Can Technology-Based Representations Deepen Math Learning?

Findings from Scale Up Project

National Science Foundation Grant # 0437861
(4 prior awards also)

Jeremy Roschelle, Principal Investigator

SRI International

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Co-Principal Investigators

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Center for Technology in Learning

Apologies

- Bob Murphy could not present on EETI – report not yet out

Important Mathematics

Proportionality is critical to the transition from middle school to high school mathematics and science

proportionality includes:

- linearity
- rate
- function
- slope in graphs
- interpreting tables with an underlying rate
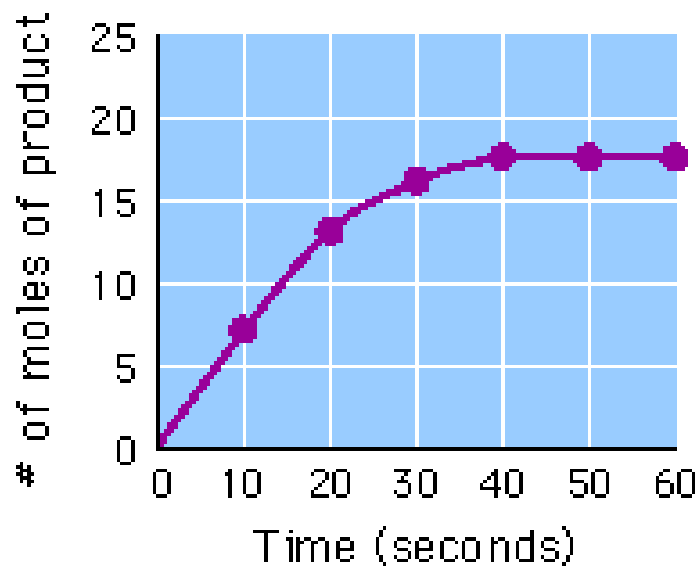
Proportionality & NCTM Focal Points

- **Developing an understanding of proportionality – a 7th Grade Focus**

…Students graph proportional relationships and identify the unit rate as the slope of the related line.

Rate and Proportionality in High School Science

F=ma

y=kx

LEAF SIZE OF MAPLE TREES

Tree	Average Length (cm)	Average Width (cm)
1	16.0	9.0
2	10.0	5.0
3	19.0	10.0
4	15.0	8.0

The importance of technology

Technology represents mathematics for learning in ways that are more:

- Visual

- Dynamic

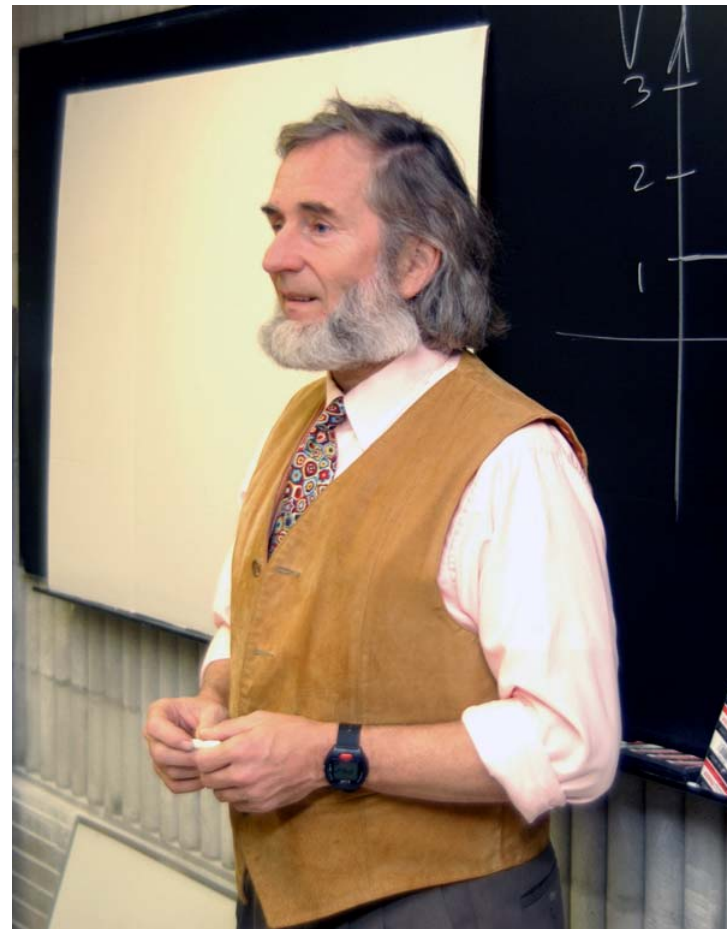- Linked (hence "with Connections")

The SimCalc Mission: Jim Kaput

"Democratizing Access to the Mathematics of Change and Variation"

Vision: a set of modules, 1 each grade level from 7th grade proportionality to high school calculus
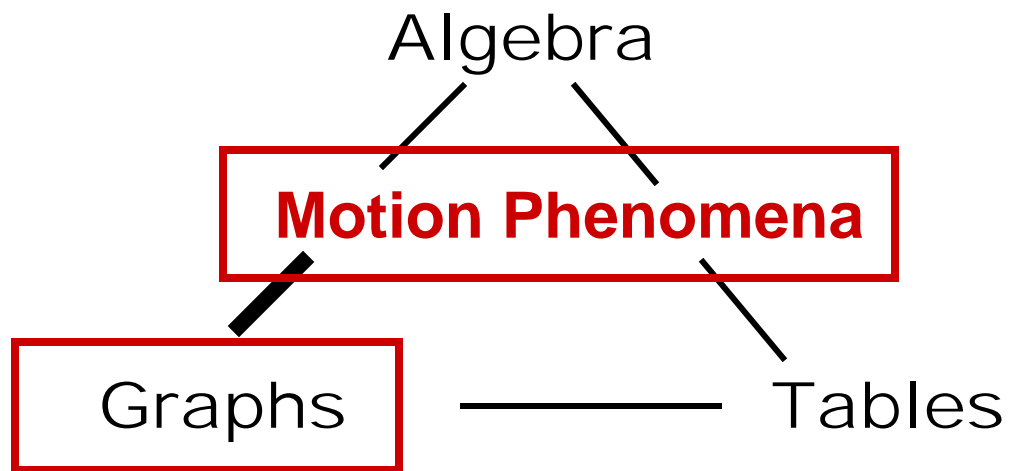
12 years of research! Beginning in 1994...

