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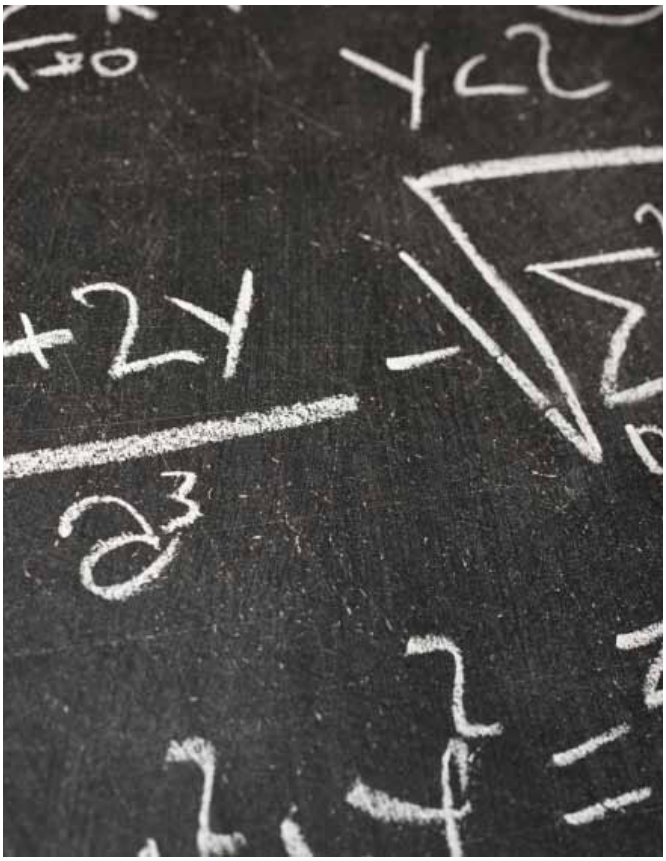

Broadening Access to Algebra I:
The Impact on Eighth Graders Taking an Online Course

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www.air.org

A brief summarizing Access to Algebra I: Online Mathematics for Grade 8 Students, a study conducted by the American Institutes for Research and Education Development Center

About This Research Brief

This research brief is part of the American Institutes for Research's continuing effort to make research relevant to policymakers and practitioners. Our mission is to conduct and apply the best behavioral and social science research and evaluation toward improving peoples' lives, with a special emphasis on the disadvantaged. This brief highlights the findings of a rigorous, federally funded three-year randomized control trial examining the impact of an online Algebra I course on eighth-grade students.

Who Conducted the Original Study?

The *Access to Online Algebra* study was conducted by the American Institutes for Research (AIR) and the Education Development Center, Inc. (EDC) for the 2006-2001 Regional Educational Laboratory Northeast and Islands (www.relnei.org/). Authors of the study's final report are Jessica Heppen, AIR; Kirk Walters, AIR; Margaret Clements, EDC; Ann-Marie Faria, AIR; Cheryl Tobey, EDC; Nicholas Sorensen, AIR; and Katherine Culp, EDC. The report was prepared for the National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, under contract ED-06C0-0025.

The citation for the final report is:

Heppen, J.B., Walters, K., Clements, M., Faria, A., Tobey, C., Sorensen, N., and Culp, K. (2012). *Access to Algebra I: The Effects of Online Mathematics for Grade 8 Students.* (NCEE 2012–4021). Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education.

For the full final report, visit: http://ies.ed.gov/ncee/edlabs/regions/northeast/pdf/REL_20124021.pdf

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Introduction

Online courses are increasingly seen as a viable way to expand the number and types of courses offered and broadening access to key courses, particularly in small and rural schools.[i] Algebra I in middle school exemplifies an important course that educators and policymakers want to be more available to students.

To study the effectiveness of using an online course to broaden eighth graders' access to Algebra I, the American Institutes for Research (AIR) and the Education Development Center, Inc. (EDC) performed the first rigorous evaluation of the impact of an online course on student outcomes. This three-year study examined the effects of offering a fully online Algebra I course to eighth-grade students in mostly rural schools in Maine and Vermont.

