EARLY CHILDHOOD MATH EDUCATION REFORM: SURPRISINGLY IMPORTANT

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Surprise 1: Math's Predictive Power

Best predictor of school success. Mathematical thinking is cognitively foundational.

Surprise 2: Children's Math Potential

Children can possess an informal knowledge of mathematics that is amazingly broad, complex, and sophisticated.

Surprise 3: Educators Underestimate

This surprises most educators, who then do not challenge children.

Surprise 4: Math Intervention for All

Most children benefit from a math intervention.

Surprise 5: We Know *a Lot*

...about how children think about and learn math. Learning trajectories synthesize this knowledge..

The Building Blocks of Math

Building Blocks, developed using a comprehensive research framework, finds the math in, and develops math from, children's activity. This helps children mathematize their everyday activities, from building blocks to art to puzzles and games. Studies show Building Blocks significantly and substantially increases the knowledge of low-SES preschool children, with large effect sizes (.85 to 1.47). Used with the TRIAD (Technology-enhanced, Research-based, Instruction, Assessment, and professional Development) scale-up model, it yields similar effects for entire districts. TRIAD emphasizes teaching using well-documented learning trajectories (progressions). It also uses technology at multiple levels.

Read more about each of these surprising findings on the following pages.

Page 2: Surprises 1, 2, 3! We review research on the first three surprises listed above.
Page 3: We use research to illustrate surprises 4 and 5, emphasizing surprising and positive findings on interventions.
Page 4: Read more about us, a summary of the findings, and some interesting numbers from research.

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Surprises 1, 2, 3!

The predictive power of early mathematics is surprise #1. Children's early knowledge of math strongly predicts their later success in math (Denton & West, 2002). More surprising is that preschool mathematics knowledge predicts achievement even into high school (National Mathematics Advisory Panel, 2008; National Research Council, 2009; Stevenson & Newman, 1986). Most surprising is that it also predicts later reading achievement, even better than early reading skills (Duncan et al., 2007; see also Farran, Aydogan, Kang, & Lipsey, 2005; Lerkkanen, Rasku-Puttonen, Aunola, & Nurmi, 2005). Mathematical thinking is cognitively foundational (Clements & Sarama, 2009; Sarama & Clements, 2009). Given the importance of mathematics to academic success in all subjects (Sadler & Tai, 2007), all children need a robust knowledge of mathematics in their earliest years.

Surprise #2 is that given opportunities to learn, young children possess an informal knowledge of mathematics that is amazingly broad, complex, and sophisticated (Baroody, 2004; Clarke, Clarke, & Cheeseman, 2006; Clements, Swaminathan, Hannibal, & Sarama, 1999; Fuson, 2004; Geary, 1994; Thomson, Rowe, Underwood, & Peck, 2005). For example, preschoolers can learn to invent solutions to solve simple arithmetic problems (Sarama & Clements, 2009). Also, almost all preschoolers engage in substantial amounts of pre-mathematical activity in their free play. They explore patterns, shapes, and spatial relations; compare magnitudes; and count objects. Importantly, this is true regardless of the children's income level or gender (Seo & Ginsburg, 2004).

High-quality education can help children mathematize (Doig, McCrae, & Rowe, 2003; Thomson et al., 2005). However, if high-quality mathematics education does not start in preschool and continue through the early years, most children are trapped in a trajectory of failure (Rouse, Brooks-Gunn, & McLanahan, 2005). This leads to two questions. Do most present-day early childhood classrooms feature such high-quality mathematics? If not, what can be done? The quality of mathematics education varies across setting, but is generally disappointing, especially in the earliest years. For example, 60% of 3-year-olds had no mathematical experience of any kind across 180 observations (Tudge & Doucet, 2004). Even if a program adapts an ostensibly "complete" curriculum, mathematics is often inadequate, with the most commonly used engendering no more math instruction than a control group (Aydogan et al., 2005; Preschool Curriculum Evaluation Research Consortium, 2008). It is little surprise, then, that evaluations show little or no learning of mathematics in these schools (Clements & Sarama, 2007; DHHS, 2005). As an example, observations of Opening the World of Learning (OWL), which includes mathematics in its curriculum, found that out of a 360-minute school day, only 58 seconds were devoted to mathematics. Most children made no gains in math skills and some lost mathematics competence over the school year (Farran, Lipsey, Watson, & Hurley, 2007). Teachers often believe that they are "doing mathematics" when they provide puzzles, blocks, and songs. Even when they teach mathematics, that content is usually not the main focus, but is "embedded" in a fine-motor or reading activity (Clements & Sarama, 2009; National Research Council, 2009). Unfortunately, evidence suggests such an approach is ineffective (National Research Council, 2009).

Surprise #3 is that teachers vastly underestimate what their children know and can learn (Clements & Sarama, 2009).

