Empirical Education

RESEARCH REPORT

A Description of Maui Educational Consortium's Implementation Practices of Carnegie Learning's *Cognitive Tutor*

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December 2008

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About Empirical Education Inc.

Empirical Education Inc. was founded to help school districts, publishers, and the R&D community assess new or proposed instructional and professional development programs through scientifically based pilot implementations. The company draws on the expertise of world-class researchers and methodologists assuring that the research is objective and takes advantage of current best practice in rigorous experimental design and statistical analysis. The company's findings let educators quantify the value of programs and help them partner with providers to implement those most effective for their students.

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Introduction

In the fall of 2005 the Maui Educational Consortium began a project that was funded through the Math Science Partnership program to implement the *Cognitive Tutor® (CT)* program, published by Carnegie Learning, in some of the Algebra 1 classes in the Maui School District and at the Maui Community College. At that time, Empirical Education was brought on to conduct an experimental evaluation of the *CT* algebra program during the 2005-2006 school year and of the *CT* pre-algebra program during 2006-2007. These studies are reported in Cabalo, Jaciw, & Vu (2007) and Cabalo, Ma, & Jaciw (2007). While both studies found mixed results in terms of student achievement in math, they also found that the implementation of the program, in both school years, was not optimal. During both years, teachers reported generally positive experiences with *CT* and increased student engagement, but also reported a lack of access to computers (in classrooms and computer labs) and delayed start of the program. Some teachers did not receive materials until the second semester in the first-year experiment; some teachers did not use the software during the second year; and many *CT* program teachers resorted to using their existing math program.

We conducted the study reported here during the 2007-2008 school year with the goal of collecting descriptive data on program implementation. The study encompassed all algebra and pre-algebra teachers using *CT* and focuses on the successes and challenges of implementation. We did not investigate student outcomes. The Consortium was particularly interested in investigating the barriers and challenges to implementing *CT* other than, or in addition to, what had become apparent during the past two years (e.g. lack of computer access, technical difficulties, etc.), and sustainability from the teachers' perspectives. Data were collected through classroom observations, informal interviews, and two web-based surveys.

Methods and Design

Sample

We conducted this follow-on study of the successes and challenges of implementing *CT* among pre-algebra and algebra teachers in five schools within the Maui School District and at the Maui Community College. Researchers invited *CT* teachers in these schools to participate in the study. We had originally invited 23 teachers, but when we learned that one did not use *CT* with her students, we removed her data from survey analysis. Our analysis, therefore, included all 22 eligible teachers. While our sample size is small, it is important to note that 100% of eligible teachers were included in the study.

As we analyzed the results for the *CT* teacher group, we also considered that teachers involved in this study had different levels of use and length of exposure to the *CT* program. Therefore, we also categorized teachers according to the Usage Matrix displayed in Table 1. We distinguished between teachers who chose to use *CT* as the primary materials in the course (Main) and those who chose to use them as a supplement to other texts (Supplementary). The other dimension, Duration of Usage, is based upon when the teachers began using *CT.* Two teachers could not be positioned in the matrix because they did not provide responses to the background questions.

Table 1. Usage Matrix: Number of Teachers in Each Group

Duration of usage	Usage type	
	Main	Supplementary
Long term: used *CT* for two-three school years	4	2
Medium term: used *CT* for one-two school years	4	3
Short term: used *CT* for less than one school year	6	2

Cognitive Tutor

As described by Carnegie Learning (2008), *Cognitive Tutor (CT)* is a research-based approach to improving student understanding of mathematical concepts. According to the publisher, the program is characterized as having six unique aspects, including a simple and straightforward design, research-based pedagogy, multiple representations of word problems, just-in-time feedback, a "skillometer" that shows students skills they have mastered and where they need to improve, and a blended curriculum of computer lab and classroom activities that complement each other. In practice, Carnegie Learning recommends that students spend about 40% of their class time using software for individualized lessons and the balance of their time engaged in teacher facilitated collaborative real-world problem-solving activities. The design of the program emphasizes the use of verbal, numerical, algebraic, and graphical representations to solve problems.

The instructional method used in the *CT* program is that of a collaborative classroom. Class time is to be spent in cooperative groups, and careful planning and a well structured environment are intended to promote effective collaboration and cooperative teamwork. Carnegie Learning's Learning by Doing® philosophy states that students must take an active role in their own learning. An environment must be set up in which teacher and students can share knowledge and authority openly, where all, regardless of ability, interest, or achievement level, can benefit. Teachers must move away from creating a teacher-centered classroom and toward a learner-centered classroom. Teachers must facilitate and guide, rather than dictate, the learning process. Arrangement of desks or tables and supplies promote group problem-solving processes, and students are grouped in order to best meet their needs. All group members must participate in discussion and problem-solving activities. Problem-solving methods are shared, thus exposing students to multiple methods. Entire groups are held accountable for their end product (such as a presentation), and all students are encouraged to monitor their own learning and to participate in reflective self-evaluation.

The *CT* technology component uses Cognitively Guided Instruction. Students work at the computer independently and engage with one individual math problem at a time. Students pick strategies to solve the problem. The skillometer provides feedback and displays which pieces of the problem they completed correctly. The student is allowed to use "hints" to complete the steps of solving the problem. The program is mastery based and the students must rework the problem until they have correctly completed all steps. The Teacher's Toolkit, also part of the *CT* software, summarizes the skillometer feedback and progress provided to the students and allows teachers to view student progress in each unit and to determine how they have performed. Teachers are also given the option to promote students to other units, if they choose.

Table 2 provides a list of resources provided to the teachers and students by the publisher.

Table 2. Publisher Provided Materials

Teacher resources	Student resources
• Teacher Training Workbook and CD • Teacher Textbook • Teacher's Resources and Assessments Text • Teacher's Implementation Guide (text) • Software Implementation Guide	• Student Textbook • Student Assignments (text) • Homework Helper

Data Collection

We collected observational and interview data, including classroom observations, a formal group interview and informal teacher interviews, and two web-based surveys. These data provided both descriptive and quantitative evidence of the implementation of *CT* and of student and teacher interactions with the *CT* materials. In general, survey data informed the description of the learning environment, access to resources, use of materials, and student engagement. These data were minimally coded.

Observations and Interviews

Classroom observations occurred in April 2008. Their purpose was to help us understand and document (1) student and teacher interactions with the *CT* materials, (2) the kinds of resources teachers had available for their use, and (3) the extent to which the *CT* program was being implemented. We used an observation protocol designed specifically for *CT* while conducting classroom observations.

We selected classes to observe and determined the length of time for each observation based on the class schedules. The observation schedule was created by the district study liaison from the Maui School District. We visited four of the five schools in the study. Classroom observations occurred in three of the four schools we visited. A group interview was conducted at the fourth school because teachers were administering the Hawaii State Assessment during class time. We did not visit the fifth school on the island of Molokai due to time and budgetary constraints.

