The Connected Classroom for Promoting Mathematics and Science Achievement: Implementation and Research Trial

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Classroom Connectivity in Promoting Algebra 1 & Physical Science Achievement and Self-Regulated Learning: Year 1 Results

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TI Navigator slides adapted from a presentation by **Eileen Shihadeh, Texas Instruments**

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Background of *CCMS* Study

- Economic performance depends on mathematics and science education, but students exhibit little motivation to learn these subjects (Cote & Levine, 2000)
- International comparisons: U.S. HS students compare poorly, but U.S. elementary students perform comparably or better (NCES, 2003)

Changing Views of Mathematics and Science Education

- Conceptual understanding
- Learning through problem solving and inquiry
- Self-regulated learning
- Oral and written communication
- Connections
- Representation
- Reasoning and Proof

Changing roles for teachers *include*

- To think beyond skills-based conceptions
- To set norms for discourse
- To challenge and support mathematical and scientific reasoning
- To support knowledge construction through problem solving and inquiry
- To develop mathematical and scientific competence more broadly defined
- To incorporate formative assessment (as well as summative assessment)

Changing conceptions of mathematics competence (Kilpatrick, Swafford, & Findel, 2001)

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

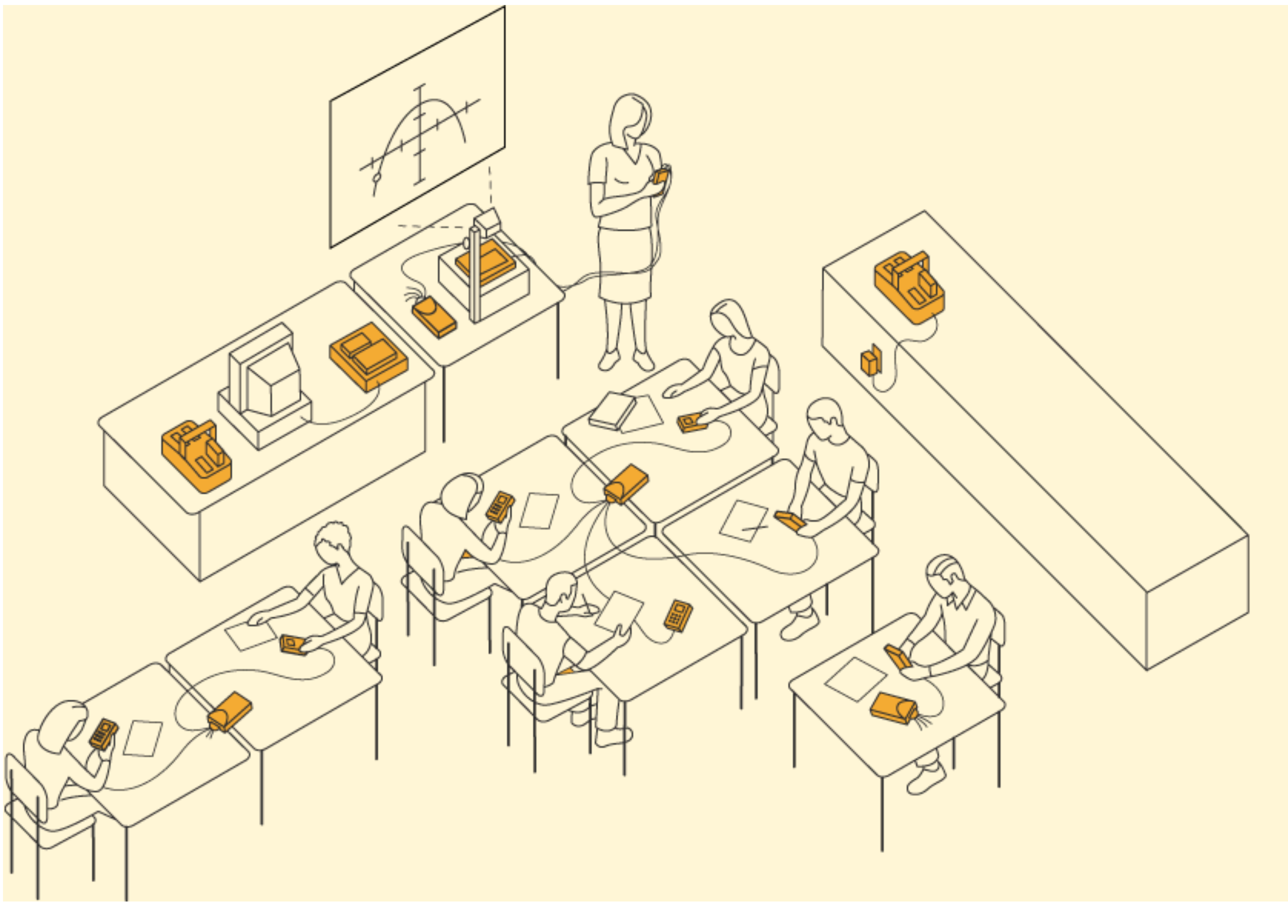
Changing conceptions of science competence (NSES, 1996)

