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REPORT

Analysis of Costs in an Algebra I Curriculum Effectiveness Study

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RAND EDUCATION

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Preface

In 2007, the U.S. Department of Education's Institute of Education Sciences awarded the RAND Corporation a grant to evaluate the wide-scale effectiveness of the Cognitive Tutor® Algebra I (CTAI) curriculum. CTAI is a technology-based curriculum that combines classroom instruction with individualized instruction by a computer-based tutor.

RAND researchers employed a randomized, controlled trial experiment in approximately 150 schools in seven states to measure student learning of algebra I using this curriculum compared with the algebra I curricula that were in place in participating schools. Half of participating schools were randomly assigned to adopt CTAI and the other half to continue using their existing algebra I curriculum. Results of this effectiveness evaluation are forthcoming.

To complement questions regarding effectiveness, the RAND research team also collected and analyzed information regarding the costs of implementing the CTAI curriculum and the comparison curricula. The purpose of this technical report is to document this effort. It reflects costs reported by district or school officials regarding the adoption and implementation of their algebra I curricula. This component of the research was carried out between October 2009 and January 2010.

This report will be of interest to educators and policymakers who would like to understand and weigh costs along with effectiveness in their decisions regarding the selection of algebra I curricula.

This research was conducted by RAND Education, a division of the RAND Corporation. Its mission is to bring accurate data and careful, objective analysis to the national debate on education policy. Additional information about RAND is available at www.rand.org.

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Summary

As part of RAND's ongoing evaluation of the effectiveness of Carnegie Learning's Cognitive Tutor® Algebra I (CTAI) curriculum in realistic school settings, the research team examined the costs of implementing the CTAI curriculum and comparison algebra I curricula. The CTAI curriculum provides a computer-based tutor for individualized support to students, uses consumable textbooks that students write in, and recommends higher levels of initial training and professional development than comparison curricula. While these features may make the curriculum more or less effective in raising student achievement, a primary focus of the effectiveness study, the affordability of the curriculum is another factor that districts may wish to consider in deciding whether to adopt it. At the time of this evaluation, districts were experiencing significant budget pressures, which may place constraints on whether to adopt a new curriculum and which one to select.

The purpose of this report is to document the cost information collected in this study so that school districts can evaluate the costs associated with adopting and implementing the CTAI curriculum, and how those costs compare with a set of three other algebra curricula used in these districts and across the nation. This information can assist school districts in assessing cost feasibility—whether implementing the CTAI curriculum is feasible given their available resources. This report is intended to complement forthcoming reports on the effectiveness of CTAI, in order to provide educators and policymakers with essential information for future decisions regarding the adoption of algebra I curricula.

Data and Methods

The RAND evaluation of CTAI includes the participation of approximately 150 middle and high schools in 50 U.S. school districts in seven states. The study employed an experimental research design in which half of participating schools were randomly assigned to adopt the CTAI curriculum and the other half to continue using their existing algebra I curriculum. The cost data for this report were collected from schools participating during the first two years of the evaluation, from 49 school districts in six states.

Researchers surveyed one district-level official, such as the superintendent or director of curriculum and instruction, in each district regarding curriculum costs associated with three categories: materials, which include textbooks and software; software implementation resources, such as computers; and teacher training costs. The surveys were initially fielded online, with follow-up by mail and telephone, and the response rate for the survey was 74 percent. Responding and nonresponding districts did not differ significantly, although districts in

Louisiana or with a high proportion of students eligible for free or reduced-price lunch tended to be less likely to respond.

Results

A thorough cost feasibility analysis of Carnegie Learning's CTAI curriculum demonstrated that its reliance on computer-aided instruction and its recommended levels of teacher training result in higher per-student costs than many existing algebra I curricula in participating schools. We report annualized per-student costs that consider inflation, length of adoption or useful life of ingredients, and the average number of students participating in the two study years. Overall costs of CTAI were, on average, about $69 per student higher than the comparison curricula (published by Prentice Hall, Glencoe, and McDougal Littell) that were in place in the participating districts. The CTAI curriculum cost was estimated to be $97.18 per student, compared with $27.88 per student for the other algebra I curricula. The following paragraphs examine the costs associated with each of the three categories.

Although the purchase price of student textbooks (and accompanying workbooks) was higher for the comparison curricula, those curricula did not require replacement of the textbooks each year. In contrast, the CTAI textbooks must be replaced every year. Thus, over the course of curriculum adoption the cost of the CTAI curriculum was estimated to be higher: $21.55 versus $11.28. The cost of the CTAI software was also higher than other algebra I software programs in use by the districts: $29.92 versus $14.04.

Technology equipment, infrastructure, and support expenditures for the CTAI curriculum were higher than for districts using other software packages in their algebra I classrooms. Thirty percent of districts adopting CTAI spent additional money on computers, infrastructure, and/or support staff to implement the curriculum. While the investment in technology may have benefited all students in the school, even those not enrolled in algebra, it was clear that the technology demands of CTAI triggered extensive technology investments that might not otherwise have occurred. These investments raised the up-front cost to implement CTAI compared with other technology curricula.

Teacher training was another reason for CTAI's higher per-student cost. Schools adopting CTAI in this study were provided an amount of professional development that was equal to the amount that schools typically purchase when they adopt the CTAI curriculum on their own, as reported by Carnegie Learning. Forty percent of the comparison districts reported providing little to no curriculum-specific training to their algebra I teachers. While many of these schools were not newly adopting their algebra curriculum, we asked them to report on any professional development they provided at the time of adoption as well as ongoing professional development. The level of training recommended by Carnegie Learning cost about $15 per student more than training provided for the comparison curricula.

Discussion

This analysis found that CTAI was more expensive to adopt than comparison curricula. The cost of Carnegie Learning curriculum materials, including student textbooks and licenses, was higher than the comparison curricula published by Prentice Hall, Glencoe, and McDou-

gal Littell. The Cognitive Tutor software had greater technology infrastructure and support requirements than other software programs, which caused districts to purchase new computers, upgrade their technology infrastructure, and/or hire technology staff. Although these upgrades may positively impact all students, this additional up-front cost of adopting CTAI may be prohibitive.

The CTAI curriculum is largely based on an approach in which students lead the classroom discussions of mathematics, and teachers facilitate their discussions. According to Carnegie Learning, the combination of the instructional approach and software warranted a significant amount of teacher training. Investments in teacher training lead to higher-quality implementation of the curriculum and could have the potential to improve student achievement outcomes.

Overall, adoption of the CTAI curriculum was likely to cost a district significantly more than what was typically spent on the other algebra I curricula used by participating schools. The RAND research team is completing its analysis of the effectiveness of the CTAI curriculum. Findings from this effectiveness evaluation may play a critical role in supporting districts' decisions to adopt the CTAI curriculum. If findings suggest significant positive outcomes for students the additional costs associated with implementing CTAI may be viewed as warranted. This report can complement the effectiveness results to serve as a resource to educators and policymakers in weighing the costs and benefits of CTAI adoption.

Acknowledgments

The authors thank the district and school personnel who provided much of the data for this study by generously taking the time to respond to our survey. For assistance with the study and this report, we are also grateful to reviewers Patrick McEwan and Heather Schwartz and RAND colleagues Laura Hamilton and Melanie Rote. We also thank Mary Ann Stine, who pilot tested the survey instrument.

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Abbreviations

CBA	cost-benefit analysis
CCC	Computer Curriculum Corporation
CEA	cost-effectiveness analysis
CTAI	Cognitive Tutor Algebra I
EL	English learner
EO	English only
HISD	Houston Independent School District
IRS	Internal Revenue Service
NAEP	National Assessment of Educational Progress
PISA	Program for International Student Assessment

CHAPTER ONE

Introduction

Despite recent small gains in mathematics achievement among public school students, data from the National Assessment of Educational Progress (NAEP) continue to show very low mathematics proficiency rates for high school students. In 2009, only 3 percent of 12th-grade students reached an advanced level of performance, only 26 percent were performing at the proficient level or above, and 36 percent scored below the basic level (National Center for Education Statistics, 2010).

Furthermore, large gaps in the performance of students from different racial/ethnic and socioeconomic groups persist on NAEP and other measures of academic achievement. The 2009 NAEP 12th-grade results (National Center for Education Statistics, 2012a) show that 63 percent of black students and 55 percent of Hispanic students scored below the basic level of proficiency in mathematics, compared with 25 percent of white students. The picture is similar for socioeconomically disadvantaged students. According to the 2011 NAEP results (National Center for Education Statistics, 2011), eighth-graders who were eligible for free lunch scored 28 points lower on average than those not eligible.

Data from the Program for International Student Assessment (PISA) show U.S. students performing below their peers in most developed countries (OECD, 2010). The United States also performs more poorly than other countries in the proportion of college students graduating with degrees in mathematics, the sciences, and engineering (Snyder and Hoffman, 2003), and the problem is even more severe at the graduate level (National Science Foundation, 2002). Yet the nation's need for engineers and other mathematically proficient professionals in the workforce is expected to continue to grow (Bureau of Labor Statistics, 2002). Meeting this demand will require development of a diverse workforce that is well prepared in mathematics skills before entering college (Noeth, Cruce, and Harmston, 2003). Taken together, these data highlight the importance of improving the mathematics preparation offered by middle and high schools so that students are positioned to pursue careers in mathematics-related fields, contributing to their own future life opportunities and the U.S. economy.

One approach to addressing the challenge of mathematics preparation is to identify curricula that are effective in raising student achievement and implementing them in middle and high schools across the country. In 2007, the U.S. Department of Education's Institute of Education Sciences (IES) awarded the RAND Corporation a grant to evaluate the effectiveness of Carnegie Learning's Cognitive Tutor® Algebra I (CTAI) curriculum. CTAI is a technology-based curriculum that combines classroom instruction with individualized instruction by a computer-based tutor. RAND researchers employed a randomized, controlled trial experiment in approximately 150 schools in seven states to measure student learning of algebra I using this curriculum compared with the algebra I curricula that were already in place in participating

schools. Half of participating schools were randomly assigned to adopt CTAI and the other half to continue using their existing algebra I curriculum. Results of this effectiveness evaluation are anticipated to be published in 2012.

As part of RAND's ongoing evaluation of the effectiveness of the CTAI curriculum in realistic school settings, the RAND research team also collected and analyzed information regarding the costs of implementing the CTAI curriculum and the comparison curricula. This report documents the cost information collected from 35 school districts participating in the randomized control trial regarding the adoption and implementation of their existing algebra I curricula and costs to implement the CTAI curriculum.

The CTAI curriculum provides a computer-based tutor for individualized support to students, uses consumable textbooks that students write in, and recommends higher levels of initial training and professional development than comparison curricula. While these features may make the curriculum more or less effective in raising student achievement, the cost of the curriculum is another principal consideration in deciding whether to adopt it. In 2007, Cognitive Tutor curricula (i.e., pre-algebra, algebra, and geometry) were already in use by more than 375,000 students in more than 1,000 school districts, and their widespread adoption was the most direct evidence of their perceived affordability. At the time of this evaluation (October 2009–January 2010), school districts were experiencing significant budget pressures that may place constraints on whether to adopt a new curriculum and which one to select.

The information in this report is intended to help school districts evaluate the costs associated with adopting and implementing the CTAI curriculum, and how those costs compare with a set of other algebra curricula in typical use. This information can assist school districts in assessing cost feasibility—whether implementing the CTAI curriculum is feasible given their available resources.

Cost to Adopt and Implement Algebra I Curricula

Comparing the cost for adopting and implementing CTAI and comparison curricula was exacting. Our analysis considered three categories of cost of adoption—curriculum materials, professional development, and the cost of technology needed to implement curriculum software—over the period of curriculum adoption. Most of the districts or schools adopting CTAI outside this study purchase the curriculum directly from the developer, Carnegie Learning. Before volume discounts, schools purchasing the CTAI curriculum in 2006[1] paid approximately $69 per student for all materials and software, plus professional development costs. This appeared comparable to the student textbook prices of comparison curricula. For example, in 2006 Prentice Hall's Algebra I Classics Edition student text cost about $50 per student in small quantities, and McGraw Hill's Glencoe Algebra I student text cost about $60 per student in small quantities. However, many of the comparison texts could be reused for several years, while the CTAI text, with tear-out pages, was not reusable. Additionally, the CTAI software licenses had to be renewed annually.

