Impact of Classroom Connectivity on Student Performance and Attitude in High School Algebra Classrooms

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Overview

• Background to SimCalc Research Projects
• Short demonstration
• Results of Quasi-Experimental study to provide a theoretical and quantitative lens
• Examining differences in learning and attitude
• Video analysis
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Following this conduct Fans Activity
Iterative Design

- Classroom Connectivity Project 2 (2004-2008): Participation and Engagement
- Two primary streams of work: (1) to consolidate and subject to systematic convergent research the preliminary insights of prior work on forms and levels of participation within reasonably stable technologies and consistent contexts, and (2) to continue the generative discovery and invention that have proven to be fruitful in the prior project, taking advantage of, and account of, how evolving underlying technologies impact key aspects of teaching and learning.
Two intersecting streams of inquiry

• Stream 1: unpacks and addresses the hypothesis that participation and engagement matter to learning.

• Intended outcomes: categories and operationalized measures of classroom participation and individual student engagement, evidence of possible correlations with learning of important subject matter as measured by combinations of widely used test items and additional probes as well as possible correlations with selected teacher characteristics.

• Stream 2 consists of three substreams, systematically, but opportunistically, exploiting the affordances of evolving technologies to explore (a) new participation structures, (b) representational supports for teacher use of CC, and (c) the growth in teacher capacity to use CC productively, as individuals and as members of peer communities.
Overview of Research Program

- Opportunistic design work in stream 2 fed into more structured empirical work in stream 1.
- Stream 2 work occurred in low-risk classroom settings (e.g. Undergraduate classrooms; pre-service)
- Stream 1 work in both high-school and undergraduate settings leading to a quasi-experimental study in the third year
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Example of Stream 1 Work

- Development
- Mathematically-meaningful participatory activity
- Students create mathematical objects that they assign ownership to and hence situate their work vis-à-vis others.
- Identification of work relative to others vs identity of self
- Activity: \( y = kx \) \{software demo\}
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Quasi-Experimental Study

• 3-6 week replacement unit on core Algebra concepts: linearity, slope as rate, function, y=mx+b
• 9th grade Algebra 1 classrooms in two middle-achieving districts in SE MA
• Initial sample: Comparison (217 students), SimCalc (156 students)
• Final sample: Comparison (184 students), SimCalc (133 students)
• SimCalc: 7 classrooms (5 teachers) in 2 districts
• Comparison: 8 classrooms (8 teachers) in same districts
Methods

- Mathematics Algebra 1 Content Test
- Student Attitude Survey
- Student and Teacher Interviews
- Classroom Observation: Video + Structured observation (e.g. RTOP)
- Lesson Study
Content

• A total of 60 test items were compiled from various state high stakes assessment tests, such as the Massachusetts Comprehensive Assessment System (MCAS), Texas Assessment of Knowledge and Skills (TAKS), Regents Exam in New York, and the California High School Exit Examination (CAHSEE), as well as National Assessment of Educational Progress (NAEP) items, and Advanced Placement Calculus items

• Reduced to 22 items via principled-assessment design

• 20 multiple-choice; 1 short answer; 1 open-response

• 12% of tests checked across 3 raters (inter-rater reliability of 92%)

• Four sub-scales: Graphical interpretation (41% of the test), Rate and proportion (22.7%), Number sense and patterns (4.5%), and Making connections across representations (31.8%).
• Pre-to Post, there was a significant learning gain for the SimCalc group (M=1.99, SD=3.535) compared to the Comparison group (M=0.96, SD=3.301).

• This group difference is statistically significant, t(322)=2.711, p=0.007, d=0.30 (r=0.15)

• Gains on only the multiple-choice items, 20 of the 22 items, reveal a greater significant difference between groups, t(322)=3.069, p=0.002. This represents a medium effect, d=0.34 (r=0.17)
Disaggregate by Class

- Comparison class C7 and SimCalc class C12, are both Honors classes taught by the same teacher. There is not a statistically significant difference between these two classes on the pre-test, $t(44)=0.236$, $p=0.815$. While a learning gain occurred in both classes, the SimCalc class had a significantly greater learning gain than the Comparison class, $t(40)=-2.242$, $p=0.031$. This represents a medium to large sized effect, $d=0.7089$. 
Teacher Interview

- There were a lot of things I was taking [from his SimCalc class and into his Comparison class] it wasn't what we did technology-wise, it was the base model they [the SimCalc kids] had for position versus time, I took a lot of that stuff and brought it over [to my Comparison class]. It just made things more concrete, a lot clearer for the students [in the Comparison class].” When asked about the discussions that occurred in his SimCalc class compared to his Comparison class, the teacher stated: “I liked letting them [SimCalc students] take over the discussion because they always have that example [SimCalc] to go back to. It's harder when they only have the abstract. [My Comparison class] couldn't verbalize what they needed to… They could explain why after but they wouldn't be able to express it themselves and in their own words.”
Multiple Representations

- SimCalc students have a significantly greater gain than the comparison group on multiple representation items $t(322)=-4.771$, $p<0.0001$ which represents a medium sized effect, $d=0.53$. 
The Circumference, \( C \), of a circle is found by using the formula \( C = \pi d \), where \( d \) is diameter.