Classroom observations lasted between 50 and 60 minutes. We visited a total of six classrooms. Of these six, one class was a "workshop" and another class was in the computer lab.

The group interview occurred during a brief lunch period and lasted 30 minutes. Six *CT* teachers participated in the interview.

Informal interviews were conducted with two of the teachers because time constraints did not allow us to observe their classrooms.

These observational and interview data, in combination with what we found in the algebra and pre-algebra studies, helped us formulate questions for the final web-based survey.

Survey Data

Two web-based surveys were administered to all participating teachers. The first survey was administered in January 2008 and asked teacher background questions and the extent of experience teachers had with *CT* materials (e.g., teachers were asked to list math course titles, whether *CT* materials constituted the main or a supplemental curriculum, the number of class sections, and other math programs used for the 2005-2006, 2006-2007, 2007-2008 school years). The second survey was administered in April 2008, after classroom observations and interviews

were completed. This survey asked about use of curricular materials, access to resources, teachers' confidence and comfort with technology, and collaboration between teachers and among students. We obtained a 91% response rate for each survey.

Rationale for the Indicators of the Extent of Implementation

Based on what we learned about the local context in previous studies and on the needs and interests of the district, we expanded our measures of implementation. In our first study, we collected data about teacher background, teacher access to and use of materials, professional development and planning, student engagement, collaboration, assessments, and teacher satisfaction with materials. In our second study, we measured the same variables as in the first and added curricular content and progress, as well as teacher comfort with technology, as strong indicators of program implementation. In the current study we continued to measure many of the same variables but focused on the daily instructional routine and addressed the extent of changes to instructional practices.

Site Context: The Need for Change

The Maui Educational Consortium instituted this new math program to bring about instrumental change in mathematics instruction. The impetus for this change was the district's need to align instruction to the NCTM standards and to improve student achievement in mathematics, especially at the Algebra 1 level.[1] We used the same principles that the Consortium used to guide their thinking about the changes expected in classroom instructional practices to analyze the teachers' self reports and observations. Using the process standards (NCTM, 2000) as a starting point, we note two areas of focal interest:

- Teachers' attitudes towards and comfort with technology. Because the NCTM standards encourage integrating technology into mathematics instruction and the *CT* program requires the use of computers by both teachers and students, this is an important aspect of the implementation.
- Movement away from predominantly teacher-centered instructional strategies towards student-centered instructional strategies as evidenced by establishing and maintaining a collaborative classroom environment.

Level of Use and Length of Exposure to the *CT* Program

Our first survey asked teachers for the following information so that we would be able to analyze results based on length and type of program implementation:

- Math course titles
- Number of sections of each course
- Use of *CT* as main or supplemental curriculum
- Other math programs used in the 2005-2006, 2006-2007, and 2007-2008 school years

Teacher experience with and implementation of *CT* informed the assignment of teachers into the categories of the Usage Matrix.

[1] notes from phone conversation, July 2005

Access to Resources

In the previous two studies, we found that the primary challenge to implementing the *CT* program was access to resources, including lack of access to computers, limited availability of technology support, and/or other technical difficulties. On a survey administered during the first study, six of seven teachers reported that their *CT* classes were behind schedule due to lack of access to computers (Cabalo, Jaciw, & Vu, 2007). During the second study, 77% of teachers reported that they did not have adequate resources to properly implement the program as specified at the *CT* training (Cabalo, Ma, & Jaciw, 2007). During both years, many teachers resorted to using their existing math materials for a portion of the school year. For a technology-integrated curriculum to be successfully implemented, it is imperative that instructors are able to (1) have access to the appropriate technological components and (2) solve technical issues as they arise.

To determine whether the challenges to accessing resources teachers previously faced were resolved, we asked them to describe their access to computers and to rate how well their technical support needs were met. We measured the number of working computers, by type and location, available to students' use during class time. We asked teachers to list this information for computers in the classroom and outside of the classroom (in the school library, media lab, computer lab, and other areas to which students have access) and how many of these were connected to the school network.

Teachers' Confidence with and Beliefs about Technology

As was true in the previous two years of implementation, the district continues to be interested in the teachers' level of comfort and confidence in using the technology components. Therefore, we asked teachers how frequently they use computers outside of *CT* to get an idea of their computer proficiency level. Our rationale for asking this question is that, if teachers are not confident or comfortable in their general computer use, they will be less likely to use computers/technology in their instruction. On the other hand, if their confidence and comfort level are high, they will be more open to using computers/technology in their instruction. We also asked their opinions about computer technology as an instructional method and its impact on student learning. The district was also interested in learning whether the teachers' levels of comfort with *CT* changed over time, as they became more familiar with and had more exposure to the curriculum. We asked teachers to rate their level of comfort implementing the program both when they began using *CT* and at the time the survey was administered.

Use of Curricular Materials

In addition to measuring access to resources, we also wanted to examine how closely teachers were following the recommended implementation model. In particular, we looked at whether teachers were able to meet the suggested implementation ratio of 60% *CT* text and 40% *CT* software. (This ratio had been reinforced during the *CT* training.) We asked teachers how closely they adhered to textbook lessons (and what modifications they made, if any) and their frequency in using the different features of the Teacher's Toolkit. Both measurements indicate whether teachers were using these features as intended by the publishers.

Collaborative Classroom

The publishers specifically stated in the teacher text that "an effective implementation of the Carnegie Learning Cognitive Tutor mathematics curricula is most likely to occur in the collaborative classroom, that is, a classroom in which knowledge is shared" (*Algebra I Cognitive Tutor Teacher Text*, 2004). As this is the pedagogy driving the *CT* curriculum, and is a pedagogy that may be different from what most (math) teachers are accustomed to, researchers attempted to measure the extent to which teachers initiated a collaborative classroom, as defined by Carnegie Learning and described in the Intervention section.

Analysis Approach

We used descriptive statistics to analyze the modes and methods of implementation and the teachers' perspectives of the program, and we report findings both for the whole group's perspective and using the Usage Matrix categories. We analyzed whether there is a difference in the successes and challenges to implementation reported by teachers in each category. For example, do teachers who have used the program for three years report better access to necessary program-related resources than teachers who have used it for only one year? Due to the small number of participants, we did not perform any statistical tests on the implementation data we received. We also note that the number of years of use is confounded with whether the teachers were early adopters. The differences associated with years of implementation cannot be used as an indication of change over time in individual teachers. Our reporting is meant to be suggestive and purely descriptive.

