Relationships Between Motivation And Student Performance In A Technology-Rich Classroom Environment

John Tapper & Sara Dalton
Arden Brookstein, Derek Beaton, Stephen Hegedus
jtapper@donahue.umassp.edu, sdalton@umassd.edu

Kaput Center for Research and Innovation in Mathematics Education
Director: Stephen J. Hegedus

University of Massachusetts Dartmouth
kaputcenter.umassd.edu

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Overview

• Motivating research questions for analysis
• Introduction & short demonstration
• Results of Quasi-Experimental study to provide a theoretical and quantitative lens
  – Overall Results
  – Class Case Study
    • Examining differences in learning and attitude
• Video analysis
• Conclusion
Motivating Questions

(Analysis of subset of larger 4 year study)

• What relationship(s) exists between student gains in performance on pre-and post content tests and measures of attitude?

• In what ways might attitude influence performance gains?
  • Which classroom behaviors and/or interactions suggest an attitude-performance connection?

• How might the SimCalc environment impact relationships between student performance gains and attitude?
Demonstration of software!
From Student Calculator

To Teacher Display
Quasi-Experimental Study

Intervention
- 3-6 week replacement unit on core Algebra concepts: linearity, slope as rate, covariation, function, \( y=mx+b \)

Population
- All 9th grade Algebra 1 classrooms in two middle-achieving districts in Southeastern Massachusetts participated in the study
  - SimCalc: 7 classrooms (5 teachers) from both districts
  - Comparison: 8 classrooms (8 teachers) from both districts

Sample
- Initial: Comparison (236 students), SimCalc (160 students)
- Final: Comparison (187 students), SimCalc (137 students)
Data Collection

- Mathematics Algebra 1 Content Test
- Student Attitude Survey
- Student and Teacher Interviews
- Classroom Observation: Daily video, field notes + piloted structured observation (e.g. RTOP) for 5 SimCalc classes and 1 Comparison class
Algebra 1 Content Test


Four Content Sub-scales:

1. Graphical Interpretation (41% of the test)
2. Rate and Proportion (23%)
3. Number sense and patterns (9%)
4. Multiple representations (27%)

Example: The circumference, \( C \), of a circle is found by using the formula \( C = \pi d \), where \( d \) is the diameter. Which graph best shows the relationship between the diameter of a circle and its circumference?

A.  

![Graph A](image)

B.  

![Graph B](image)

C.  

![Graph C](image)

D.  

![Graph D](image)
Results

Overall Learning Gains

• The difference in total gain between groups is statistically significant, $t(322)=2.711$, $p=0.007$

• Gain on the multiple representations sub-scale is also significant, $t(322)=-4.771$, $p<0.0001$

<table>
<thead>
<tr>
<th></th>
<th>Experimental Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SimCalc</td>
</tr>
<tr>
<td>Mean Total Gain</td>
<td>1.99</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>3.535</td>
</tr>
<tr>
<td>Mean Multiple Representation Gain</td>
<td>1.58</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>1.769</td>
</tr>
</tbody>
</table>
## Results

### Class Case Study - Overall Learning Gains

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean Total Gain (n)</th>
<th>Mean Gain on Multiple Rep. (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case Study Class</td>
<td>2.42 (19)</td>
<td>2.30 (19)</td>
</tr>
<tr>
<td>SimCalc (All)</td>
<td>1.99 (137)</td>
<td>1.58 (137)</td>
</tr>
<tr>
<td>Comparison (All)</td>
<td>0.96 (187)</td>
<td>0.70 (187)</td>
</tr>
</tbody>
</table>

**Mean Gains by Class**

- **Comparison**
- **SimCalc**

Bars show Mean
Student Attitude Survey

Our model yielded 4 constructs:

1. Deep Affect/ Beliefs not subject to casual change ($\alpha = .782$)
   - “I think mathematics is important in life.”

2. Anxiety ($\alpha = .739$)
   - “I sometimes feel nervous talking out-loud in front of my classmates.”

3. Preference to work alone ($\alpha = .754$)
   - “I learn more about mathematics working on my own.”

4. Perception and Use of Technology ($\alpha = .610$)
   - “Technology can make mathematics easier to understand.”
Results

Student Attitude Components

- Positive change for Deep Affect → more positive overall attitude towards math and school
- Negative change for Anxiety → students were less anxious at the end of the intervention than they were at the beginning

<table>
<thead>
<tr>
<th>Dimensions of Attitude</th>
<th>Mean Gain in Deep Affect (n)</th>
<th>Mean Gain in Anxiety (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case Study Class</td>
<td>0.40 (17)</td>
<td>-1.20 (18)</td>
</tr>
<tr>
<td>SimCalc (All)</td>
<td>-0.19 (85)</td>
<td>-0.27 (85)</td>
</tr>
<tr>
<td>Comparison (All)</td>
<td>-0.48 (133)</td>
<td>-0.07 (121)</td>
</tr>
</tbody>
</table>
## Results

**Relationships between Student Attitude and Learning Gains for the SimCalc Case Study Class**

2-tailed correlation matrix for the SimCalc case study class.

