# Evaluation of the Ho`okahua Project at the Maui Community College

December 2008

## Overview

Ho'okahua is a five-year NSF-funded project designed to increase the number of Maui Community College students entering, persisting in, and succeeding in college level Science, Technology, Engineering, and Mathematics (STEM) courses and degree programs, with particular focus on Hawaiian students. This research study measures several indicators of the success of the Ho'okahua project. Specifically, we focused on outcomes for students who received algebra instruction through Ho'okahua's courses using the math curriculum, *Cognitive Tutor® (CT),* which is published by Carnegie Learning. The indicators consist of subsequent course selection and grades achieved for all *CT* students and for native Hawaiian *CT* students in particular.

Under contract with the Maui Educational Consortium and funded through the Math Science Partnership (MSP), Empirical Education has conducted several rigorous evaluations of *CT* as implemented in the Maui School District and Maui Community College. Randomized control trials were conducted of the *CT* algebra program during the 2005-2006 school year and the *CT* pre-algebra program during 2006-2007 school year (Cabalo, Jaciw, & Vu, 2007 and Cabalo, Ma, & Jaciw, 2007). During the 2007-2008 school year, Empirical Education continued the evaluation of *CT* with a descriptive analysis of program implementation, which included teachers from the previous experiments within the Maui School District and Maui Community College (Zacamy, Miller, & Cabalo, 2008). In addition, we extended the experimental analysis within the Maui School District. We tracked the students who had participated in the earlier experiments to determine whether the program had a lasting effect, as shown in their math course progression and success in the year following their involvement in the algebra and pre-algebra studies (Maui School District, 2008).

The current study continues to build on our previous research and is similar in approach to the math course progression study conducted in the Maui School District during the 2007-2008 school year. The research questions addressed in this study ask whether there is a difference in terms of course progression and performance between students who have taken an algebra course that used *CT* and those who have taken the same course but did not use *CT*. The main research questions are:

1. Did a higher percentage of *CT* students than comparison students go on to take at least one more math course after their initial algebra course during the subsequent three semesters?
2. Did students who had exposure to *CT* choose subsequent math courses that were of a higher course progression level than students who did not have exposure to *CT*?
3. Did student who had exposure to *CT* students obtain higher grades in their subsequent math courses than students who did not have exposure to *CT*?
4. Did the impact of *CT* on course selection and performance vary with ethnicity—specifically, whether or not the student was native Hawaiian?

**This research was conducted as a MeasureResults™ service by Empirical Education Inc.**

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## Methods

We examined the subsequent course taking of students enrolled in three math courses, some sections of which made use of *CT*.

Based on the Maui Community College Math Course Sequence Flow Chart, researchers coded each course on a scale from 1 to 11, as shown in Table 1 and described in more detail in Appendix A.

**Table 1. Course Level Coding**

| Course Level | Course Number |
|---|---|
| **1** | Math 1 |
| **2** | Math 22, Math 50U, Math 50H |
| **3** | Math 21A, Math 23, Busn 189 |
| **4** | Math 25, Math 100, Math 111, Math 115 |
| **5** | Math 27, Math 107, Math 112 |
| **6** | Math 135 |
| **7** | Math 140, Math 203 |
| **8** | Math 205 |
| **9** | Math 206 |
| **10** | Math 231 |
| **11** | Math 232 |

We identified the three algebra courses in which *CT* was used (Math 23, Math 25, and Math 27) and obtained data on students who took one of these courses during the 2005-2006 or 2006-2007 school year. Because all students (30) taking Math 27 received *CT,* and because there was no comparison group for this course level, we removed the data for these students from our sample. We planned to include two cohorts of students in our study: students from the 2005-2006 cohort and students from the 2006-2007 cohort. However, due to the small number of *CT* students from the 2005-2006 cohort, our study only includes students from the 2006-2007 cohort. We started from the semester each student first took one of these algebra courses (during the given school year) and then looked at the math courses taken during the subsequent, consecutive three semesters. The sample used in this study is shown in Table 2 and further explained in Appendix D.