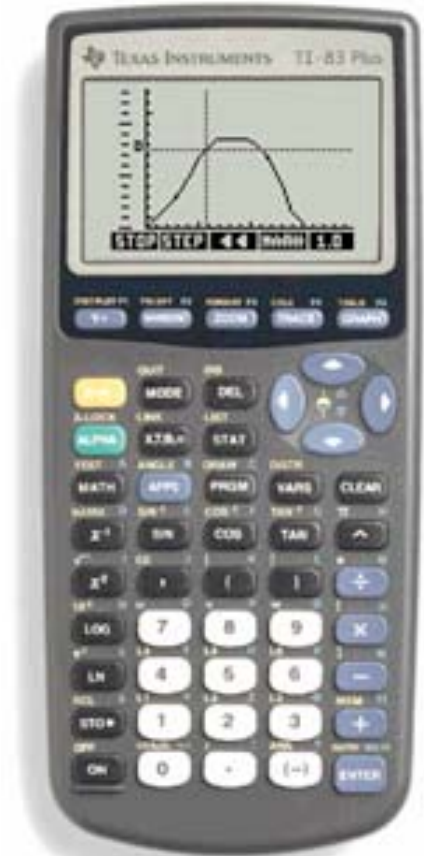# Jim's Contribution:
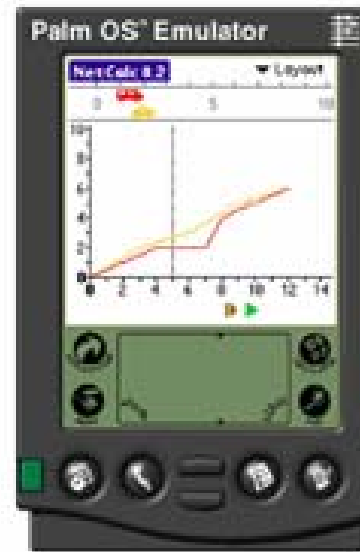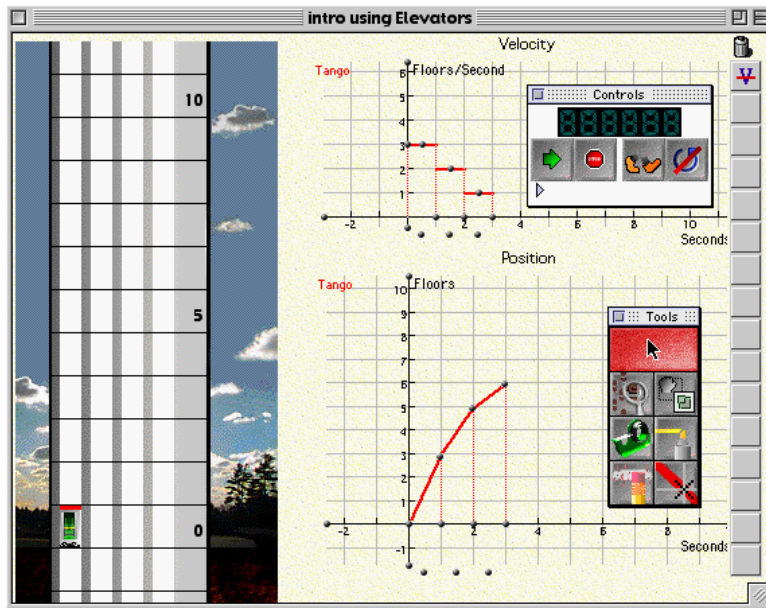# Integrated Curriculum & Technology

SimCalc restructures the pathway to knowing by
changing the classroom representational infrastructure
to feature dynamic, linked representations

Algebra

Motion Phenomena

Graphs ——— **Tables**

SimCalc MathWorlds runs on multiple platforms

Demonstration

**Teacher Notes for
Managing
the Soccer Team:
A 7th-grade unit
on rate and proportionality**

**Scaling up
SimCalc**

Research on Scaling Up

- From 10 students to 10 teachers to 10 schools to 10 regions

- 1600 students,
  95 teacher
  74 schools

- It took MANY research methods to get us here

A Team Effort

- Five Partner Institutions

- Five co-PIs

- Interdisciplinary Team:
  Mathematician, Cognitive/developmental psych, Computer science, Teacher Educators, Curriculum Experts, Experimental Psychologist, Assessment Experts, Curriculum Author, TPD Center (Dana Center), Statisticians

- Math Advisory Board

- Experimental Advisory Board

7th Grade Research Question
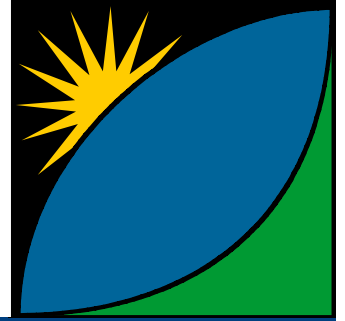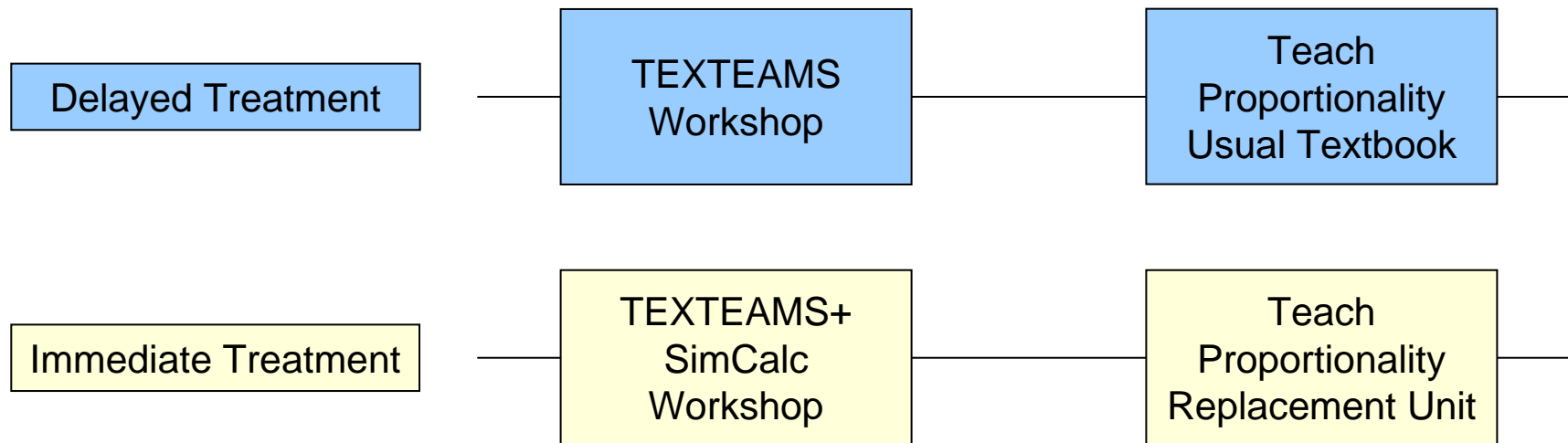
- Focus on a <u>wide variety of teachers and students</u>