Key Findings

The study found that offering Algebra I as an online course is an effective way to broaden access for students in schools where access to the course is typically limited. Specifically:

- For students whose schools deemed them eligible for Algebra I in eighth grade, **taking the course**:
  - **Improved their algebra achievement at the end of eighth grade**, and
  - **Doubled their chances of taking an advanced math course sequence in high school.**
- Taking the online course (instead of the usual eighth-grade math class) had **no negative effect on students' general math achievement at the end of eighth grade.**
- Removing eligible students from the general math class to offer them the online Algebra I course **had no discernible side effects on *non*-eligible students' achievement or course-taking outcomes.**

This brief describes the study's purpose, methods, findings, and implications.

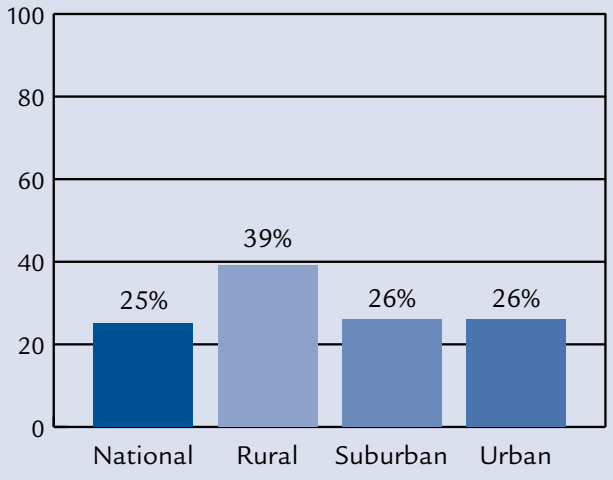
Study Rationale and Design

In 1997, the U.S. Department of Education asserted that all states should invest in expanding access to Algebra I for middle school students. This sentiment was echoed in 2008 by the National Mathematics Advisory Panel, which recommended that "all prepared students [should] have access to an authentic algebra course — and [that districts] should prepare more students than at present to enroll in such a course by Grade 8." These policy statements are based on research that shows that Algebra I is a gateway to more advanced courses in high school and college and that students who succeed in Algebra I in middle school have more success in math throughout high school and college than students who take Algebra I later.[ii]

With the push to expand access to Algebra I in middle grades, national grade-8 Algebra I enrollments have increased from 16 percent in the 1990s to 31 percent in 2007.[iii] In general, students who take Algebra I in (or before) eighth grade are higher-achieving students than those who take the course in high school.[iv]

However, not all high-achieving students have the opportunity to take Algebra I in or by grade 8. As of 2009, about one-quarter of the highest-achieving students did not take a formal Algebra I course in middle school.[v] In rural schools, nearly 40 percent of high-achieving students did not take Algebra I in grade 8. In suburban and urban schools, by comparison, the proportions were close to the national average of about 25 percent.

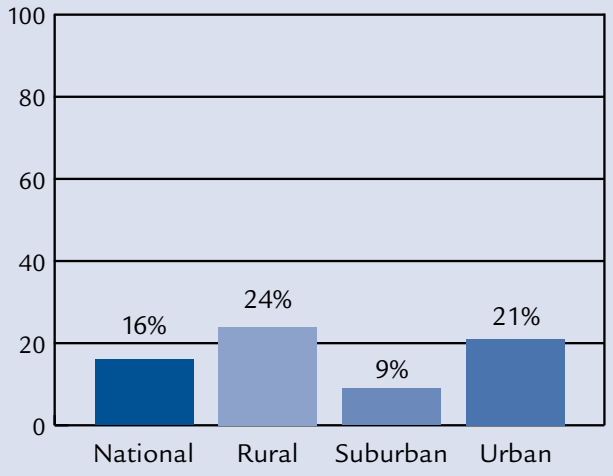
Figure 1: Percentage of high achievers (as of 5th grade) that did NOT take Algebra I in 8th Grade as of 2009



Source: NCES Early Childhood Longitudinal Study — Kindergarten Cohort (ECLS-K) K-8 Full Sample Public-use Data File (U.S. Dept of Education, 2009).