**Table 2. Maui Community College Students in Control and *CT* Groups**

| | | Total number enrolled in starting course during the 2006-2007 school year | Students who enrolled in subsequent math course |
|---|---|---|---|
| **Math 23** | **Control** | 202 | 68 |
| | ***CT*** | 23 | 3 |
| **Math 25** | **Control** | 11 | 3 |
| | ***CT*** | 38 | 14 |
| **Totals** | | **274** | **88** |

To answer research question 1, we looked at the percentage of *CT* and comparison students who went on to take another math course during the three subsequent semesters. We examined these results separately for students who took Math 23 and for those who took Math 25.

Next, we examined the effect of *CT* on students' course level selections (question 2). To do this, we removed students who did not take a second math course during these three semesters so we could examine the differences in math course selections among students who did take at least one additional math course. The course within these three semesters with the highest rank serves as our outcome measure for question 2. This allowed us to test whether or not the *CT* group, following their experience with the program, took courses that are further along on the course progression than the students who did not use *CT*.

Next we measured the impact of *CT* on the grades students received in their highest ranking subsequent math course (question 3). Appendix B explains our conversion of course grades into integer values. We recognized that if exposure to *CT* affects course-taking, then course grades may reflect not only student proficiency but also selection of more difficult or easier courses. To make a fair comparison between students who did and did not receive *CT* in terms of their subsequent performance, we adjusted for the differences in course choices between conditions (*CT* or comparison group). We did this by measuring the average difference in performance between conditions while controlling for the average difference in the level of course progression. This allows us to determine whether *CT* is related to achievement within a given level of course progression.

***Levels of confidence in our results:*** *We report results based on statistical tests that give us a measure of confidence expressed as a probability. We often see a difference between, for example, the heights of two bars in a graph, but have no confidence that it is any more than a chance difference. We use* p *values where a low value indicates a low probability that we would detect a difference like the one found in the experiment if no difference actually existed. A* p *value less than .05 gives us strong confidence in the result (a level conventionally called statistically significant), while a* p *value greater than .20 gives no confidence. Between the two we may have some or limited confidence. We may also provide the 80% confidence intervals for some graphs, denoting our interpretation that an 80% probability exists that the tops of the bars fall somewhere within their respective interval. Where the intervals overlap, the* p *value is greater than .20.* ***Note that a high level of confidence does not rule out the possibility that other factors that may have biased the results—see "Cautions" at the end of this report.***

Finally, we examined whether course selection and course grade, as well as the impact of *CT* on these outcomes, varied when we compared Native Hawaiian and part-Hawaiian students to students not belonging to these categories of ethnicity (question 4).

# Results

### Question 1: Did a higher percentage of *CT* students than comparison students go on to take at least one more math course after their initial algebra course during the subsequent three semesters?

*For Math 23, more comparison students went on to take another math course. For Math 25, there is no discernible difference between the two groups.*

Figure 1 shows the percentage of Math 23 students who took a subsequent math course. Among the Math 23 students, 33.7% of the comparison students took at least one additional math course compared to 13.0% of the *CT* students. Our statistical test showed that we can have some confidence ($p$=.06) that this difference in the percentage of students taking subsequent math courses is not a chance result.

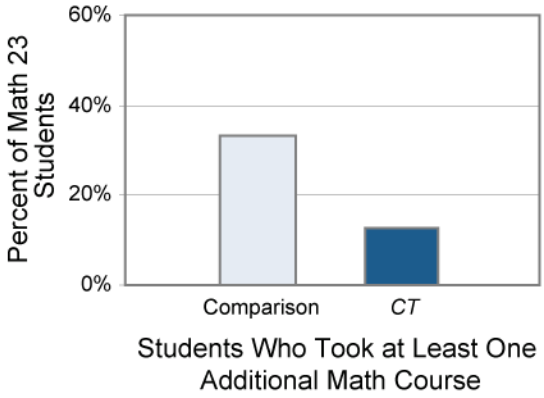


**Figure 1. Percent of Math 23 Students who Took a Subsequent Math Course**

Figure 2 shows the percent of Math 25 students who took a subsequent math course. Among the Math 25 students, 27.3% of comparison students took at least one additional math course compared to 36.8% of *CT* students. However, this small difference could easily be due to chance ($p$=.70).

