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Stephen J. Pape, University of Florida

What are the effects of adding TI-Navigator to a graphing calculator classroom?



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Research Team Members

Douglas T. Owens, PI Karen E. Irving, Co-PI Frank Demana, Co-PI Soonchun Lee	<i>The Ohio State University</i>
Stephen J. Pape, Co-PI Jonathan Bostic	<i>University of Florida</i>
A. Louis Abrahamson , Co-PI	<i>The Better Education Foundation</i>
Joan Herman, David Silver Hye Sook Shin, Aye Htut	<i>UCLA, CRESST</i>
Vehbi A. Sanalan	<i>Erzincan University, Turkey</i>
Clare Bell	<i>University of Missouri, Kansas City</i>
Sukru Kaya	<i>The Scientific and Technological Research Council of Turkey</i>
Sharilyn Owens	<i>Appalachian State University</i>
Melissa Shirley	<i>University of Louisville</i>

Project Overview

- Professional development & research project
- Algebra 1 & physical science
- TI-Navigator—Classroom connectivity technology (CCT)
- Summer institute
- *Teachers Teaching with Technology Conference*, annual follow-up

Prior Research – Audience Response Systems

- Early research – ARS without instructional change has little impact
- More recent research has provided evidence for several affordances:
 - Increased attendance and participation
 - Collaborative learning
 - Student engagement
 - Increased comprehension
 - Student satisfaction
 - Increased teacher knowledge of student understanding
- Technology-facilitated interactive engagement in ARS lecture classes is correlated with student conceptual gains

(Judson & Sawada, 2002)

Changing conception of mathematics competence

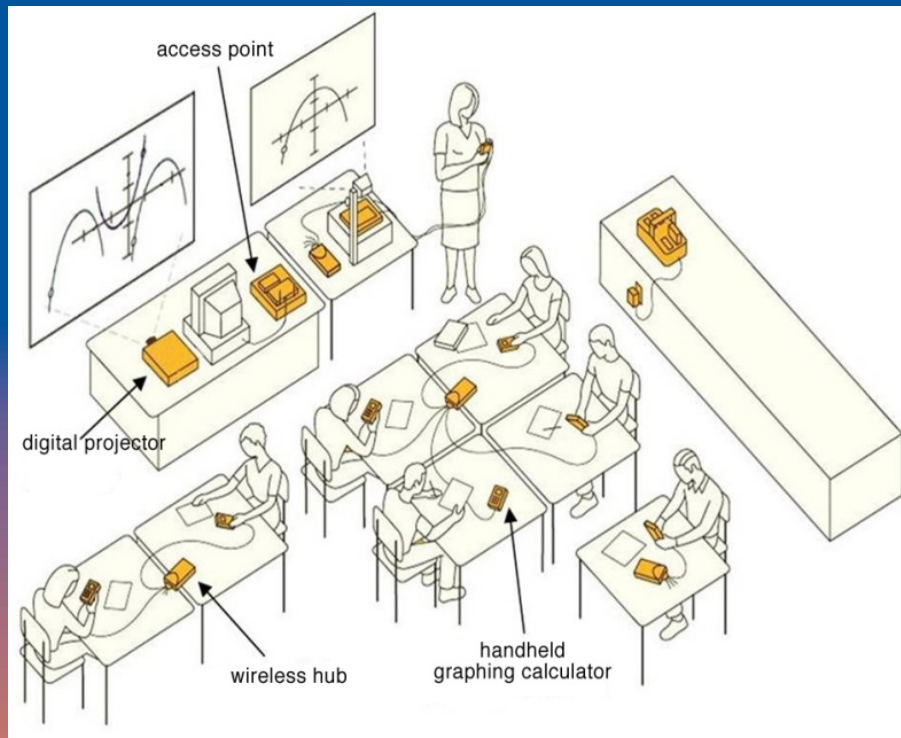
(Kilpatrick, Swafford, & Findel, 2001)

- Adaptive Reasoning
- Strategic Competence
- Conceptual Understanding
- Productive Dispositions
- Procedural Fluency

