What Works Clearinghouse

ies INSTITUTE OF EDUCATION SCIENCES

Cognitive Tutor® Algebra I

Program description

Cognitive Tutor® Algebra I, a full year course, delivers instruction in single variable data, simplifying linear expressions, mathematical modeling, solving systems with linear equations, problem solving using proportional reasoning, and powers and exponents. Students work at their own pace to develop problem-solving skills. The duration of each lesson can vary, depending on the length of a school's class period. Generally, three periods a week are spent using the *Cognitive Tutor® Algebra I* text for classroom activities, and two are spent in the computer lab using the *Cognitive Tutor® Algebra I* software.

Research

One study met the What Works Clearinghouse (WWC) evidence standards and one study met the WWC evidence standards with reservations. Together, the two studies included more than 800 ninth graders in more than 40 classrooms in Florida and Oklahoma. The studies examined the effects of *Cognitive Tutor® Algebra I* on students' math achievement.[1]

The WWC considers the extent of evidence for *Cognitive Tutor® Algebra I* to be moderate to large for math achievement.

Effectiveness

Cognitive Tutor® Algebra I was found to have potentially positive effects on math achievement.

	Math achievement
Rating of effectiveness	Potentially positive effects
Improvement index[2]	Average: +8 percentile points
	Range: –1 to +16 percentile points

1. The evidence presented in this report is based on available research. Findings and conclusions may change as new research becomes available.
2. These numbers show the average and range of improvement indices for all findings across the studies.

Additional program information

Updating previous report

This report updates the previous WWC report on *Cognitive Tutor®* that was released on the WWC website in December 2004. The report released in 2004 reviewed research on a variety of *Cognitive Tutor®* math programs. However, this report focuses on *Cognitive Tutor® Algebra I*.

Since the original review of *Cognitive Tutor®* was released in December 2004, the WWC has updated its evidence standards and developed peer-review procedures for adjusting such methodological flaws in studies as nonequivalent groups at pretest and a mismatch between the unit of assignment and the unit of analysis. These standards and procedures have been applied to all studies in this updated review.

Developer and contact

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Scope of use

Pilot implementation of the curriculum began in 1992 with 84 students in one school. As of December 2006, *Cognitive Tutor®* curricula, which include Bridge to Algebra, Algebra I, Algebra II, Geometry, and Integrated Math, have been used by more than 475,000 students in 1,300 urban, rural, and suburban school districts across the United States. In 2006, Carnegie Learning revised some of the instructional and technological aspects of *Cognitive Tutor® Algebra I*. According to the developer, no fundamental changes to the pedagogical approaches or content were made.

Teaching

Typically, three class periods a week are organized around textbook materials and small group activities. Teachers facilitate small group problem solving and whole classroom discussions. In the other two class periods, students work at their own pace to develop problem-solving skills by working on the computer with the *Cognitive Tutor® Algebra I* software. In the computer lab, teachers interact with students individually.

Carnegie Learning provides a four-day preservice training. In-service professional development is also available during the year. Teacher training for *Cognitive Tutor® Algebra I* (software and text) covers the philosophy and application of these products. The training sessions are conducted by Certified Implementation Specialists—current or former mathematics teachers who have completed in-depth training from Carnegie Learning's staff of educators, technology specialists, and curriculum developers.

Cost

Cognitive Tutor® Algebra I is offered to schools as annual site license configurations. According to the developer, pricing per student starts at $58.80 for the full curriculum—software, books, and maintenance. Volume and term discounts are available. Professional development costs $600 per teacher attending a regional training site or $2,500 a day for onsite training.

Research

Five studies reviewed by the WWC investigated the effects of *Cognitive Tutor® Algebra I*. One study (Morgan & Ritter, 2002), which was reviewed in the original WWC report, was a randomized controlled trial that met WWC evidence standards. One study (Shneyderman, 2001), which is new to this report, used a quasi-experimental design that met WWC evidence standards with reservations. The remaining three studies did not meet WWC evidence screens.

Morgan and Ritter (2002) included 369 ninth-grade students in four suburban junior high schools in the Moore Independent School District in Oklahoma. Students in intervention classrooms used *Cognitive Tutor® Algebra I*, and students in the comparison group used McDougal Littell's Heath Algebra 1, a traditional, teacher-directed curriculum. Students in the intervention and comparison groups attended the same schools and were taught by the same teachers.

Research *(continued)*

Shneyderman (2001) included 439 ninth-grade students from six public high schools[3] in Miami-Dade County, Florida, during the 2000-01 school year. The intervention group used the *Cognitive Tutor® Algebra I* textbook, classroom activities, and software. No information was provided on the comparison group other that these students did not use the *Cognitive Tutor® Algebra I* textbook and software. Students in the intervention and comparison groups attended the same schools.

Extent of evidence

The WWC categorizes the extent of evidence in each domain as small or moderate to large (see the What Works Clearinghouse Extent of Evidence Categorization Scheme). The extent of evidence takes into account the number of studies and the total sample size across the studies that met WWC evidence standards with or without reservations.[4]

The WWC considers the extent of evidence for *Cognitive Tutor® Algebra I* to be moderate to large for math achievement.

Effectiveness

Findings

The WWC review of interventions for middle school math addresses student outcomes in the math achievement domain.