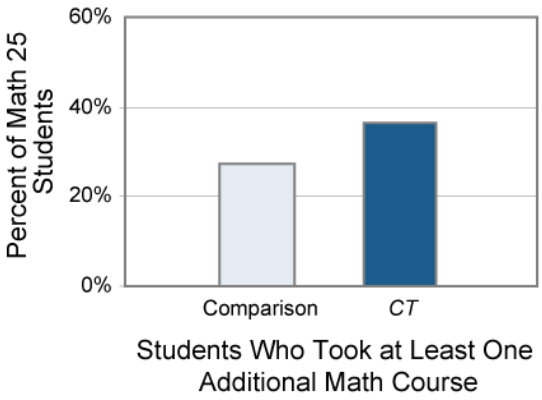


**Figure 2. Percent of Math 25 Students who Took a Subsequent Math Course**

### Question 2: Did students who had exposure to *CT* choose subsequent math courses that were of a higher course progression level than students who did not have exposure to *CT*?

*No, the comparison students were more likely to take courses higher in the course progression.*

Students who received *CT,* on average, subsequently took lower level courses than students who did not receive *CT*. We obtained a *p* value of <.01 for the statistical test of the mean difference between the two groups, indicating that there is a very low probability of observing a difference this large by chance. See Appendix E for greater detail.

Figure 3 shows the estimate of the highest ranking course taken by students. We observe that the highest ranking courses for students who received *CT* are .55 points lower than for comparison students.

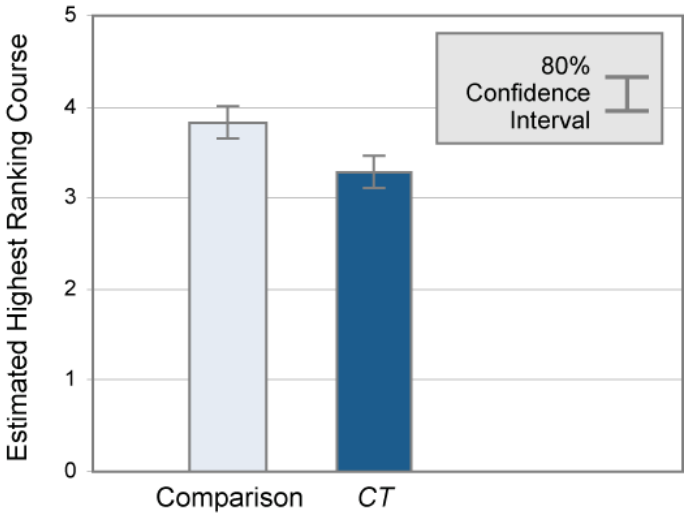


**Figure 3. Estimate of the Highest Ranking Course**

The following graphs show the highest ranking course taken by students in the three semesters following their enrollment in one the identified starting math courses. These are provided for descriptive purposes to illustrate the general course level progression for the students. The graphs show the *CT* and control group students combined and illustrate that most students who are recorded as taking a subsequent math course, progressed from their initial course to a higher-level course. Students who started in Math 23 started at level 3; students in Math 25 started at level 4; students in Math 27 started at level 5. Because no student progressed beyond a level 7 course, the graphs only show up to level 8.

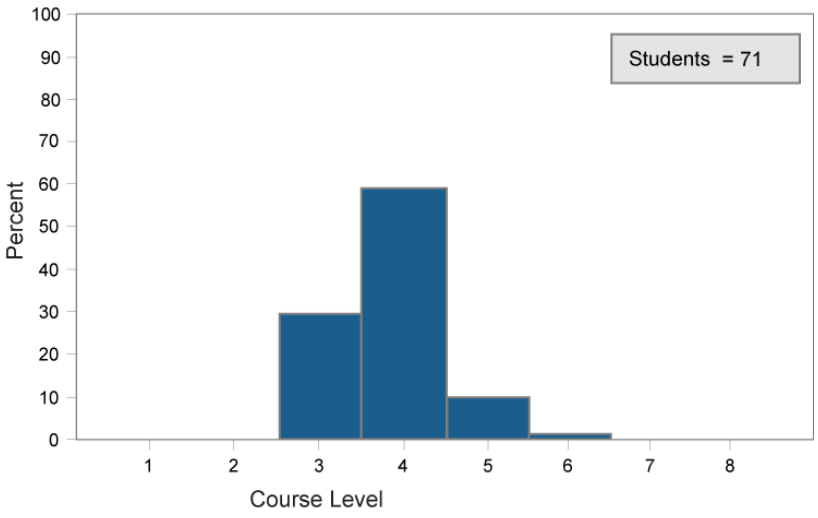


Figure 4 shows the results for students starting in Math 23. The bars show the percentage of students whose highest ranking subsequent course is within the indicated course rankings (1-8).