The costs quoted above for the Prentice Hall or McGraw Hill textbooks do not include all of the curriculum components that schools might acquire. These publishers charge addi-

[1] The study uses curricula costs for adoption in 2006, prior to the adoption of the CTAI curriculum for the CTAI effectiveness study.

tional fees for student workbooks and other supplemental materials, whereas similar materials are included in the CTAI price. Carnegie Learning's three-day teacher professional development could be obtained on-site for $6,500 for up to 25 teachers, or at regional sites for $600 per teacher. The Cognitive Tutor, the technology component of the CTAI curriculum, requires computer and online access. Comparison curricula with software may also require these items; however, the requirements vary. If the requirements of a particular curriculum are more stringent, the overall cost could be higher in comparison with other curricula. These costs may not appear in purchase price comparisons but may have significant budgetary impacts on school districts.

Research Questions

Nearly all students enroll in algebra I over their K–12 career, and algebra has been argued to be a particularly important gateway to success in advanced mathematics (Shettle et al., 2008; Smith, 1996). Thus, some schools may be willing to adopt a curriculum found to be effective in raising student achievement regardless of cost. However, many districts have experienced significant pressure to improve mathematics achievement while facing budgetary pressures that may place constraints on whether to adopt a new curriculum and which one to select. That said, comparisons of algebra I curriculum costs are not straightforward. Per-student costs for adopting and implementing one curriculum may not include all aspects of the per-student cost for a comparison curriculum.

Given this background, the study addressed the following questions:

- What were the reported costs associated with adopting and implementing the CTAI curriculum?
- What were the reported costs associated with adopting and implementing the three algebra I curricula used in nearly all of the schools participating in the effectiveness study (Prentice Hall, Glencoe, and McDougal Littell)?
- How did costs for adopting and implementing CTAI compare with costs of adopting and implementing schools' existing algebra I curricula?

The RAND research team used an online survey to collect information regarding curriculum costs associated with three categories: materials, which include textbooks and software; software implementation resources, such as computers; and teacher training costs. The survey was sent to one district-level official (e.g., a superintendent, director of curriculum and instruction, mathematics/science coordinator) per district in 49 school districts in six states.[2] Follow-up efforts were conducted by mail and telephone. If, after these follow-up attempts, a district-level official still had not responded to the survey, it was sent to a school principal, assistant principal, or teacher with a leadership role in mathematics. The survey contained items regarding three categories of cost for the district's existing algebra I curriculum, as well as the CTAI curriculum if any schools in the district were randomly selected to implement CTAI.

[2] This cost analysis considers schools participating in the first two years of the study. In the third and fourth years, an additional 12 schools in one district in a seventh state participated, but their data are not included in this cost analysis.

Purpose of This Report and Limitations

This report presents a cost feasibility analysis for implementing CTAI and comparison curricula. The intent is that this report will complement forthcoming reports on the effectiveness of CTAI, in order to provide educators and policymakers with essential information for future decisions regarding the adoption and implementation of algebra I curricula.

Cost feasibility analysis does not consider student performance or outcomes, which are also highly relevant to districts' decisions regarding which curriculum to adopt. Forthcoming reports on the effectiveness of CTAI on student performance may help to address this limitation of the cost analysis.

We requested that districts review their financial records when completing the survey; however, the project team did not independently review these records to determine the accuracy of responses. We gauged the accuracy of reported information by comparing reported costs across districts that implemented the same curriculum. Cost estimates that appeared to be outside of the range reported by other districts that implemented the same curriculum resulted in follow-up conversations for clarification. Chapter Two contains further discussion of the limitations of this approach.

Organization of This Report

The remainder of this report is organized into three chapters. Chapter Two discusses the techniques we used to collect and analyze the cost data, including a rationale for the selection of a cost feasibility analytic technique and a description of the cost survey instrument. Chapter Three summarizes results on the cost to adopt and implement CTAI and the comparison algebra I curriculum, and Chapter Four discusses implications. The appendix provides an example of the cost survey instrument.

CHAPTER TWO

Data and Methods

Survey Sample

The evaluation of the effectiveness of the CTAI curriculum included schools from 49 urban, suburban, and rural districts in six states.[1] Schools were randomly assigned to receive CTAI or to continue using the school's existing algebra I curriculum. The number of participating schools within each district ranged from one, in small districts, to 45 in a large urban district. For the effectiveness study, schools were paired prior to random assignment based on similarity of characteristics (e.g., middle or high school, mathematics proficiency rates, socioeconomic status, and racial/ethnic composition, state, etc.). In larger districts, schools were paired within-district; in medium to small districts, schools were often paired with a school from another district in the same state. One school within each pair was randomly assigned to implement the CTAI curriculum. Thus, after random assignment, some districts had participating schools implementing only the CTAI curriculum, some had schools implementing CTAI and the district's existing algebra curriculum, and other districts had schools implementing only the comparison curriculum. In sum, 32 of the 49 districts had schools implementing CTAI, and 31 had schools implementing one of the comparison curricula.

Survey Development

Thus, there were three types of surveys—one for districts with both CTAI and comparison curricula schools (n=14), one for districts with only CTAI schools (n=18), and one for districts with only comparison curricula schools (n=17).

Prior to the development of our surveys, we had used a teacher survey to collect basic information about the district's algebra I curricula. This revealed that the districts used Prentice Hall, Glencoe, McDougal Littell, or a district-created curriculum. We used this information to customize the survey for each district. Each survey item referred specifically to the comparison curriculum in use in the district. Comparison curriculum-only districts received a survey with 43 questions on the algebra I curriculum used in their district during the study period. CTAI-only districts received a survey with 18 questions about the Carnegie Learning CTAI curriculum. Districts with CTAI and comparison curricula schools received a combined version of the two surveys with 61 questions (the comparison curricula questions followed by

[1] This cost analysis considers schools participating in the first two years of the study. In the third year, an additional 12 schools in one district in a seventh state participated, but their data are not included in this cost analysis.

the CTAI curriculum questions, customized by curriculum name).[2] The surveys included skip patterns, so the typical respondent was presented with only about half of the survey's questions.

The research team developed survey questions after some preliminary research to determine how districts price and purchase mathematics curricula and software. The combined survey, including questions about the comparison and CTAI curriculum, was piloted with a former mathematics teacher and Director of Curriculum and Instruction in a nonparticipating district in Washington state who was familiar with the CTAI curriculum. This person provided feedback by telephone to the research team, with a particular focus on the clarity of the questions and ease in answering them. Information gathered during this pilot test was used to revise the questions and finalize the survey versions.

Data Collection

To obtain the information for this cost analysis, we identified a contact in each of the districts that would be likely to have access to information on the material and training costs associated with the adoption and implementation of algebra I curriculum in the study schools. These district contacts included superintendents, directors of instruction, and mathematics/science coordinators. Surveys were initially fielded on October 28, 2009, using SurveyMonkey, an online survey tool. Emails were sent to district contacts with a brief description of the survey and a link to the appropriate online version of the survey. Prior to sending these email links to the surveys, district personnel received letters by mail that described the purpose of the survey and included an incentive to increase response rates, a $50 gift card to Target. Fifty-three percent of districts responded to this first attempt.

A reminder email was sent to nonrespondents two weeks after the initial email, and several reminder calls were made in the weeks thereafter. To further increase our response rates, on November 18, 2009, the research team sent paper versions of the survey to nonrespondents. These contact attempts yielded an additional two surveys.

After one month of no response from initial contacts, the research team identified principals in the nonresponding districts (in which only one school participated) who might be able to provide the cost information. On December 9, 2009, we sent the identified principals letters with hard copies of the survey, links to the online survey, and $50 gift card incentives. We also followed up by email with clickable links to the online survey. Final reminder emails were sent to nonresponding principals and district contacts on January 4, 2010, and reminder calls were made later that week. The survey closed on January 15, 2010, with a 71 percent response rate.

The majority of the responses to the survey were collected online, though one district contact filled out the paper survey and one provided the information by phone. Many of the responses were incomplete or contained information that seemed unlikely or contradictory. To ensure that the data were consistent and accurate, we followed up by email or telephone to clarify. Twenty districts required clarifying conversations; we were able to gather the missing information from nine of the districts. In cases where the unclear or contradictory responses could not be resolved through follow-up, we treated the data in question as missing. Nonetheless, the majority of respondents (87.5 percent) had complete data for all questions.

[2] An example of the survey instrument administered to districts implementing both the CTAI and comparison curricula appears in the appendix.

Table 2.1 presents the response rates for the districts implementing (1) only the CTAI curriculum, (2) the comparison-only curriculum, and (3) both CTAI and the comparison curricula. Of the 15 respondents from CTAI-only districts, nine were district-level contacts, two were principals or assistant principals, one was a teacher, and three chose not to identify their position. Of the 15 respondents from comparison districts, six were district-level contacts, five were principals or assistant principals, and four chose not to identify their position. For districts implementing both the CTAI and comparison curricula, three of the five respondents were district-level contacts, and two were principals or assistant principals. The response rates for the CTAI and comparison curricula groups were 83.3 percent and 88.2 percent, respectively. Responses rate for districts implementing both curricula during the study was low, 35.7 percent. In our analyses, we combined responses regarding the comparison curricula from districts implementing the comparison curriculum only and districts implementing both CTAI and comparison curricula. Similarly, we combined responses regarding the CTAI curriculum from districts implementing CTAI only and districts implementing both CTAI and comparison curricula. In total, there were responses from 40 districts in the following cost analysis, 20 providing information about CTAI costs and 20 providing information about comparison curriculum costs.

Using data available from the National Center for Education Statistics (2012b) from the 2007–2008 school year, we examined differences in responding and nonresponding schools (Table 2.2). Responding and nonresponding districts did not differ significantly after correcting for multiple hypothesis testing using the Benjamini and Hochberg (1995) procedure with a false discovery rate of 0.05. Other than Connecticut and New Jersey, which each had a single urban district that did not respond, responses were received from each state represented in the study. However, districts from Louisiana tended to be less likely to respond, as were districts with a high proportion of students eligible for free or reduced-price lunches. A subsequent test found no significant relationship between the proportion of district students eligible for free or reduced-price lunches and the district's reported curriculum costs.

Table 2.1
Respondents and Response Rates

	CTAI Curriculum Only	Comparison Curriculum Only	Both CTAI and Comparison Curricula
Type of respondent			
District-level contact	9	6	3
Principal or assistant principal	2	5	2
Teacher	1[a]	0	0
Unidentified	3	4	0
Total number of responses	15	15	5
Number of districts in sample	18	17	14
Response rate	83.3%	88.2%	35.7%

[a] The responding teacher is from a special school operated by the intermediate unit and was able to answer questions about the curriculum but not training.

Table 2.2
Comparison of Nonresponding and Responding Districts

	Nonrespondents	Respondents	Mean difference	Standard error
District is in Connecticut	12.50%	0.00%	–0.125	0.116
District is in Kentucky	3.13%	32.00%	0.289	0.161
District is in Lousiana	56.25%	12.00%	–0.443	0.174
District is in Michigan	12.50%	11.00%	–0.015	0.098
District is in New Jersey	15.63%	0.00%	–0.156	0.140
District is in Texas	0.00%	45.00%	0.450	0.255
District is in a city	41%	57%	0.164	0.259
District is in a suburb	22%	13%	–0.089	0.137
District is in a rural area or in a distant/ remote town	38%	30%	–0.075	0.209
District has less than 2,000 students	9%	12%	0.026	0.099
District has 2,000 to 3,000 students	22%	16%	–0.059	0.143
District has 4,000 to 20,000 students	44%	25%	–0.188	0.205
District has more than 20,000 students	25%	47%	0.220	0.282
Logarithm of number of students in district	8.90	10.07	1.174	1.032
Percentage of students eligible for free or reduced-price lunch	71.22%	57.13%	–0.141	0.055
Pupil-teacher ratio	14.79	15.96	1.167	0.634
Textbook expenditure per student	$67.94	$71.38	$3.44	$29.65
Instructional equipment expenditure per student	$140.82	$95.35	$(45.47)	$80.49
Percentage of district population below poverty level	21%	18%	–0.025	0.022

SOURCE: National Center for Education Statistics, 2012b.

