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# Moore Independent School District

This report summarizes data about the use of Cognitive Tutor Algebra I in the Moore Independent School District during the 2000-01 school year. The district evaluated the curriculum using a true experimental design, with students randomly assigned to either the Cognitive Tutor or a traditional curriculum. Some teachers taught both Cognitive Tutor and traditional classes, providing an opportunity to control for teacher effects.

The Cognitive Tutor students showed a significant advantage on all dependent measures, including the ETS Algebra End-of-Course assessment, course grades and measures of student attitudes towards mathematics.

Due to the rigor of the experimental design and use of multiple outcome measures, this study represents one of the strongest tests of any mathematics curriculum performed to date. The results in favor of the Cognitive Tutor curriculum make a strong case that the curriculum can increase student learning and improve student attitudes towards mathematics.

**Quick Facts**

Urban Public School District, located in Moore, Oklahoma

5 junior high schools

18,000 total students enrolled

1,035 total students studied

2000-2001 school year

**Study Design**

Random Assignment, Within-Teacher

**Measures**

Standardized Exam: ETS Algebra End-of-Course Exam

Teacher report/Course Grade

Attitude Survey

**Study Conducted by**

Moore Independent School District

**Ethnic Breakdown of School**

White: 65%

Native American: 18%

Black: 5%

Asian: 5%

Hispanic: 4%

**Participants**

Participants were students in Moore Independent School District attending one of its five junior high schools. Cognitive Tutor Algebra I was used at four of the junior high schools among eight teachers (two at each school). A traditional Algebra curriculum, employing McDougal Littell's Heath Algebra I, was used at all five schools. Six teachers (two at each of three schools) taught both Cognitive Tutor and traditional classes. In addition, honors students taking Algebra I in eighth grade (with a traditional curriculum) participated in the attitude survey portion of the study. In all, 272 Cognitive Tutor students, 544 traditional students and 219 honors students participated in the study, though the numbers differ slightly for different dependent measures.

**Method**

As a part of regular class registration, students were randomly assigned to a Cognitive Tutor or traditional classroom. At the end of the school year, students were administered a survey of their attitudes towards mathematics, and some students were administered the ETS Algebra I End-of-Course assessment. All students taking a Cognitive Tutor course were asked to take the exam. To reduce costs, not all traditional students took the ETS exam. Instead, traditional classes were randomly selected to ensure that there were an adequate number of within-teacher comparisons and that approximately equal numbers of Cognitive Tutor and traditional students took the ETS exam.

**Results**

ETS Algebra End-of-Course Assessment

In order to isolate the effects of curriculum, we need to consider whether students who were classified as using a particular curriculum in fact used that curriculum for the full school year. To accomplish this, we classified students based on their enrollment status at the end of the first semester and at the time that the ETS end-of-course exam was taken. The analyses reported here are restricted to students who stayed with a single curriculum, taught by the same teacher, throughout the school year. This comprises 94% of the original sample.

*63% of students surveyed felt that the Cognitive Tutor was more effective than other mathematics courses.*

The ETS Algebra End-of-Course Assessment consists of 25 multiple-choice and 15 constructed-response questions, with each type of question accounting for 50% of the student's score. Scores are reported on a 0-50 scale. For the national population taking this assessment in 2001, the mean score on this test was approximately 18, with a standard deviation of 9. Although students at Moore scored slightly below this mean, we do not have any information about the population taking the test nationally, so it is difficult to compare the results at Moore to the general population taking the test.

Table 1 shows the results on the ETS Algebra End-of-Course exam. Analysis of variance shows the difference between curricula to be significant, $F(1,442)=8.8$, $p<.01$.

| | Cognitive Tutor | Traditional |
|---|---|---|
| # of Students | 224 | 220 |
| Mean Scaled Score (sd) | 16.7 (5.7) | 15.1 (5.5) |

Table 1: *Student scores on the ETS End-of-Course Algebra exam by curriculum*

If we consider only those students whose teachers taught both Cognitive Tutor and traditional classes, we see that the Cognitive Tutor advantage still holds when controlling for teacher, $F(1,253)=6.6$, $p<.02$.

