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.

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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.