Presumably, many of the students who miss out attend schools that do not offer the course or where access is limited — a particular issue in rural schools. As of 2009, nearly one-quarter (24 percent) of rural schools did not offer Algebra I in grade 8, higher than the percentage of urban schools (21 percent) and suburban schools (9 percent) that did not offer the course.

Figure 2: Percentage of schools that reported they did NOT offer Algebra I to 8th-grade students



Source: NCES Early Childhood Longitudinal Study — Kindergarten Cohort (ECLS-K) K-8 Full Sample Public-use Data File (U.S. Dept of Education, 2009).

Measuring the Impact of Online Algebra

To measure the overall impact of offering online Algebra I to eighth graders, the study team randomly assigned eligible and willing schools either to offer the online course to students they considered ready, or to offer their "business-as-usual" math curriculum (described below). This strong and simple research design allowed the research team to examine the potential benefits and possible unintended consequences of implementing the online course.

Measuring Potential Benefits

Sixty-eight middle schools in Maine and Vermont participated. They either did not offer Algebra I to eighth graders at all, or for various reasons they offered the course to only some of their algebra-ready students.

Definition of "Algebra-Ready" Students

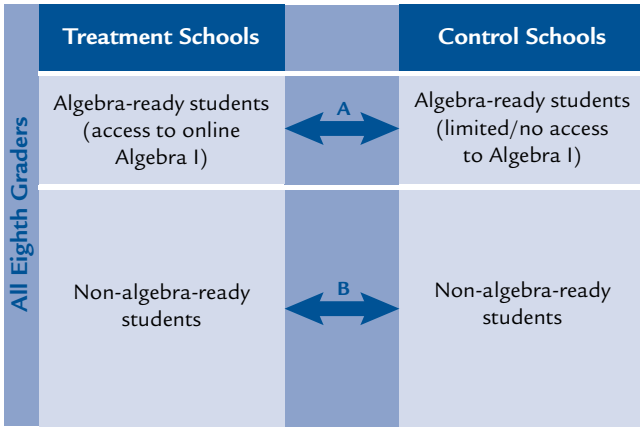
Schools decided which students would be eligible for the course. That way, the situation reflected a "real-world" setting. Schools determined students' eligibility based on teacher recommendations, grades in sixth and seventh grade math courses, prior test scores, and related factors. Eligible students were identified *before* schools were randomly assigned to offer the online course.

Study Design — Random Assignment of Schools to Offer Online Algebra I or Not

The 68 schools were randomly assigned to one of two groups. Half of the schools received an online Algebra I course (at no cost) to offer during the 2008-09 school year. The "control schools" offered their usual mathematics curriculum.

The algebra-ready students are represented in the top boxes in the figure below. To measure the potential benefits of online Algebra I, algebra-ready students in treatment schools were compared to algebra-ready students in control schools (arrow A).

Figure 3: Measuring potential benefits of online Algebra I



The rest of the eighth graders in the school were the "*non*-algebra-ready" students, represented in the lower boxes. These students were included in the study to test for the possible unintended consequences of offering an online course to eligible students. The study did not compare outcomes for algebra-ready students vs. non-algebra-ready students, but it did compare their baseline characteristics. Students identified by schools as eligible for Algebra I in grade 8 were, in fact, significantly higher achieving than students who were not identified as algebra-ready.

Why Measure Potential Unintended Consequences?

Offering an online Algebra I course in schools that do not typically offer the course represents a clear change to the business-as-usual eighth-grade mathematics program. Therefore, the study also examined whether there are potential unintended consequences of offering online Algebra I to algebra-ready students — for them or their non-algebra-ready peers.

For example, taking online Algebra I instead of the general eighth-grade math class could adversely affect algebra-ready students' general math achievement (as measured, for example, on statewide assessments).

Moreover, providing online Algebra I to algebra-ready students could have unintended consequences for the *non*-algebra-ready students in the school. These students remain in the general grade-8 math class. Various changes could occur in the general math class when the algebra-ready students are removed to take online Algebra I — such as smaller class sizes, a change in course emphasis (for example, less algebra), and more homogenous and lower ability levels among the students.

