ICTCM: New Forms of Participation with Wireless Classrooms

Stephen J. Hegedus, Sara K. Dalton, James P. Burke
shegedus@umassd.edu, sdalton@umassd.edu, jburke@umassd.edu

James J. Kaput Center for Research and Innovation in Mathematics Education
SimCalc Research Projects,
Department of Mathematics
University of Massachusetts, Dartmouth
merg.umassd.edu
www.simcalc.umassd.edu

Developed under NSF-based Grants: REC-0087771, Understanding Classroom Interactions Among Diverse, Connected Classroom Technologies; REC-0337710, Representation, Participation and Teaching in Connected Classrooms; REC-0228515, Scaling Up SimCalc: Professional Development for Leveraging to Teach More Complex Mathematics, Phase I; REC-0437861, Scaling Up Middle School Mathematics Innovations, Phase II
Democratizing Access

- Mathematical alienation
- Motivation repressed via opaque classroom objectives
- Curriculum restrictions
- Classroom participation is an expectation rather than a phenomenological artifact of productive learning
SimCalc MathWorlds

- Dynamic interactive representations that are linked, e.g. edit a position function and automatically see velocity graphs update
- Graphically and algebraically editable functions
- Import motion data and re-animate (CBR & CBL2)
- Simulations are at the heart of SimCalc - executable representations (Moreno, 2001)
SimCalc MathWorlds - The Product

• The historic evolutions of two software into one integrated product

• SMW for the TI 83+/84+ - Version 6.0

• SMW for the Desktop PC (cross-platform for non-connected work) - Version 4.0

• Mental Model for users: Microsoft Office - Can be used in integrated ways or independently - documents can be written to be used in other applications
SimCalc “Connected” MathWorlds

• New generation of SimCalc that increases participation, motivation and learning

• Exploits wireless networks to allow the aggregation of student work in mathematically meaningful ways

• Teachers have powerful classroom management tools to focus attention and pedagogical agenda

• Student work becomes contextualized into a class of contributions for comparison and generalization

• Mathematical thinking goes from a local to a social activity
Parallel Software

From Student Device

Executable Representations

To Teacher Display
Three fundamental powers of connectivity

• To harvest students work to examine variation and common misconceptions (error analysis)
• To aggregate students work in a mathematically meaningful way – use natural variation to examine parametric variation (i.e. each students varies a parameter)
• To focus on connections across representations, i.e. students work with representation A (e.g. a velocity graph) and the teacher displays/works with representation B (e.g. a position graph) - cf. Kaput 1991
SimCalc in action!

Let’s have an Exciting Sack Race!
Dynamic Mathematics

• Dynamic representations are a new access route to new visions of mathematical ideas and problem solving

• Connectivity is a foundation to allow public collaboration, mutual expression in dynamic media, physical expression through time and space via gesture, discourse and action, and social cognition.
Classroom Management: a fundamental design principle in a representationally-rich environment

- Collecting/Receiving – allows two forms of agency in the classroom/distributed agency
- Post-Connectivity: Data management vs Representational management - role of filters to assess students’ progressive understanding (i.e. representational timestamps) and systematically generate public reasoning and generalization
- Note: This is not always about allowing students to have ownership of the public display space (cf. Stroup) - we tightly control this
- Design challenges and solution strategies - roster as a central ordering principle
Let’s Try Another

Make a motion for Actor B so that Actor B travels at a constant speed and starts at three times your group number in feet ahead of Actor A BUT ends in a tie with Actor A.
Extensions

• SimCalc MathWorlds: Using it to lay the foundation for Calculus and broadening access for more students

• Y=MX+B

• Dealing with Rate graphs - Averages, Mean Value Theorem, Fundamental Theorem of Calculus
CMW Supports Three New Classes of Functions

Class 1: Piecewise editable functions graphically and algebraically

1. Piecewise Linear Functions
2. Piecewise Quadratic Functions
Class 2: Parametrically Defined Functions

1. Linear: $Y = MX + B$

2. Quadratic: $Y + AX^2 + BX + C$

3. Quadratic (product of roots): $Y = A(X - \alpha)(X - \beta)$
Class 2: Parametrically Defined Functions

4. Exponential: \( Ae^{(BX+C)} \)

5. Periodic: \( Y = Asin(BX+C) + D \)
Class 3: Sampled Data: CBR & CBL

- Ability to support a wide variety of probes
- Ability to disconnect on collection and use a variety of smoothing methods
- Ability to count in seconds/minutes/hours to offer “faster” animation
Exploiting Connectivity

- Facilitate work-flow,
- Aggregate student constructions to: i. vary essential parameters on a per-student basis, ii. elevate student attention from single objects to parameterized families of objects,
- Provide opportunity for generalization and expose common thought-patterns (e.g. errors)
- Students make personally meaningful mathematical objects to be publicly shared and discussed
- Students project their personal identity into the objects and constructed motions
- Students math and social experience are deeply intertwined
- Teachers are in a central role to orchestrate whole class of events
Some Top-Level Thoughts

• Students experience and contributions are embedded in a social workspace

• Mathematical structure and understanding can be emergent, e.g. What do you expect to see before I show you the ...

• Representational infrastructure includes data management systems to manage the flow of information and examination of mathematical sub-structures; such power serves a variety of pedagogical needs, and sustains pedagogical flexibility
Impact on Learning
Scale-Up Study (SRI in Texas)
All 9th grade High School Algebra 1 students in two
districts took a pre- and post-test. A selection of
teachers in these schools participated in a SimCalc
Intervention in which they temporarily replaced
part of their regular curriculum with SimCalc
materials for 3-6 weeks.

The bar graph to the left illustrates the mean gains
from pre to post for the Comparison versus
Treatment groups. In the Treatment group the
mean gain is about 2 points out of a total of 26
points. In the Comparison group the mean gain is
about 1 point. This group difference is statistically
significant, $t=2.465$ ($p<0.015$).

Along with Pre-post data, we have video data (to
develop student case studies), attitude survey data,
student and teacher interviews.
Conclusions

- Research-to-date shows positive impact on mathematical knowledge (necessary and advanced) AND participation and motivation to do mathematics (attitude & behavioral data)

- Over 6 years of design & experimentation has produced a software environment that redefines the educational landscape of the mathematics classroom in the 21st century

- Dynamic Representations and in-class communication infrastructure + mathematically meaningful activities = powerful opportunities for MORE students.
For further Interest:

- There is a session pertaining to TI-Navigator tomorrow morning. “Experiencing TI-Navigator In A Calculus Classroom” at 8AM (in Essex South) with Robert Kowalczyk and Adam Hausknecht
ICTCM: New Forms of Participation with Wireless Classrooms

Dr Stephen J. Hegedus, Sara K. Dalton, James P. Burke
shegedus@umassd.edu, sdalton@umassd.edu, jburke@umassd.edu

James J. Kaput Center for Research and Innovation in Mathematics Education
SimCalc Research Projects,
Department of Mathematics
University of Massachusetts, Dartmouth
merg.umassd.edu
www.simcalc.umassd.edu

Developed under NSF-based Grants: REC-0087771, Understanding Classroom Interactions Among Diverse, Connected Classroom Technologies; REC-0337710, Representation, Participation and Teaching in Connected Classrooms; REC-0228515, Scaling Up SimCalc: Professional Development for Leveraging to Teach More Complex Mathematics, Phase I; REC-0437861, Scaling Up Middle School Mathematics Innovations, Phase II