Which graph best shows the relationship between the diameter of a circle and its circumference?

A. 

![Graph A: Linear relationship between circumference and diameter]

B. 

![Graph B: Curved relationship between circumference and diameter]

C. 

![Graph C: Constant circumference regardless of diameter]

D. 

![Graph D: Curved relationship with a change in slope]

E. I Don't Know.
So, the estimated risk of students with a SimCalc intervention (on item#21) is 60% (ORx100%) of that without the SimCalc intervention (control) with a 95% confidence interval of 34% to 100% (p=0.04)

<table>
<thead>
<tr>
<th></th>
<th>EVENT</th>
<th>NO EVENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention (SimCalc)</td>
<td>87</td>
<td>31</td>
</tr>
<tr>
<td>Control (Business-as-usual)</td>
<td>135</td>
<td>29</td>
</tr>
</tbody>
</table>
Comparing Gains

• Two out of three items that are greater than one standard deviation above the mean are common for the SimCalc and comparison groups and the third is just below one sd for the SimCalc group.

• One item focuses on calculating the slope of a linear function.

• Correct responses are similar for both groups on the pre-test (mean=0.3) and both groups’ gains from pre to post are significant (SimCalc=0.42; Comparison=0.26) but the SimCalc group’s gain is significantly different (p<0.05) with the comparison group.

• The story is similar for second item. Gains from pre to post are significant for both groups but the SimCalc group’s gain of 0.350 is significantly different from the Comparison group’s gain of 0.19 (p<0.05).

• EX: Which graph below best describes y= -3x+4?
- SimCalc Males and Females gain significantly more: females: $t(160)=4.442$, $p=0.000$; males: $t(160)=2.076$, $p=0.039$
- SimCalc Females gain (1.93) significantly, and are sig. different from SimCalc males (1.14) $t(135)=2.65$, $p=0.009$
An Attitude Model derived from a previous study yielded 4 constructs:

1. Positivity towards math and school ($\alpha = .717$)
   - “I think mathematics is important in life.”
2. Working collaboratively & related affect ($\alpha = .692$)
   - “I sometimes feel nervous talking out-loud in front of my classmates.”
3. Working privately ($\alpha = .727$)
   - “I learn more about mathematics working on my own.”
4. Technology ($\alpha = .674$)
   - “Technology can make mathematics easier to understand.”
### Content x Attitude

#### 2-tailed correlation matrix for Treatment Group. (Spearman rho)

<table>
<thead>
<tr>
<th></th>
<th>Gain on Multiple Choice</th>
<th>Gain in Graphical Int.</th>
<th>Gain in Rate &amp; Proportion</th>
<th>Gain in Recognizing &amp; Determining a Pattern</th>
<th>Gain in Multiple Representations</th>
<th>Change in Attitude 1</th>
<th>Change in Attitude 2</th>
<th>Change in Attitude 3</th>
<th>Change in Attitude 4</th>
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</thead>
<tbody>
<tr>
<td>Total Gain</td>
<td>.940**</td>
<td>.643**</td>
<td>.582**</td>
<td>.307**</td>
<td>.678**</td>
<td>.098</td>
<td>.001</td>
<td>-.037</td>
<td>-.126</td>
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<tr>
<td>Gain on Multiple Choice Items</td>
<td>.690**</td>
<td>.678**</td>
<td>.327**</td>
<td>.667**</td>
<td>.106</td>
<td>-.012</td>
<td>.030</td>
<td>-.117</td>
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<tr>
<td>Gain in Graphical Int.</td>
<td>.121</td>
<td>.084</td>
<td>.188**</td>
<td>-.038</td>
<td>.013</td>
<td>-.079</td>
<td>-.041</td>
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<td></td>
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<tr>
<td>Gain in Rate &amp; Proportion</td>
<td>.105</td>
<td>.186**</td>
<td>-.071</td>
<td>-.021</td>
<td>-.222**</td>
<td>-.162</td>
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<tr>
<td>Gain in Recognizing &amp; Determining a Pattern</td>
<td>.155**</td>
<td>-.086</td>
<td>.039</td>
<td>-.002</td>
<td>.026</td>
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<tr>
<td>Gain in Multiple Representations</td>
<td>.180</td>
<td>-.108</td>
<td>.025</td>
<td>-.051</td>
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<tr>
<td>Change in Attitude 1</td>
<td>.139</td>
<td>.106</td>
<td>.263*</td>
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<tr>
<td>Change in Attitude 2</td>
<td>-.066</td>
<td>-.015</td>
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<tr>
<td>Change in Attitude 3</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p<.05, **p<.01, ***p<.1

- No significant correlations for comparison group
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Case Studies

• Classroom from each group demonstrating high pre-post test student gains
• Veteran teacher and well-experienced teacher (5 yrs) - both used SimCalc but the comparison is not in this study.
• Focus on forms of participation and reference
1-tailed correlation matrix for a specific SimCalc class (Class 13). Pearson r unless otherwise indicated.