<u>Beyond Today's Presentation:</u>

- **Effect of additional PD in 7th Grade**

- **Parallel 8th Grade Study**

- **Algebra in 9th and 10th grades, with network connectivity** (Stephen Hedegus, UMass)

- **Replication in Singapore**
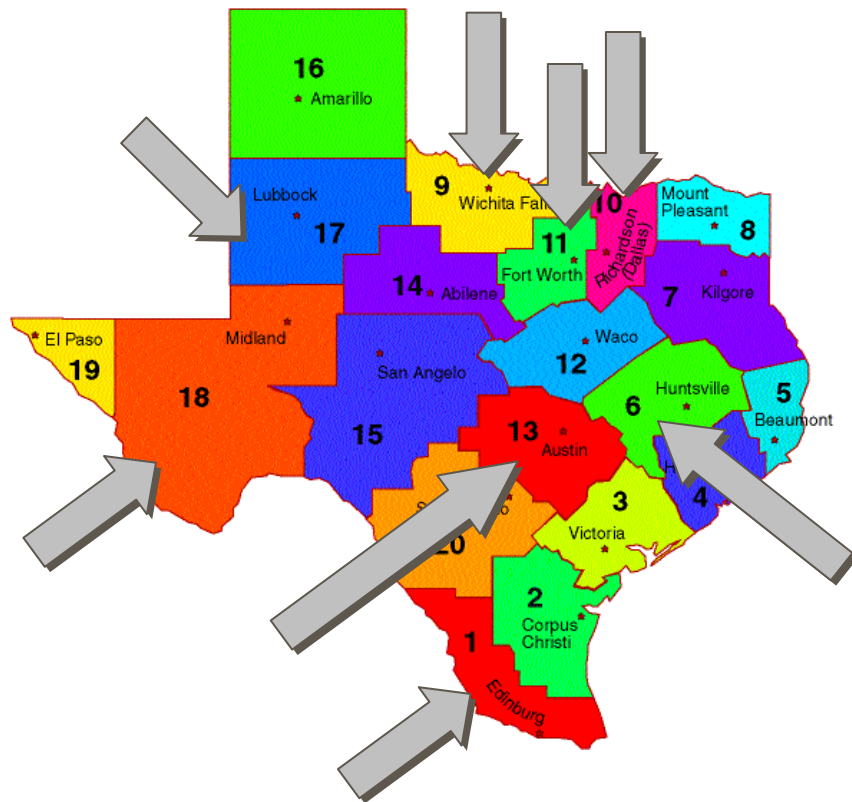
7th Grade Study
Research Design 1st year (2005-2006)

SUMMER ⟶ **SCHOOL YEAR** ⟶

Delayed Treatment — | TEXTEAMS Workshop | — | Teach Proportionality Usual Textbook |

Immediate Treatment — | TEXTEAMS+ SimCalc Workshop | — | Teach Proportionality Replacement Unit |

SimCalc's "integration" vs. "best existing"

7th Grade Recruitment Strategy

- Recruitment contracted to the Educational Service Centers (ESCs) in 8 regions throughout Texas

- Recruiters trained to seek a "wide variety of teachers" from each of their regions
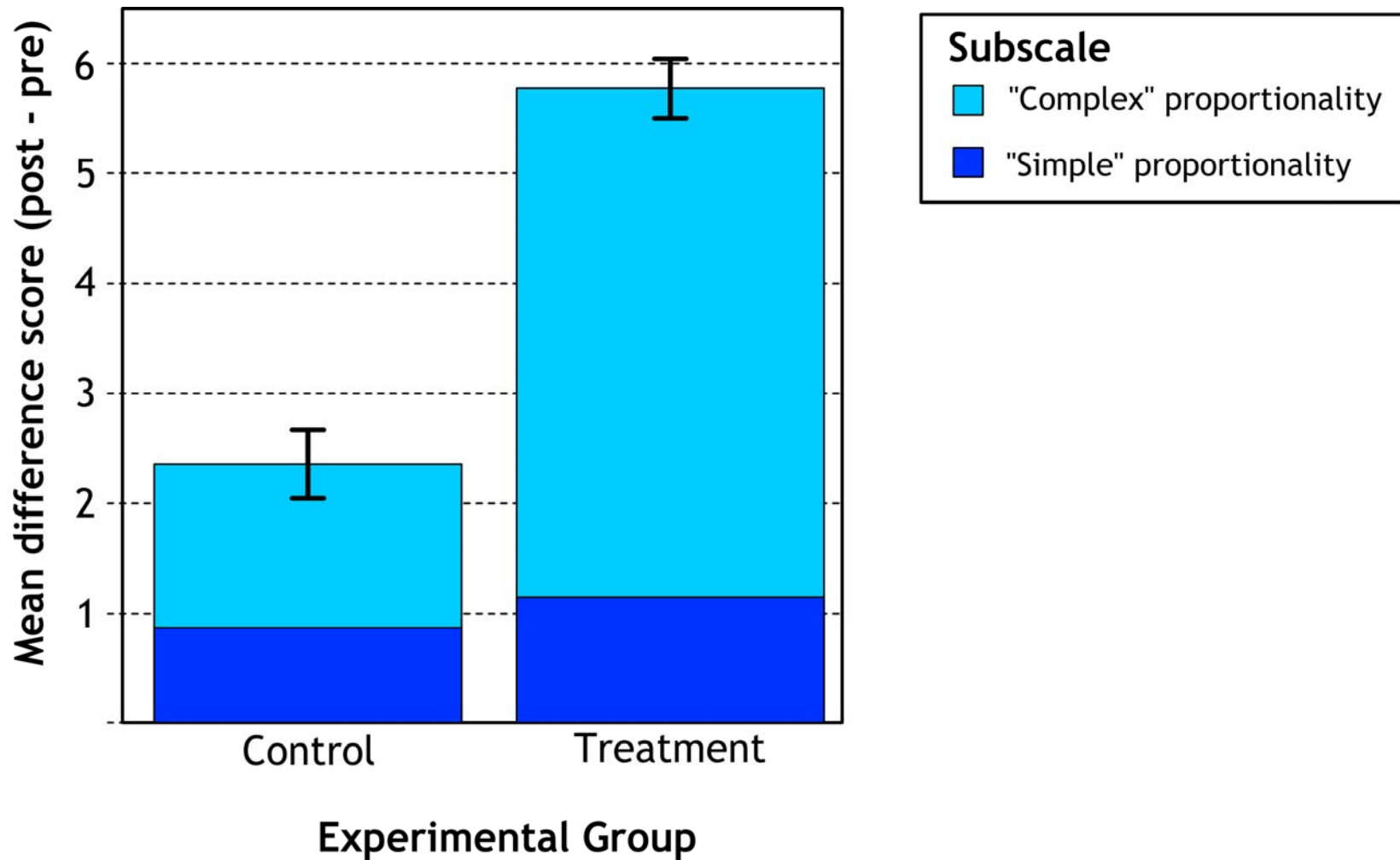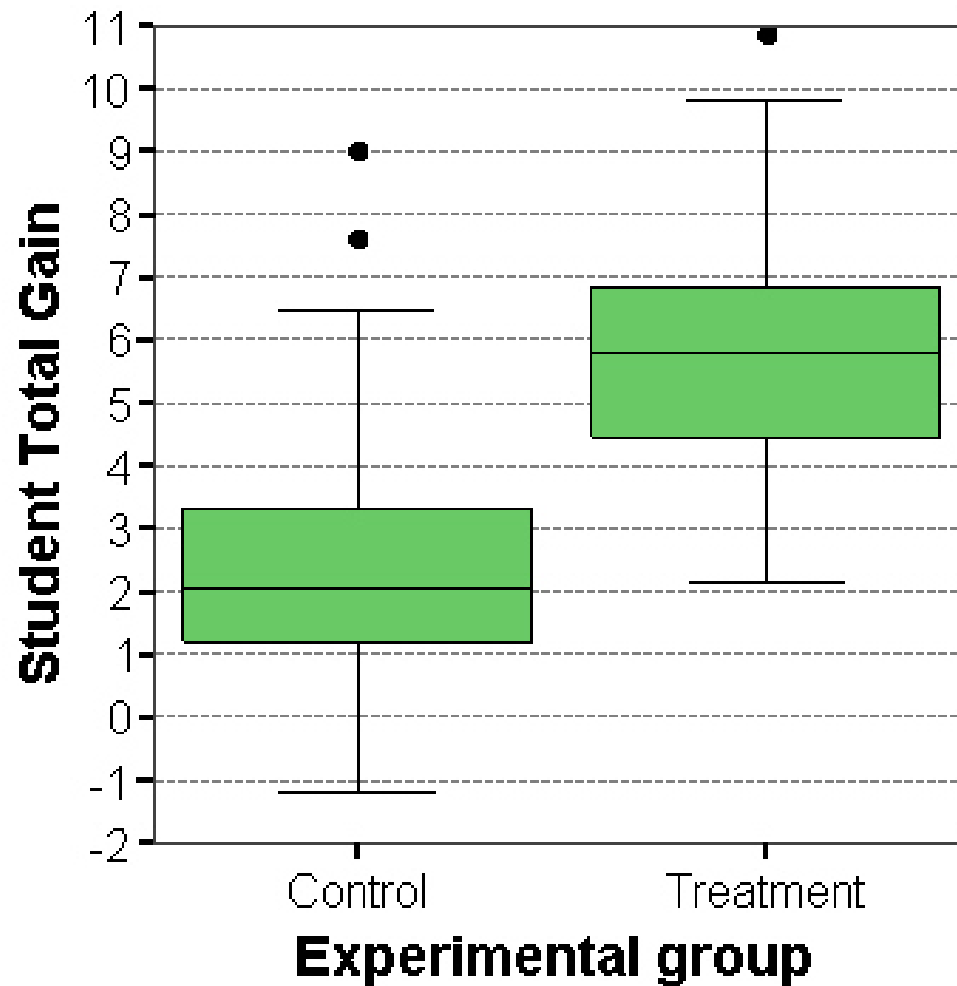
Drum roll, please….