Results

Implementation Results

As described in the Methods section, we gathered data on a variety of indicators for implementation. Data from classroom observations, interviews, and surveys provided teacher feedback about the *CT* program and helped us understand the implementation process and the reported challenges and successes. We report our findings in each of the broad indicators of implementation, both for the whole group and, when significant, by subgroups as noted in the Usage Matrix.

Access to Resources

Table 3 presents teacher self-reports of the number of computers by type and location available for student use during class time. Access to computers varies by school and by teacher. One teacher reported that students had access to only one computer in the classroom and did not have access to any computers outside of the classroom. On average, teachers reported having 13.5 computers in their classrooms connected to the school network and 48.5 computers outside of the classroom (located in the library, media lab, computer lab, or other areas) connected to the school network and available to their students during class time.

Table 3. Computer Availability

How many total computers, by type and location, are available for your students' use during class time?	Total # of computers in your classroom	Total # of computers in your classroom connected to school network	Total # of computers available outside of classroom	Total # of computers available outside of classroom connected to school network
Min	1	1	0	0
Max	33	33	200	200
Average	13.7	13.5	46.2	48.5

Note. N for the first two columns is 20. N for the third column is 19 (one teacher did not know). N for the fourth column is 19 (one teacher did not know, the other teacher responded "many" but did not indicate a specific number).

Table 4 reflects teachers' responses when asked how well their needs for technical support are met. Many of the teachers (40%) reported that their school provides support extremely well in terms of installing equipment and networks, whereas more than half (65%) reported that their school provides support fairly well or extremely well for troubleshooting and maintaining equipment

and networks. However, 45% of teachers reported that troubleshooting and maintaining operating systems and software was either not provided at all or not well provided.

Table 4. Technical Support Provided

To what extent is technology support available to you in your school?	1= This is not provided	2= Not well provided	3= Fairly well provided	4=Extremely well provided	I don't know
Installing equipment and networks	5%	15%	30%	40%	10%
Troubleshooting and maintaining equipment and networks	10%	20%	35%	30%	10%
Troubleshooting and maintaining operating systems and software	10%	35%	30%	25%	10%
Selecting and acquiring computer-related hardware, software, and support materials	0%	25%	35%	25%	15%

Note. N= 20

Teachers' Confidence with and Beliefs about Technology

Table 5 presents the frequency teachers reported using the computer outside of *CT* (for work, instruction, personal use, or any other use not related to *CT*). A majority of teachers (80%) reported using the computer outside of *CT* several times a day. One teacher reported never using a computer outside of *CT*.

Table 5. Frequency of Time Spent on the Computer Outside of *CT* Use

On average, how often do you use a computer outside of the *CogTutor* program?				
Never	Once a week	Several times a week	Once a day	Several times a day
5%	0%	5%	10%	80%

Note. N=20

We asked teachers to rate how much they agree with the following statements about computer technology and teaching and learning:

1. Computer technology can help students learn math.
2. Computer technology can enhance my teaching capabilities.
3. Computer technology can help improve instruction in math.

Overall, between 85% and 90% of teachers reported agreeing or strongly agreeing with each of the statements.

Figure 1 (a and b), Figure 2 (a and b), and Figure 3 (a and b) show how teachers within the Usage Matrix groups rated their agreement to each statement. Figure 1a, Figure 2a, and Figure 3a show the level of agreement among teachers who use *CT* as their main curriculum. Figure 1b, Figure 2b, and Figure 3b show the level of agreement among teachers who use *CT* as their supplemental curriculum. For the first two statements (Figure 1 and Figure 2), only teachers with a short term level of exposure to *CT* disagreed or strongly disagreed with the statements. The same is true for the third statement (Figure 3), with one teacher (in the short term/main use group) strongly disagreeing that computer technology can help improve instruction in math. Alternatively, teachers with greater exposure to *CT* all agreed that computer technology can help students learn math, enhance their teaching capabilities, and improve instruction in math.

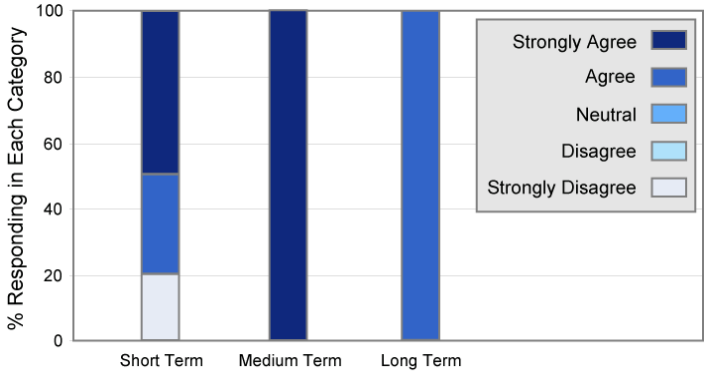

Figure 1a. Main Use Teachers' Level of Agreement to Computer Technology Statement 1.

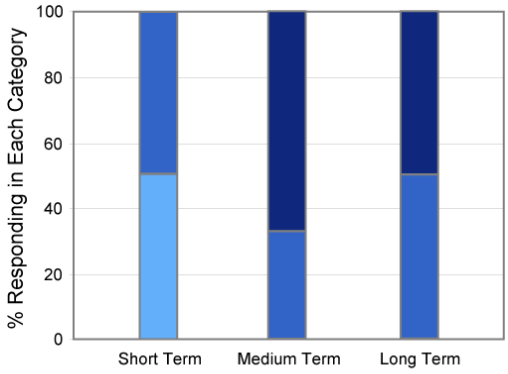

Figure 1b. Supplemental Use Teachers' Level of Agreement to Computer Technology Statement 1.

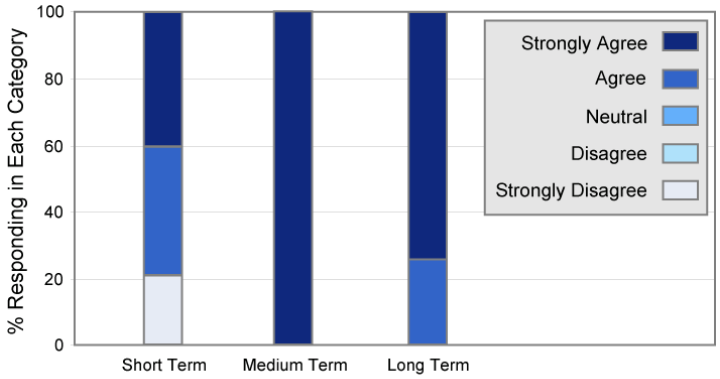

Figure 2a. Main Use Teachers' Level of Agreement to Computer Technology Statement 2.

