Two randomized experiments with 115 schools show: The SimCalc approach increases learning of advanced mathematics

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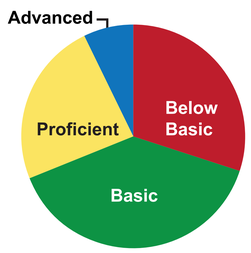
Democratizing Access to Advanced Mathematics

American students are making progress in middle school mathematics, however, the majority of students are still performing only at the basic level or below. Too few students have the opportunity to learn more advanced mathematics concepts and skills. The SimCalc approach democratizes access to cognitively demanding mathematics by integrating representational technology, paper curriculum, and teacher professional development. Since initially receiving NSF support in 1994, the SimCalc team has used multiple research methods to refine their approach to enabling all students to learn advanced mathematics and to bring this approach to scale.

Percentages of Students at NAEP Achievement Levels in 2007



SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), various years, 1990–2007 Mathematics Assessments.

Core Innovation: Multiple Representations

- Dynamic linking of graphs to simulated motions
- Direct editing of piecewise-defined position and velocity functions
- Connecting and contrasting narrative, symbolic, graphical, and table-based representations
- Leveraging new representations to reorganize the curriculum

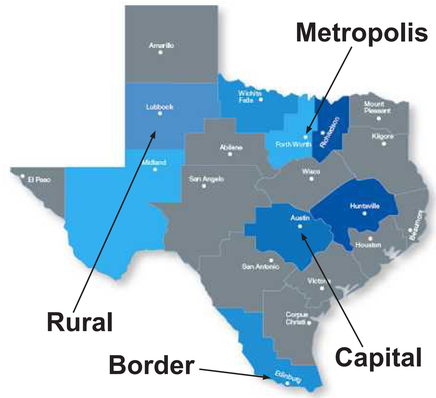
Replacement Units That Integrate Software with Curriculum

Two Randomized Experiments in Texas

SRI International conducted two randomized experiments starting in the 2005-06 and 2006-07 school years to evaluate the effectiveness of the approach in seventh and eighth grade mathematics, with regards to the question:

Can a wide variety of middle school math teachers use this innovative approach to increase student learning of important mathematics?

	Seventh Grade Experiment	Eighth Grade Experiment
Start of the study:	Summer 2005	Summer 2006
Duration of the study:	2 years (Delayed treatment: Control group received SimCalc intervention in Year 2)	1 year
Participants:	Treatment: 48 teachers / 796 students Control: 47 teachers / 825 students	Treatment: 33 teachers / 522 students Control: 23 teachers / 303 students
Mathematical content focus:	Rate and proportionality	Linear function
Student workbook theme:	Managing a soccer team	Designing cellphone games
Teacher professional development:	Treatment: Math content + SimCalc training Control: Math content only (SRI trains all teachers)	Treatment: SimCalc training Control: Equally valuable training in use of technology to teach statistics (SRI trains Texas teacher trainers)

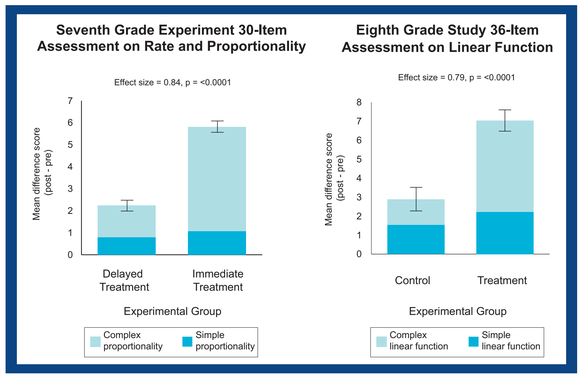


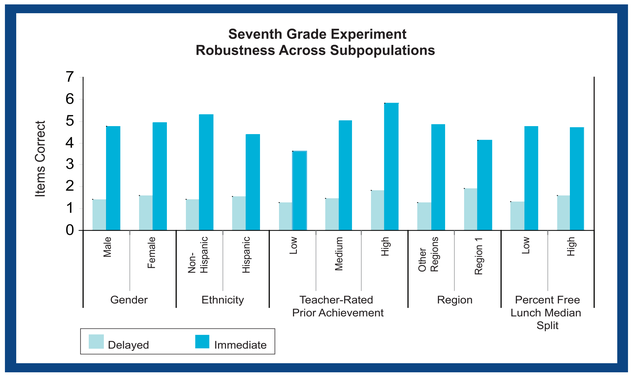
Why Texas?