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<th>Gain in Multiple Representations</th>
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<th>Change in Attitude 2</th>
<th>Change in Attitude 3</th>
<th>Total Gain</th>
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</thead>
<tbody>
<tr>
<td>Total Gain</td>
<td>.993**</td>
<td>.718**</td>
<td>.450**</td>
<td>.371**</td>
<td>.711**</td>
<td>-.327**</td>
<td>-.360**</td>
<td>.380**</td>
<td>.400**</td>
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<tr>
<td>Gain on Multiple Choice Items</td>
<td>.759**</td>
<td>.421**</td>
<td>.366**</td>
<td>.693**</td>
<td>.330**</td>
<td>-.261**</td>
<td>.351**</td>
<td>.370**</td>
<td>.370**</td>
</tr>
<tr>
<td>Gain in Graphical Int.</td>
<td>.154*</td>
<td>.070</td>
<td>.212*</td>
<td>.259*</td>
<td>.116*</td>
<td>.302**</td>
<td>.366**</td>
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<td></td>
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<tr>
<td>Gain in Rate &amp; Proportion</td>
<td>.285*</td>
<td>.054</td>
<td>-.131*</td>
<td>-.083*</td>
<td>-.177*</td>
<td>.231**</td>
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<tr>
<td>Gain in Recognizing &amp; Determining a Pattern</td>
<td>.089**</td>
<td>-.011**</td>
<td>-.422**</td>
<td>-.356**</td>
<td>-.209**</td>
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<tr>
<td>Change in Attitude 1</td>
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<td>.214</td>
<td>.563**</td>
<td>.615**</td>
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<td>Change in Attitude 2</td>
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<td>.180**</td>
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<tr>
<td>Change in Attitude 3</td>
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<td>-.004</td>
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*p<.05, **p<.01, ***p<.1" Spearman \( \rho \)

• No significant correlations with the comparison class
Theoretical Lens

- We are TRANSFORMING the classroom NOT changing/reinventing it. We do this by modifying the structure of the classroom
- Customizability — critical - its simple to use
- NEW HUMAN INFRASTRUCTURE that erodes past curriculum by opening a window to new ways of conceiving math at school
- Intersection of Representational Infrastructure and a Communication Infrastructure
- Yields “Representational Expressivity” in the form of physical action (e.g. gesture, bodily action, positioning) and speech (e.g. deixis, metaphor, informal registers, identification. argumentation)
Active Participation in Discourse

• Hypothesis: In connected classrooms, turn-taking is fluid and often ungoverned by the teacher (Tabak & Baumgartner, 2004)

• Example: Adjacency Pair Analysis
• Adjacency pairs refer to pairs of utterances in the flow of communication
• Proportion of teacher-student and student-student pairs index fluidity in conversation and indicate who (if anyone) dominates discourse
• Content analysis required to judge whether discourse entails coherent argument
Discourse Flow

Ratio of Student-Student Turns to Total Student Turns in the Class

\[ y = 0.0137x + 0.3593 \]
\[ R^2 = 0.5286 \]

\[ y = 0.0027x + 0.0368 \]
\[ R^2 = 0.1273 \]

1 class period is approximately 48 minutes.
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What is unique to CC?

• Recall the design strands
• Mathematically-meaningful activity structure
• Transforming communication
• Focus on communication, interaction, and forms of expression, forms of identification in videos.
• Semiotic analyses
Video Analysis

• Video 1: Exciting Sack Race (SimCalc) - 1’14”
  • Luke says he can identify his graph out of the mess of graphs that are in the public display space. Luke says he knows which one is his based on the numbers and then points out his graph. He knows which one is his because his is the only one “that went negative.”

• Video 2: Sack-Race cont. (SimCalc) - 3’55”
  • Amanda, reads the story of another student, Jess. While she is reading the story, Jess’ piecewise linear graph is displayed for the class to see and we see a third student, Catie, matching the story to the graph at her seat.

• Video 3: Accumulation-Time graphs (Comp) - 5’41”
  • This activity asks the students to plot the number of apples on a tree over the course of a year

• Video 4: Accumulation-Time graphs (Comp) - 4’39”
  • In this episode, students are plotting the distance from home plate vs. time, after you hit a home run. A student draws his graph and explains his result.
clip #19
clip #39 – PW graphs of apple growth
Comparing graphs publicly as drawings
Non-Personified objects – No contrast supported by teacher between drawings or interpretations
Static representations
Static pedagogy (IRE + Clapping of hands to keep responses aligned)
Student respect => learning gains? but not emotive
Video 4

clip #38
Thank You!

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