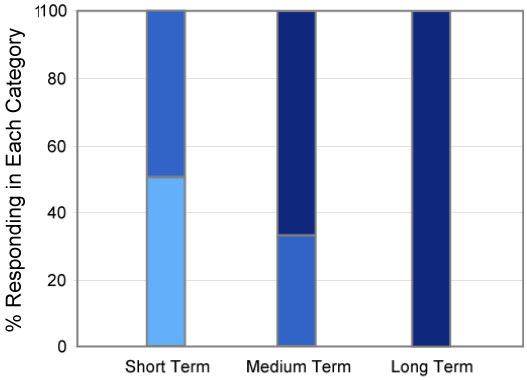

Figure 2b. Supplemental Use Teachers' Level of Agreement to Computer Technology Statement 2.

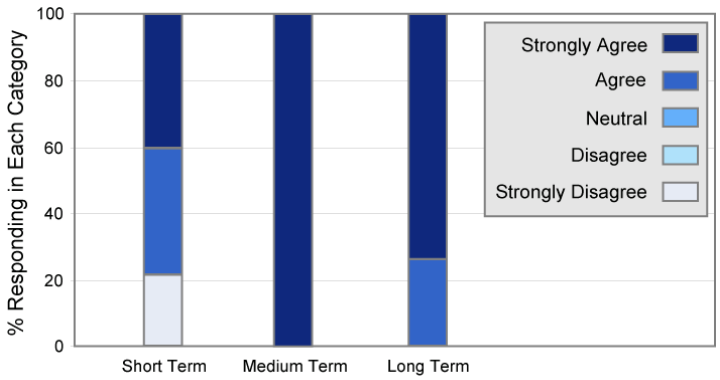

Figure 3a. Main Use Teachers' Level of Agreement to Computer Technology Statement 3.

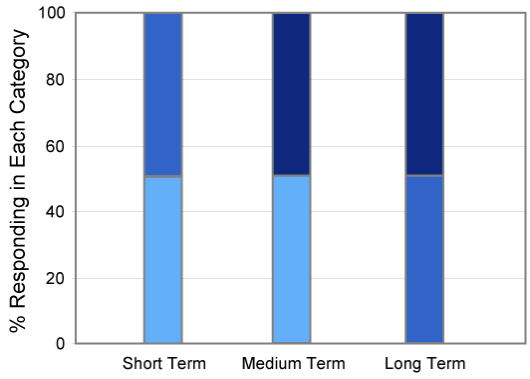

Figure 3b. Supplemental Use Teachers' Level of Agreement to Computer Technology Statement 3.

Use of Curricular Materials

Table 6 shows how closely teachers reported adhering to the lessons in the *CT* textbook. The table reveals that 50% of teachers responded that they follow the main program or make some minor adjustments.

Table 6. Follow the *CT* Program As Provided

How closely do you adhere to the lessons in the *CT* textbook?	I go through the lessons/ activities in order and complete all steps for each lesson	I make minor adjustments but follow the main program	I use some of the lessons /activities when it seems appropriate	I almost never use lessons/ activities from the textbook	I have never used lessons/ activities from the textbook
	10%	40%	35%	5%	10%

Note. N=20

All teachers who responded that they go through the lessons/activities in order and complete all steps for each lesson were teachers with the longest length of *CT* use and who use *CT* as their main curriculum. All teachers reporting that they almost never or never use the lessons/activities from the textbook are teachers who reported using *CT* as their supplemental curriculum. One special education and one ELL teacher reported that they found the reading level of the text too high for many of their students. Therefore, they select specific problems in the text that their students are capable of reading. Another teacher reported being farther along in the text this year at this point in the school year than last year because of knowing how to use the program better.

Use of the Teacher's Toolkit

We also asked teachers about their use of the Teacher's Toolkit. Fifteen percent of respondents reported never using the Teacher's Toolkit. All of these teachers reported using *CT* as supplemental to their math curriculum.

We surveyed teachers about how often they use the following functions of the Teacher's Toolkit: repeat/skip a problem, view problems and solutions, change student placement, use detailed student reports for progress monitoring, and use class summary reports for progress monitoring. Of those teachers who use the Toolkit, a majority reported rarely repeating/skipping a problem,

viewing problems and solutions, or changing student placement, whereas most reported viewing class progress, using detailed student reports for progress monitoring, and using class summary reports for progress monitoring.

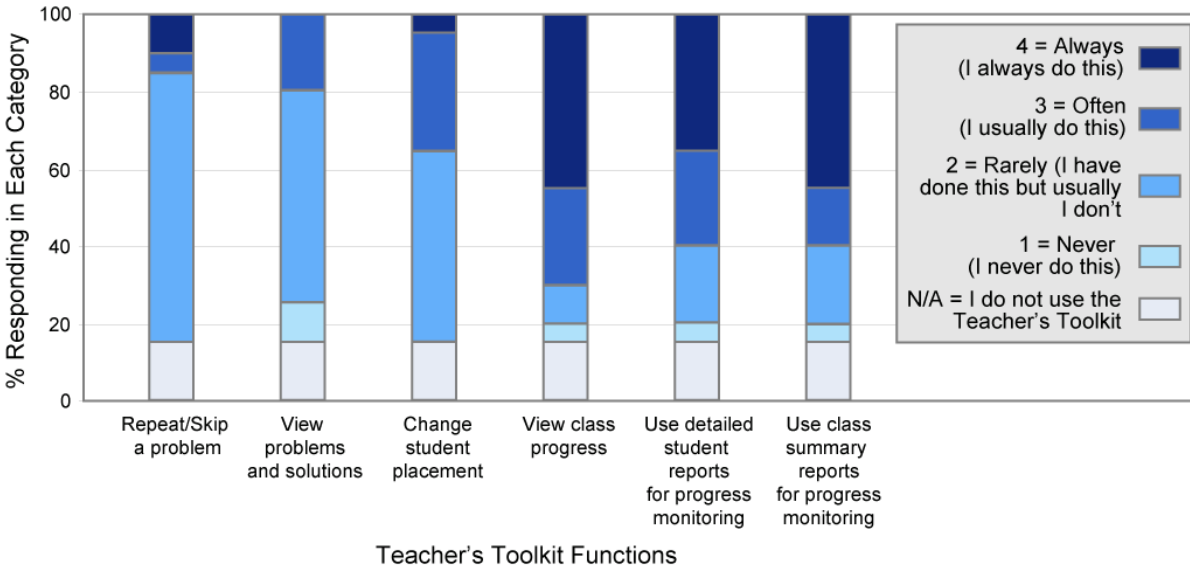

Figure 4. Teachers' Self Reports of Toolkit Use

Allocation of Instructional Time

During the pre-algebra study, many teachers expressed frustration about not being able to use *CT* as it is designed to be used because of the lack of technical capacity. Many students spent most of their time using the *CT* textbook and were not able to use the software 40% of their instructional time, as it is intended. In this study, we asked teachers to report the percentage of instructional time they spend using the *CT* textbook, software, and other curricular materials. Overall, teachers reported spending 36% of their instructional time using the textbook, 29% of time using the software, and 35% of time using other curricular materials. Figure 5a and Figure 5b show the teachers' responses to this question in each of the Usage Matrix groups. Figure 5a represents the responses of teachers who use *CT* as their main curriculum and Figure 5b represents the responses of teachers who use *CT* as their supplemental curriculum.