**Figure 4. Course Level for Students From Math 23 Starting Course**

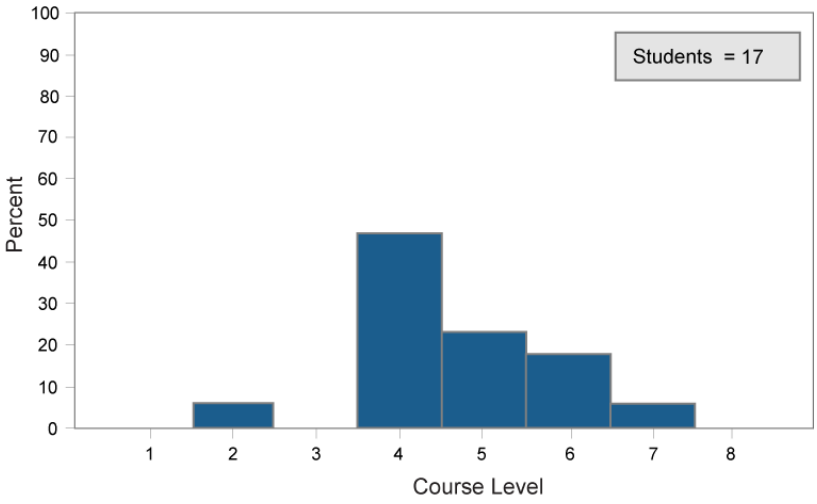


Figure 5 shows the results for students starting in Math 25. The bars show the percentage of students whose highest ranking subsequent course is within the indicated course rankings (1-8).

**Figure 5. Course Level for Students From Math 25 Starting Course**

Figure 6 shows the results for students starting in Math 27. The bars show the percentage of students whose highest ranking subsequent course is within the indicated course rankings (1-8). We included a graph showing the progression for students in Math 27 for descriptive purposes even though we did not include this data in our analysis.

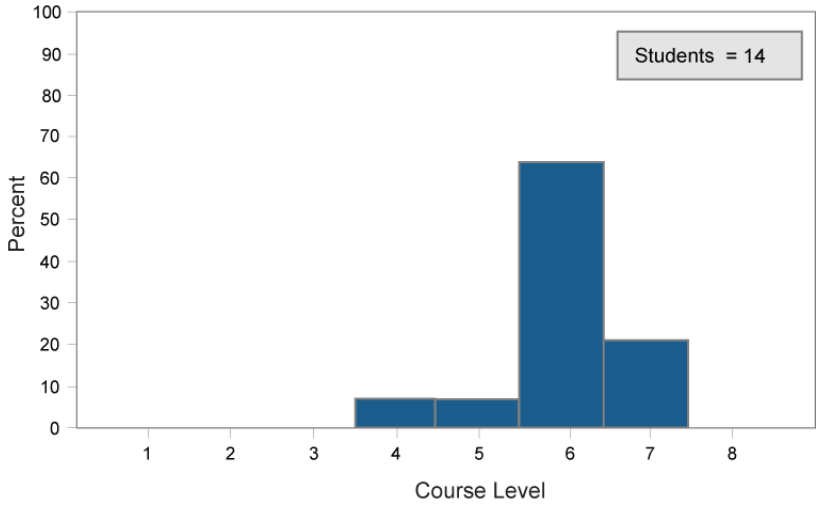


**Figure 6. Course Level for Students From Math 27 Starting Course**

**Table 3. Non-Calculus Career Pathway Courses**

| Course Number | *CT* Group | Comparison Group | Total Students |
|---|---|---|---|
| **Math 50s** | 1 | 0 | **1** |
| **Busn 189** | 0 | 0 | **0** |
| **Math 100** | 3 | 15 | **18** |
| **Math 111** | 0 | 2 | **2** |
| **Math 115** | 1 | 14 | **15** |
| **Math 112** | 0 | 3 | **3** |
| **Math 107** | 0 | 2 | **2** |

Table 3 provides additional detail with respect to the number of students (total and within each condition) whose highest ranking course was a non-calculus career pathway course (as identified by Maui Community College).

### Question 3: Did students who had exposure to *CT* obtain higher grades in their subsequent math courses than students who did not have exposure to *CT*?