- Conceptual understanding
- Evidence-based reasoning
- Inquiry in scientific process skills
- Understanding the nature of science
- Broad science knowledge base

CCMS Project Overview

- Interdisciplinary professional development and research project
- Algebra I and Physical Science
- Classroom connectivity technology
- Summer Institute – training
- T^3 conference follow-up

The TI-Navigator™ Connected Classroom



The TI-Navigator System allows the teacher to:

- Create a collaborative learning environment
- Engage in formative assessment by way of immediate feedback
- Enhance classroom management of TI graphing technology
- Quick Poll provides teacher understanding by receiving impromptu feedback

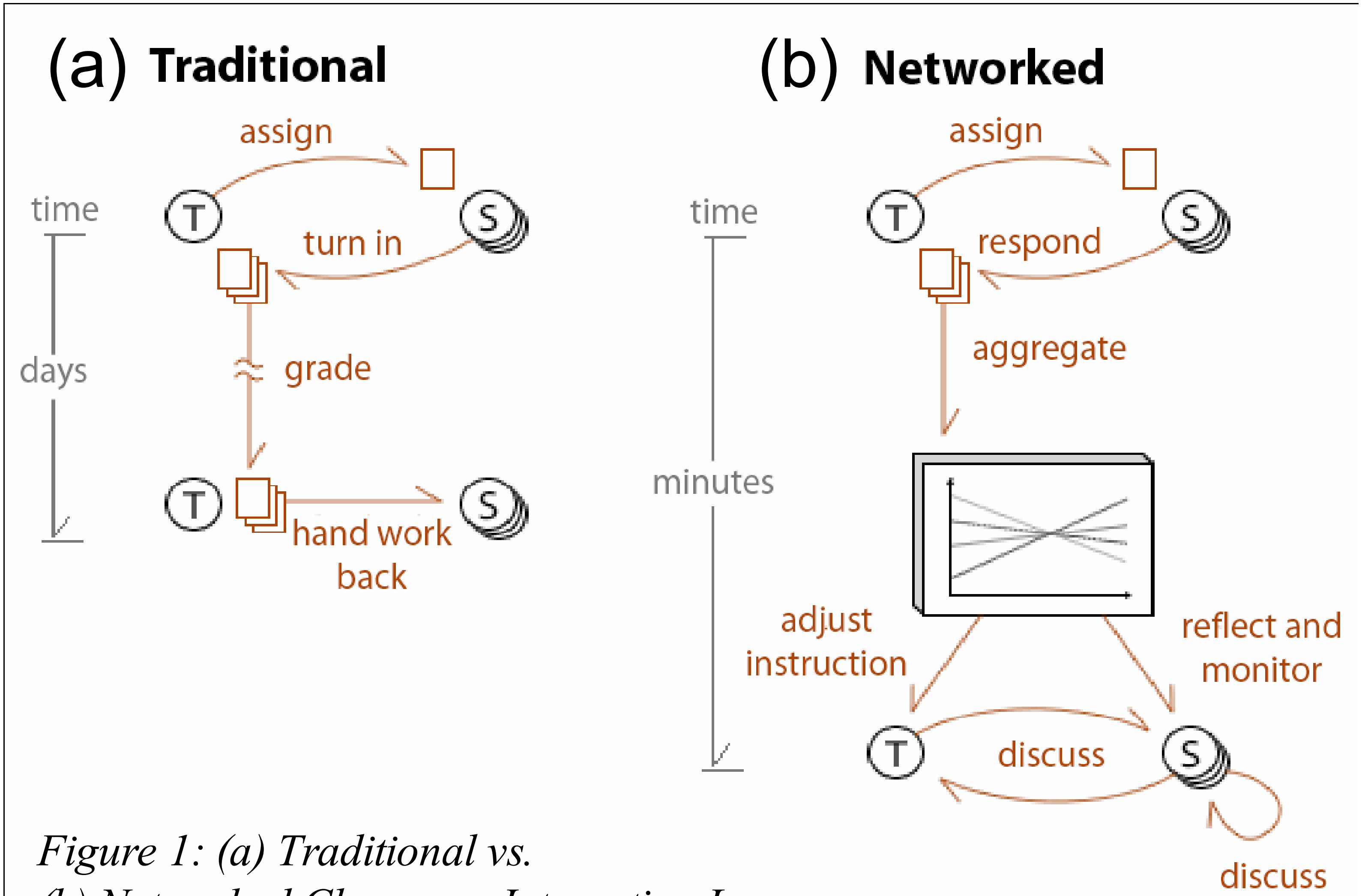


Figure 1: (a) Traditional vs.
(b) Networked Classroom Interaction Loops
(from Roschelle et al. 2004)

Prior Research on Connected Classrooms (Roschelle, Penuel, & Abrahamson, 2004)

- Students:
  - Increased student engagement; student understanding; interactivity
  - Improved classroom discourse
  - Knowledge of classmates' learning
- Teachers:
  - Improved pre- and post- assessment of student learning
  - Increased awareness of student difficulties
  - Improved questioning

Aspects of Learning Environments which Appear to be Catalyzed by Wireless Networked Graphing Calculators

1. Learner Centered
(transfer)

Questions, tasks, and activities to:
- show existing conceptions that students bring to setting
- extend and make connections with previous knowledge

2. Learner Centered
(Active Engagement)

Appropriate amount of pressure on students to:
- think through the issues
- establish positions
- commit to positions

3. Assessment Centered

Formative assessment naturally gives:
- feedback to students provides opportunities to reverse and improve quality of thinking and learning
- feedback to teacher gives cognizance of class positions and window in student conceptions

4. Knowledge Centered

Focus on:
- conceptual understanding
- reveal, diagnose, and remedy misconceptions

5. Sense of Community

Class discussion
Peer interaction
Reasons for actions taken
Knowledge of class positions
Same side as teacher

Lack of embarrassment
Pride in class achievement
Know others have same difficulties
Cheering and enthusiasm
Non-confrontational competition

Owens, Demana, Abrahamson, Meagher, & Herman (2004)

The Potential of the Connected Classroom *Includes*

- Multiple interconnected representations
