may vary according to district or state policies), this study suggests that virtual instruction delivered by Courseware Algebra 1 may be similar to in-person instruction in a large urban district.

The results were statistically significant. Ninth graders taking Algebra 1 for the first time, enrolled in Courseware, demonstrated higher mathematics achievement than students who took Algebra 1 in an in-person setting. The increase in Mathematics achievement equates to an effect size of 0.13, which translates to an improvement index of +5, thereby meeting ESSA Tier 2 evidence standards and arguing for Courseware Algebra 1 to be an effective option for high school students.

The study is also of practical significance. Online course taking is increasing rapidly for high school students. Whereas prior evidence in K–12 tended to find that the online setting offers mixed effects, our findings suggest that students who took Algebra 1 Courseware performed on average better than their peers who attended class in person. This research offers policymakers a high-quality virtual alternative to in-person instruction, which in this day of limited resources and understaffing, may make a difference in students' lives and academic aspirations. Moving forward, researchers should continue to investigate the effectiveness of Courseware core courses by looking at other academic outcomes, such as graduation rates, as well as non-academic outcomes of significance such as attendance.

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Appendix

Table A1. Algebra 1 Courseware Usage Statistics, 2021-2022 (*N*=72)

Variable	Mean	SD
% of course completed	0.62	0.40
Time on task (mins.)	1974.08	2430.09
% of students who completed their course	0.58	0.50
% of students who earned a high school credit	0.53	0.50

Table A2. Regression Coefficients for Algebra 1 Impact Estimates, 2021-2022 (*N*=1,205)

Coefficient	Estimate	SE	95% CI		*p*
			LL	UL	
Courseware – Algebra 1	2.98	1.18	0.66	5.30	0.012
Female	0.92	0.57	-0.19	2.03	0.105
Black	-0.38	0.90	-2.14	1.38	0.671
Hispanic	-0.02	0.87	-1.73	1.69	0.980
White	-2.08	0.98	-4.01	-0.15	0.035
Disability status	-0.43	0.77	-1.94	1.08	0.579
ELL	-3.21	0.80	-4.79	-1.63	< 0.001
Economic Disadvantage	-0.68	0.72	-2.08	0.73	0.344
Days suspended	-0.002	0.06	-0.12	0.11	0.967
8th grade Spring MAP	0.97	0.02	0.92	1.01	< 0.001
Intercept	11.44	4.98	1.66	21.21	0.022

Notes. CI = confidence interval; LL = lower limit; UL = upper limit.