SimCalc Students Scored Higher
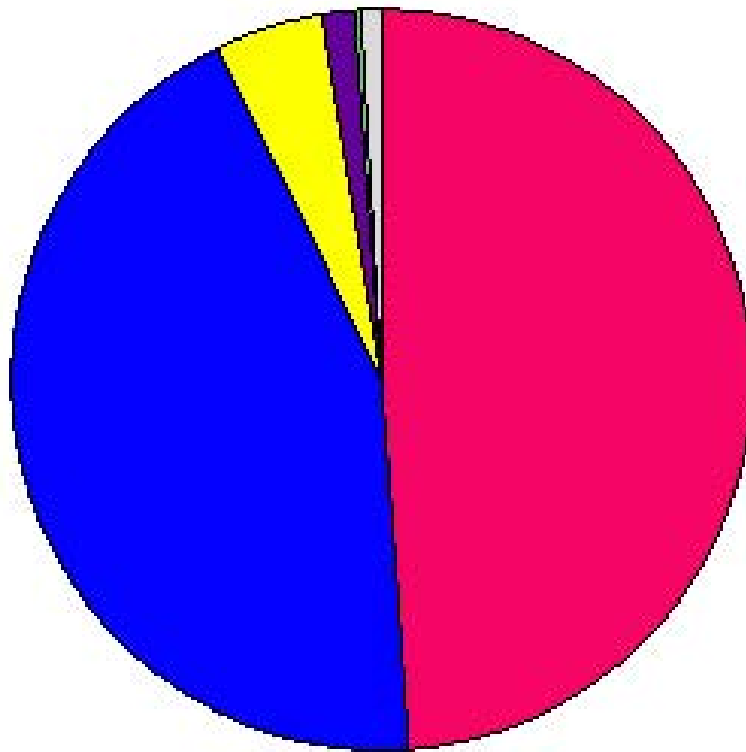## (Classroom Level)

