SimCalc Connected Classrooms: New Forms of Learning, New Forms of Teaching

Stephen J. Hegedus
shegedus@umassd.edu

Sara Dalton
sdalton@umassd.edu

SimCalc Research Projects,
Department of Mathematics
University of Massachusetts, Dartmouth
merg.umassd.edu
www.simcalc.umassd.edu

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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 Connected MathWorlds - The Product

• The historic evolutions of two software into one integrated product

• SMW for the TI 83+/84+ - Version 5.0

• SMW for the Desktop PC (cross-platform for non-connected work) - Version 3.0

• 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
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 student 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
Parallel Software

From Student Device

Executable Representations

To Teacher Display
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.
Representational Infrastructure
(inherently or explicitly mathematical)

+ 

Communication Infrastructure
(explicitly not mathematical, i.e. a generic hardware/protocol, yet inherently mathematical)
Demonstration

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

• Demonstrate simulations in computer software then calculator software

• 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: $Y = A\sin(BX+C)+D$
Class 3: Sampled Data: CBR & CBL2

- 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
Classroom Management: a fundamental design principle in a representationally-rich environment

- Aggregation/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
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
- Teacher 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
Forms of Interaction

• We are focusing on interactions cycles particularly classifying what types of questions teachers ask, how often, and how students respond, contrasting with non-CC contexts across teachers.

• Interaction between oral and public workspace. How the teacher interacts with the inscriptions within the software (hide/show for pedagogical and curricular purposes) and as annotations, i.e. how the teacher uses a white board marker on top of the displayed window. Both alter focus of attention.

• New forms of questions emerging from CC phenomenology: e.g. What do you expect to see when I show the motions/ graphs? Where are you in the public display? How does your group’s motions/graphs compare with another group?
Teacher Collaboration and Examining Practice

- Communities of Practice: Teachers meet to discuss impact on students learning and their practice – what videos of each others classes and answering structured questions
- Epistemic distancing – being more than reflective of ones teaching but about its structure, its evolution, making knowledge about teaching from a distance
- Building school-capacity: Enable teachers to learn while teaching vs. external professional development, develop flexible modes of instruction, develop metacognitive awareness of learning-opportunities through flexible curriculum-centered technology (adaptive expertise)
Impact on Learning

- Results pre-post from interventions
- hons class: increase from 0.56 to 0.76 (alpha<0.0001) - similar performance to regular high school students
- Highlight past and future interventions
- Demonstrate students engagement at the start and end of an intervention – 2 video clips from Julie’s class (one with Luke and Sackrace, then the arrows clip)
- Correlations between attitude surveys and test scores
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.
Dynamic Mathematics: SimCalc MathWorlds and Classroom Connectivity

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