*No, there was no discernible difference between the two groups.*

We did not find a difference in average course grade between students who received *CT* and those who did not. The *p* value of .30 gives us no confidence that the effect of *CT* on course grade, controlling for the difference between conditions in course progression level, is different from zero. See Appendix F for the table of results.

Figure 7 shows the estimate of the average difference in course grade, controlling for imbalance on course progression level. The confidence intervals overlap, indicating that the difference could easily be the result of chance.

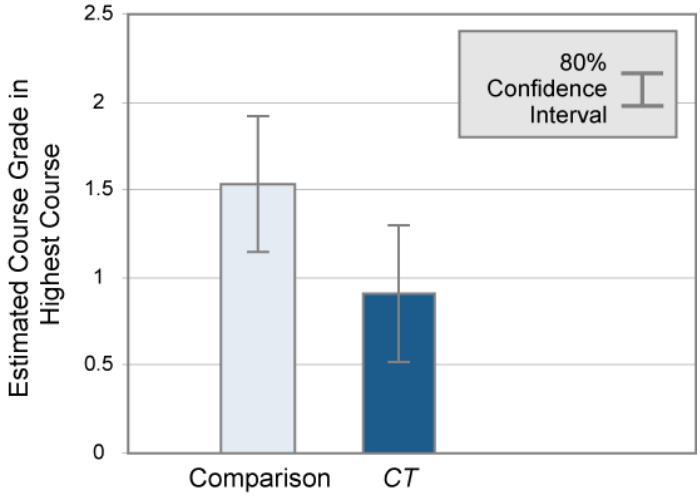


**Figure 7. Difference in Course Grade, Controlling for Imbalance on Course Progression Level**

### Question 4: Did the impact of *CT* on course selection and grade performance vary with ethnicity—specifically, whether or not the student was native Hawaiian?

*There was a difference related to ethnicity in course selection but not for grade performance.*

**Course Selection**

We observed a difference between Hawaiian and non-Hawaiian students that is associated with whether or not they had received *CT* and their subsequent course level selection.

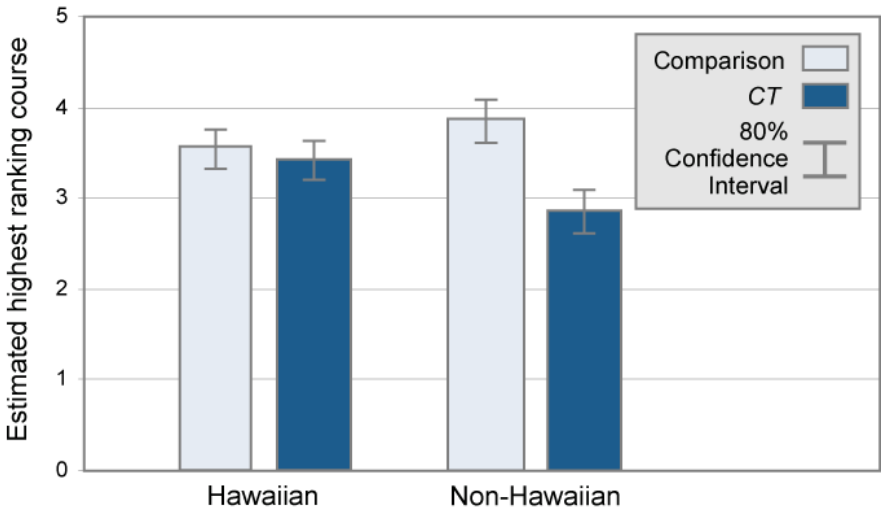


**Figure 8. Difference in Highest Ranking Course between Hawaiian and non-Hawaiian Students in the Comparison and *CT* Conditions**

As Figure 8 shows, non-Hawaiian students who have received *CT* subsequently took courses that are ranked lower than non-Hawaiian students who have not received *CT*. The lack of overlap in the confidence intervals for this subgroup of students shows that this difference is unlikely to have been caused simply by chance. On the other hand, Hawaiian students who have received *CT* subsequently took courses that are at about the same level as Hawaiian students who have not received *CT*. The technical details for this result are shown in Appendix G; the *p* value of .06 gives us some confidence that the difference described here between Hawaiian and non-Hawaiian students is not just a chance result.