NOTE: District values are weighted by the number of district schools participating in the study. None of the differences between responding and nonresponding districts are significant after correction for multiple tests.

Cost Analysis Techniques

There are many different techniques that can be used to compare the costs and benefits of various curricula. Cost-benefit analysis (CBA) is the method that is most commonly used in government analyses. CBA requires calculation of a monetary estimate of all of the costs associated with a policy or intervention, as well as all of the benefits. Benefits are then divided by costs to provide a benefit-cost ratio, which provides the value of the benefits per dollar spent (Levin and McEwan, 2001). CBA typically discounts costs and benefits that come in the future and attempts to include the value of things that are not tangible (e.g., teacher satisfaction). Policymakers then decide whether the benefit per dollar of expenditure is worth putting the policy or intervention into place.

Another method, cost-effectiveness analysis (CEA), is more commonly used to compare the relative costs and effects of two courses of action (such as CTAI versus existing algebra I curriculum). CEA is distinct from CBA because it provides a relative comparison rather than

a monetary measure of benefit per dollar spent. To calculate the cost-effectiveness of implementing a new curriculum, the procedure would be to compare the difference in average per-student costs with the difference in average student test scores (Levin and McEwan, 2001). Policymakers would then have to determine whether the cost for increased test scores is low enough to make the curriculum worth implementing. Whether using CBA or CEA, schools could compare the results for the intervention with results for other educational interventions or other curricula to determine which provides the most benefit for a given cost.

The analysis reported herein uses a third method, cost feasibility analysis, which does not attempt to combine the findings on the effects of the CTAI curriculum on student achievement (or other student outcomes) with its costs relative to other algebra I curricula. Cost feasibility analysis simply attempts to estimate the comparative costs of the CTAI curriculum and other algebra curricula being used in the study districts (Levin and McEwan, 2001). Cost feasibility analysis can help districts and/or schools to determine whether it is financially possible to implement the CTAI curriculum given the limited resources that are available for mathematics curricula. The results of this cost feasibility analysis can also be converted into a CEA by combining these results with the RAND study's forthcoming results on CTAI's effect on student outcomes such as achievement.

Cost feasibility analysis is relatively straightforward. The objective is to identify all of the ingredients necessary for a program and to try to obtain estimates for the cost of these ingredients (Levin and McEwan, 2001). We determined that the majority of costs for an algebra I curriculum can be accounted for by three types of expenditures. The first was costs of materials, including textbooks, student workbooks, teacher guides, and software. The second source of costs was specific to curricula that include software components. Schools may have had to invest in technology resources, such as computers, wiring, or technology staff to allow them to implement this software. Because the software component was such a significant portion of the CTAI curriculum, it was important for us to account for these costs. The final source of costs that may come with implementation of an algebra curriculum was the cost of teacher training. Our cost feasibility analysis therefore compared the CTAI curriculum with other algebra I curricula in each of these three areas, as well as combining these costs to create an estimate of the overall per-student cost for the curricula.

The analysis amortizes ingredient costs over their useful life and adjusts for the opportunity costs of making up-front investments in resources that are used over several years. To calculate the useful life of materials, we used information provided by districts regarding the length of their curriculum adoption cycles. We also referred to Internal Revenue Service (IRS) tables regarding the useful life of technology investments such as computers.

Methods

The analysis in this cost feasibility study was primarily descriptive. Costs were broken into three categories: materials costs, which include textbooks and software; software implementation resources, such as computers; and training costs. The survey also asked participants if there were any additional costs associated with the adoption and implementation of either the CTAI or comparison curricula that were not captured in these three main ingredients. No districts reported additional costs beyond the materials, software implementation resources, and teacher training costs.

All but one district purchased the comparison algebra I curriculum from a curriculum publisher; the survey did not ask about costs associated with developing the curriculum. In follow-up conversations, we planned to ask the one district that reported it developed its own curriculum for information about the staff costs associated with doing so. However, our attempts to follow up with that district were unsuccessful.

Curriculum pricing typically follows a national pricing model where the material costs are adjusted based on the size of the adoption (or number of students using the curriculum materials). Curriculum developers are able to lower the cost of the textbooks for large districts because the number of textbooks the district purchases is considerably higher than a medium-sized or small district. For this reason, we separate Houston Independent School District (HISD) from other districts because the size of the district and pricing model for adoption are not comparable to other districts completing the survey. For example, while the cost of Carnegie Learning textbooks was the same for HISD as two other districts, the software licenses were notably less expensive per student because of the size of enrollment in algebra I. As such, we believed it would make sense to report averages, both including and excluding HISD, in tables throughout Chapter Three. Additionally, we discuss results for HISD separately from other districts in our sample.

For the comparison curricula, respondents provided the total cost of a single textbook (and the cost of accompanying materials, such as workbooks and teacher guides). Because districts typically used textbooks for more than one year and sometimes have multiple students in a single year using a single textbook, we calculated the total cost of the materials and the annualized total cost for the adoption (Walker and Kumaranayake, 2002), then divided by the average number of students in the effectiveness study from years 1 and 2 to yield a per-student cost. To this we added the costs of any materials that must be replaced yearly, such as supplemental workbooks. In terms of software costs, districts using software were asked for the cost of a single software license the number of students served by the license each year, and the duration, in years, of the license. We used these figures to obtain a per-student license cost.

The research study used grant funds to pay for CTAI materials and training; therefore, respondents were unable to answer questions about the costs of Carnegie Learning textbooks, software, and training. Further, the research study was provided with a substantially discounted cost of these ingredients. Using this discounted price would not accurately reflect the cost of adoption for districts purchasing the curriculum on their own. Therefore, we used a pricing guide from Carnegie Learning from 2006, the year of curriculum adoption for the effectiveness study, to estimate the costs these districts would have incurred had they purchased the materials, software, and training themselves. We use a five-year adoption cycle to annualize the cost of materials and divide by the average number of students participating in the effectiveness study per year to calculate the per-student cost. This approach may not provide the optimized cost for adoption in each district. This approach does not consider a competitive bid or negotiating process that districts and companies might undertake for a particular curriculum (algebra I) or district-wide all-math-course adoption, which might lower the overall cost of adoption.

Because CTAI software plays a substantial role in classroom instruction, where it is recommended to be used for 40 percent of overall class time, it was likely that many schools needed to make investments in technology and/or support staff to assist with implementation of the software. We asked all CTAI districts, as well as districts using other software programs, about the costs incurred for computers, wiring, technology staff, and any other purchases made

specifically for the implementation of software in algebra I classes. We did not specifically ask how many years computers were used. We referred to tables prepared by the IRS (2010) regarding the lifespan of the equipment that districts reported purchasing. Recognizing that the IRS tables apply to all types of businesses and that schools might use equipment longer, we also reviewed other available documents on the typical lifespan for technologies in schools. For example, Davis (2010) suggests that schools continue to use laptops beyond the three years suggested by the IRS lifespan tables. This was corroborated in interviews with leaders and teachers conducted by the research project for purposes beyond the cost study. Thus we adopted a useful life for computers of five years for this cost study.

We calculated the annualized cost for technology, then divided by the average number of students participating in the effectiveness study per year to yield a per-student cost. In districts implementing the CTAI and comparison curricula, we used the average number of students using the CTAI if the technology cost was incurred to implement CTAI, and the number of students using the comparison curricula if the cost was incurred to implement the comparison curricula or software.

Training costs, like the other costs, are presented at the student level. We accounted both for the cost of the trainer and for payments to teachers or substitute teachers if the curriculum-specific training was given outside of the district's required in-service training days. Our survey items for training were specific to the curriculum. If teachers did not receive specific training in the curriculum, they were instructed to report zero hours, even though the district almost certainly offers training opportunities to enhance teachers' general practice over the course of a school year. We do not include costs for more general mathematics training or professional development that teachers may receive during a school year. These sessions likely occur regardless of which curriculum a district implements.

A limitation of the estimated training cost is that it does not provide for the cost of training new teachers when there is turnover. We did not explicitly ask about this in our survey, and we do not have access to district-wide turnover rates for each of our districts. Assuming that turnover rates are similar for CTAI and comparison curriculum schools, the relative curricula costs would be similar if turnover training costs were factored into the calculations.

After identifying the per-student cost for materials, technology, and training, we calculated the weighted district average of these costs. We use the number of schools in a district implementing the CTAI to weight for costs specific to the CTAI curriculum, and the number of schools implementing the comparison curricula to weight costs specific to the comparison curriculum. As discussed above, the average weighted costs are presented in two ways: excluding HISD and including HISD.

Limitations

A limitation of our method for determining costs of comparison curricula is the reliance on self-reported cost information. Our survey asked district personnel to report retrospectively on curriculum expenditures that may have occurred several years in the past. We requested that respondents review financial records while responding, but acknowledged that precise records might not be available and that estimation might be necessary. The project team did not independently review district records to determine the accuracy of responses. Thus, the cost reporting could be subject to recall bias. We gauged the accuracy of reported information

by comparing costs across districts for those implementing the same curriculum. Although the majority of districts provided full responses to the survey items online or through follow-up phone conversations, some data were missing for a few districts. For example, one district developed its own algebra I curriculum, but we do not have the cost of the materials, number of students using the materials, or the costs for developing the curriculum. We cannot address costs for materials in that district because the information is missing.

We estimate the cost of the CTAI curriculum using a pricing guide and general information for costs of licenses based on a particular adoption model. There are potential methods to lower the cost of the curriculum, such as negotiating the rate for the materials, using a competitive bid process, or identifying a more cost-effective approach for the software licenses (i.e., per-student versus per-building versus district-wide). Our approach uses a consistent model that might not yield optimized adoption costs for each individual district.

The cost for comparison curricula are more likely to reflect an optimized cost whereby districts might have used a competitive bid or negotiation process. Districts may have received lower materials costs from a curriculum company if they adopted multiple curricula from a single company at the same time (i.e., algebra I, geometry, and algebra II). Therefore, costs for comparison curriculum could reflect unknown cost reductions that our calculations do not consider. If this is a common practice among curriculum developers, we expect that Carnegie Learning would also adjust its costs for a district-wide, multiple-course adoption of its materials.

Specific to the ingredients in the cost feasibility analysis, we restrict the cost to three ingredients, which is not exhaustive. Technology resources were reportedly limited in many schools. If algebra software implementation required significant technology resources, as did CTAI for some schools, this use might displace access to these resources for other students or other courses. For example, the team does not ask about or consider how the school might be affected by the reallocation of Title I funding to construct a computer lab, purchase computers, or upgrade wiring. Similarly, our approach to estimating technology support costs did not account for situations in which schools reallocated the use of existing computer facilities and staff. To the degree that this occurred, the technology support costs we calculated underestimate the true costs of implementing a software component of an algebra I curriculum. Moreover, software that schools implement to complement the algebra I textbook may not be comparable in content to the CTAI software. This reiterates the importance of districts to also consider student achievement effects of the curricula when assessing the best curriculum to adopt.

Materials costs were based on estimates for the number of students that use a textbook each year and the average number of students participating in the effectiveness study in years 1 and 2. It is likely that the actual number of students taken from enrollment files for all algebra I classes for each school in a district is different. Schools selected all or some algebra I classes to participate in the study. Our per-student costs are based on the number of students participating in the effectiveness study, which may place a district in a lower enrollment CTAI cost category than the cost of adoption for all algebra I classes in all schools across the district.