The graphs reveals that, while teachers are not able to divide the instructional time as recommended (60% textbook; 40% software), those using *CT* as their main curriculum were closer to that ideal than the others, with the long term/main use teachers nearly ideal. Figure 5b shows that teachers using *CT* as their supplemental curriculum used *CT* materials less than half of the time, with medium and short term use teachers using the *CT* materials 10% of the time or less.

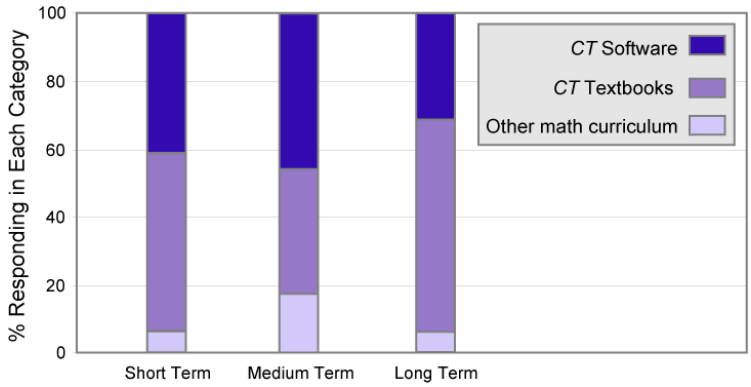

Figure 5a. Main Use Teachers' Self Reports of Instructional Time

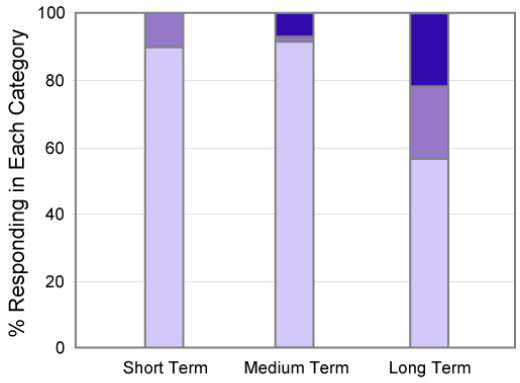

Figure 5b. Supplemental Use Teachers' Self Reports of Instructional Time

Figure 6, Figure 7, Figure 8, and Figure 9 show how teachers self-reported their comfort level for implementing various components of the *CT* curriculum when they started using *CT* and at the time they responded to the survey. For analysis purposes we collapsed our original 5-point Likert scale (Not at All Comfortable, Not Very Comfortable, Neutral, Comfortable, Very Comfortable) into a 3-point scale (Below Comfort, Neutral, Above Comfort). Upon examining the results, we concluded that a 3-point scale is sufficiently sensitive and preferred, since only one teacher selected an anchor item in any category.[2] Figure 6, Figure 7, and Figure 8 show that a higher percentage of teachers report an Above Comfort level at the time of the survey than when they began using *CT*; in other words, comfort levels are increasing over time. More than 75% of teachers reported Above Comfort level, whereas 7% reported a Below Comfort level in using the *CT* textbook, software, and Teacher's Toolkit. While Figure 9 also shows more teachers reporting a higher comfort level in implementing *CT*'s definition of collaborative classroom at the time of the survey than when they first began using *CT*, less than half of the teachers (47%) reported the Above Comfort level, while 18% reported a Below Comfort level at the time of the survey.

[2] In addition, we are missing three data points for this question.

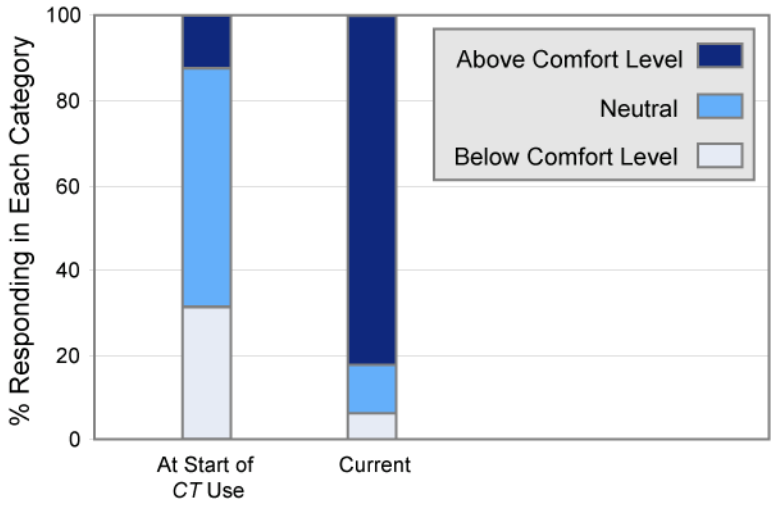

Figure 6. The Use of *CT* Text Materials

Note. Two teachers reported not using the textbook when they began using *CT* and one teacher reported still not using the textbook at the time the survey was administered. These teachers were removed from the analysis of this question. At Start of *CT* Use N=16; Current N=17.

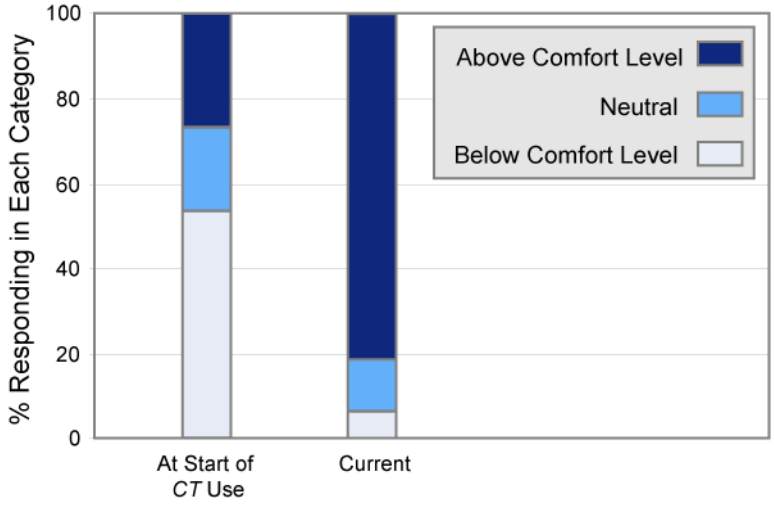

Figure 7. Helping Students with Software

Note. Three teachers reported not using the software when they began using *CT* and two teachers reported still not using the software at the time the survey was administered. These teachers were removed from the analysis of this question. At Start of *CT* Use N=15; Current N=16.