Schools and Students in the Study

Most of the schools (61 out of 68) in the study were classified as rural, and nearly all (94 percent) of them were Title I schools. In 76 percent of the schools, the grade span was K-8 or pre-K-8. As of the 2007-08 school year, average total school enrollment for the participating schools was 186 students and the student population was 95 percent white, with nearly half (48 percent) eligible for a free or reduced-price lunch. Slightly more than half (53 percent) of the students in the participating schools had scored at or above proficiency on the state math assessment the prior year.

The average number of eighth graders in each school was 32, and more than half of the schools had 16 or fewer students in that grade.

On average, the schools identified 6.5 students per school as algebra-ready — roughly 22 percent of their eighth graders. The next table summarizes participating students' background characteristics.

Table 1: Participating students' background characteristics

	Algebra-ready students	Non-algebra-ready students
Free/reduced-price lunch eligible	32%	46%
Special education	3%	17%
Limited English proficiency	3%	3%
Female	49%	50%
Racial/ethnic minority	7%	5%
Average grade 7 score on state math assessment[a]	0.95	-0.24
Number of students	440	1,445

[a] State assessment scores were standardized because the two states used different assessments. Standardized scores have a mean of zero and a standard deviation of 1. Algebra-ready students scored, on average, 1 standard deviation above the average relative to all students in the sample. Non-algebra-ready students scored, on average, one-quarter of a standard deviation below the average.

Of the 440 algebra-ready students, 218 attended schools assigned to the "treatment" group and were offered the option of taking the online Algebra I course. Nearly all of them — 97 percent (211 students)— enrolled. A total of 222 algebra-ready students attended the control schools and took a variety of math classes, which are described below.

Of the 1,445 non-algebra-ready students, 744 attended treatment schools and 701 attended control schools. Analysis of baseline characteristics confirmed that the random assignment process produced treatment and control groups that were not significantly different from each other at the outset of the study.

Description of the Online Algebra I Course

The online course used in the study is a completely Web-based course offered by Class.com, based in Lincoln, Nebraska. The course was one of Class.com's off-the-shelf products. It had three instructional components: the online course software, an online teacher (provided by Class.com), and an on-site proctor (provided by the school).

Analysis of the course content determined that the topics covered in Class.com's course were similar to those in textbooks typically used in the region. The material for each topic was presented as an electronic, interactive textbook that included computerized direct instruction, guided practice ("your-turn" problems) and practice problem sets (both with automated feedback), and quizzes and exams that provided immediate scores. Other activities included demonstrations of content materials, audio clips, interactive applets that present questions and guided solutions, a messaging feature that allowed students to exchange messages with the online teacher, and a discussion board to which students could post questions and comments.

Students taking the online course were assigned to a specific section and taught by a teacher hired, trained and supervised by Class.com. The teacher was responsible for providing instruction and supporting student learning.

There were a total of 11 course sections across the treatment schools, taught by a total of 8 online teachers. The total number of students enrolled in the online course was 242.[1]

Schools had to provide a staff member to serve as an on-site proctor. The proctor did not have to be a math teacher and was not required to provide instruction. Proctors were expected to supervise behavior, serve as a contact person for students and parents, oversee quizzes and exams, and act as a liaison between the online teacher and the school, students and parents.

1 This included the 211 algebra-ready students already mentioned plus another 31 non-algebra-ready students who were enrolled in the course in fall 2008. Schools were allowed to enroll additional students who had not been on their initial list of algebra-ready students in spring 2008. However, students who were not on those lists were considered non-algebra-ready for the purpose of all study analyses.