Finally, the cost feasibility analysis does not consider student performance or outcomes, which are also highly relevant to districts' decisions on curriculum adoption. This report complements forthcoming reports on the effectiveness of CTAI that will address the performance of students using the CTAI and comparison curricula.

CHAPTER THREE

Results

Cognitive Tutor Algebra I Curriculum Costs

The CTAI textbooks are designed to be written in and consumed by a single student, so a full set of new textbooks must be provided to each student. The Cognitive Tutor software program is a major aspect of the CTAI curriculum, with Carnegie Learning recommending that 40 percent of class time be spent using the software. In addition to the CTAI textbook, districts must therefore purchase software licenses. These licenses can be purchased either for individual students or for entire schools. The significant role that the software component plays in the CTAI curriculum may also necessitate significant investments in technology for many schools, or reallocation of existing technology resources.

Carnegie Learning's recommendations regarding teacher training have evolved over the years. When this study commenced, the company was recommending three days of initial training prior to the start of implementation, followed by four days of observation and monitoring of classroom implementation and four days of co-planning and co-teaching using toolkit data to inform instruction. Carnegie Learning provided the research team with statistics regarding the actual amount of professional development that school districts purchased when they adopted CTAI on their own. These amounts, which were less than the amounts recommended by the company, were used to determine how much professional development was provided to schools adopting CTAI in the study. The study provided three days of initial training and two days of follow-up training per year, because this was how much was typically purchased by schools adopting CTAI on their own. We also estimated a range of costs by using two other training scenarios: one in which the district obtains only the initial three days of training, and one in which the district uses the full 11 days of training recommended by Carnegie Learning in 2006.

Material Costs

The 2006 price of a Carnegie Learning algebra I textbook was $22.00 for districts purchasing fewer than 250 textbooks, and $18.50 otherwise. Along with the textbook, students received a homework helper and another workbook of practice problems that were included in the cost of a textbook. Teacher texts were $85.00, and software implementation guides were $47.50. Teacher guides were provided as part of the initial three-day training for the curriculum implementation, so if we assume that all teachers received this training, there was no additional cost for teacher guides. Even if new teacher guides were purchased occasionally, amortizing the cost across all of the teachers' students would result in a likely per-student cost of less than $1.00. Thus, we assume that teacher guides did not impose a significant cost. This results in an esti-

mate of the annual range of per-student costs for nonsoftware CTAI materials of $19.06 to $22.66, accounting for inflation.

Carnegie Learning provided several options for purchasing software licenses. Licenses could be purchased for individual students or for an entire school. Prices varied by the number of licenses purchased (or the number of students enrolled in a school), the number of years for which the licenses were purchased (one, three, or five years), whether the school was purchasing the algebra I software only or whether it was also purchasing Carnegie Learning's other curricula (such as pre-algebra, geometry, or algebra II), and whether the school purchased support and maintenance for the software. We used the costs for the purchase of individual student licenses in our base estimates. This can be viewed as an upper bound, because presumably if districts recognized that a different licensing method would be less expensive they would opt for that method. As seen in Table 3.1, the lowest cost per student was $17.92, for a large district (at least 25,000 software users) that purchased the software for five years without the support and maintenance option. The maximum cost per student was $40.00, the cost for a small district (less than 250 software users) to purchase the software for a single year without the support and maintenance option.

As a check to ensure that we were not grossly overestimating the costs of the software by using the per-student license costs, we used the school-wide site license costs (Table 3.2) to estimate the student enrollment necessary to make this option cheaper than the per-student software license cost. The site licenses were least expensive for large schools with five-year contracts. In a school with 25,000 students purchasing the software for five years with support and maintenance, more than 27 percent of students would have to use the software each year to bring the per-student cost below $23.76. For a school with 499 students, more than 32 percent of students would need to use the software to bring the cost below $27.60. It is unlikely that more than one-third of students at a school will be enrolled in algebra I in a given year, so we concluded that only the largest schools would benefit from the school-wide site license, and that the cost of software, support, and maintenance was likely to cost at least $15.00 per student no matter which license purchase scheme was used. Thus, the use of individual student licenses for software with support and maintenance appeared to be a valid approximation of what typical schools would pay for the software component of the CTAI curriculum.

We used the above figures to calculate the cost of a five-year CTAI adoption for districts implementing CTAI. We used the actual number of students participating in years 1 and 2 of the effectiveness study to calculate each district's size-based costs, and we annualized the figures, including an adjustment for the cost of making an up-front multiyear investment

Table 3.1
Individual Student License Costs for CTAI Software

Item Description	Quantity	1-Year Unit Cost ($)	3-Year Unit Cost ($)	5-Year Unit Cost ($)
Software license	1–249	40.00	34.00	32.00
	250–499	28.00	23.80	22.40
	500–999	24.00	20.40	19.20
	1,000–24,999	23.20	19.72	18.56
	25,000+	22.40	19.04	17.92
Support and maintenance	1	5.20	5.20	5.20

Table 3.2
Site License Costs for CTAI Software

Term	Student Enrollment	Annual License ($)	Support and Maintenance ($)	Total Cost ($)
1 year	1–499	6,000.00	780.00	6,780.00
	500–999	9,600.00	1,560.00	11,160.00
	1,000–1,999	16,800.00	3,119.76	19,919.76
	2,000+	21,000.00	3,899.70	24,899.70
3 years	1–499	4,000.00	520.00	13,560.00
	500–999	6,400.00	1,040.00	22,320.00
	1,000–1,999	11,200.00	2,079.84	39,839.52
	2,000+	14,000.00	2,599.80	49,799.40
5 years	1–499	3,900.00	507.00	22,035.00
	500–999	6,240.00	1,014.00	36,270.00
	1,000–1,999	10,920.00	2,027.84	64,739.20
	2,000+	13,650.00	2,534.80	80,924.00

NOTE: Student enrollment refers to total school enrollment.

(Walker and Kumaranayake, 2002). Table 3.3 shows the calculated annualized per-student cost of textbooks, software licenses, and maintenance. Districts with enrollment sizes in algebra I below 250 students were estimated to have total per-student costs of $60.98, whereas districts with algebra I enrollment sizes between 250 and 500 students had estimated per-student costs of $47.48. The largest district, HISD, had an estimated per-student cost of $43.53. On average, the cost to adopt CTAI in districts other than HISD was estimated to be $56.82 per student; the figure is $50.58 when HISD is included in the average. As discussed above, these averages are weighted by district size.

Technology Expenditures

Thirty percent of CTAI districts spent additional money on computers; technology infrastructure, such as wiring or laptop carts; and/or technology staff, specifically to implement the CTAI software. As previously mentioned, school districts that did not purchase new technology were likely to have reallocated existing technology resources toward CTAI, reducing its availability to other students in the school. Thus, the new technology expenditures reported to us probably underestimate the true technology costs across all CTAI schools. On the other hand, the study design may have posed an unnatural situation that led to overestimates of the technology investments that a district would have made had it purchased CTAI on its own. Because the study paid the bulk of material and training costs (with the exception of payments of wages to teachers or substitutes), districts may have used money that they would have spent on curriculum materials and training to purchase technology. In addition, it was a study requirement for schools to have the technology necessary to implement the software component of the CTAI curriculum, so many schools may have chosen to deploy their resources to purchase technology in order to qualify for the study and receive the free curriculum materials. Finally, it may also be the case that, consciously or subconsciously, district officials wanted to do whatever they could to ensure that the study would be successful and that their algebra I

Table 3.3
Per-Student Costs for a Five-Year CTAI Adoption in Schools Implementing CTAI

District	Algebra I Enrollment	Textbook ($)	Software License ($)	Maintenance ($)	Total ($)
Catholic Diocese Schools	1–249	22.66	32.96	5.36	60.98
Chippewa Valley	1–249	22.66	32.96	5.36	60.98
Hancock County	1–249	22.66	32.96	5.36	60.98
Warren County	250–499	19.06	23.07	5.36	47.48
Ascension Parish	1–249	22.66	32.96	5.36	60.98
Bossier Parish	1–249	22.66	32.96	5.36	60.98
Center Line Area Schools	1–249	22.66	32.96	5.36	60.98
Fayette County	1–249	22.66	32.96	5.36	60.98
Hart County	1–249	22.66	32.96	5.36	60.98
Lake Shore Area Schools	250–499	19.06	23.07	5.36	47.48
Macomb Intermediate	1–249	22.66	32.96	5.36	60.98
Monroe County	1–249	22.66	32.96	5.36	60.98
Recovery School District	1–249	22.66	32.96	5.36	60.98
Russellville Independent	1–249	22.66	32.96	5.36	60.98
Somerset Independent	1–249	22.66	32.96	5.36	60.98
Tangipahoa Parish	1–249	22.66	32.96	5.36	60.98
Taylor County	250–499	19.06	23.07	5.36	47.48
Van Dyke Area Schools	1–249	22.66	32.96	5.36	60.98
Whitley County	250–499	19.06	23.07	5.36	47.48
Weighted district average (excluding HISD)		21.55	29.92	5.36	56.82
HISD	1,000–24,999	19.06	19.12	5.36	43.53
Weighted district average (including HISD)		20.38	24.85	5.36	50.58

students would get the greatest possible value out of this opportunity. This desire to receive free curriculum materials and/or make the study successful could have led some districts to allocate funding toward technology purchases for algebra I that would not otherwise have been spent in this way, or to leverage the opportunity to obtain free curriculum materials through this study in applications for technology grants from other sources.

We annualized technology costs using the average number of students participating in years 1 and 2 of the study and useful life or adoption cycle of technology in districts. After consulting the IRS's estimate of the useful life for computers in business (three years; IRS, 2010), an article discussing computer replacement cycles in education (three to five years; Davis, 2010), and educator interviews that revealed that a district (in the comparison group of the study) purchased its computers seven years ago, we opted to annualize the cost of computers over five years. Across the CTAI districts that purchased equipment, annualized per-student computer costs ranged from $20.47 to $122.90, with a weighted average of $22.32 for districts other than HISD and $69.53 including HISD (Table 3.4). For other support costs, such

Table 3.4
Annualized Technology Expenditures in Schools Using CTAI Curriculum

District	Technology Staff	Computers ($)	Other Support ($)	Total ($)
Catholic Diocese Schools	–	–	–	–
Chippewa Valley	–	–	–	–
Hancock County	–	–	–	–
Warren County	–	20.47	0.94	21.41
Ascension Parish	–	33.34	IDK	33.34
Bossier Parish	–	–	–	–
Center Line Area Schools	–	87.83	Carts included	87.83
Fayette County	–	–	–	–
Hart County	–	–	–	–
Lake Shore Area Schools	–	–	–	–
Macomb Intermediate	IDK	–	–	–
Monroe County	–	–	–	–
Recovery School District	–	118.39	29.01	147.40
Russellville Independent	–	–	–	–
Somerset Independent	–	–	–	–
Tangipahoa Parish	–	–	–	–
Taylor County	–	–	–	–
Van Dyke Area Schools	–	–	–	–
Whitley County	–	80.52	2.24	82.76
Weighted district average (excluding HISD)	–	22.32	2.51	24.84
HISD	1	122.90	7.68	130.58
Weighted district average (including HISD)	–	69.53	4.94	74.47

NOTE: "IDK" indicates respondent did not know the answer.

as wiring, we used the IRS (2010) useful life appraisal to compute annualized costs ranging from $0.94 to $29.01 per algebra I student in districts that reported such costs. We estimated the total technology expenditures per student to be $24.84 for districts other than HISD, and $74.47 when HISD is included in the calculation. These average costs are weighted by district size. Use of the technology by other, non-algebra students would further reduce the per-student cost of the technology to support algebra.