- Large variations across regions and diverse subpopulations of teachers and students.
- Conducts a yearly census of teachers, schools, and districts which allowed us to evaluate our sample relative to more general demographic information.
- Has an established, stable, and well-aligned system of standards and accountability.
- Has an established pattern of addressing scale, for example, initiating changes by providing training for service centers located in its 20 regions.
- Prior work in Texas had already been promoting an aligned sequence of instruction leading from middle school through AP calculus – SimCalc naturally fit into and promoted this sequence.

Findings

SimCalc increases student learning in a wide variety of settings. All tested subgroups of students benefit from using SimCalc. More than a year since project completion, 49% of responding teachers report continued use of the SimCalc materials.





Implications

- The SimCalc approach enables students to learn more advanced concepts. Students learn the basics equally well with either SimCalc or existing curriculum.
- Innovative technology can improve mathematics learning in a variety of settings, as found in the diverse regions of Texas.
- Integrating technology with curriculum and teacher professional development is essential.

Publications

Roschelle, J., Tatar, D., & Kaput, J. (2008). Getting to scale with innovations that deeply restructure how students come to know mathematics. In A. E. Kelly, R. Lesh & J.Y. Baek (Eds.), *Handbook of Design Research Methods in Education.* New York: Routledge. 369-395.

Roschelle, J., Tatar, D., Schectman, N. & Knudsen, J. (2008). The role of scaling up research in designing for and evaluating robustness. *Educational Studies in Mathematics, 68*, 149-170.

Roschelle, J., Tatar, D., Shechtman, N., Hegedus, S., Hopkins, B., Knudsen, J., et al. (2007). *Extending the SimCalc approach to grade 8 mathematics (No. 2).* Menlo Park, CA: SRI International.

Roschelle, J., Tatar, D., Shechtman, N., Hegedus, S., Hopkins, B., Knudsen, J., et al. (2007). *Can a technology-enhanced curriculum improve student learning of important mathematics? Results from 7th Grade, Year 1 (No. 1).* Menlo Park, CA: SRI International.

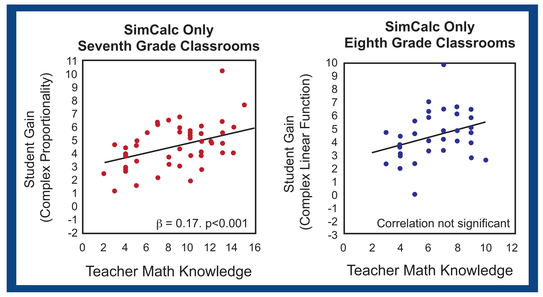
Tatar, D., Roschelle, J., Knudsen, J., Shechtman, N., Kaput, J., Hopkins, B. (2008). Scaling Up Innovative Technology-Based Math. *Journal of the Learning Sciences, 17*(2), 248-286.

More publications are available at http://math.sri.com/.

Additional Findings

Role of teacher knowledge

Overall, students tend to learn more with teachers who know more, however the effect is small in relationship to the overall effect of SimCalc. Further, some teachers with low mathematics content knowledge produce high classroom gains and vice versa. *Teachers' content knowledge is unlikely to be the driving factor in successful implementation of classroom innovations.*



Role of technology, workbooks, teacher training

Students who used technology more learned more; students who completed their workbooks and did more complex work learned more; variations in teacher training seemed to have lesser impact.

Source: Margie Dunn's Dissertation.

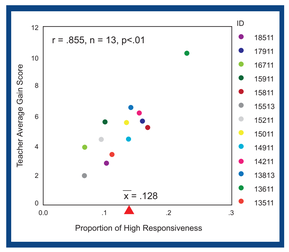
Role of teacher language and ethnicity

A linguistic or ethnic match between a teacher and her students was not a detectable factor in student learning.

Source: Antoinette Stroter's Dissertation.

Role of teacher discourse patterns

Teachers who responded to student ideas in ways that were respectful of student thinking and pressed students for additional intellectual work had higher classroom learning gains.



Source: Jessica Pierson's Dissertation.

Role of teacher presentations

Teachers who used SimCalc materials continued to teach the basics, but also spent time each day doing more demanding mathematics. Teachers varied in the depth, breadth and connectedness of their presentation of concepts. It seems logical that this would impact student learning, but the case studies produced unclear findings.

Source: Susan Empson's Case Studies.

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This material is based upon work supported by the National Science Foundation under Grant No. 0437861. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.