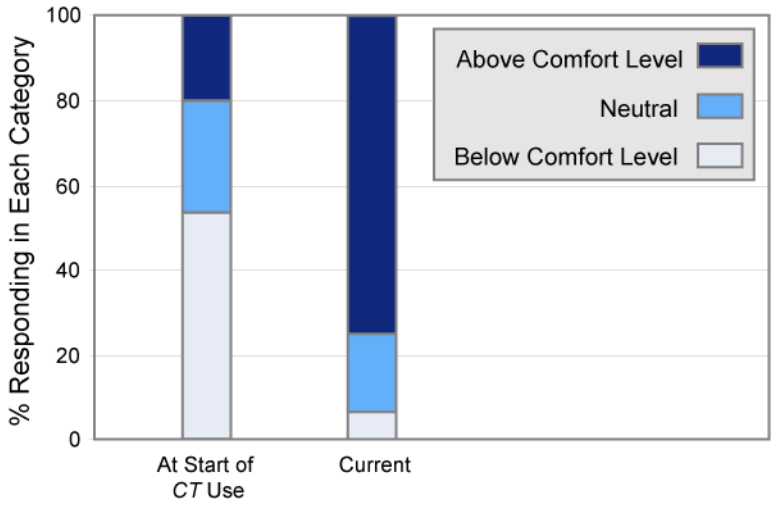

Figure 8. Teacher's Toolkit Functions

Note. Three teachers reported not using the Teacher's Toolkit when they began using *CT* and two teachers reported still not using the Teacher's Toolkit at the time the survey was administered. These teachers were removed from the analysis of this question. At Start of *CT* Use N=15; Current N=16.

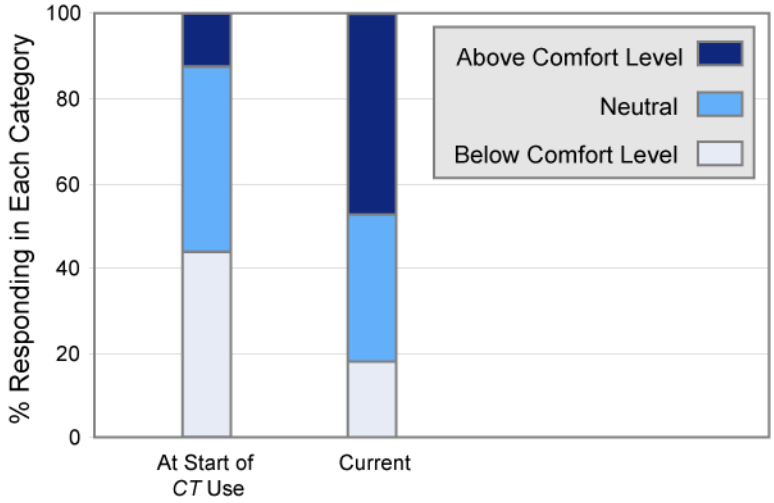

Figure 9. Implementing a Collaborative Classroom

Note. Two teachers reported not using the textbook when they began using *CT* and one teacher reported still not using the textbook at the time the survey was administered. These teachers were removed from the analysis of this question. At Start of *CT* Use N=16; Current N=17.

Collaborative Classroom

To expand our indicators of implementation beyond access to resources, use of materials, and teachers' comfort and confidence with technology, we also examined teachers' daily instructional practices to get an idea of classroom context and to determine whether they were successfully implementing *CT*'s description of a collaborative classroom.

The *CT* Teacher Text extensively covers how to initiate a collaborative classroom environment. Teachers are encouraged to facilitate the learning process rather than direct or lead it. Students are to work collaboratively in groups to discuss, solve, and review problems and to present their solutions to the class. In order to get an idea of how closely teachers were adhering to this description, we asked them to estimate, when covering a new topic or lesson, the average percentage of time spent on the following five areas in their classroom:

- Teacher-led introduction to new subject matter
- Students working independently
- Students working in pairs or groups of two or more
- Teacher-led review
- Other

If teachers were following the *CT* description of a collaborative classroom, we would expect to find students working in pairs or groups a large majority of the time. As displayed in Table 7, teachers reported that students spend less than a majority of time working collaboratively in groups. On average, one-half of the lesson time is spent with the teacher leading with an introduction and with students working independently.

Table 7. The Introduction of New Subject Matter

On average, when covering a new topic or lesson, what percentage of time in your classroom is spent in the following five areas during the lesson?				
Students work in groups	**Students work independently**	**Teacher led introduction**	**Teacher led review**	**Other**
34%	24%	26%	14%	3%
Note. N=21				

Figure 10a and Figure 10b show the responses to this question according to the Usage Matrix groups (Figure 10a portrays the responses of the main use teachers; Figure 10b, the supplemental use teachers). Teachers with the longest and most exposure (main use/long term) to *CT* reported the highest percentage (53%) of lesson time with students working in pairs or groups. However, in all other groups, teachers responded that their students spend less than one-third of the lesson time working in pairs or groups.

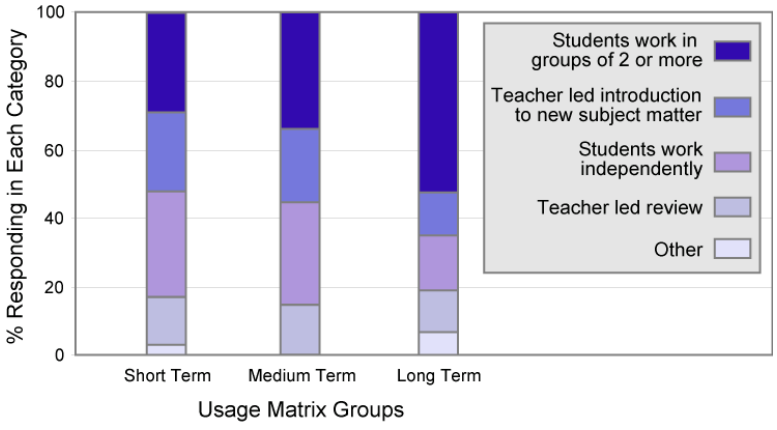

Figure 10a. Main Use Teachers: Introduction of new subject matter

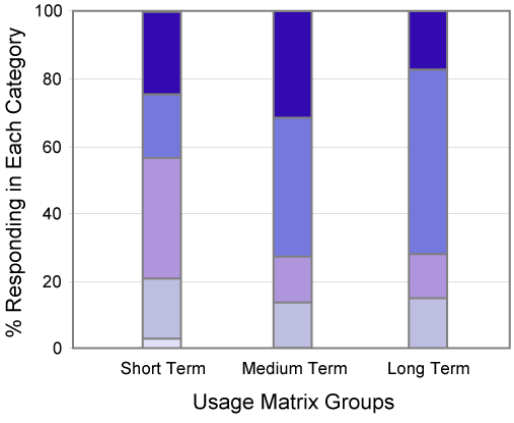

Figure 10b. Supplemental Use Teachers: Introduction of new subject matter

In addition to recommending a certain percentage of time students spend working in groups, the *CT* curriculum also stipulated that the groups be "collaborative working groups." To better understand the nature of group work, we asked teachers to select which of the following descriptions most closely describe how group work in their classroom typically looks:

- Students share responsibilities and everyone suggests, questions, and is encouraged to solve a problem.
- Students work as a group to solve a problem, with some students participating more than others.
- Students spend time thinking independently about how to solve a problem, then discuss ideas with their group.
- Students sit in groups but work independently to solve a problem.