Training Costs

In 2006, Carnegie Learning offered several options for training. For larger districts that wanted to arrange their own trainings, the cost of the trainer was $6,000 for three days, with a per-teacher cost of $85 for training materials. The other option was for teachers to attend a regional training. The per-teacher cost to attend a regional training was $685. These costs worked out the same if ten teachers attended an in-district training, with savings for the in-district train-

ing if more than ten teachers attended. For the purposes of this analysis, we used $685 as an upper-bound estimate of the per-teacher costs for the initial three-day training. We used the number of teachers that participated in the study the first two years in schools implementing the CTAI to calculate a total district cost for the first-year teacher training. We annualized the cost of initial training over five years of the CTAI adoption (consistent with the length used for materials) and used the average number of students participating in the study per year to calculate the per-student cost. The average per-student cost was estimated to be $3.97 excluding HISD, and $3.36 when HISD is included (Table 3.5). We calculated the per-student cost for the first year of HISD teacher training to be $2.67. This could be assumed to be a lower bound, where all training took place during in-service training hours so that teachers or substitute teachers did not need to be paid for their time. Eight districts opted to hold additional CTAI training for teachers outside of in-service time. The average per-student cost of this

Table 3.5
Annualized Costs for Teacher Training over a Five-Year CTAI Adoption

District	Initial First-Year 3-Day Training Cost ($)	First-Year Ongoing Training Cost ($)	Additional First-Year Training Hours	Additional First Year Training Cost ($)	Total First-Year Training Cost ($)	Total Second-Year Ongoing Training Cost ($)	Total Adoption Teacher Training Cost ($)
Catholic Diocese Schools	4.67	10.24	–	–	14.91	12.61	27.52
Chippewa Valley Area Schools	2.62	2.87	18	0.57	6.07	3.54	9.61
Hancock County	1.26	2.75	24	1.83	5.84	3.39	9.24
Warren County	2.92	2.56	12	0.21	5.69	3.15	8.85
Ascension Parish	3.43	2.50	–	–	5.93	3.08	9.01
Bossier Parish	5.98	13.10	18	1.57	20.66	16.14	36.80
Center Line Area Schools	1.67	1.83	–	–	3.50	2.25	5.76
Fayette County	11.81	8.62	–	–	20.43	10.62	31.05
Hart County	5.98	13.10	6	0.70	19.78	16.14	35.92
Lake Shore Area Schools	2.71	2.37	18	0.40	5.48	2.92	8.40
Macomb Intermediate Schools	8.80	19.27	–	–	28.06	23.74	51.80
Monroe County	3.37	2.46	–	–	5.84	3.03	8.87
Recovery School District	4.51	3.95	–	–	8.45	4.86	13.31
Russellville Independent	3.18	3.48	7	0.16	6.82	4.29	11.12
Somerset Independent	4.67	3.41	–	–	8.09	4.20	12.29
Tangipahoa Parish	1.04	2.27	–	–	3.31	2.80	6.12
Taylor County	1.58	1.38	24	0.07	3.04	1.71	4.74
Van Dyke Area Schools	6.23	13.65	–	–	19.88	16.81	36.69
Whitley County	3.50	2.30	–	–	5.80	2.84	8.64
Weighted district average (excluding HISD)	3.97	5.07	6.68	0.24	9.28	6.24	15.52
HISD	2.67	1.54	–	–	4.21	1.89	6.09
Weighted district average (including HISD)	3.36	3.41	6.68	0.13	6.89	4.20	11.10

training was minimal over the CTAI adoption period ($0.24 per student excluding HISD and $0.13 including HISD).

Although we assumed that the initial three days of training was the minimum required to properly implement the CTAI curriculum, Carnegie Learning recommended that teachers receive an additional four days of in-classroom support and four days of instructional coaching. For these ongoing trainings, Carnegie Learning instructors visited the schools at a cost of $1,500 per day, and it was recommended that they serve no more than four teachers during each day's visit. Following Carnegie Learning's recommendations of no more than four teachers per day and assuming districts would purchase ongoing training the first and second years of adoption, we determined the number of days each district required for ongoing support. It was reasonable to assume that the in-classroom support took place during teachers' regular classroom and instructional coaching took place during planning periods, so no additional payment to teachers or substitutes was required for ongoing training. Following the methods outlined for the first-year training cost, we estimated the average per-student cost of ongoing support for the first year of adoption for all districts to be $5.07 excluding HISD and $3.41 including HISD. For the second year of adoption, we found the cost (annualized over the four remaining years of the adoption) for all districts other than HISD to be $6.24 and the per-student cost including HISD to be $4.20. We assume that districts would not purchase the ongoing training after the second year of curriculum adoption.

The overall per-student costs for the full 11 days of training, including additional first-year training costs districts incurred, was estimated to be $15.52 excluding HISD and $11.10 including HISD.

Comparison Group Algebra I Curricula Costs

Three textbooks accounted for the majority of the algebra curricula used in comparison curricula school districts: those published by Prentice Hall, Glencoe, and McDougal Littell (Table 3.6). As mentioned earlier, the only district not using one of these three textbooks used district-created materials. That district is excluded from the cost calculations because we were not able to obtain sufficient cost information.

Material Costs

As a rule, the textbooks were adopted for multiple years. This ranged from four to ten years in our sample, with an average of 6.8 years. Each district adopted its curriculum at least one school year prior to our data collection. It was common for districts to purchase a textbook for every student rather than requiring students to share books. Typically, a single student would use the textbook for the entire academic year, with two types of exceptions: when a single set of textbooks was purchased for each teacher and all of the students in that teacher's classroom shared the textbooks, or when algebra I was taught for only part of the school year, so that when one student finished algebra I mid-year, the textbook was passed on to another student taking algebra I later in the year. Only three of the 20 responding comparison districts had more than one student using a textbook in a single year. HISD and Armada Area Schools reported that up to two students used a textbook in a given year, and Warren Woods Area Schools reported that it had one textbook for every three students. The length of curriculum adoption (years the textbook was used) and number of students using a textbook are shown in Table 3.6 and used in the cost calculations below.

Table 3.6
Summary of Comparison Algebra I Curricula Across Districts

District	Textbook	Year of Curriculum Adoption	Number of Students Using a Textbook	Years Textbook Used	Annual Replacement of Materials	Software
Catholic Diocese Schools	Prentice Hall	2007	1	5	Workbooks	IDK
Chippewa Valley Area Schools	Glencoe	2007	1	10	–	–
Hancock County	Prentice Hall	2004	1	6	–	CCC*
HISD	McDougal Littell	2007	1 to 2	10	Workbooks	–
Warren County	Prentice Hall	2007	1	7	M	IDK
Adair County	Prentice Hall	2006–2007	1	7	Workbooks	GeoSketchpad
Armada Area Schools	Prentice Hall	2008–2009	1.5	6	IDK	E2020
Campbellsville Independent	McDougal Littell	2005	1	6	Workbooks	McDougal Littell
Caverna Independent	Glencoe	2003	1	5	–	–
East Detroit Area Schools	Glencoe	2007–2008	1	6	Workbooks	–
Fraser Area Schools	Prentice Hall	2005	1	9	–	–
Lafayette Parish	Glencoe	2005	1	7	Workbooks	Glencoe
Metcalfe County	Prentice Hall	2003–2004	1	6	–	Accelerated Math
Ohio County	Glencoe	2007–2008	1	7	–	Number World
Romeo Area Schools	Romeo High School	–	M	M	M	–
Russell County	Glencoe	2003	1	6	Workbooks	Glencoe
Simpson County	Glencoe	2003	1	7	–	–
St. Bernard Parish	McDougal Littell	2005	M	M	M	–
Warren Woods Area Schools	McDougal Littell	2007	3	4	–	–
Winn Parish	Glencoe	–	1	7 to 10	Workbooks	–

NOTES: M = missing; IDK indicates respondent did not know the answer.

* CCC = Computer Curriculum Cooperation. This software is used for multiple subjects and does not appear to be specifically purchased for algebra I. To estimate the cost of the use of this software for algebra, we use one-tenth of the total cost.

Approximately half of the districts replaced student workbooks on a yearly basis. However, in all but one of these districts the publishers replaced the workbooks at no additional cost because the annual replacement of workbooks over the course of the adoption was included in the up-front textbook cost. Just one district reported having to pay to replace the student workbooks annually. Several respondents mentioned that they had to replace a subset of the textbooks each year due to damage or loss. This was likely true for most districts, but because we did not specifically ask this question, we cannot be sure and did not include this factor in the estimated materials costs. Assuming that no more than 10 percent of textbooks need to be

replaced in a given year, a reasonable upper bound for material costs would be 110 percent of the costs we estimated below for materials.

Table 3.7 shows that the per-student costs for comparison curricula textbook materials ranged from $1.17 to $18.56, with a weighted average of $11.28 for all districts other than HISD, and $5.97 when HISD is included. The per-student costs for HISD were lower than most other districts because the size of the district lowers cost of materials curriculum companies charge and HISD continues to use the same textbooks for ten years. For these calculations, we used the length of the district's adoption period and the average number of students participating each year in the effectiveness study.

Forty percent of the comparison districts used a software program alongside their algebra I textbook materials, although only 20 percent incurred additional software costs. Hancock County reported that students used the Computer Curriculum Corporation (CCC) software for multiple subject areas. The district reported that the CCC program was used 15 minutes

Table 3.7
Annualized Comparison of Per-Student Curricula Material Costs ($)

District	Cost of Textbook	Cost of Software Licenses	Total
Catholic Diocese Schools	12.65[a]	–	12.65
Chippewa Valley Area Schools	7.62	–	7.62
Hancock County	8.62	10.30	18.92
Warren County	10.91	–	10.91
Adair County	10.59	20.60 to 25.75	34.28
Armada Area Schools	9.23	42.92	52.15
Campbellsville Independent	13.29	16.48	29.77
Caverna Independent	18.56	–	18.56
East Detroit Area Schools	11.08	–	11.08
Fraser Area Schools	10.92	–	10.92
Lafayette Parish	9.14	–[b]	9.14
Metcalfe County	12.92	103.00	115.92
Ohio County	12.84	18.73	31.57
Russell County	10.70	–[b]	10.70
Simpson County	11.24	–	11.24
Warren Woods Area Schools	1.17	–	1.17
Winn Parish	7.69	–	7.69
Weighted district average (excluding HISD)	11.28	14.04	25.32
HISD	3.81	–	3.81
Weighted district average (including HISD)	5.97	7.32	15.03

[a] Textbook cost includes the $1.50 workbook. This is the only district that reported a cost associated with the use of a workbook; seven districts use student workbooks provided to the district at no additional cost.

[b] Districts use software that does not have a cost associated with it.

per day for algebra I and 15 minutes for other subjects, so we attribute 50 percent of the costs of this software to the algebra I curriculum. The E2020 software used by Armada Area Schools was also used for multiple subjects and was used only by students who are struggling with algebra. The district must pay additional license fees for each student who uses it for algebra (estimated by the district contact to be one-third of all algebra students), so we accounted for the additional cost associated with these licenses. Of the remaining six districts using software, three used software supplied at no cost by the textbook provider. The remaining three districts used three different software programs devoted to mathematics. Several district contacts mentioned that the software was used for only one year, and they made other statements indicating that the role of these software programs in their algebra I classrooms was somewhat minor.

McDougal Littell's software was reported by the Campbellsville Independent district to cost approximately $16.48, while the GeoSketchpad software used by Adair County was reported to cost between $20.60 and $25.75 per student (Table 3.7). Based on costs provided by the Ohio County district, Number World cost $18.73 per student. Several other districts reported significantly higher software license costs ($42.92 for E2020, reported by the Armada Area Schools, and $103.00 for Accelerated Mathematics, used by Metcalfe County), but these programs are used in multiple subject areas, so the actual cost that can be attributed to the algebra I component of the software is likely to be substantially lower. Following methods described above for CTAI software costs, the weighted average per-student cost was estimated to be $14.04 excluding HISD and $7.32 including HISD.