Math achievement. Morgan and Ritter (2002) reported statistically significant differences favoring *Cognitive Tutor® Algebra I* students over comparison students on end-of-first semester and end-of-second semester math grades. The level of statistical significance for these outcomes was confirmed by the WWC. The study also reported no statistically significant differences between the groups on the Educational Testing Service (ETS) Algebra End-of-Course Assessment. The average effect size across all three outcomes (as calculated by the WWC) was statistically significant.

Shneyderman (2001) reported a statistically significant difference between *Cognitive Tutor® Algebra I* students and comparison students on the ETS Algebra End-of-Course Assessment and no statistically significant differences on the Florida Comprehensive Assessment Test. These analyses included all the students in the sample. The WWC analysis, based on additional information received from the study author that included only students who took both the pretest and posttest, found no statistically significant differences between the groups on either measure. Further, the average effect size across the two outcomes was neither statistically significant nor large enough to be considered substantively important according to the WWC standards (that is, at least 0.25).

In sum, one study showed statistically significant positive effects, and one study showed indeterminate effects in the math achievement domain.

Rating of effectiveness

The WWC rates the effects of an intervention in a given outcome domain as positive, potentially positive, mixed, no discernible effects, potentially negative, or negative. The rating of effectiveness takes into account four factors: the quality of the research design, the statistical significance of the findings,[5] the size of the difference between participants in the intervention and comparison conditions, and the consistency in findings across studies (see the WWC Intervention Rating Scheme).

3. The ninth-grade sample of the Shneyderman (2001) study was reviewed for this report because the middle school math topic review focuses on grades 6–9 regardless of setting (middle school, junior high school, or high school). For further details see the Middle School Math Protocol.
4. The Extent of Evidence categorization was developed to tell readers how much evidence was used to determine the intervention rating, focusing on the number and size of studies. Additional factors associated with a related concept, external validity, such as students' demographics and the types of settings in which studies took place, are not taken into account for the categorization.
5. The level of statistical significance was reported by the study authors or, where necessary, calculated by the WWC to correct for clustering within classrooms or schools and for multiple comparisons. For an explanation, see the WWC Tutorial on Mismatch. See Technical Details of WWC-Conducted Computations for the formulas the WWC used to calculate the statistical significance. In the case of *Cognitive Tutor® Algebra I*, corrections for clustering and multiple comparisons were needed.

The WWC found *Cognitive Tutor® Algebra I* to have potentially positive effects for math achievement

Improvement index

The WWC computes an improvement index for each individual finding. In addition, within each outcome domain, the WWC computes an average improvement index for each study and an average improvement index across studies (see Technical Details of WWC-Conducted Computations). The improvement index represents the difference between the percentile rank of the average student in the intervention condition versus the percentile rank of the average student in the comparison condition. Unlike the rating of effectiveness, the improvement index is entirely based on the size of the effect, regardless of the statistical significance of the effect, the study design, or the analyses. The improvement index can take on values between –50 and +50, with positive numbers denoting results favorable to the intervention group.

The average improvement index for math achievement is +8 percentile points across the two studies, with a range of –1 to +16 percentile points across findings.

Summary

The WWC reviewed five studies on *Cognitive Tutor® Algebra I*. One of these studies met WWC evidence standards and another study met the WWC evidence standards with reservations; the remaining three studies did not meet WWC evidence screens. Based on these two studies, the WWC found potentially positive effects in the math achievement domain. The evidence presented in this report may change as new research emerges.

References

Met WWC evidence standards

Morgan, P., & Ritter, S. (2002). *An experimental study of the effects of Cognitive Tutor Algebra I on student knowledge and attitude.* Retrieved November 22, 2006, from http://www.carnegielearning.com/research/research_reports/morgan_ritter_2002.pdf.

Met WWC evidence standards with reservations

Shneyderman, A. (2001, September). *Evaluation of the Cognitive Tutor Algebra 1 Program.* Unpublished manuscript. (Miami-Dade County Public Schools Office of Evaluation and Research, 1500 Biscayne Boulevard, Miami, FL 33132)

Did not meet WWC evidence screens

Koedinger, K. R., Anderson, J. R., Hadley, W. H., & Mark, M. A. (1997). Intelligent tutoring goes to school in the big city. *International Journal of Artificial Intelligence in Education, 8,* 30–43.[6]

Plano, G. S., Ramey, M., & Achilles, C. M. (2005, August). *Implications for student learning using a technology-based algebra program in a ninth-grade algebra course.* Unpublished manuscript. (Mercer Island School District).[7]

Additional source:

Plano, G. S. (2004). The effects of the Cognitive Tutor® Algebra on student attitudes and achievement in a 9th grade algebra course. *Dissertation Abstracts International, 65*(04), 1291A. (UMI No. 3130130).

6. Lack of evidence for baseline equivalence: the study, which used a quasi-experimental design, did not establish that the comparison group was equivalent to the intervention group at baseline.
7. Lack of evidence for baseline equivalence: the study, which was reviewed as a quasi-experimental design, did not establish that the comparison group was equivalent to the intervention group at baseline. This study, which was designed as a regression discontinuity design, did not properly assign students at the cutoff grade.

References *(continued)*

Sarkis, H. (2004). *Cognitive Tutor® Algebra 1: Miami-Dade County Public Schools.* Lighthouse Point, FL: The Reliability Group.[6]

For more information about specific studies and WWC calculations, please see the WWC *Cognitive Tutor®* *Algebra I* Technical Appendices.