- Conceptual development supported through activity-based learning experiences
- Immediate, anonymous formative assessment
- Public displays of class knowledge
- Teacher identified critical junctures

The Potential of the Connected Classroom *Includes*

- Classroom discourse
  - Explanations and justifications
  - Focus on process
  - Strategic behavior as object of discourse
- Changing classroom atmosphere making possible:
  - Increased motivation/engagement
  - Positive dispositions toward mathematics and science

Theoretical Framework

- National imperatives for improving student achievement
- Teaching for understanding in a mathematics or science classroom
- Technology-assisted formative assessment
- Improved student-student & student-teacher discourse
- High contrast displays of thinking
- Classroom environments that foster the development of student self-regulated learning
- Understanding student thinking and alternate conceptions

Purpose & Research Questions

- Purpose: To report preliminary results of the *CCMS* project Year 1 data

- Research Questions: How does teachers' use of connected classroom technology affect:
  - Student achievement in algebra 1?
  - Self-regulated learning strategic behavior?
  - Student views of mathematics?

Research Design

- Year 1 (2005-2006) – Algebra I
- Randomized assignment to treatment and control/delayed treatment groups
- Cross-over design – control group provided treatment in second year of participation
- Mixed methodology

Participants

- Initial data – 115 Algebra I teachers and 1,761 students from 28 states
- 87 (76%) teachers remained at the end of year 1
- 1,128 students from 68 classrooms (78% of 87) with complete data
- Treatment: n = 615; 50.2% female
- Control: n = 531; 56.8% female

Teacher Demographic Information

	Treatment		Control	
Number of teachers	34		34	
% Female	70.6		70.6	
% White	88.2		82.3	
% Math majors	67.6		79.4	
	X	SD	X	SD
Yrs Tchg Exper	13.18	7.19	14.79	10.66
Yrs Alg Tchg	7.42	5.62	9.97	8.82
% Free Lunch (at school level)	16.79	16.10	27.04	19.82
% Minority (at school level)	15.03	21.51	26.21	26.43

Data Analyses

- Cronbach's alpha reliability estimates
- IRT analysis conducted to ensure technical quality of Algebra pre- & post-test
- Hierarchical Linear Modeling (HLM) to examine effect of treatment
  - Accounting for nested data
  - Pretest data included as covariate
  - Two-level models consisting of within-class (level 1) and between-class (level 2)