Technology Expenditures

In comparison districts using software for their algebra I classes, only one reported any technology expenditures (Table 3.8). The per-student technology cost for this district is $19.50. The average weighted cost across districts is $1.62 per student excluding HISD and $0.85 including HISD.

Table 3.8
Technology Expenditures in Schools Using Algebra I Software

District	Technology Staff	Computers ($)	Other Support ($)	Total ($)
Hancock County	–	–	–	–
Adair County	–	–	–	–
Armada Area Schools	–	–	–	–
Campbellsville Independent	–	–	–	–
Lafayette Parish	–	–	–	–
Metcalfe County	–	–	–	–
Ohio County	–	–	–	–
Russell County	–	19.50	–	19.50
Weighted district average (excluding HISD)	–	1.62	–	1.62
HISD	–	–	–	–
Weighted district average (including HISD)	–	0.85	–	0.85

Training Costs

Forty percent of comparison districts provided little or no curriculum-specific training to their algebra I teachers (Table 3.9). These districts did not opt to purchase teacher training to facilitate the curriculum adoption; they opted to purchase only the curriculum. These decisions may have been based on available financial resources, skills and expertise of district staff, or other unknown reasons. We also do not know whether providers of the comparison curricula recommended certain levels of training for effective implementation of their curricula. Estimated training costs for the comparison curriculum reflect what was typical for the districts in our study that adopted those curricula, just as the training costs for CTAI reflect typical amounts of professional development for that curriculum (as reported by Carnegie Learning). Of those districts that provided training, more than half provided training only in the year the curriculum was adopted, while the remaining five districts provided ongoing training. The annualized, average weighted per-student training cost for comparison curricula was $0.33 excluding

Table 3.9
Comparison Algebra I Curricula Training Costs

	Textbook Training		Software Training		Total Training Cost
	Type	Per-Student Cost ($)	Type	Per-Student Cost ($)	
Catholic Diocese Schools	Ongoing, in-service	–	–	–	–
Chippewa Valley Area Schools	One time, in-service	–	–	–	–
Hancock County	Ongoing, in-service	–	Ongoing, not in-service	7.30	7.30
Warren County	Ongoing, in-service	2.54	–	–	2.54
Adair County	No training	–	–	–	–
Armada Area Schools	Two times, not in-service	3.15	No training	–	3.15
Campbellsville Independent	M	M	M	M	M
Caverna Independent	No training	–	–	–	–
East Detroit Area Schools	One-time, in-service	–	–	–	–
Fraser Area Schools	One-time, not in-service	1.34	–	–	1.34
Lafayette Parish	One-time, in-service	–	No training	–	–
Metcalfe County	One-time, not in-service	0.43	One-time, not in-service	3.73	4.16
Ohio County	No training	–	No training	–	–
Russell County	Minimal training	–	Minimal training	–	–
Simpson County	No training	–	–	–	–
Warren Woods Area Schools	No training	–	–	–	–
Winn Parish	No training	–	–	–	–
Weighted district average (excluding HISD)		0.33		0.46	0.94
HISD	One time, in-service	–	–	–	–
Weighted district average (including HISD)		0.17		0.24	0.49

NOTES: M = Missing. Costs are annualized based on the adoption cycle of the district.

HISD and $0.17 including HISD. This includes trainer costs and supplemental teacher pay or costs for substitute teachers. Of the eight comparison districts using software, only two provided any teacher training related to the software. The average per-student cost of software training was estimated to be $0.46 excluding HISD and $0.24 including HISD. Finally, the average per-student total cost of all training for districts was estimated to be $0.94 excluding HISD and $0.49 including HISD.

Comparative Curriculum Costs

In this section, we compare the CTAI and comparison curricula costs for each of the three ingredients in the cost feasibility analysis.

Material Costs

The average per-student textbook cost was estimated to be higher for CTAI than the comparison curricula. We estimate the cost of the CTAI textbook to be $21.55 and the comparison curricula to be $11.28 in districts, excluding HISD (Table 3.10). When HISD is included, these figures are $20.38 and $5.97, respectively.

An examination of the cost of software licenses and maintenance also shows CTAI to be more expensive: The estimated per-student cost for CTAI was $35.28, versus $14.04 for the comparison curricula in districts excluding HISD. When HISD is included, these figures are $30.21 and $7.32, respectively.

Overall, the total cost of adopting and implementing the materials associated with the CTAI curriculum was higher than the comparison curricula. Districts other than HISD were estimated to pay, on average, $56.82 per student for CTAI adoption compared with $25.32 for their comparison adoption cost. When HISD is included, these figures are $50.58 and $15.03, respectively.

Technology Expenditures

Cost information suggests that the implementation of CTAI could necessitate substantial technology expenditures. Many districts were required to purchase computers or make other technological updates, such as wiring, in order to meet either the operating requirements of the CTAI software or the proportion of time the curriculum allocates to use of the software. Thus, the overall technology expenditures are estimated to be higher for districts using CTAI

Table 3.10
Annualized Per-Student Materials Costs for CTAI and Comparison Curricula (weighted district averages, $)

Curriculum	Textbook	Software Licenses	Maintenance	Total
Excluding HISD				
CTAI	21.55	29.92	5.36	56.82
Comparison	11.28	14.04	–	25.32
Including HISD				
CTAI	20.38	24.85	5.36	50.58
Comparison	5.97	7.32	–	15.03

than districts using the comparison curricula. Only one district using comparison software reported expenditures on technology, whereas 30 percent of districts implementing CTAI reported them. The average per-student cost for technology expenditures was $24.84 for CTAI compared to $1.62 for comparison curricula, excluding HISD (Table 3.11). These figures are $74.47 and $0.85, respectively, when HISD is included.

Training Costs

We estimate that CTAI also requires higher training costs than the comparison curricula. As discussed above, for the purposes of determining the cost of CTAI training, we followed Carnegie Learning's recommendations regarding the amount of training a district should purchase when adopting the curriculum in order to implement CTAI well. We estimated the cost of the first year and ongoing training from Carnegie Learning, and we included additional training costs districts incurred to implement the curriculum. We estimate the per-student cost of training for CTAI to be $15.52, versus $0.94 for the comparison curricula, in districts excluding HISD (Table 3.12). When HISD is included, these estimates are $11.10 and $0.49, respectively. Although districts implementing comparison materials are likely to provide training to algebra I teachers, such training appears to be general in nature; respondents did not attribute the cost of these trainings directly to the implementation of comparison curricula.

Table 3.11
Annualized Per-Student Technology Expenditures for CTAI and Comparison Curricula (weighted district averages, $)

Curriculum	Computers	Other Support	Total
Excluding HISD			
CTAI	22.32	2.51	24.84
Comparison	1.62	-	1.62
Including HISD			
CTAI	69.53	4.94	74.47
Comparison	0.85	-	0.85

Table 3.12
Annualized Per-Student Training Costs for CTAI and Comparison Curricula (weighted district averages, $)

Curriculum	Total First Year Training Cost	Total Second Year Training Cost	Total Curriculum Adoption Training Cost
Excluding HISD			
CTAI	9.28	6.24	15.52
Comparison	0.94	–	0.94
Including HISD			
CTAI	6.89	4.20	11.09
Comparison	0.49	–	0.49

Given CTAI's higher per-student cost in each ingredient of the cost feasibility analysis, it is not surprising that the estimated total per-student cost for CTAI is higher than for the comparison curricula. In districts excluding HISD, we estimated total per-pupil costs of CTAI to be $97.18, versus $27.88 for the comparison curricula (Table 3.13). When HISD is included, these figures are $136.15 and $16.37, respectively.

Table 3.14 shows the estimated weighted mean difference in cost for each of the three ingredient categories as well as the total cost. Positive mean differences indicate that the estimated CTAI costs are higher than the comparison curricula costs. All of these estimates are significant after adjusting for multiple tests using the Benjamini and Hochberg (1995) method with a false discovery rate of 0.05. However, the significance may be partly due to low variability in the treatment group because we applied standard calculations based on district size (discussed above).

Table 3.13
Annualized Per-Student Total Costs for CTAI and Comparison Curricula (weighted district averages, $)

Curriculum	Total Adoption Cost
Excluding HISD	
CTAI	97.18
Comparison	27.88
Including HISD	
CTAI	136.15
Comparison	16.37

Table 3.14
Cost Differences for Each Ingredient of CTAI and Comparison Curricula (weighted district averages, $)

	Materials		Technology		Training		Total	
	Mean difference	Standard error	Mean difference	Standard error	Mean difference	Standard error	Mean difference	Standard error
Excluding HISD	31.51*	6.28	23.21*	9.48	14.58*	2.50	69.30*	10.97
Including HISD	35.55*	7.26	73.62*	27.53	10.60*	2.76	119.78*	22.88

NOTES: Positive mean differences indicate CTAI is more costly than the comparison curricula.

* Indicates statistical significance after adjustment for multiple tests.

CHAPTER FOUR

Discussion

This cost feasibility analysis indicates that, for the most common types of expenditures that make up curriculum costs, CTAI is more expensive than what is typically spent on other algebra curricula in districts participating in this study. Table 4.1 presents the cost estimates for the various aspects of the CTAI and comparison curricula for districts, excluding HISD (discussed below).

Although comparison curriculum algebra I textbooks tend to have higher initial purchase prices, they are used for multiple years and end up costing less than CTAI materials over the course of an algebra I curriculum adoption. Excluding HISD, the textbook cost for CTAI is $21.55 per student, compared with $11.28 for the comparison curricula, so the CTAI textbook is about $10 more expensive than comparison textbooks. The software cost for CTAI is about $16 per student more expensive than the comparison software, $29.92 versus $14.04, respectively, excluding HISD. The average comparison software cost includes districts that did not use software in the algebra curriculum. Averaging the software costs among only the comparison districts that implemented such software produces an estimated cost of $42.11 (not shown in Table 4.1). The comparison software, where it is used, is thus estimated to be about $12 per student more expensive than the CTAI software.

Because the CTAI software is designed to be a major component of the overall curriculum (a recommended 40 percent of classroom time) and has demanding technology requirements, schools implementing it often made investments in technology. Comparing total per-student costs of technology expenditures in districts excluding HISD reveals that districts implementing CTAI spent, on average, $23 per student more than districts implementing the compari-

Table 4.1
Comparison of Average Per-Student CTAI Curriculum Costs with Other Algebra I Curricula, Excluding HISD

Type of Cost	Cost of CTAI ($)	Cost of Comparison Algebra Curricula ($)	Relative Cost of CTAI
Textbook (material costs)	21.55	11.28	1.91
Software license (material costs)	29.92	14.04	2.13
Software maintenance (material costs)	5.36	–	5.36
Technology (technology expenditures)	24.84	1.62	15.33
First-year training (training costs)	9.28	0.94	9.87
Total training (training costs)	15.52	0.94	16.51
Total adoption (first-year and ongoing training)	97.18	27.88	3.48

son curricula. Considering all districts, the software cost for technology in CTAI districts is $74.47, compared with $0.85 in comparison districts. As discussed above, this method of calculating technology costs did not account for reallocation of existing technology resources (i.e., grant money or planned upgrades in a technology budget). To the degree that districts made special accommodations to ensure their participation in the study or the success of the study, there is a possibility that costs for the sample were larger than would be seen if these districts independently adopted this curriculum. Calculating an average cost only for CTAI and comparison districts (excluding HISD) that reported technology expenditures, districts implementing CTAI spent $71.75 per student, whereas the comparison district spent $19.50, a factor of 3.7 (not shown in Table 4.1). Overall, 75 percent of CTAI districts reported upgrading technology, whereas only one comparison district reported such expenditures. Although the per-student cost depends on a district's existing technological infrastructure, it is relatively safe to assume that successful implementation of the CTAI curriculum requires significant investments in technology in many schools.