**Grade Performance**

After controlling for imbalance between the *CT* and comparison groups on course progression, we found no evidence either of an overall difference among ethnicities in performance or that the effect of *CT* depends on ethnicity. See Appendix H for the technical details.

**Cautions for Interpreting These Results:**

- We undertook this study knowing that, although there would be limitations, that, as an initial exploration of patterns of course-taking, we can better understand future opportunities for rigorous research using improved methods.
- We worked with a limited amount of data about the students. We did not have a standardized pre-test available for all students and this limited our options for statistical adjustment on a characteristic that often predicts later performance. We also did not have their course-taking history prior to the baseline school year, so were unable to determine whether there had been prior exposure to *CT*.
- We did not have information about the extent to which students may have selected to take classes that used, or did not use, *CT*. The factors that led students to prefer or not prefer *CT* may have also influenced their course-taking choices as well as performance.
- There was a limited number of students in the sample, especially in the group exposed to *CT*.
- There was only one teacher who used *CT,* so we are unable to distinguish *CT* as a factor in later course selection and performance from that individual's influence. This is a very important limitation that makes it impossible to attribute differences in student course selections or outcomes to the *CT* program.
- We knew the courses that the students took, but not their teachers or the individual sections. It is very useful to know which students were taught by the same teacher in the same section because, without information about how students are clustered together, we have to treat the observations as though they are independent. Doing so, when they are in fact dependent, leads us to overstate the confidence we can have in the results.

## References


Cabalo, J.V., Ma, B., & Jaciw, A. (2007, October). *Comparative effectiveness of Carnegie Learning's Cognitive Tutor Bridge to Algebra Curriculum*. (Empirical Education Rep. No. EEI_EdCT2-06-FR-Y2-0.2). Palo Alto, CA: Empirical Education Inc.

Cabalo, J.V., & Vu, M. (2007, May). *Comparative effectiveness of Carnegie Learning's Cognitive Tutor Algebra I curriculum: A report of a randomized experiment in Maui School District*. (Empirical Education Rep. No. EEI_EdCT-05-FR-Y1-O.2). Palo Alto, CA: Empirical Education Inc.

Maui School District (2008). *A Study of the Effect of* Cognitive Tutor *on Long-Term Course Selections and Performance in the Maui School District* (MeasureResults Rep. No. EEI_MR-MAUI_SD_07_FR1-Y3.O1). Palo Alto, CA: Empirical Education Inc.

Zacamy, J., Miller, G. I., & Cabalo, J.V. (2008, December). *A Description of Maui Educational Consortium's Implementation Practices of Carnegie Learning's Cognitive Tutor*. (Empirical Education Rep. No. EEI_MR-Maui_SD_07_FR2-Y3.01). Palo Alto, CA: Empirical Education Inc.

# Appendix

## A. Course Ranking Development

To establish a scale with course progression levels as the outcome, we worked from the Maui Community College Math Sequence Flowchart. Courses were grouped together within the same ranking based on the branching of course progression. For cases in which students had multiple math courses with different rankings, we selected the highest ranking course and corresponding grade as the outcomes for this study. Table A- 1 summarizes the categorizations that we used to establish the course ranking scale.

**Table A- 1.**

| Course Level | Course Number |
|---|---|
| **1** | Math 1 |
| **2** | Math 22, Math 50U, Math 50H |
| **3** | Math 21A, Math 23, Busn 189 |
| **4** | Math 25, Math 100, Math 111, Math 115 |
| **5** | Math 27, Math 107, Math 112 |
| **6** | Math 135 |
| **7** | Math 140, Math 203 |
| **8** | Math 205 |
| **9** | Math 206 |
| **10** | Math 231 |
| **11** | Math 232 |

## B. Course Grade Scale

Standard letter grades were used as measures of performance. These were converted to integer values (F=0, D=1, C=2, B=3, A=4). There were no + or – grades in the source data. A grade of “IC,” “IF,” or “RD” were counted as incomplete and were given a 0. Grades of “CR” or “NC” were mapped to 2 and 0 respectively (pass/fail). Course grade was treated as a continuous outcome measure.