Gains in all quartiles
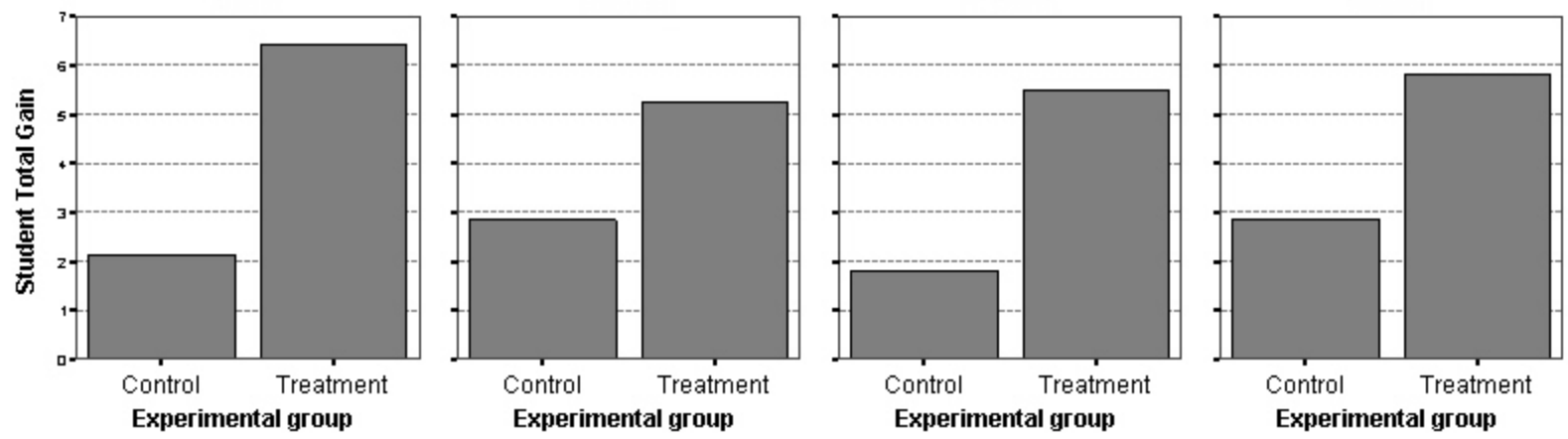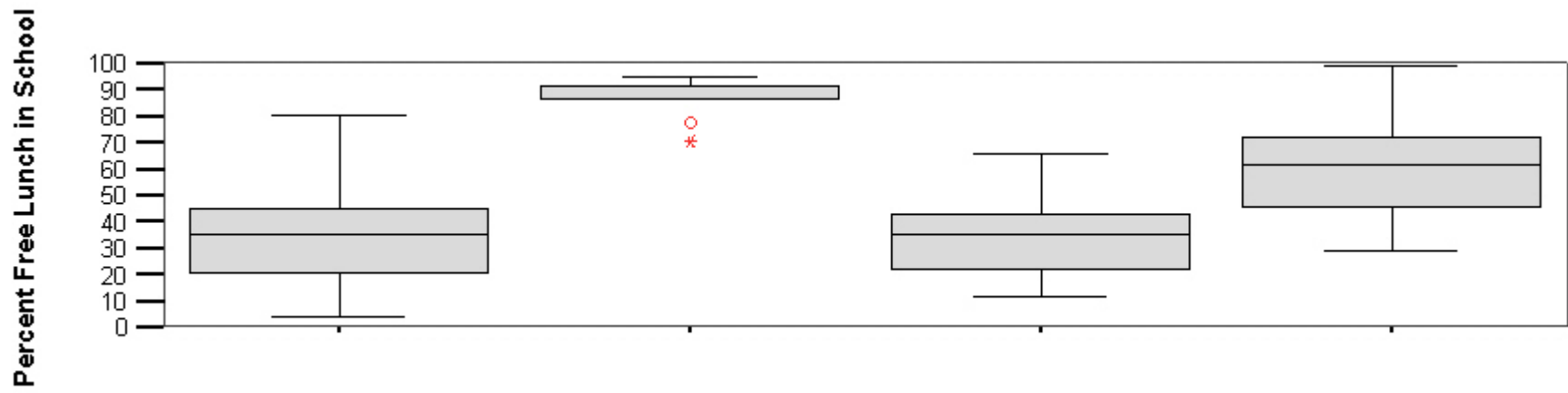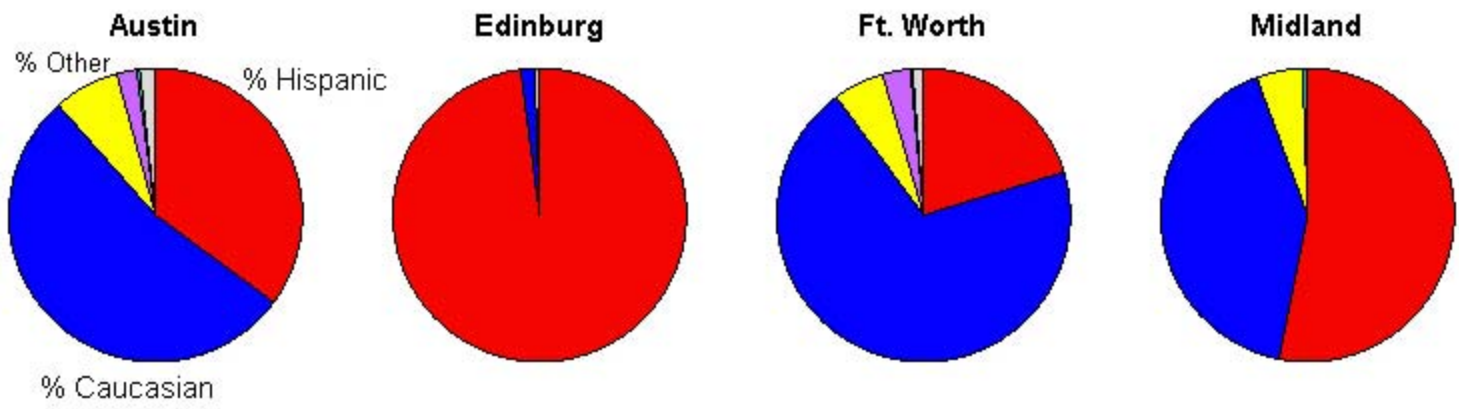**(Classroom Level)**