The CTAI curriculum is more than just an algebra textbook and software; it also employs a relatively complex teaching strategy that requires significant training for successful implementation. The classroom instruction approach requires students to play the lead roles in the learning environment, and collaborative activities drive the lessons. The addition of an innovative software component with a wide range of options for assessment and data-driven teaching further increases the perceived need for teacher training. In semistructured interviews with teachers who had not attended training, we were told that the lack of training led to significant issues with implementation in the first few months. Carnegie Learning recommended a large amount of training—three days before starting classroom implementation and four days of additional training throughout the year. At minimum, the company said, teachers should have the three days of initial training in order to successfully use the CTAI curriculum. The average per-student cost of the initial training was estimated to be $3.97 in districts excluding HISD and $3.36 including HISD.

Few districts purchased training from comparison curriculum companies at the time of adoption, perhaps believing such training was unnecessary, opting to cut costs to meet budgetary requirements, or believing that any needed training could be accomplished using district staff. Curriculum companies may not suggest training, and this should be considered when interpreting the following costs of comparison curricula compared with CTAI. The average per-student cost for comparison curriculum specific training was $0.94 in districts excluding HISD and $0.49 including HISD. CTAI total first-year training costs are $8 per student more expensive excluding HISD, at an estimated $9.28; the training costs are $6 more expensive including HISD, at an estimated $6.89. When including the recommended ongoing training time in districts for the second year of adoption, the CTAI per-student cost estimate increases to $15.52, excluding HISD, about $15 more expensive than the cost of training for the comparison curricula (about $11 more including HISD).

Overall, considering all of the types of costs involved, the Carnegie Learning curriculum was likely to cost a district significantly more than what was typically spent on comparison algebra curricula. The final row of Table 4.1 includes the per-student costs for textbook, software, technology, and training. This yields an estimated total per-student cost, excluding HISD, of $97.18 for CTAI and $27.88 for comparison curricula. The CTAI cost for districts participating in the study, excluding HISD, was $69 per student more the comparison curricula cost. Including HISD, the estimated total cost was $136.15 for CTAI and $16.37 for

comparison curricula, so CTAI cost about $120 per student more than the comparison curricula when including HISD.

In an effectiveness study of various reading and mathematics software products, Campuzano and colleagues (2009) report an annualized per-student cost for the CTAI curriculum of $69.00. This cost accounts for textbooks, software, and an initial four days of training in the cost calculation. To gauge the alignment of our cost calculations with theirs, we used the average per-student costs (excluding HISD) for the Campuzano ingredients, which exclude portions of or entire ingredients used in this study. Table 4.2 reveals a lower estimated cost to adopt and implement CTAI in this study than that estimated by Campuzano et al., but the difference could be attributed to the lower textbook and software license costs that some CTAI districts can receive based on large algebra I enrollments, as well as a difference in training costs. The initial first-year training in Campuzano was four days, whereas the initial training offered by Carnegie Learning for our study was a set cost for three days. As another check for cost, Campuzano found that 43 percent of the per-student cost is license fees and 57 percent is teacher training and support, technical support, and printed materials and supplies. Excluding HISD, we find that 49 percent of the total cost in the districts we studied is associated with licenses, which is in close agreement with Campuzano. Using the proportion of cost to the total, we find that our costs for districts excluding HISD are relatively consistent with those estimated by Campuzano.

As a gauge of the validity of the annualized per-student textbook expenditures reported by comparison group districts, we reviewed annual expenditure data reported by districts on the Survey of Local Government Finances for School Systems (U.S. Census Bureau, 2009). To estimate an annual per-student textbook expenditure for each district we used the 2007–2008 textbook expenditures reported on this survey, divided by the number of students enrolled in grades one through twelve in the district that same year (NCES, 2012b). This survey item asked specifically about textbook expenditures for classroom instruction and excluded other book purchases, such as materials purchased for nonclassroom instruction, library resources, or instructional equipment. This cost category, like our textbook materials category, includes textbooks, student workbooks, and teacher guides. Although districts might purchase textbooks for kindergarten students or younger, we did not include these students in the divisor because textbooks for these students are unlikely to make up a significant portion of districts' textbook expenditures. This approach suggests that districts in our comparison group spent between $16.35 and $91.95 annually per student on textbooks for classroom instruction. This range is probably a lower bound on their textbook expenditures for secondary students, who tend to take a larger variety of classes that require textbooks. This annualized per-student cost includes all textbooks that a student might use, including mathematics, English, social studies, science,

Table 4.2
Annualized Per-Student CTAI Costs Found in Campuzano et al. Compared with Costs from This Study, Adjusted for Comparability ($)

	Textbook	Licenses	Technical Support (Maintenance)	3-Day Initial Training	Total
Campuzano et al.					69.00
This study (adjusted)	21.55	29.92	5.36	3.97	60.80

NOTES: Calculations exclude HISD. Adjusted initial training costs.

foreign language, and electives. Therefore, district expenditures on mathematics textbooks in particular are a fraction of this range. If we conservatively assume that secondary students take only four courses that use textbooks (e.g., English, mathematics, social studies, and science), a range of $4.08 to $22.99 per student per year is implied for mathematics textbook expenditures. The weighted average expenditures for textbook materials reported by comparison group districts in our study ($11.28 per year excluding HISD; $5.97 including HISD) falls within this range.

The greatest part of the estimated cost difference between CTAI and the comparison curricula can be attributed to technology expenditures and training. Districts with modern computers and technological infrastructure that meet the requirements of the CTAI software might have significantly lower costs for technology than estimated by this study. Districts could review their technological capacity in order to more accurately estimate their cost for this ingredient. Another consideration is that improvements to technology could benefit all students in the school, not just those enrolled in algebra I, and these collateral benefits are not considered in our calculations.

Training costs are the other large source of differences in estimated costs of CTAI and the comparison curricula. Interpreting these costs is more challenging. Districts may consider their existing teacher training plans and the overall needs of their algebra I teachers when deciding how much of the CTAI training to purchase. Some districts may find that the increased professional development and training specific to the CTAI curriculum aligns with future plans. Other districts may find the cost comparable to professional development costs they already provide to algebra I teachers over the course of a school year. In general, costs within the technology and training categories may vary more in districts not participating in this study than they did for districts in our sample.

Many school districts are under significant pressure to improve the mathematics achievement of their students in the face of budgetary constraints. These budget pressures may affect decisions about whether to adopt a new curriculum and which one to select. District and school officials are therefore considering both the costs and the benefits of various curricula. Many districts may view the approximately $69 higher expected cost per student for the CTAI curriculum worthwhile if the curriculum is found to affect mathematics achievement more positively than other curricula.

It may also be useful to compare these additional costs for the CTAI curriculum with other potential interventions that schools might implement to improve mathematics achievement, for example, hiring mathematics tutors. If districts opted to use tutoring, its use would likely be for struggling students. Conservatively, assuming that one-third of students are struggling, each of these students receives one hour of one-on-one tutoring per week, and the cost of a mathematics tutor is $40 per hour, it would cost districts approximately $480 for each student to receive this tutoring for three months. When this cost is averaged over all students, the per-student cost of the tutoring effort would be $160.00. This is greater than the average estimated difference between the CTAI curriculum and comparison algebra I curriculum ($120 including HISD). Thus, the estimated costs associated with implementing the CTAI curriculum materials are less than, but comparable to, the costs of providing one hour of tutoring weekly to one-third of the students who are struggling in algebra I. If districts were to provide tutors to more than one-third of students, pay more than $40 per hour for this tutoring, or sustain the tutoring for more than three months, the costs of providing mathematics tutors could be substantially higher, increasing the relative cost advantage of the CTAI materials.

In sum, the CTAI curriculum was more expensive to adopt and implement than the comparison curricula used by districts participating in the CTAI effectiveness study, though not necessarily more costly than other interventions districts might adopt in attempts to improve mathematics achievement. Districts' willingness to expend additional resources to adopt and implement a curriculum like CTAI might depend on a number of factors, such as available funds, the curriculum's effect on students' mathematics achievement, and preferences for curricula that use technology. Findings from the effectiveness evaluation may play a critical role in districts' decisions whether to adopt CTAI. If findings suggest significant positive outcomes for all or a subset of students, the additional costs associated with implementing CTAI may be warranted.

APPENDIX

Example of Survey Instrument Administered to Districts Implementing Both Curricula

The RAND Corporation, a non-profit public-policy research institution, is evaluating the effectiveness of the Carnegie Learning Cognitive Tutor curriculum. The study is funded by the U.S. Department of Education and includes over 130 schools and 50 districts. Schools from your district participated in our study during the 2007–2008 and 2008–2009 school years. Some schools participating in the study used the district's Algebra I curriculum while others used the Carnegie Learning Cognitive Tutor Algebra I curriculum in their classrooms. An important aspect of this study is to gather information about the costs your district incurred in order to implement **each of these curricula**.

This survey asks about district expenses occurring in the first two years of adoption for the curricula textbooks/materials, software/computers, staffing, and teacher training for each of these curricula. We understand that exact numbers may not be possible to obtain for each of these questions. If an exact number cannot be given, please estimate to the best of your ability. If you cannot estimate a value, please skip the question, leaving the answer blank, and we will discuss the question in a follow-up phone interview.

Although the survey is voluntary, your participation in this survey is very important to the study. Your responses will be held in the strictest confidence and with the rigorous security required by RAND's rules and regulations. All information RAND collects will be used for research purposes only; we will keep your name and any information you provide strictly confidential. We will not release this information to anyone outside the project, unless we are required by law. Your responses will be combined with the responses of other districts and reported in the aggregate. We will destroy all information that identifies you at the end of the study.

The survey will take approximately 30 minutes to complete. We would like you to complete the survey at your earliest convenience. In recognition of your participation and valuable time, we sent you a gift card for your personal use.

If you have any questions or concerns about this survey, please contact Andie Phillips at aphillip@rand.org or at 800-722-4780 ext. 4291.

Teachers in your district or district administrators told us that Prentice Hall Algebra I was the district-adopted Algebra I curriculum during the 2007–2009 school years. This section asks questions about the cost of implementing the Prentice Hall Algebra I curriculum in your district, any computer software your teachers use in Algebra I classrooms, and the cost of professional development for the Prentice Hall Algebra I curriculum and computer software.

Please consider the *Prentice Hall Algebra I* curriculum the district purchased for Algebra I coursework when answering the following questions.

1. When was the Prentice Hall Algebra I curriculum adopted?

(year)

2. Please estimate the per-student cost of Prentice Hall Algebra I textbook materials in the initial two years of adoption.

(cost; $)

3. If you do not know the per-student cost of the Prentice Hall Algebra I curriculum, please respond to the statements below.

Please estimate the total cost of student textbook materials for Prentice Hall Algebra I curriculum in the initial two years of adoption.

Please estimate the total number of students using the Prentice Hall Algebra I curriculum in the initial two years of adoption.

4. We recognize that a single copy of the main textbook for the Prentice Hall Algebra I curriculum might be used by more than one student during its useful life.

Please estimate how many times a single copy of the main textbook is used in your schools.

(number of students)

5. Do any of the Prentice Hall Algebra I curriculum materials (other than the main textbook) need to be replaced after one student uses them?

Yes
No
I don't know

6. Did teachers supplement the Prentice Hall Algebra I curriculum with computer software or a computer program?

Yes
No (skip to question 20)
I don't know (skip to question 20)

7. What was the name of the computer software?

8. When was the computer software adopted?

(year)

9. Please estimate the per-student cost of computer software in the initial two years of adoption.

(cost; $)

10. If you do not know the per-student cost of the computer software, please respond to the statements below.

Please estimate the total cost of the computer software in the initial two years of adoption.

Please estimate the total number of students using the computer software in the initial two years of adoption.

11. How many years were software licenses valid?

(years)

12. In the initial two years of computer software adoption, did the district hire technology staff to assist with implementation?