Changing roles for teachers *include*

- Thinking beyond skills-based conceptions
- Setting norms for discourse
- Using problem solving and inquiry to support knowledge construction
- Using formative as well as summative assessment
- Developing self-regulated learning

Connected Classroom Technology



- Features of the TI-Navigator™ connected classroom
 - Collaborative & motivating learning environment
 - Technology-assisted formative assessment
- Increased teacher knowledge of students
- Increased feedback to students & teacher
- Interactive learning
- Engage students in discourse to examine correct and incorrect responses
 - Access multiple representations
 - Higher demands for participation

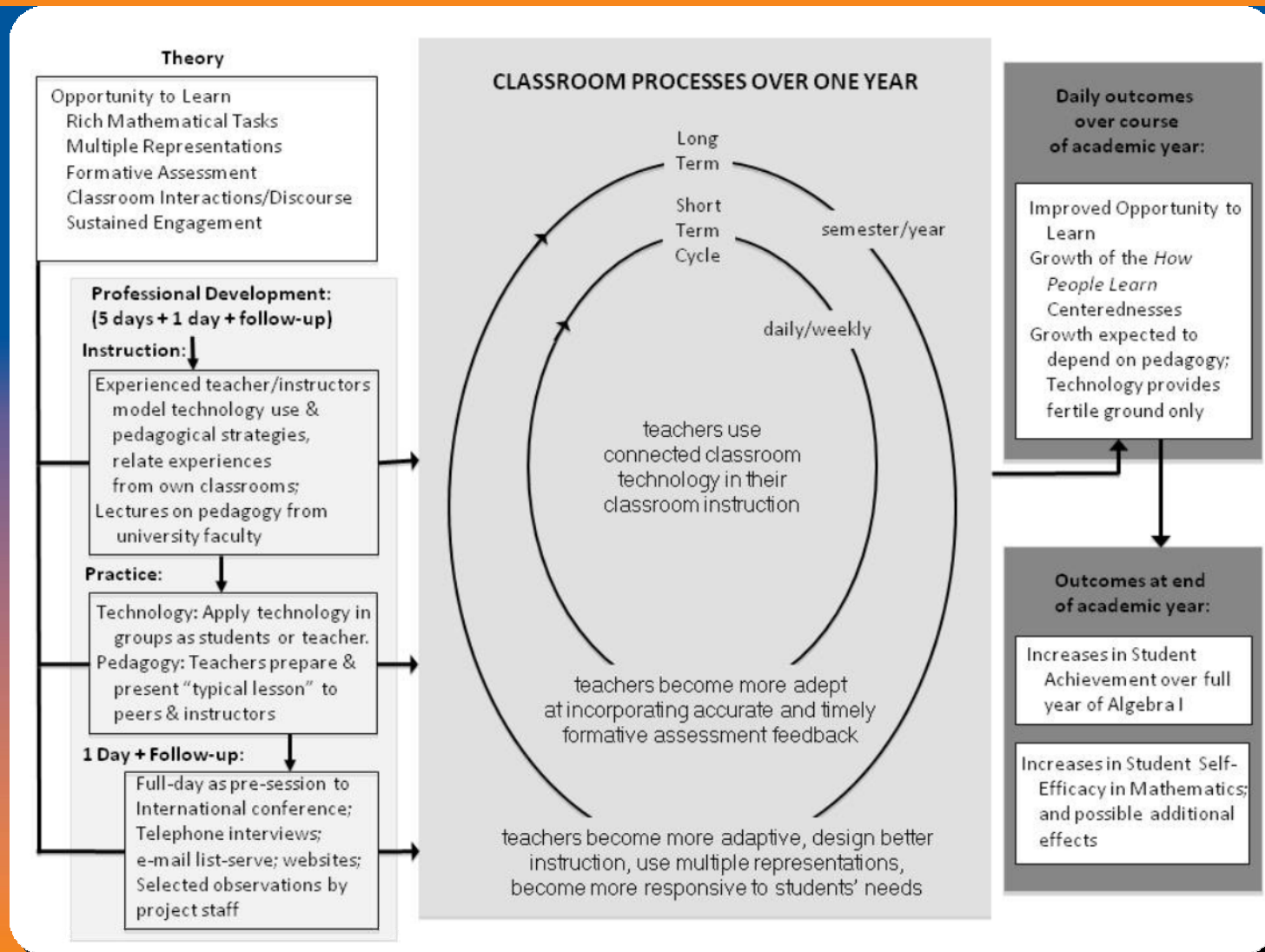
Affordances of Classroom Interactions

- Classroom interactions support ...
 - Students' understanding of mathematics
 - Students' understanding of what it means to act competently as mathematics students
 - Teachers' use of formative assessment
- CCT provides a mechanism for classroom communication that increases students' ability to engage with mathematics content

Research Questions

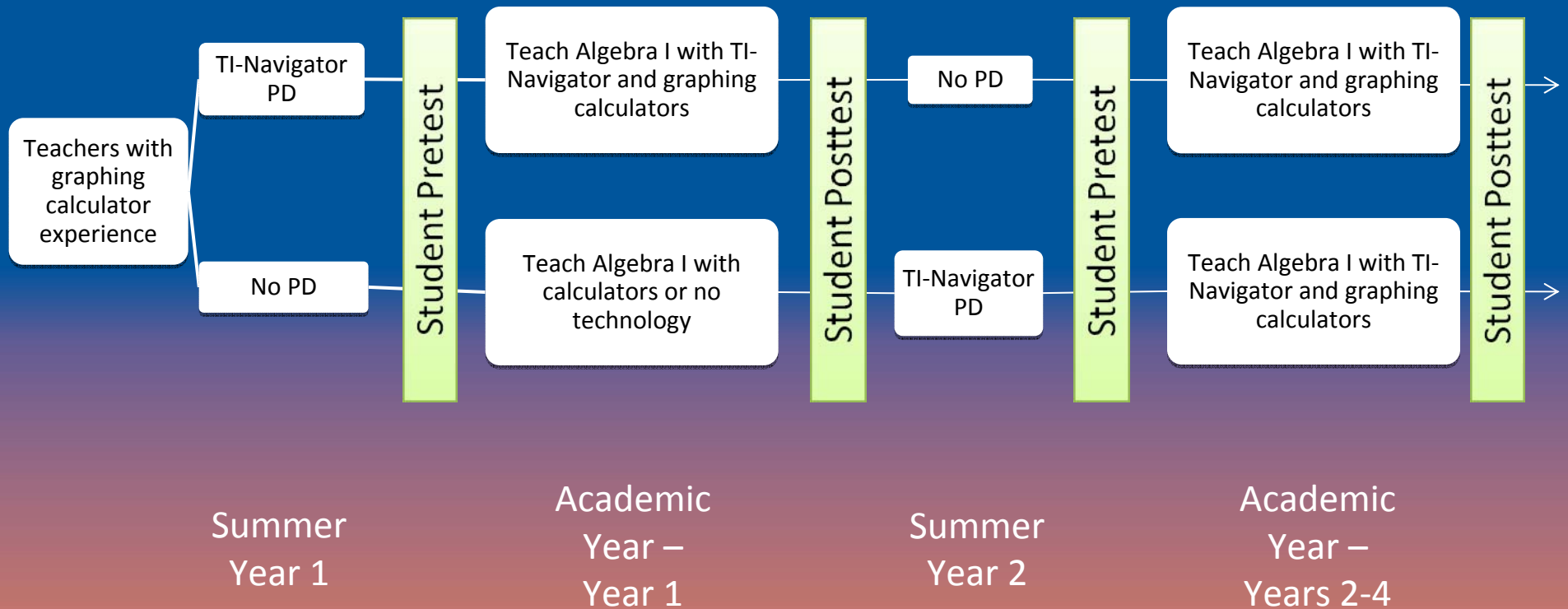
- What is the impact of teacher implementation of CCT on ...
 - Students' algebra achievement?
 - Classroom communication?

