Comparative Effectiveness of the TI-84 Graphing Calculator on Geometry Outcomes

Empirical Education

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Introduction/Abstract/Purpose.

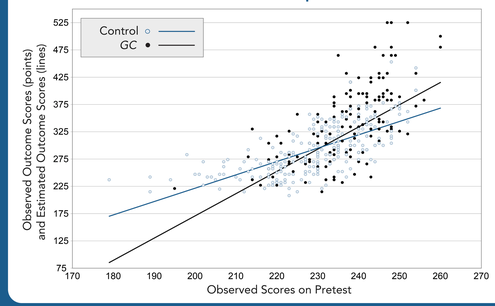
This paper presents geometry outcomes from a randomized control trial funded by Texas Instruments that compares classrooms provided with graphing calculators (*GC* group) to classrooms that used their existing materials (control group). The research employs a mixed-methods approach using pretest and posttest scores with observations and teacher surveys. The question specifically addressed is: Does the program, consisting of graphing calculators with related TI technologies and professional development, result in higher student achievement on the Geometry California Standards Test? The goal of this RCT is to provide TI and district decision-makers with evidence of whether the graphing calculators work in a particular setting. A measure of the program's impact could provide useful evidence to inform district decisions about which math technologies to adopt. Quantitative analyses of individual sites produced dissimilar findings. Further investigation may reveal possible explanations for these results.

Design/Data Sources/Analysis.

- Design
  - RCT with implementation observations
  - Unit of randomization: Teacher
  - Matched pair design with fair coin toss assignment
  - Blocked by district
- Data Sources
  - Standardized assessment outcomes
    - NWEA General Math Goals Survey 6+ CA pretest
    - CST Geometry End of Course posttest
  - Biweekly self-report teacher surveys
  - Classroom observations
  - Formal and informal teacher interviews
- Analysis
  - HLM analysis controlled for pretest (*presented*)
  - Socioeconomic status and English proficiency moderators (*not presented*)

Site A

Comparison of Predicted and Actual CST Outcomes for *GC* and Control Group Students at Site A



Estimated Impact of the Graphing Calculator on CST Geometry Outcomes at Site A

Descriptive Statisitics	Raw group means	Standard deviation	No. of students	No. of classes	No. of teachers	Unadjusted effect size
GC	336.17	67.69	184	8	4	0.86
Control	286.17	46.55	343	16	5	

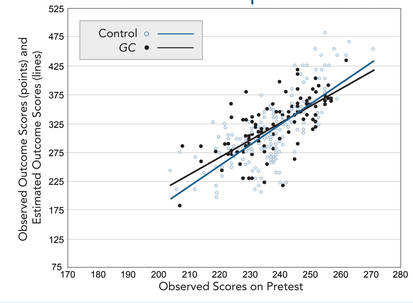
Mixed model: Fixed factors	Estimate of coefficient	Standard error	DF	*t* value	*p* value
Outcome for the control student with an average pretest	298.59	10.25	6	29.13	<.01
Change in outcome for the control student for each unit-increase on the pretest	2.45	0.20	365	12.09	<.01
Effect of *GC* for a student with an average pretest	0.59	16.33	6	0.04	.97
Change in the effect of *GC* for each unit-increase on the pretest	1.63	0.37	365	4.35	<.01

Mixed model: Technical details for random componenets	Estimate of variance componenet	Standard error	*z* value	*p* value
Teacher mean achievement	390.97	272.44	1.44	.08
Within teacher variation	1494.41	110.43	13.53	<.01

Note. We can refer to the student with an 'average pretest' because the pretest score is centered at the mean. The teacher factor is modeled as random.