Yes
No (skip to question 14)
I don't know (skip to question 14)

13. In the initial two years of computer software adoption,

How many full-time equivalency technology staff were hired?
What was the average salary of a full-time technology staff member?

14. In the initial two years of computer software adoption, did the district purchase any additional computers in order to implement the software?

Yes
No (skip to question 16)
I don't know (skip to question 16)

15. In the initial two years of computer software adoption,

How many additional computers were purchased?
How much did each computer cost?

16. In the initial two years of computer software adoption, did the district purchase additional technology supports like laptop carts, internet service, or wiring of the school in order to implement the software?

Yes
No (skip to question 18)
I don't know (skip to question 18)

17. Please list the additional supports the district purchased to assist with implementation of the computer software.

Description of cost
Total cost of support
Description of cost
Total cost of support
Description of cost
Total cost of support

18. In the initial two years of adoption, were there any additional costs for the Prentice Hall Algebra I curriculum *or* the computer software that we have not accounted for?

Yes
No (skip to question 20)
I don't know (skip to question 20)

19. Please list the additional costs related to the Prentice Hall Algebra I curriculum *or* computer software.

Description of cost
Total cost
Description of cost
Total cost
Description of cost
Total cost

We are interested in learning more about professional development your teachers might have received for the Prentice Hall Algebra I curriculum. The following questions address professional development for the Prentice Hall Algebra I curriculum.

20. Prior to implementation, did teachers receive initial professional development for the Prentice Hall Algebra I curriculum?

Yes
No (skip to question 26)
I don't know (skip to question 26)

21. Did *all* of the initial professional development of the Prentice Hall Algebra I curriculum occur during in-service time the district regularly schedules for teachers?

Yes (skip to question 24)
No
I don't know

22. For a typical teacher, how many hours outside of the district in-service time were used for the initial professional development for the Prentice Hall Algebra I curriculum?

(hours; if none, enter 0)

23. Please estimate the per-teacher cost of participation in initial professional development occurring outside of regularly scheduled district in-service time for the Prentice Hall Algebra I curriculum.

Per-teacher cost should include teacher substitute costs and additional payment for teachers attending initial professional training over the weekend or during the summer.

($; if none, enter 0)

24. Please estimate the per-teacher cost of the initial professional development *trainer*, of the Prentice Hall Algebra I curriculum.

($; if none, enter 0)

25. If you do not know the per-teacher cost of the initial professional development *trainer*, please respond to the statements below.

Please estimate the total cost of the trainer for initial professional development for the Prentice Hall Algebra I curriculum.

Please estimate the total number of teachers attending the initial professional development for the Prentice Hall Algebra I curriculum.

26. During the initial two years of implementation, did teachers receive ongoing professional development subsequent to the initial training for the Prentice Hall Algebra I curriculum?

Yes
No (skip to question 32)
I don't know (skip to question 32)

27. Did *all* of the ongoing professional development in the initial two years of implementation for the Prentice Hall Algebra I curriculum occur during in-service time the district regularly schedules for teachers?

Yes (skip to question 30)
No
I don't know

28. For a typical teacher, how many hours outside of the district in-service time were used for the ongoing professional development of the Prentice Hall Algebra I curriculum in the first two years of implementation?

(hours; if none, enter 0)

29. Please estimate the per-teacher cost of participation in ongoing professional development occurring outside of regularly scheduled district in-service time for the Prentice Hall Algebra I curriculum in the first two years of implementation.

Per-teacher cost should include teacher substitute costs and additional payment for teachers attending initial professional training on weekends or during the summer.

($; if none, enter 0)

30. Please estimate the per-teacher cost of the ongoing professional development *trainer* of the Prentice Hall Algebra I curriculum in the initial two years of implementation.

($; if none, enter 0)

31. If you do not know the per-teacher cost of the ongoing professional development *trainer* in the initial two years of implementation, please respond to the statements below.

Please estimate the total cost of the trainer for ongoing professional development for the Prentice Hall Algebra I curriculum.

Please estimate the total number of teachers attending the ongoing professional development for the Prentice Hall Algebra I curriculum.

We are interested in learning more about professional development your teachers might have received for the supplemental *computer software* that accompanied the Prentice Hall Algebra 1.

The following questions address professional development for the supplemental *computer software*.

If you reported that there was no computer software used alongside Prentice Hall Algebra 1, please respond NO to the question below.

32. Prior to implementation, did teachers receive initial professional development for the computer software?

Yes
No (skip to question 38)
I don't know (skip to question 38)

33. Did *all* of the initial professional development for the computer software occur during in-service time the district regularly schedules for teachers?

Yes (skip to question 34)
No
I don't know

34. For a typical teacher, how many hours outside of the district in-service time were used for initial professional development of the computer software?

(hours; if none, enter 0)

35. Please estimate the per-teacher cost of participation in initial professional development occurring outside of the regularly scheduled district in-service time for the computer software.

Per-teacher cost should include teacher substitute costs and additional pay for teachers attending initial professional development over the weekend or during the summer.

($, if none, enter 0)

36. Please estimate the per-teacher cost of the initial professional development *trainer* of the computer software.

($, if none, enter 0)

37. If you do not know the per-teacher cost of the initial professional development *trainer*, please respond to the statements below.

Please estimate the total cost of the trainer for initial professional development for the computer software.

Please estimate the total number of teachers attending the initial professional development for the computer software.

38. During the initial two years for implementation, did teachers receive ongoing professional development subsequent to the initial training on the computer software?

If you reported that there was no computer software used alongside Prentice Hall Algebra 1, please respond NO to the question below.

Yes
No (skip to question 44)
I don't know (skip to question 44)

39. Did *all* of the ongoing professional development in the initial two years of implementation for the computer software occur during the in-service time the district regularly schedules for teachers?

Yes (skip to question 42)
No
I don't know

40. For a typical teacher, how many hours outside of the district in-service time were used for ongoing professional development of the computer software in the initial two years of implementation?

(hours; if none, enter 0)

41. Please estimate the per-teacher cost of participation in ongoing professional development that occurred outside of regularly scheduled district in-service time for the computer software in the initial two years of implementation.

Per-teacher cost should include teacher substitute costs and additional payment for teachers attending ongoing professional development over the weekend or during the summer.

($; if none, enter 0)

42. For the initial two years of implementation, please estimate the per-teacher cost of the ongoing professional development *trainer* of the computer software.

($; if none, enter 0)

43. If you do not know the per-teacher cost of the ongoing professional development *trainer* for the initial two years of implementation, please respond to the statements below.

Please estimate the total cost of the trainer for ongoing professional development for the computer software.

Please estimate the total number of teachers attending ongoing professional development for the computer software.

We ask that you now shift your thinking to the **Carnegie Learning Cognitive Tutor Algebra I** curriculum. The remainder of the survey will ask questions about costs associated with the Carnegie Learning Algebra I classroom curriculum, Cognitive Tutor for the computer, and professional development surrounding the full curriculum.

The following questions focus on costs your district may have incurred for the *Cognitive Tutor*, or computer software portion, of the Carnegie Learning Cognitive Tutor Algebra I curriculum.

We are familiar with the basic costs of the Carnegie Learning Cognitive Tutor Algebra I curriculum, including the textbooks and licenses for the computer portion; however, we do not know about any additional costs the district or school may have incurred in order to implement the Cognitive Tutor Algebra I curriculum.

44. In the initial two years of adoption for the Cognitive Tutor, did the district hire technology staff to assist with implementation?

Yes
No (skip to question 46)
I don't know (skip to question 46)

45. In the initial two years of adoption for the Cognitive Tutor,

How many full-time equivalency technology staff were hired?

What was the average salary of the full-time technology staff member?

46. In the initial two years of Cognitive Tutor adoption, did the district purchase any additional computers in order to implement the software?

Yes
No (skip to question 48)
I don't know (skip to question 48)

47. In the initial two years of Cognitive Tutor adoption,

How many additional computers were purchased?
How much did each computer cost?

48. In the initial two years of Cognitive Tutor adoption, did the district purchase additional technology supports like laptop carts, internet service, or wiring of the school in order to implement the software?

Yes
No (skip to question 50)
I don't know (skip to question 50)

49. Please list the additional supports the district purchased to assist with implementation of the Cognitive Tutor.

Description of cost
Total cost of support
Description of cost
Total cost of support
Description of cost
Total cost of support

50. In the initial two years of adoption, were there any additional costs for the Carnegie Learning Algebra I classroom curriculum *or* Cognitive Tutor software that we have not accounted for?

Yes
No (skip to question 52)
I don't know (skip to question 52)

51. Please list the additional costs related to the Carnegie Learning Algebra I classroom curriculum *or* Cognitive Tutor.

Description of cost
Total cost
Description of cost
Total cost
Description of cost
Total cost

Prior to the first year of implementation for the Carnegie Learning Cognitive Tutor Algebra I curriculum, teachers received 3 full days of initial professional development. We do not know the specific details of when your teachers received this professional development or the additional costs your district incurred.

The following questions ask you to provide information on when teachers received training and the additional costs incurred.

52. Prior to implementation of the Carnegie Learning Algebra I curriculum, did *all* of the professional development occur during in-service time the district regularly schedules for teachers?

Yes (skip to question 55)
No
I don't know

53. For a typical teacher, how many hours outside of the district in-service time were used for the initial professional development for the Carnegie Learning Cognitive Tutor Algebra I curriculum?

(hours; if none, enter 0)

54. Please estimate the per-teacher cost of participation in initial professional development occurring outside of the regularly scheduled district in-service time for the Carnegie Learning Cognitive Tutor Algebra I curriculum.

Per-teacher cost should include teacher substitute costs and additional payment for teachers attending initial professional development over the weekend or during the summer.

($; if none, enter 0)

55. Please estimate the per-teacher cost of the initial professional development *trainer* of the Carnegie Learning Cognitive Tutor Algebra I curriculum.

($; if none, enter 0)

56. If you do not know the per-teacher cost of the initial professional development *trainer*, please respond to the statements below.

Please estimate the total cost of the trainer for initial professional development for the Carnegie Learning Cognitive Tutor Algebra I curriculum.

Please estimate the total number of teachers attending the initial professional development for the Carnegie Learning Cognitive Tutor Algebra I curriculum.

57. After the initial 3-day training, did *all* of the ongoing professional development occur during in-service time the district regularly schedules for teachers?

Yes (skip to question 60)
No
I don't know

58. For a typical teacher, how many hours outside of the district in-service time were used for the ongoing professional development of the Carnegie Learning Cognitive Tutor Algebra I curriculum in the first two years of implementation?

(hours; if none, enter 0)

59. Please estimate the per-teacher cost of participation in ongoing professional development occurring outside of regularly scheduled district in-service time for the Carnegie Learning Cognitive Tutor Algebra I curriculum in the first two years of implementation.

Per-teacher cost should include teacher substitute costs and additional payment for teachers attending ongoing professional development over the weekend or during the summer.

($; if none, enter 0)

60. Please estimate the per-teacher cost of the ongoing professional development *trainer* of the Carnegie Learning Cognitive Tutor Algebra I curriculum in the initial two years of implementation.

($; if none, enter 0)

61. If you do not know the per-teacher cost of the ongoing professional development *trainer* in the initial two years of implementation, please respond to the statements below.

Please estimate the total cost of the trainer for ongoing professional development for the Carnegie Learning Cognitive Tutor Algebra I curriculum.

Please estimate the total number of teachers attending the ongoing professional development for the Carnegie Learning Cognitive Tutor Algebra I curriculum.

We will conduct a brief follow-up interview to ask any remaining questions about the Prentice Hall Algebra I and Carnegie Learning Cognitive Tutor Algebra I curricula. These follow-up questions will be based on your responses and unique to your district and schools. We will contact you by phone or email to conduct the interview.

Please provide your contact information below.

62. Contact Information

Name
Job Title
Email Address
Phone Number

Thank you for your participation! We appreciate your time and the district's continued support of the Carnegie Learning Cognitive Tutor Algebra I effectiveness study.

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