Logic Model



Research Design

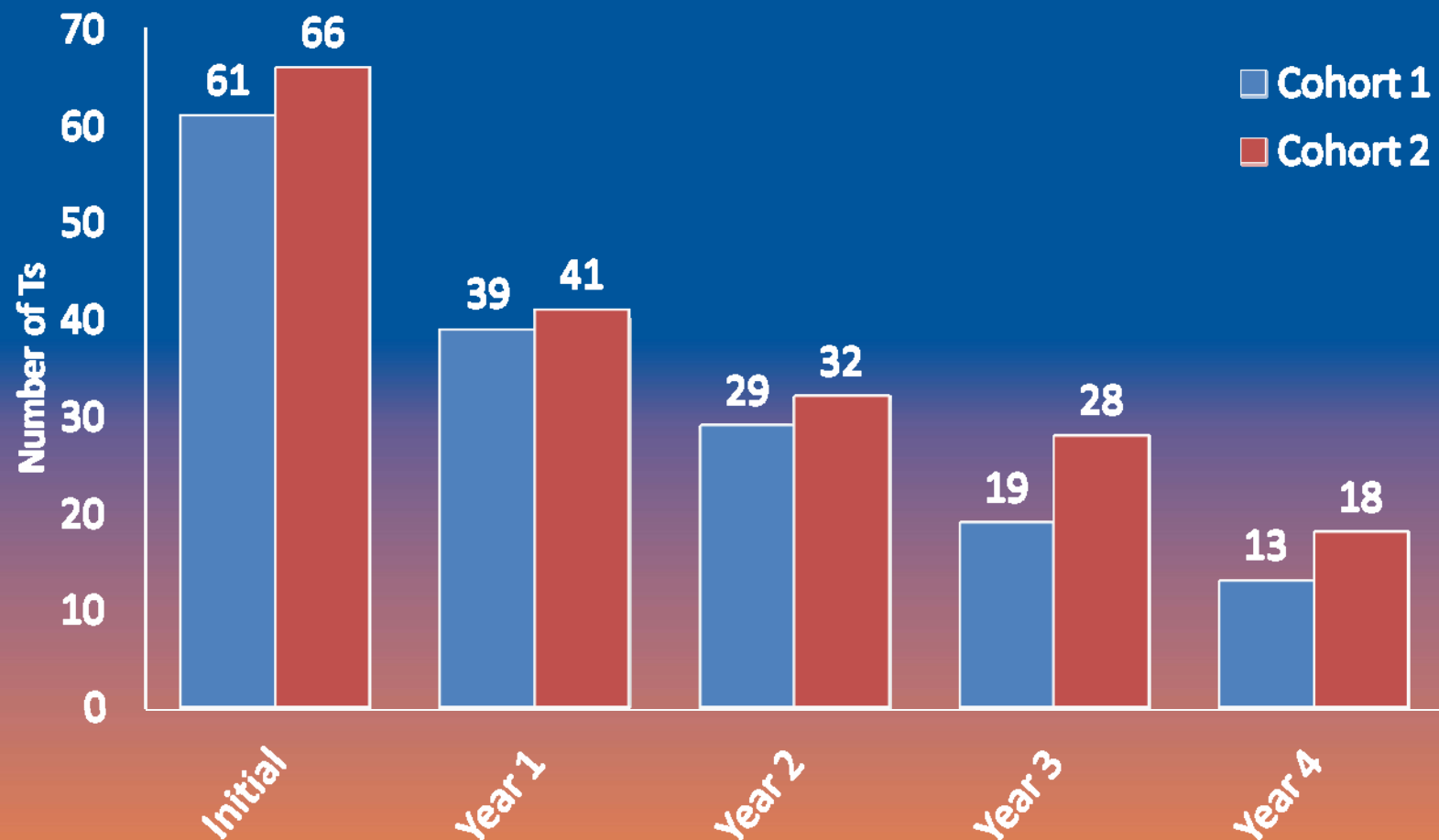
- Randomized assignment to treatment and control/delayed treatment groups
- Control group provided treatment in year 2



Participants (Year 1)

- 68 teachers (Rx = 34, C = 34)
- 1,128 students
 - Rx = 617; 50% female
 - C = 511; 57% female
- Classroom observations in 18 treatment and 16 control classrooms