Representing the Future

Children…

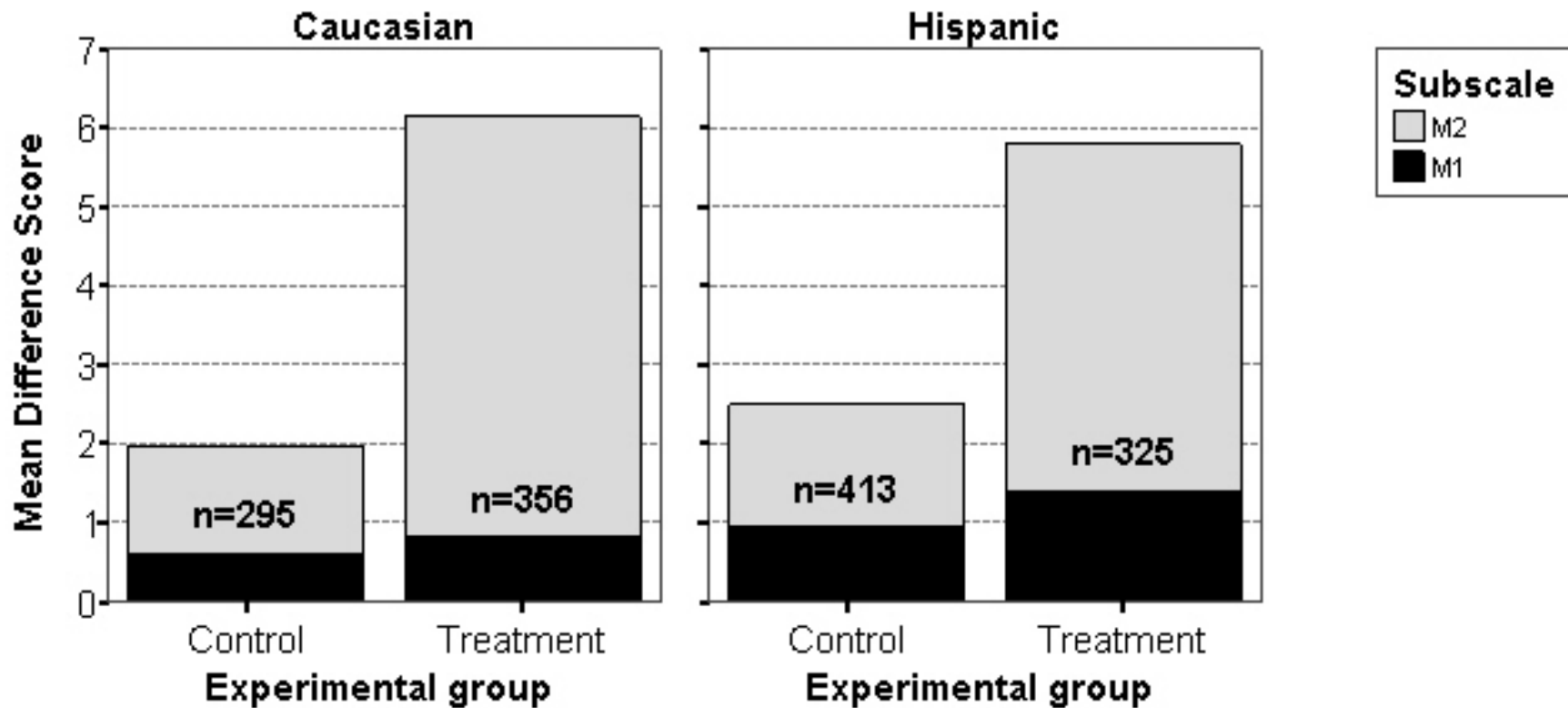

Ethnicity
- % Hispanic
- % Caucasian
- % African American
- % Asian
- % Native American
- % Unknown/Other ethnicity

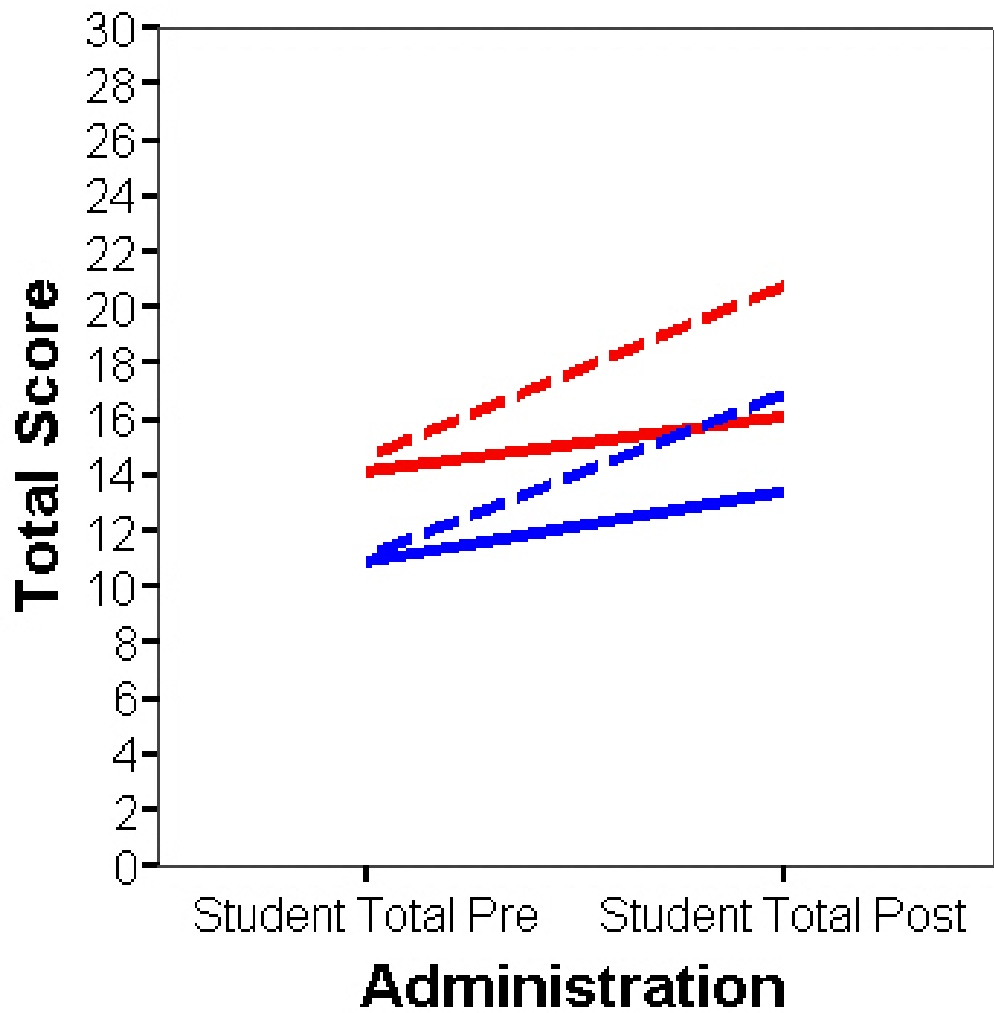**Austin**   **Edinburg**   **Ft. Worth**   **Midland**

% Other   % Hispanic

% Caucasian

Percent Free Lunch in School

Student Total Gain

Control   Treatment   Control   Treatment   Control   Treatment   Control   Treatment

Experimental group   **Experimental group**   **Experimental group**   **Experimental group**

Gain Scores by Ethnicity

Ethnicity and Achievement
(student level)