Implementation Findings

This description of the implementation of online Algebra is based on the analysis of data from the online course management system and proctors' weekly logs. Key findings include:

- Most schools opted *not* to place students taking the online course in a separate space or at a different time from the regular eighth-grade math class.
  - **In most (80 percent) of the treatment schools, the regular eighth-grade math teacher served as the proctor.**
  - **In 69 percent of the schools, students taking the online course sat in the same classroom as students taking the regular eighth-grade math class.**
- The types and amount of interaction between students taking the online course and their teachers and proctors deviated sharply from initial expectations.
  - **Online teachers spent less time communicating directly with students than expected.** The online teachers logged in to the course at least once a day to monitor students' activity or progress, but they communicated directly with only about 25 percent of the students every day. Communications containing math content were infrequent; however, when a student contacted the online teacher directly, the teacher almost always (96 percent of the time) replied within 24 hours.
  - **In-class proctors spent more time providing math content support than expected.** Although the proctors' role did not require providing math instruction, they spent an average of about 60-75 minutes per week answering algebra-related or other non-algebra-related math questions for students taking the online course.
- Rates of course completion in the online course varied.
  - **The average number of course units completed was 7.5, or 85 percent of the online course.**
  - **43 percent of the online algebra students completed the entire course**, including all 9 core units of the full-year course (5 units in Algebra IA and 4 in IB).
  - **82 percent of the online algebra students completed the first half of the course (Algebra IA) and part of Algebra IB.**

Content of the Business-as-Usual Math Classes – to What Was Online Algebra Compared?

At the outset of the study it was known that grade-8 students in schools with no or limited access to a formal Algebra I course are still exposed to algebraic content. Therefore, this study was not a comparison of online algebra with no algebra whatsoever. To clarify the true nature of the contrast between the treatment and control conditions, the study team closely documented the mathematics offered to students in control schools.

The study found that most (80 percent) of the algebra-ready students in control schools took a general grade-8 math class. To understand the content of the math classes offered, the study team analyzed course materials and gauged the extent to which the topics covered are typically found in formal Algebra I courses.

- In nearly half of the control schools, the general math class focused on algebraic content 75 percent or more of the time, and nearly all of the classes (94 percent) had a curricular focus on algebraic content of half or more. Thus, algebra-ready (and non-algebra-ready) students in control schools were exposed to a substantial amount of algebra content, even though they had little or no access to a formal Algebra I course.
- Moreover, 45 students — 20 percent of the algebra-ready students in control schools — took a separate Algebra I course taught at the local high school or middle school.

Study Results: Impacts of Online Algebra I

Potential Benefits for Algebra-Ready Students

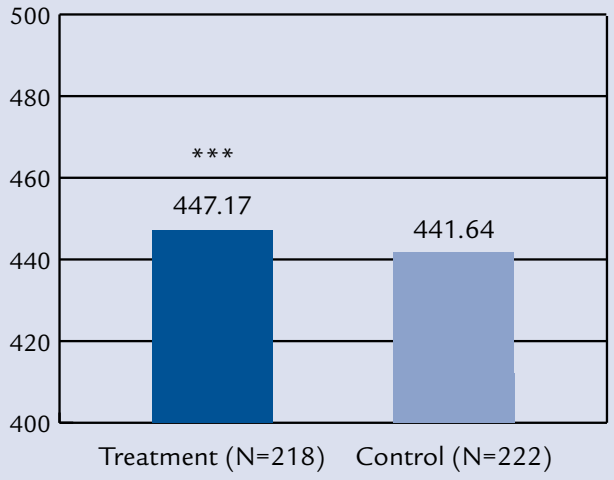
The study measured **potential benefits for algebra-ready students** for two main outcomes:

- Algebra knowledge and skills, measured with an end-of-year computer-adaptive algebra assessment taken by all students in participating schools.
- High school course-taking — specifically, the likelihood of participating in an advanced math course sequence — based on information about ninth-grade courses taken, grades earned, and tenth-grade course enrollments.[vi]

To test whether the online course benefitted students' algebra knowledge and skills and high school coursetaking patterns, the study compared outcomes for all 218 algebra-ready students in treatment schools (who had access to online Algebra I) to outcomes for all 222 of their algebra-ready counterparts in control schools. The results showed that the online course had a significant positive impact on both outcomes.