ETS results are also reported by the students' level of understanding, categorized as minimal, basic, proficient, or advanced. Table 2 shows the percentage of students in each category. The table shows that the primary advantage of the Cognitive Tutor course was to move students from the basic to the proficient level. ETS describes students at the basic level as "able to work with algebra at a concrete or procedural level of understanding," while those at the proficient level can "work … at an abstract level of understanding," "exhibit conceptual understanding" and "recognize relationships in multiple representations."

| | Cognitive Tutor | Traditional |
|---|---|---|
| Advanced | 1% | 1% |
| Proficient | 31% | 17% |
| Basic | 64% | 74% |
| Minimal | 4% | 8% |

Table 2: *Percent of students at each level of understanding, by curriculum*

### Course Grades

The Moore school district assigns grades of A, B, C, D and F. These grades were collected in both the first and second semesters of school. Grades were then converted to a standard numeric score (A=4; F=0).

Since grading is subjective and since not all teachers taught both curricula, it makes sense to look at grades for only those teachers who taught both curricula. This analysis controls for differences between teachers in the strictness of their grading. As shown in Table 3, the difference between curricula is statistically significant for both semesters' grades: $F(1,367)=4.0$, $p<.05$ for the first semester and $F(1,362)=5.5$, $p<.02$ for the second semester.

| | Cognitive Tutor | Traditional |
|---|---|---|
| First Semester | 2.94 (1.10) | 2.70 (1.20) |
| Second Semester | 2.67 (1.19) | 2.36 (1.30) |

Table 3: *Grade point averages for students whose teachers taught both curricula. Standard deviation is in parentheses.*

*100% of teachers responding to a survey said they would recommend the Cognitive Tutor to others.*

In part, this difference is due to a reduction in the failure rate from 10.2% in the traditional classes to 6.9% in the Cognitive Tutor classes. There was a corresponding increase in the percentage of "A"s given in the Cognitive Tutor classes, to 30% from 23.7% in the traditional classes.

### Student Attitudes

A survey based on one developed by Fennema and Sherman (1976) was used to assess attitudes towards mathematics. It contained 24 items representing subscales devoted to students' confidence in mathematics and their feelings about the usefulness of mathematics. For example, an item on the confidence scale was "I think I could handle more difficult math." An item on the usefulness scale was "I use mathematics in many ways outside of school." Students rated their agreement with each item on a five-point scale.

Table 4 shows the mean results on the two subscales (confidence and usefulness) of the attitude survey. An analysis of variance shows that the effect of course is significant for the confidence scale, $F(2,979)=60.5$, $p<.0001$ and the usefulness scale, $F(2,979)=36.3$, $p<.0001$. Planned comparisons of both confidence and usefulness show students in the honors classes providing significantly higher ratings than students in the other two classes and Cognitive Tutor students providing significantly higher ratings than students in the traditional classes.

| | Cognitive Tutor | Traditional | Honors |
|---|---|---|---|
| Confidence | 3.5 (0.9) | 3.2 (1.0) | 4.0 (0.8) |
| Usefulness | 3.8 (0.8) | 3.6 (0.9) | 4.1 (0.7) |

Table 4: *mean scores on attitude subscales, by course. Standard deviations are in parentheses*

**Discussion**

Results on all measures favor Cognitive Tutor students. The fact that these results were obtained in a true experimental context eliminates many bias explanations that might be used against a correlational or quasi-experimental design. Furthermore, the fact that the results were consistent even when controlling for teacher, strengthens their validity and eliminates explanations having to do with teacher selection. Finally, the results described here are not only statistically significant but substantial. Effect sizes range from about 0.18 to 0.3, all moderate size effects.

Further analysis shows that the Cognitive Tutor students' advantage on the content knowledge measures was consistent across ethnic groups represented in this population (since attitude surveys were submitted anonymously, we cannot look at individual student factors in the attitude data).

Follow-up surveys show that both teachers and students were enthusiastic about the Cognitive Tutor course. When asked whether the Cognitive Tutor Algebra I course was more, less or equally effective compared to other math courses they had taken, 63% of students indicated that they felt the course was more effective. Only 13% said it was less effective. Seven of the eight Cognitive Tutor teachers returned a questionnaire distributed at the end of the school year. All seven responded "yes" when asked if they would recommend the Cognitive Tutor to others.

Reference:
Fennema, E. & Sherman, J.A. (1976). Fennema-Sherman mathematics attitude scales. Instruments designed to measure attitudes toward the learning of mathematics by males and females. JSAS Catalog of Selected Documents of Psychology, 6(31). (Ms. No. 1225).

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