Scale Up Research - Robustness

- Regions, Schools

- Prior Achievement

- Varied teacher background, attitudes, practices

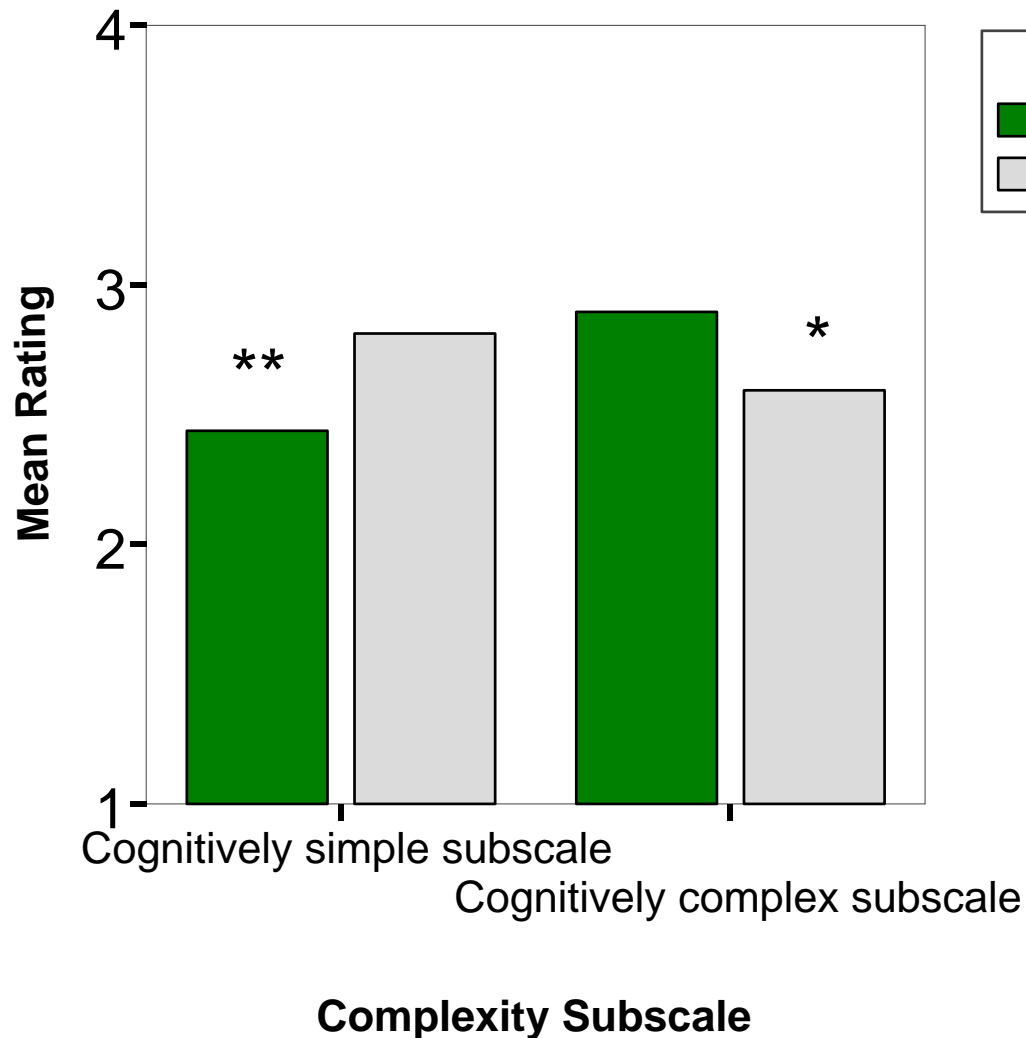- Gender

Gains By Teacher Vary: Why?
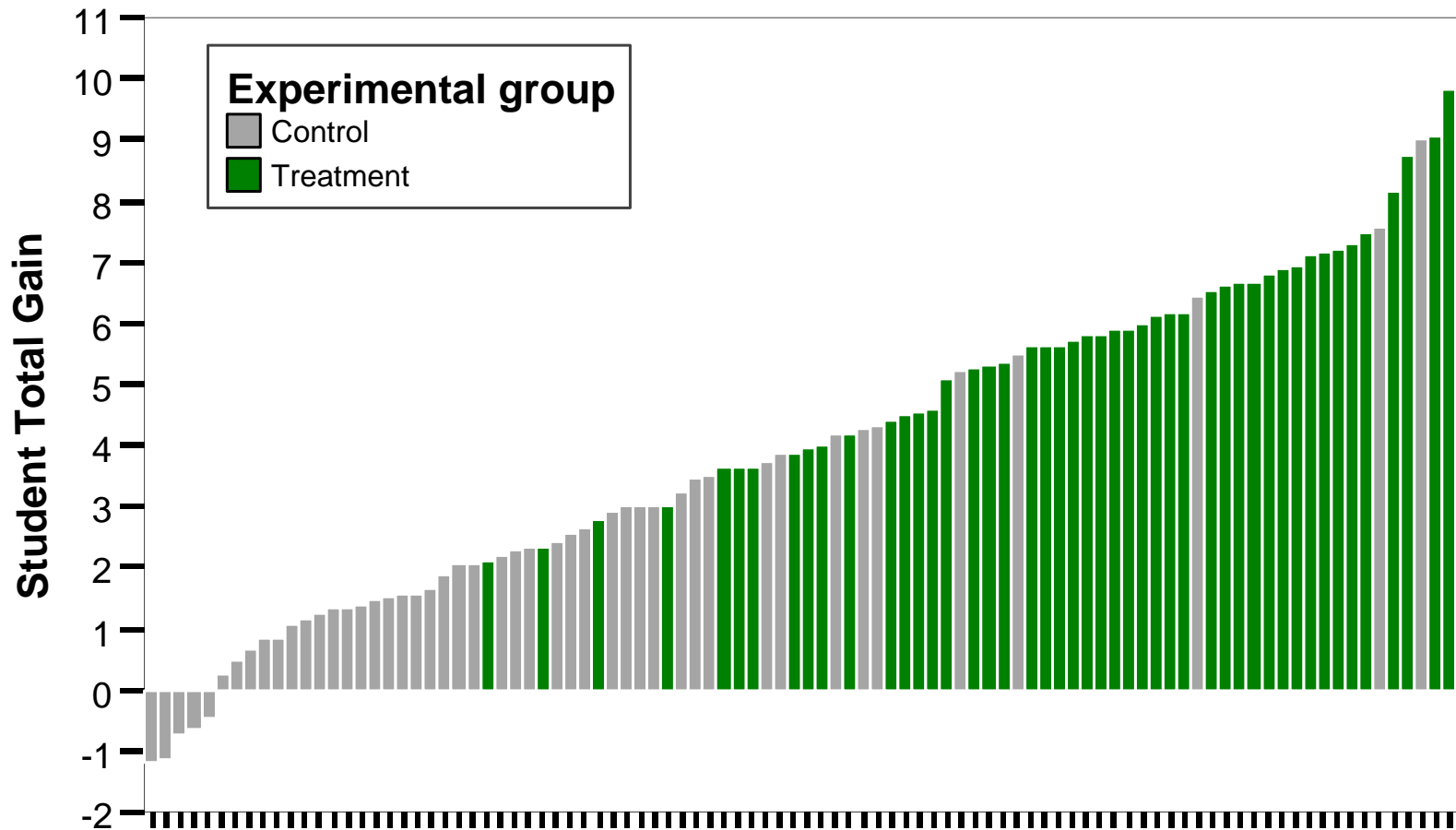
Daily Log

7. To what extent did you and your class focus on the following performance goals for students?

	Not at all 1	2	3	A major focus 4
Memorize facts, definitions, formulas (e.g., students recall traditional skills and knowledge and/or learn computational procedures)	☐	☐	☐	☐
Perform procedures/solve routine problems (e.g., students demonstrate practical competence with skills by using them effectively to accomplish a task)	☐	☐	☐	☐
Communicate understanding of concepts (e.g., students write or discuss their mathematical understandings)	☐	☐	☐	☐
Solve non-routine problems/make connections (e.g., students solve multi-step or open-ended problems with more than one right answer or solution and/or look for relationships between different topics in mathematics)	☐	☐	☐	☐
Conjecture, generalize, or prove (e.g., students make, justify, or investigate mathematical conjectures and/or find a mathematical rule to generate a pattern)	☐	☐	☐	☐