1. **Students in treatment schools (that offered online algebra) scored higher than students in control schools** on an algebra achievement test given at the end of eighth grade. The difference between students in treatment schools and students in control schools was 5.5 points on a scale ranging from 400-500 (shown in the graph at right).[vii] This difference is equivalent to moving students from the 50th to the 66th percentile in achievement by taking the online course.

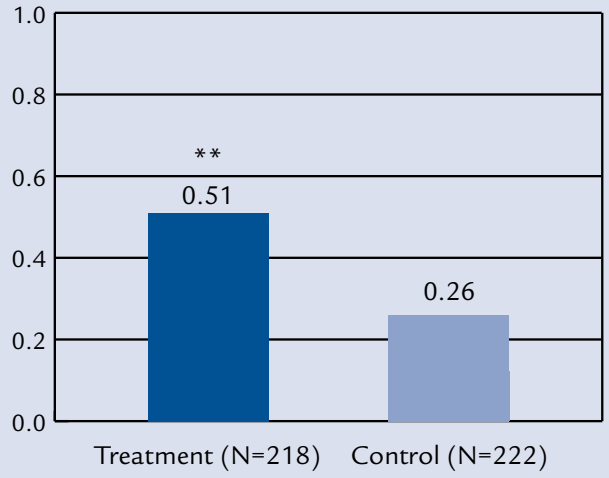
Figure 4: Algebra-ready students' end-of-eighth grade algebra scores



Note. *** p < .001.

2. **Students from treatment schools (that offered online algebra) were more than twice as likely as control students to take an advanced math course sequence in high school.** Using information about courses taken, grades earned, and courses planned in the first 2 years of high school, we found that the chances of being in an advanced course sequence were 51 percent for students who attended middle schools that offered the online Algebra I course versus 26 percent for control students.[viii]

Figure 5: Algebra-ready students' predicted probability of advanced math course-taking



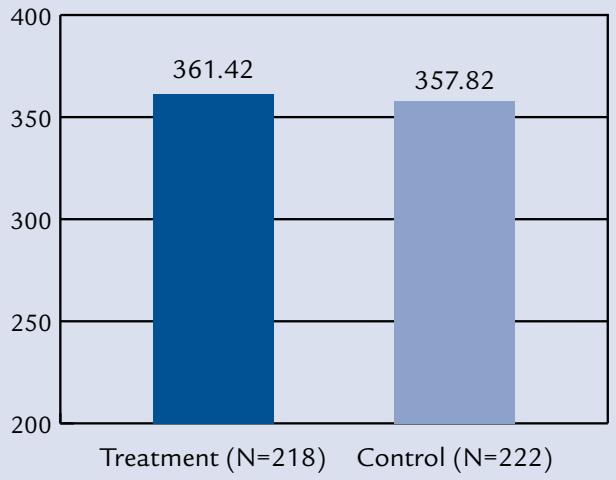
Note. *** p < .01.

Potential Side Effects

We also found **no significant unintended consequences** as a result of offering online Algebra I to eligible students. Specifically:

1. **Algebra ready students' general math achievement was not affected by taking online Algebra I.** All students in the participating schools took a computer-adaptive general math assessment at the end of eighth grade, and scores for algebra-ready students in treatment schools did not differ significantly from their counterparts' in control schools.

Figure 6: Algebra-ready students' end-of-eighth grade general math scores



This important finding responds to potential concerns that students who take Algebra I in eighth grade — in this case as an online course — will miss out on general math content. Eighth grade state math assessments typically cover a range of topics, and some schools may worry that offering online Algebra I will lead to lower proficiency rates. The study findings suggest that students who take online Algebra I in eighth grade do not score significantly differently on a general math assessment than they would have had their schools not offered the online course.

2. **Non-algebra-ready students were not affected by their schools' adoption of the online Algebra I course on any of the outcomes AIR examined.** These included their algebra and general math scores and their projected high school course-taking.

Summary of Findings

This study demonstrated that, compared with business-as-usual math instruction, students with access to online Algebra I in eighth grade learned more algebra that year and later doubled their chances of taking advanced math courses in high school. These results show that online Algebra I offered in grade 8

benefits students by boosting algebra knowledge and skills and by opening doors to more advanced course opportunities in later years.