The first descriptor is the closest to *CT*'s ideal implementation, and is therefore the descriptor we would expect *CT* teachers to select. However, Table 8 shows that only 10% of teachers selected this descriptor. Half of the teachers responded that students work as a group to solve a problem, with some students participating more than others.

Table 8. Group Work

Students share responsibility and everyone suggests, questions, and is encouraged to solve a problem	Students work as a group to solve a problem, with some students participating more than others	Students spend time thinking independently about how to solve a problem, then discuss ideas with their group	Students sit in groups but work independently to solve a problem
10%	50%	30%	10%

Note. There were 21 teachers who responded to these questions. One teacher's responses were removed from analysis because she did not use *CT* with her students.

Figure 11a and Figure 11b show the responses according to the Usage Matrix groups, with Figure 11a showing the responses of teachers who use *CT* as their main curriculum and Figure 11b showing the responses of those using *CT* as their supplemental curriculum. The graph reveals that only teachers within medium term use groups selected the descriptor that describes ideal implementation. Teachers who have used the program for one year (or less) and who use *CT* as their supplemental math curriculum selected categories describing other forms of group work.

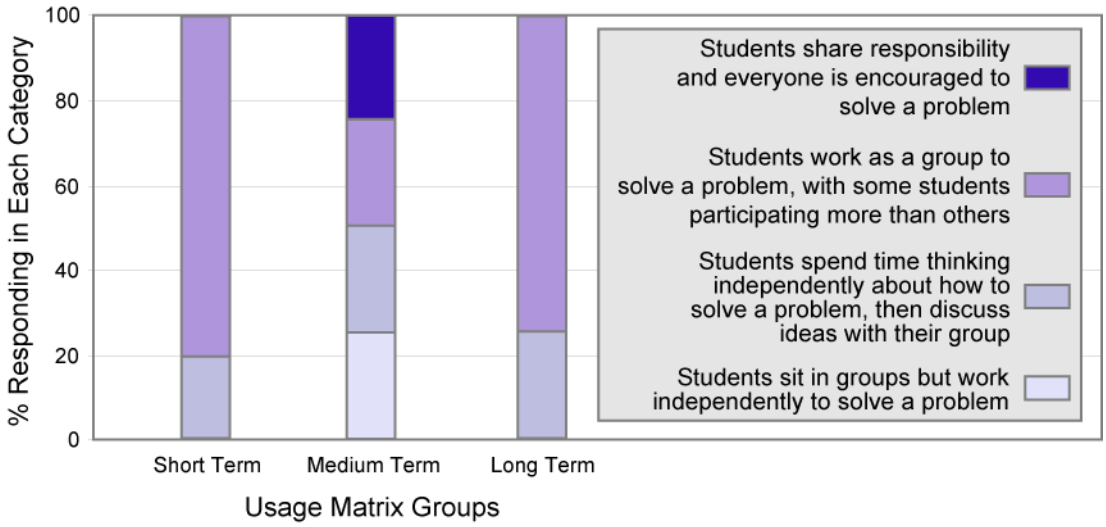

Figure 11a. Main Use Teachers: Group work description

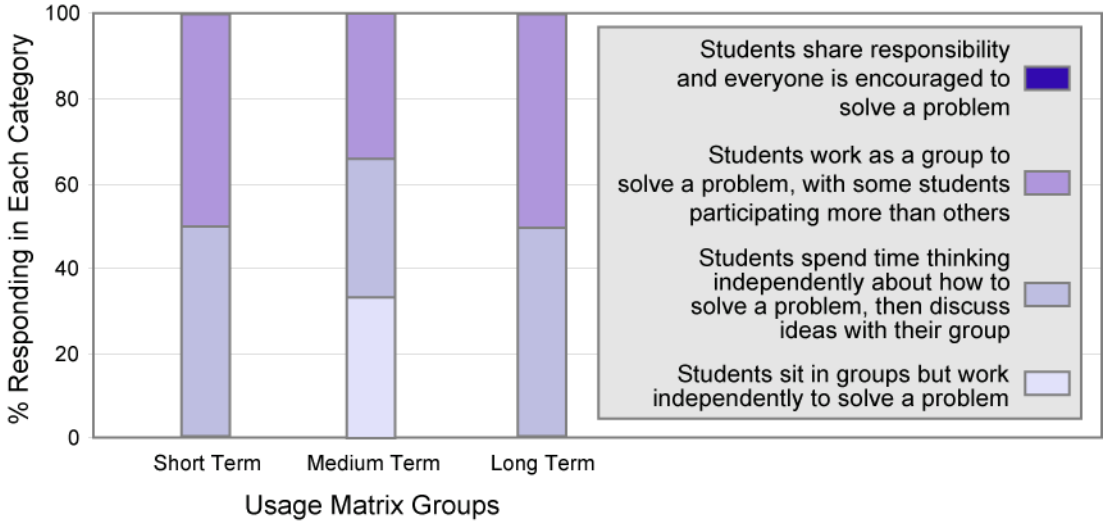

Figure 11b. Supplemental Use Teachers: Group work description

We also asked teachers how often students engaged in critical components of *CT*'s pedagogy. Table 9 shows the percentage of teachers responding in each category. The data demonstrate that a majority of teachers report that their students always or often engage in the following components:

- Engage in multiple problem-solving strategies and entertain multiple solutions (70%).
- Practice different aspects of the strategies to solve various problems to gain mastery (70%).
- Explain their reasoning or thinking in solving a problem, orally or in writing (80%).
- Apply mathematical concepts to "real world" word problems (90%).
- Maintain and reflect on a mathematics portfolio of their own work (60%).

However, 60% of teachers report that their students rarely or never engage in self-assessment or self-reflection and 90% report that students rarely or never present or demonstrate solutions to a

math problem to the whole class. When we asked teachers how they assess their students, most reported using standardized assessments, multiple choice questions, and short answer questions.