## C. Relationship between Course Level and Grade

A challenge to estimating the long term impact of *CT* on course grade is that *CT* may influence both course selection and course performance. For example, if students with exposure to *CT* are more likely to take courses higher in the course sequence pattern, then their letter-grade performance may end up being lower than the comparison group’s, not because they are lower in proficiency, but because it may be harder to obtain high scores on the courses that they are selecting as a consequence of having been exposed to *CT*. On the other hand, students who tend to achieve higher grades might also tend to take courses that are farther along in the progression as a result of their high achievement. For this reason we include the outcome, level of the course progression, as a covariate in the analysis of the relationship between *CT* and course performance. In Table A- 2, we observe that

there is an association between the level of course progression and course performance. This result justifies inclusion of level of course progression in the model relating *CT* to course performance.

**Table A- 2.**

| Fixed effects | Estimate | Standard error | DF | *t* value | *p* value |
|---|---|---|---|---|---|
| **Course grade for a student at the average level of course progression** | 1.55 | 0.14 | 100 | 11.31 | <.01 |
| **Change in course grade for each unit-increase in level of course progression** | 0.59 | 0.12 | 100 | 4.72 | <.01 |

Note that we show that there is a positive association between course progression level and course grade. This means that, on average, course grade increases as course progression level increases, which necessitates controlling for the difference between conditions in course progression level.

## D. Data Sample

Our original data sample included all students who were enrolled in Math 23, Math 25, and/or Math 27 during the 2005-2006 and/or 2006-2007 school year. Due to the small sample size of students (17) enrolled in a *CT* course during the 2005-2006 school year, we did not include these students' data in our analysis and removed them from our data sample. We also removed the data for all students (14) who did not receive *CT* in their first identified math course (Math 23, 25, or 27), but who received *CT* in a subsequent semester.

To answer our first research question, we looked at the number and percentage of students who did not take another math course in the subsequent three semesters following their enrollment in Math 23 and 25 during the 2006-2007 school year (a total of 202 students: 142 students in the comparison group and 60 students who had been exposed to *CT*). The data for these students were then removed from the data sample for the remaining analyses.

Because all 30 students in Math 27 received *CT*, there were no comparison students enrolled in this course. There was no appreciable gain in precision from including these data in the analysis, and adding them left open the question of how the results would change if controls had been available at this course level; therefore, we excluded these data from the analysis as well. Our final sample includes 88 total students, 71 in the comparison group and 17 who had been exposed to *CT*.

## E. Impact of *CT* on Course Level (for statistical reviewer)

Note: We use multiple regression models to estimate the effect of *CT* on course-level selection and achievement. The number of cases in the two conditions and the number of covariates available for inclusion in the model used to estimate the impact were relatively small, which precludes us from using more sophisticated models that have certain advantages. As a consequence, this work should be regarded as exploratory.

In all our analyses the pretest refers to the grade students achieved in their initial algebra course (Math 23, Math 25, or Math 27); because this score is received after students either do or do not experience *CT,* our estimates reflect associations between receiving *CT* and outcomes of interest for students who are at a given level of performance on this previous grade. Adding this pretest into our analysis does not control for imbalance in average performance between the two conditions at the start of the period of the study.

The following table shows the results of research question 2 in greater detail. We observe that students with *CT* exposure in their introductory course on average go on to take a subsequent highest course level that is .55 points lower (on the course level ranking) than students who do not receive exposure to *CT* in their introductory course.

**Table A- 3.**

| Effect | Estimate | Standard Error | DF | *t* value | *p* value |
|---|---|---|---|---|---|
| **Average subsequent highest course level for a student with an average starting algebra score who is originally enrolled in non-*CT* Math 23** | 3.82 | 0.08 | 84 | 50.67 | <.01 |
| **Average difference in subsequent highest course level between students enrolled in *CT* and those not enrolled in *CT*** | -0.55 | 0.27 | 84 | -2.02 | .05 |
| **Change in subsequent highest course level for each unit-increase in the starting algebra score** | 0.30 | 0.05 | 84 | 6.47 | <.01 |
| **Average difference in subsequent highest course level between students enrolled in Math 25 and those enrolled in Math 23** | 1.15 | 0.27 | 84 | 4.23 | <.01 |

Note. 'Starting algebra score' refers to the score received at the completion of Math 23 or Math 25. All effects, other than the main effect of starting algebra score, assume a constant level of the starting algebra score.