Teacher Persistence



Teacher Data Sources

- Demographic Information Form
- Teacher Telephone Interviews
 - Frequency of technology use; teacher perceptions of improved understanding of student knowledge; and teacher perceptions of instructional changes resulting from CCT use
- Videotaped Two-day Classroom Observations
 - $M = 106.15$ min, $SD = 35.36$ min
 - Max = 162.00 min; Min = 38.30 min
- Post-observation interviews

Student Measures

- Algebra I pretest – 30 item; 23 multiple choice, 3 short-answer, and 4 extended response
- Algebra I posttest – 30 items; 24 multiple choice, 1 short-answer, and 5 extended response
- Student focus groups

Quantitative Data Analyses

- Hierarchical Linear Modeling—takes into consideration that students are “nested” within classrooms
- Comparisons
 - Year 1 – CCT vs. graphing calculator only
 - Years 2-3 – CCT vs. year 1 graphing calculator only

Summary of Quantitative Findings

(Pape, Irving, et al., 2010; Irving et al., 2010)

- Students in classrooms incorporating CCT outperformed their peers in control classrooms during Year 1 implementation ($\delta = 0.30$)
 - approx 20-36% improvement over expected annual growth
 - The treatments produced similar effects to **10-15 years of teaching experience**
- On average CCT classrooms outperformed Year 1 controls across four years of the project

Summary of Quantitative Findings

(Lee et al., 2010; Pape, Irving, et al., 2010; Pape, Bell, Owens, S. K., et al., 2010)

- Teachers reported greater knowledge of their students' understanding, which was related to student achievement ($p = .013$)
- Students reported greater engagement in connected classrooms
- Frequency of technology use alone, however, was negatively associated with achievement

Qualitative Data Analyses

Classroom Observation Constructs

- Classroom observations were transcribed and coded for interactional patterns
- Questioning patterns:
 - Directionality
 - Type (Recitation, Authentic)
 - Cognitive load (LO vs. HO)
 - IRE pattern
 - Uptake
 - Press for involvement, elaboration, or explanation
- Mathematics comments:
 - S-S Interaction (duration)
- Responses to students

Typical Mathematics discourse

(Pape, Bell, et al., 2010)

- Dominated by teacher-led discourse and thinking—students frequently compute basic operations rather than think mathematically
 - Predominantly T-S questions that require short known-answer responses (4 words long)
 - Initiate-Respond-Evaluate
 - Teacher math statements—4.5 times longer than students'

Impact of CCT on discourse

(Pape, Bell, et al., 2010)

- TI-Navigator seems to disrupt the questioning episodes
 - Control teachers asked more questions overall, typically occurring in IRE sequences
 - Recitation questions that elicited lower-order responses
 - Trend: Control teachers' math statements shorter than treatment
- No differences for uptake, press for involvement, or press for explanations and elaborations

Relations Between Discourse and Achievement (Pape, Bell, et al., 2010)

- Higher order questions (total number and ratio of HO to LO) had the greatest impact on student achievement
- Trend toward positive relationship between number of words per S-T mathematical statement and achievement
- IRE patterns of interaction and teacher non-instructional talk were negatively related to achievement

Effective Implementation of CCT

(Pape, et al., in press)

- Effective use of CCT makes possible the transference of mathematical thinking from the teacher to the student
 - Principle 1: Mathematical tasks that support pattern examination leading to generalizations and conceptual development
 - Principle 2: Classroom interactions that focus mathematical thinking within students and the collective class
 - Principle 3: Formative assessment leading to teachers' and students' increased knowledge of students' present understandings
 - Principle 4: Sustained engagement in mathematical thinking

Conclusions: Strong Findings from Randomized Control Trials Are Rare in Education

- Integrating PD and TI-Navigator produced effects comparable to a 20% – 36% improvement over expected annual growth
- Improved “teacher knowledge of students” shows the unique benefit of TI-Navigator
- Typical classroom profiles, however, indicate that mathematics instruction is predominated by teacher-centered behaviors
- TI-Navigator use may have disrupted some of the typical classroom behaviors

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(spape@ufl.edu)

This presentation will be available
on the CCMS website
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(also available on CCMS website or from space@ufl.edu)

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