Table 9. Student Behavior During a Lesson

How often do your students do each of the following during a lesson?	1=Never (We never do this)	2=Rarely (We have done this but usually don't)	3= Often (We usually do this)	4= Always (We always do this)
Engage in multiple problem-solving strategies and entertain multiple solutions	0%	30%	70%	0%
Practice different aspects of the strategies to solve various problems to gain mastery	0%	30%	70%	0%
Self-assessment and/or self-reflection	5%	55%	35%	5%
Explain their reasoning or thinking in solving a problem, orally or in writing	0%	20%	65%	15%
Apply mathematical concepts to "real world" word problems	5%	5%	60%	30%
Present or demonstrate solutions to a math problem to the whole class	20%	70%	10%	0%
Maintain and reflect on a mathematics portfolio of their own work	20%	20%	60%	0%

Note. N=20

Teachers had generally positive opinions about student collaboration. When asked how the practice of teaching using *CT* has changed since first implementing the program, one teacher commented, "I'm not teaching as much. I find myself keeping groups on task and listening to them more. The classroom is less about me up front, and more about the students engaged in learning." Another teacher said, "I tend to depend on students teaching each other and answering questions for others only after I have introduced the lesson. I find that in this way, students ARE making connections with prior knowledge. Students are taking ownership for their learning." By contrast, another teacher commented that "using the text in the exploratory style is a good way to develop a stronger understanding of math concept, however, because students are not familiar with this type of instruction it is a challenge to get them to work/read and think and use the materials to their advantage and be independent learners." When asked to describe how the collaborative aspect of the program is played out in their classrooms, one teacher commented that "I can do better with the collaborative aspect. It's amazing because when I do have students work collaboratively I can now pull back and give the students more freedom."

Teacher Feedback

In this section we report direct quotes from the teacher interviews and surveys to provide further insight as to how teachers perceive the *CT* program and how the instruction and materials interact with students. Generally, they expressed positive opinions.

- "I love this program and intend to improve every year."
- "I love teaching CogTutor. I don't want to teach the old way anymore."
- "My special needs students enjoy the computer portion of the program, which provides immediate feedback in which they are able to challenge their ability levels."
- "Students love it [software] because they have visuals, instant feedback, skills, goals, instant praise and they can self-pace."
- "Students like *CT.* They don't want wrong answers because they want to [visually] see their increase on the computer."
- "We have less kids failing than ever before."
- "My [Special Education] kids are engaged so they are less likely to act out."

Teachers indicated that the use of *CT* has changed their teaching and they have observed changes in their students.

- "Students have more skills than before because they come from restructured schools. The provider for these elementary schools are keying into skills that students need to have. The elementary teachers are holding students to benchmarks."
    - "This makes our job harder because they know more now and teachers have to teach higher skills."
    - "It also makes our jobs easier because you don't have to go back and re-teach basic concepts."
- "On tests, kids are engaged in problems. They don't quit or give up so quickly and I think it's because of *CT.*"

Teachers expressed specific concerns and critiques that are focused on two broad areas: reading/skill level and lack of alignment with Hawaii state math standards.

- Reading/skill levels (some say too high or too low for students)
    - Special Education Teacher: "I pick out problems that they're capable of because the level of reading in text is too high for my special ed. students."
    - Although indicating that ultimately it is the teacher's responsibility, one teacher commented that the *CT* text doesn't have alternative next steps for higher level students with high order thinking.
    - "It does appear that the opening units are way too easy and I have found myself having the students do a few problems in each area then skip ahead."
- Curriculum not aligned with Hawaii state standards:
    - "Because the *CT* program is not aligned with Hawaii state standards and our pacing guide I am only using *CT* for Math Study Skills classes."
    - "Yes, as a school in restructuring we have to practice standardized test questions and assessments regularly. *CT* Algebra 2 doesn't include this, so I am forced to look elsewhere for my instructional materials. I believe *CT* is a good program for 11-12 grade students who do not have state exams to take, but for our 10th graders *CT* doesn't present problems that consistently tie into standardized testing."

Teachers also conveyed what students were saying and feeling in regard to the program.

- "I use it less than I thought I would because of the student's reaction to the text especially. They had a very difficult time moving through the text exercises. I think this was due to the amount of reading and writing. They enjoyed the computer software but it did not line up well with our state standards pacing."
- "I was using the *CT* textbook last school year, but I found that it took up a lot of time that we didn't have. The students were not as motivated to putting in serious thought into answering the questions, so the value of the time spent on the *CT* textbook problems were not as helpful as the time spent on the traditional textbook problems."

Summary of Results

Access to Resources

- Many teachers (40%) reported that, although computers are centrally located in computer labs rather than in their classroom, their school provides extremely well in terms of installing equipment and networks. More than half (65%) reported that their school provides fairly well or extremely well for troubleshooting and maintaining equipment and networks. However, 45% of teachers reported that troubleshooting and maintaining operating systems and software was either not at all provided at all or not well provided. After three years of implementation, computers and most resources are in place to support the program; still lacking seems to be operating system maintenance and troubleshooting.

Teachers' Confidence with and Beliefs about Technology

- Teachers with greater exposure to *CT* all agreed that computer technology can help students learn math, enhance their teaching capabilities, and improve instruction in math. Almost no differences were noted between teachers using *CT* as the main or supplemental program in this area.

Use of Curricular Materials

- The data reveal that while teachers are not able to divide the instructional time as recommended (60% textbook; 40% software), teachers using *CT* as their main curriculum were closer to that ideal than the others, with the long term/main use teachers nearly ideal. Teachers using *CT* as their supplemental curriculum used the *CT* materials less than half of the time, with medium and short term use teachers using the *CT* materials 10% or less of the time or less.

Collaborative Classroom

- Teachers generally expressed positive opinions about collaboration. However, overall, teachers reported that less than 35% of lesson time is spent with students working in pairs or groups. Teachers with the longest and most exposure (main use/long term) to *CT* reported the highest percentage (53%) of lesson time with students working in pairs or groups. However, in all other groups teachers responded that their students spend less than one-third of the lesson time working in pairs or groups. This suggests that teachers may need more time and/or support before being able to change their instructional practice from teacher-led to student-centered. We should also note that there could be a difference between the teachers who began using *CT* in earlier years and teachers who began more recently that could lead to this same result. In other words, the teachers who began using *CT* in earlier years may have been more inclined to implement a collaborative classroom.

Teacher Feedback

- Teachers expressed overall positive attitudes about implementing *CT* and in the level of student engagement, particularly with the software component.
- Some teachers are concerned that the reading level of the *CT* textbook is not aligned with their students' reading level and that the content of the program is not aligned with the Hawaii state math content standards pacing guides.

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