The study also found that there were no negative side effects on students in schools that adopted online Algebra I. Such potential consequences of implementing an online course were important to educators in the types of schools that participated in the study, and for schools around the country. When a school decides to use an online course (or any other innovation) to create opportunities for some but not all students, the school must question whether any of those students might be harmed by that choice.

In combination, the findings lead us to conclude that offering online Algebra I is an effective way to broaden access to this specific course in eighth grade and, later, to more challenging math courses in schools where access is typically limited.

Conclusions

Implications

The study was designed to provide information to educators who are looking for ways to offer a key gateway course — Algebra I — to their eighth graders who are ready for it, but for various reasons cannot typically offer full access to the course in a standard or traditional way. The goal for offering the online course was not only to benefit short-term algebra achievement but to influence a sequence of math opportunities and outcomes over time. It may seem obvious that students with access to an online Algebra I course should learn more algebra and take more advanced courses earlier in high school than those who do not. But for multiple reasons, the results observed were not necessarily obvious and addressed gaps in the research base.

Before this study, there was no prior evidence that an online version of a formal Algebra I course could successfully be offered to middle school students in terms of technology and content support. Additionally, though the logistical implementation of the course went as planned, just under half (43%) of the students who enrolled in the course fully completed it, meaning that many of the algebra-ready students in the treatment group were not exposed to the entire course. At the same time, their algebra-ready counterparts in control schools were exposed to a substantial amount of algebraic content in the context of the general math classes, and 20 percent of them actually did take a formal Algebra I course. Despite these circumstances, the results demonstrate that online Algebra I, as implemented in the study, was more effective for promoting students' success in math than existing practices in these schools.

Limitations and Future Directions

The online course chosen, Class.com's Algebra I course, was similar in content, focus and structure to the offerings of other providers. However, it is not clear that results would have been similar if another provider had been chosen. Moreover, the results observed in this study cannot necessarily be generalized to more recently developed online courses, or to courses in other subject areas.

As the use of online courses continues to increase in U.S. schools, researchers should continue to study the effects on student achievement and course-taking patterns in key content areas. Further research on online courses should compare online options to various other relevant business-as-usual situations and curricula. These include school settings in which students lack access to specific courses (where the control group does not take the course) and in which

particular courses are oversubscribed (where the control group would take a standard face-to-face version of the online course).

Schools around the country will continue to search for innovative ways to expand their course offerings, and online courses are an increasingly available option. This study provides early evidence that under particular conditions, students benefit when schools expand access to Algebra I by offering it online.

For more information about the study, please visit: http://www.air.org/focus-area/education/index.cfm?fa=viewContent&content_id=1641&id=10

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Endnotes

i Schwartzbeck et al. 2003; Hanum et al. 2009.

ii Stevenson, Schiller, and Schneider 1994; Schneider, Swanson, and Riegle-Crumb 1998; U.S. Department of Education 1996; Smith 1996; Spielhagen 2006.

iii Loveless 2008.

iv Walston and Carlivati McCarroll, 2010.

v Prior research suggests that successful completion of Algebra II by the end of tenth grade signals participation in an "advanced course sequence" (Schneider et al. 1998; Stevensen et al. 1994). Based on this research, we coded high school course sequences for students in the study as "advanced" if the students successfully completed a full-year course *above* Algebra I in ninth grade (e.g., Geometry) with a grade of C or higher, and enrolled in the next course in the sequence (e.g., Algebra II) for grade 10.

vi This difference is equal to an effect size of 0.40 standard deviations, considered moderate to large for an educational intervention.

vii Exploratory analyses conducted as part of this study tested the effect of online Algebra I in eighth grade on the likelihood that students would "double up" on full-year math courses in ninth or tenth grade (or both). The results showed that students from control schools were more than twice as likely to double up in math courses in grade 9 or 10 as students who took online algebra in eighth grade. This suggests that in addition to affected *whether* students pursued an advanced course sequence, online algebra in grade 8 had an impact on *how* students entered an advanced course pathway.

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