## F. Impact of *CT* on Course Grade, Controlling for Course Level (for statistical reviewer)

**Table A- 4.**

| Effect | Estimate | Standard Error | DF | *t* value | *p* value |
|---|---|---|---|---|---|
| **Average posttest for a student with an average starting algebra score and an average level of course progression originally enrolled in non-CT Math 23** | 1.53 | 0.17 | 83 | 9.09 | <.01 |
| **Average difference in posttest between students enrolled in *CT* and those in a non-*CT* course** | -0.62 | 0.60 | 83 | -1.04 | .30 |
| **Change in posttest for each unit increase in highest level of course progression (controlling for other effects in the model)** | 0.24 | 0.24 | 83 | 1.03 | .31 |
| **Change in posttest for each unit-increase in the starting algebra score** | 0.31 | 0.12 | 83 | 2.53 | .01 |
| **Average difference in posttest between students enrolled in Math 25 and those enrolled in Math 23** | 0.58 | 0.65 | 83 | 0.90 | .37 |

Note. 'Starting algebra score' refers to the grade achieved at the completion of Math 23 or Math 25. All effects, other than the main effect of starting algebra score, assume a constant level of the starting algebra score. All effects, other than the main effect of the level of course progression, assume a constant level of course progression.

## G. Moderating Effect of Ethnic Background on Course Level

**Table A- 5.**

| Fixed effects | Estimate | Standard error | DF | *t* value | *p* value |
|---|---|---|---|---|---|
| **Average subsequent highest course level for a Hawaiian student with an average starting algebra score originally enrolled in Math 23 without *CT*** | 3.56 | 0.18 | 82 | 19.86 | <.01 |
| **Change in subsequent highest course level for each unit-increase in the starting algebra score** | 0.30 | 0.05 | 82 | 6.65 | <.01 |
| **Average difference in subsequent highest course level between students enrolled in Math 25 and those enrolled in Math 23** | 1.45 | 0.32 | 82 | 4.61 | <.01 |
| **Average difference in subsequent highest course level between those enrolled in *CT* and those not enrolled in *CT* for Hawaiian students** | -0.14 | 0.34 | 82 | -0.42 | .68 |
| **Average difference (non-Hawaiian – Hawaiian) in average subsequent highest course level for students who did not receive *CT*** | 0.31 | 0.20 | 82 | 1.58 | .12 |
| **Average difference (non-Hawaiian – Hawaiian) in the difference in subsequent highest course level between those enrolled in *CT* and those not enrolled in *CT*** | -0.86 | 0.45 | 82 | -1.94 | .06 |
| **Random effects** | **Estimate** | | | | |
| **Residual** | 0.38 | | | | |

Note. 'Starting algebra score' refers to the grade achieved at the completion of Math 23 or Math 25. All effects, other than the main effect of starting algebra score, assume a constant level of the starting algebra score.

## H. Moderating Effect of Ethnic Background on Course Grades

**Table A- 6.**

| Fixed effects | Estimate | Standard error | DF | *t* value | *p* value |
|---|---|---|---|---|---|
| **Average posttest for a Hawaiian student with an average starting algebra score originally enrolled in Math 23 without *CT*** | 1.53 | 0.41 | 81 | 3.72 | <.01 |
| **Change in posttest for each unit-increase in the starting algebra score** | 0.30 | 0.12 | 81 | 2.42 | .02 |
| **Change in posttest for each unit increase in highest level of course progression (controlling for other effects in the model)** | 0.27 | 0.24 | 81 | 1.09 | .28 |
| **Average difference in posttest between students enrolled in Math 25 and those enrolled in Math 23** | 0.31 | 0.78 | 81 | 0.40 | .69 |
| **Average difference in posttest between students enrolled in *CT* and those not enrolled in *CT* for Hawaiian students** | -0.85 | 0.74 | 81 | -1.14 | .26 |
| **Average difference (non-Hawaiian – Hawaiian) in posttest for students who did not receive *CT*** | 0.02 | 0.44 | 81 | 0.05 | .96 |
| **Average difference (non-Hawaiian – Hawaiian) in the difference in posttest between those enrolled in *CT* and those not enrolled in *CT*** | 0.61 | 1.01 | 81 | 0.61 | .54 |
| **Random effects** | **Estimate** | | | | |
| **Residual** | 1.87 | | | | |

Note. 'Starting algebra score' refers to the grade achieved at the completion of Math 23 or Math 25. All effects, other than the main effect of starting algebra score, assume a constant level of the starting algebra score. All effects, other than the main effect of the level of course progression, assume a constant level of course progression.