Site B

Comparison of Predicted and Actual CST Outcomes for *GC* and Control Group Students at Site B



Estimated Impact of the Graphing Calculator on CST Geometry Outcomes at Site B

Descriptive Statisitics	Raw group means	Standard deviation	No. of students	No. of classes	No. of teachers	Unadjusted effect size
GC	300.02	51.64	300	14	5	-0.23
Control	313.10	62.93	211	8	3	

Mixed model: Fixed factors	Estimate of coefficient	Standard error	DF	*t* value	*p* value
Outcome for the control student with an average pretest	312.07	9.18	4	33.98	<.01
Change in outcome for the control student for each unit-increase on the pretest	3.56	0.25	289	14.50	<.01
Effect of *GC* for a student with an average pretest	4.04	13.10	4	0.31	.77
Change in the effect of *GC* for each unit-increase on the pretest	-0.57	0.38	289	-1.49	.14

Mixed model: Technical details for random componenets	Estimate of variance componenet	Standard error	*z* value	*p* value
Teacher mean achievement	228.85	183.00	1.25	.11
Within teacher variation	1281.74	106.63	12.02	<.01

Note. We can refer to the student with an 'average pretest' because the pretest score is centered at the mean. The teacher factor is modeled as random.

Description of Implementation Factors.

Typical Teacher Background Characteristics

- More than 6 years teaching experience
- Bachelors degree with a major in mathematics
- Received recent professional development
- Some previous graphing calculator experience

Typical Classroom Implementation Observed

- Graphing calculators commonly used as computational tools
- Cabri Jr. Geometry Application used less than 25% of classroom time
- Teachers taught activities that were familiar and successful in previous years
- Graphing calculators kept as classroom sets although research intended for students to have them also available for home use

Challenges to Implementation

- California mandates no calculator usage on state assessment
- Belief that paper-pencil graphing is easier and faster
- Incompatibilities and glitches between *GC* and school hardware
- Lack of ongoing technical support
- Loosely defined implementation model
- Graphing calculator poorly integrated into textbook lessons
- Lack of planning time to integrate the graphing calculator into lesson plans
- Lack of class time to teach students how to use the graphing calculator

Intervention.

The intervention consisted of:

- One-week 2005 summer institute using the TI T^3 professional development curriculum
- Notebook computer with TI graphing calculator software
- TI- SmartView calculator emulator software
- Data projection device for use with the notebook computer
- TI-84+ SE graphing calculators for each student (not a class set)
- Cabri Jr. software for use with graphing calculators

The intervention was deployed to:

- Professionals teaching mathematics
- Variety of classrooms
  - All freshman geometry classes
  - First-year geometry students of mixed grades
  - Students of mixed grades and math abilities
- Two large school districts in California

Site A: 12 schools	Teachers	Classes	Students
GC	4	8	146
Control	4	13	230

Site B: 9 schools	Teachers	Classes	Students
GC	3	7	131
Control	3	8	171

Summary of Results.

At Site A, the true effect size, when adjusted for the pretest, is 0.01. The estimated graphing calculator impact for a student with an average pretest score has a *p* value of .97; therefore, we have no confidence that the effect is different from zero. There is significant interaction ($p < .01$) between pretest score and condition (*GC* or control group). We are highly confident in the evidence that suggests students at Site A scoring higher on the pretest would benefit more from being in the *GC* group.

At Site B, the effect size, when adjusted for the pretest, is 0.06. The estimated treatment impact for a student with an average pretest score has a *p* value of .77; therefore, we have no confidence that the effect is different from zero. The interaction between pretest and condition has a *p* value of .14. We have some confidence in the evidence that suggests students at Site B scoring lower on the pretest would benefit from being in the *GC* group.

The interaction between treatment condition and pretest at Site A is opposite in direction to Site B. Analysis of both sites combined produces a significant three-way interaction ($p < .01$) between pretest score, condition, and site location. To avoid confusion with the individual sites, the table representing the combined three-way interaction is not shown.

Discussion.

Quantitative Perspective:

- The two sites had different quantitative results. For future research, we concluded that analyses need to be run separately and should not be combined.
- Teacher self-selection bias may have been an issue in this study.

Limitations: Conducting Field RCTs

- Site fit for studied program
- Missing student data
- Underpowered
- Alignment of assessments to studied program
- District priorities
- Truncated implementation time
  - Delays receiving intervention materials
  - Implementation curve