<table>
<thead>
<tr>
<th></th>
<th>Change in Deep Affect</th>
<th>Change in Anxiety</th>
<th>Change in Preference to Work Alone</th>
<th>Change in Perception and Use of Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Gain</td>
<td>0.327</td>
<td>-0.422( ^{†} )</td>
<td>0.370</td>
<td>0.460( ^{†} )</td>
</tr>
<tr>
<td>Gain in Multiple Representations</td>
<td>0.214</td>
<td>-0.576( ^{*} )</td>
<td>0.515( ^{*} )</td>
<td>-0.047</td>
</tr>
<tr>
<td>Gain in Graphical Interpretation</td>
<td>0.336</td>
<td>0.004</td>
<td>0.350</td>
<td>0.535( ^{*} )</td>
</tr>
<tr>
<td>Change in Deep Affect</td>
<td></td>
<td>-0.389</td>
<td>-0.007</td>
<td>0.633( ^{**} )</td>
</tr>
<tr>
<td>Change in Anxiety</td>
<td></td>
<td></td>
<td></td>
<td>0.065</td>
</tr>
<tr>
<td>Change in Preference to Work Alone</td>
<td></td>
<td></td>
<td></td>
<td>-0.016</td>
</tr>
</tbody>
</table>

\( ^{†} p<.1, \ ^{*} p<.05, \ ^{**} p<.01 \)

Change in Anxiety significantly predicts gain on multiple representations sub-scale

\( R^2=0.33, F(1, 16)=7.96, p=0.012 \)
Activity: “Coming Together”

GOAL: Create a motion for a SimCalc actor, B, such that B starts at 2 times your group number of feet and ends in a tie with a target function, A.

A: \( y = 2x \)

domain: \([0,6]\)
From Student Calculator

To Teacher Display
Video Clip 1

• Each student edited a function expression to fit the goal of the activity & the teacher collected their work.

• Before student work was shown, the teacher asked: “What will happen in the world when I run the animation?”

Play Clip!
S5: We're all gonna go different speeds but we're all gonna end at the same position cause that uh end at
Teacher: Where is everyone going to be at the end of the motion?
Clip 1 Analysis

• Discussion is student-led,
  – the teacher repeated what a student said twice, and
  – facilitated the conversation to come to a consensus

• Student agency was evident
  – Students debated their work
  – Discussed the work of their peers
  – Students respond to one another rather than the teacher
The students were building their understanding of how time and position co-vary.

S5: Group 6 isn't gonna move.
S8: Yes we move.
S1: No they don't move, time goes on.
S3: No, they're not gonna move at all.
Teacher: Do we agree with that?
S8: Yeah but time is moving.
S1: Yeah cause you'll like see everyone else move but them.
Video Clip 2

• While still discussing class contributions, a student notes the symmetry created by the graphs and motions.

Play Clip!
S6: We were the opposite of them.
S3: Ya.
Clip 2 Analysis

• A student conceptualizes the graphical symmetry of the class set of motions and graphs

S6: We were the opposite of them. We were their opposite. Cause they were 2 and we were negative 2.

... 
S1: That 4 and 7 are opposites.
S4: 5.
Teacher: So Group 5 and Group 7 had... opposite slopes.
S1: Ya.
S6: And Group 8 and Group 4.
S1: Ya
• Teacher asks the class what the class set of functions will look like in the graph space. Some students refer to the graphs as a “fan.”

• Teacher adds her own narrative representation of the class contributions.

Play Clip!
Teacher: How about if I see it as a hand?
Clip 3 Analysis

- Students used metaphors to understand
  - fan
  - rake with the graph of Group 6 as the *handle* of the rake because it was perpendicular to the y-axis.
  - The teacher followed up students’ initial response with her own metaphor of a hand

- Student & teacher use of gesture to assist in understanding and communication of mathematical ideas
Students relied on 3 major representations SimCalc offered to them to make deductions on the behavior of the family of functions.

- Derived a function rule that can be generalized for any group in the class.
- Relied heavily on the animation and graphs to understand which groups would have a negative and positive slope, which was at the heart of their debate.

Student to student interactions are more common.

Students are comfortable communicating their ideas.
Paper Conclusion

• Still in early stages, we speculate that three effects may be at work:
  – SimCalc provides a dynamic environment with which to explore concepts in personally meaningful ways,
  – Students can make numerous conjectures before coming to a final answer, and
  – The use of multiple representations in the curriculum and software provide for the deliberate generalization of concepts.

• Many potential explanations for motivation/learning performance relationships in SimCalc classrooms.
  – Larger randomized controlled trial (Funded by IES; PI: Stephen Hegedus)
  – Longitudinal efficacy study to investigate the connection between attitudinal changes and gains in performance

• Explore whether our hypothesized factors—the richness of the SimCalc context, the reduced emphasis on “one right answer”, and the explicit transfer of concepts to a variety of mathematical representations—contribute to such changes.
Thank You!

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