SimCalc teachers more likely to report doing complex math; students learned more

Mean Rating (y-axis: 1 to 4)

** (Cognitively simple subscale, Treatment)
* (Cognitively complex subscale, Control)

Experimental group
- Treatment (green)
- Control (gray)

Cognitively simple subscale
Cognitively complex subscale

Complexity Subscale

1. Teachers who reported greater attention to complex mathematics had students who learned more
   (r=.40, p<.001)

2. Teachers who used SimCalc emphasized complex math
   (p<.01)

Teacher Math Knowledge
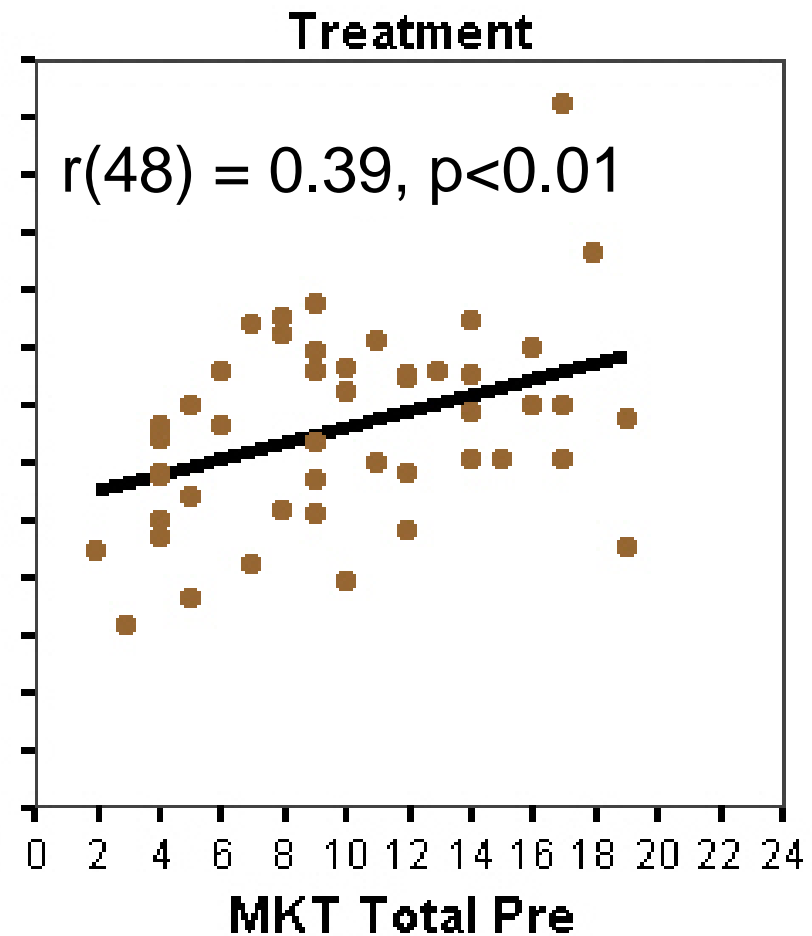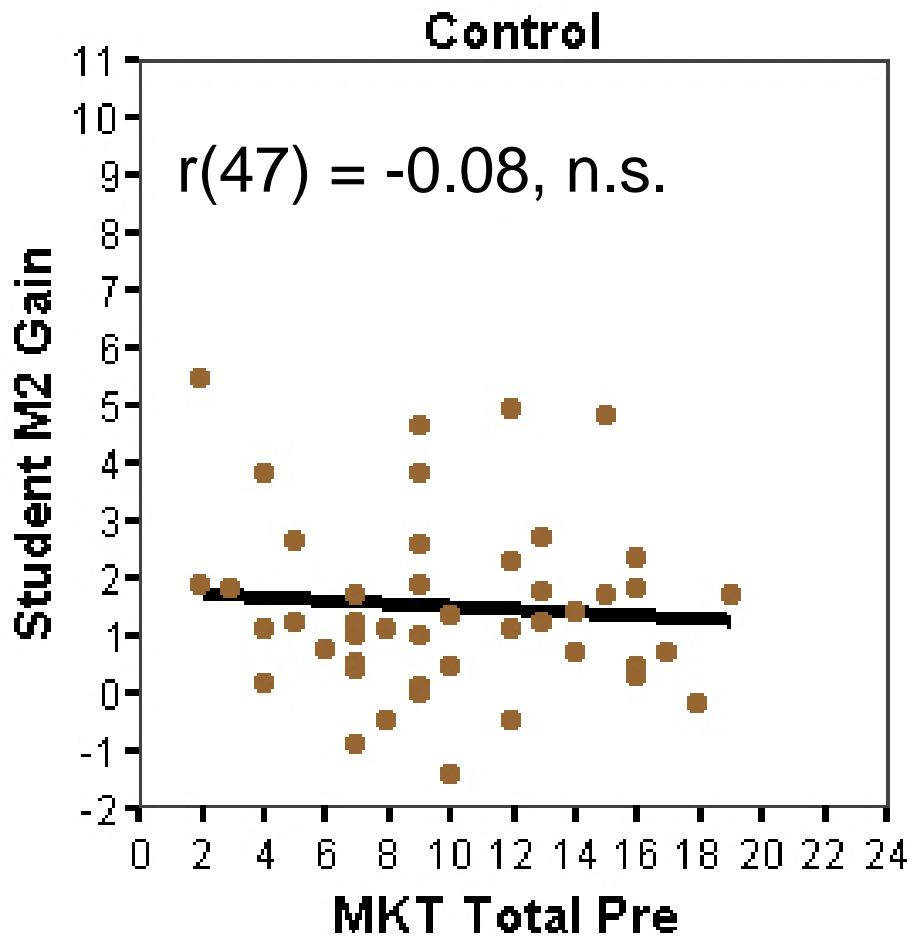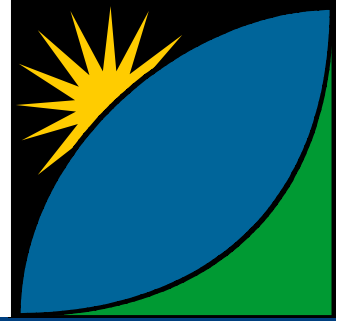
Take Away Messages

- The Future of Representation: **Dynamic Math for Diverse Learners**

- Free Materials
    - math.sri.com
    - Google for "SimCalc"

- Gold Standard Research shows robustness of the expected learning gains from integrating PD, technology & curriculum