Measures – Algebra I

- Algebra pretest – 32 item; 23 multiple choice, 5 short-answer, and 4 extended response
- Algebra post-test – 32 items; 24 multiple choice, 3 short-answer, and 5 extended response
- 11 items overlap between the pre- and post-tests

	Treatment		Control		α
	X	SD	S	SD	
Algebra Pre (32 items & 36 maximum)	18.76	5.00	18.18	5.94	.81
Algebra Post (32 items & 37 maximum)	21.36	7.23	18.92	7.17	.85

Student Beliefs about Mathematics

	Treatment (n = 442)		Control (N = 515)		α
(Scale = 1 to 6 for all subscales)	X_{post}	SD	X_{post}	SD	
Beliefs about Math (14 items)	4.21	.57	4.16	.61	.82
Confidence (5 items)	3.90	.91	3.84	.96	.69
Math Anxiety (5 items)	3.69	.76	3.70	.74	.79
Usefulness (6 items)	4.48	.92	4.42	1.04	.82
Self-Eff/Perform Expect (4 items)	4.50	1.04	4.32	1.13	.88

Motivated Strategies for Learning Questionnaire

- 6 Motivation subconstructs
  - Intrinsic/Extrinsic Goal Orientation; Task Value; Control of Learning Beliefs; Self-Efficacy; Test Anxiety
  - Alpha range = 0.67 to 0.92
- 5 Learning Strategies subconstructs
  - Rehearsal; Elaboration; Organization; Critical Thinking; Metacognitive Self-Regulation
  - Alpha range = 0.73 to 0.80
- 4 Resource Management Strategies Subconstructs
  - Time and Study Environment; Effort Regulation; Peer Learning; Help Seeking
  - Alpha range = 0.50 to 0.65

Teacher-Level Quantitative Measures

- Technology implementation
  - Open-ended teacher interviews
  - Composite created using average of 8 subscales
- Level of content implementation
  - proportion of content covered on selected state standards (associated with development of Algebra post-test)

Teacher Practices and Beliefs Survey (104 items)

- School Support for instructional innovation (α = .79, k=6)
- Familiarity with/Implementation of NCTM Standards (α = .68, k=3)
- Use of Instructional Technology (α = .86, k=4)
- Reform forms of classroom discourse (α = .73, k=4)
- Strategy discussion (α = .85, k=6)
- Focus on requiring explanations and justifications (α = .79, k=5)
- Data analysis (α = .90, k=6)
- Teacher efficacy for instructional practices (α = .80, k=6)
- Teacher beliefs about mathematics (α = .64, k=4)

Results – Pretest differences

- Control teachers reported significantly higher school support than treatment teachers (M_C = 3.25, SD_C = 0.39, M_{RX} = 2.97, SD_{RX} = 0.58; t = -2.51, p = 0.01)
- Treatment teachers reported significantly higher use of technology than control teachers (M_C = 2.86, SD_C = 0.98, M_{RX} = 3.28, SD_{RX} = 1.06; t = 2.05, p = 0.04)

Results

- **Significant treatment effect** (ES = .39) after controlling for student pretest scores, teacher's years of experience, and teacher's gender
  - Students taught by treatment group teachers performed about two points higher than control students
- Level of **technology implementation** was positively associated with student performance (ES = .12)
  - As the level of technology implementation increased the student performance also increased
- **Years of teaching was positively** associated with student performance (ES = .03)

Results (con't)

- Students of **female teachers performed higher** than male teachers (ES = .41)
- Level of content coverage (implementation) was not associated with student performance
- Contrary to hypothesis, teacher efficacy was negatively associated with student performance (ES = .49)
- None of the other teacher survey constructs were associated with student outcome

Results (con't)

- Self-efficacy/math performance positively associated with treatment (ES_{RX} = .14; ES_{Impl} = .04)
- No differences for beliefs about mathematics, confidence, anxiety, or usefulness related to treatment
- No differences for motivation, learning strategies, or resource management strategies related to treatment

Future Research

- Classroom connectivity technology impacted student achievement in Algebra I
- However, need for further exploration to examine
  - SRL strategies and student dispositions as mediating variables
  - Composite technology implementation variable using factor analysis
  - Teacher survey data and implementation ratings using SEM
  - Implementation more broadly including pedagogical factors
  - SRL strategies and student dispositions within context of implementation more broadly defined