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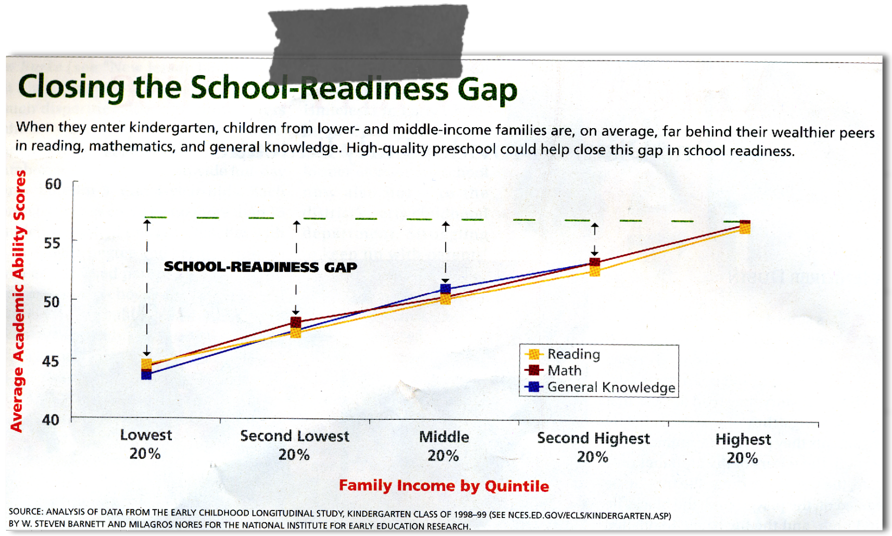
Surprise 4: Math Intervention for All

Most children benefit from a math intervention. As Barnett and others' research has shown, it is not just the very poorest children who need interventions. When they enter kindergarten, most children are behind their peers for the best-funded communities.



Surprise 5: We Know *a Lot*

Finally, we know a lot about how children think about and learn math. And we know a lot about how to use learning trajectories to synthesize this knowledge into effective interventions for children.

Our books (Clements & Sarama, 2009; Sarama & Clements, 2009) detail the learning trajectories that can help underlie scientific approaches to standards, assessment, curricula, and professional development.

Our research (see p. 1) on our Building Blocks curriculum and TRIAD scale up model show effect sizes that are large and signification. High-quality instruction has meaningful effects on children's mathematics knowledge (Clements & Sarama, 2011, 2013; Clements, Sarama, Spitler, Lange, & Wolfe, 2011; Clements, Sarama, Wolfe, & Spitler, 2013; Sarama & Clements, 2013; Sarama, Clements, Wolfe, & Spitler, 2012; Sarama, Lange, Clements, & Wolfe, 2012).

Three More Surprises from the Building Blocks and TRIAD Projects

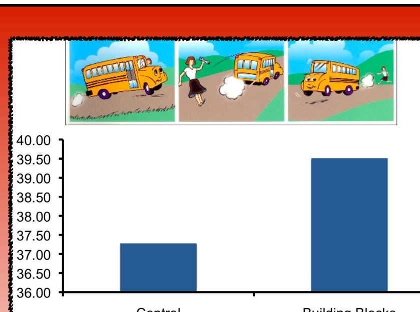
Illustrated along the bottom of this page are three more surprises from research, especially the the Building Blocks (curriculum) and TRIAD (scale-up model) research projects (see page 1).

5a. Math and Play. As our colleagues Dale Farran and Mark Lipsey have recently confirmed, instead of being a "zero sum game," mathematics and play support each other. Early childhood programs that have more mathematics have more higher-level free play, all of which promotes self-regulation and executive function.

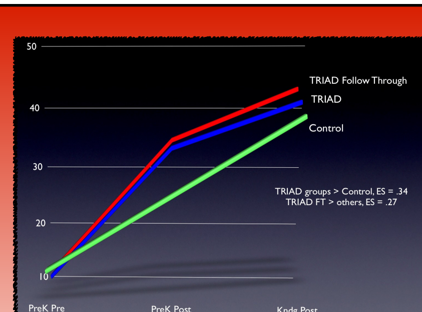
5b. Math improves language. Our TRIAD research shows that doing more mathematics increases oral language abilities, even measured during the following school year. These include vocabulary, inference, independence, and grammatical complexity.

5c. We need follow through. Our TRIAD follow-up shows that gains in preschool can be lost unless Kindergarten and primary grade teachers build on early math interventions and do more interesting, challenging, and substantial math.

5a. Math And Play Mathematics education and play are not mutually exclusive, but are mutually reinforcing. A mathematics intervention *increases high-level play.*



5B. Math Intervention Improves Language Language and literacy do not suffer when a math intervention is introduced; indeed, *language competencies are enhanced.*



5C. Early Gains Can Be Lost *Follow through is needed* to maintain the gains of successful early interventions.

ABOUT US

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Publications: 120 refereed research studies, 18 books, 70 chapters, and 275 additional publications

Funded Research: Over 20 funded projects:

Web: www.triadscaleup.org/
www.buildingblocksmath.org
childrensmeasurement.org
portfolio.du.edu/dclemen9
portfolio.du.edu/jsarama

Early math: Surprisingly important

Poll Results

What do parents and children say

about math?

Parents: math is very important

98%

Children: math is very important

89%

Children: I am good at math 55%

Schools need to help the brightest

learn math 91%

Young children have a surprising capacity to learn substantial mathematics, but most children in the U.S. have a discouraging lack of opportunities to do so. Too many children not only start behind, but also begin a negative and immutable trajectory in mathematics, with insidious long-term effects. These negative effects are in one of the most important subjects of academic life, but also affect children's overall life course.

The good news is that interventions designed to facilitate their mathematical learning from the earlier years, continued through elementary school, have a strong positive effect on these children's lives for many years thereafter.

We need to start in preschool with high-quality mathematics such as Building Blocks, but also follow through with substantial mathematics in the primary years that builds on these foundational competencies.

NUMBERS

Percent of adults who can NOT compute a 10% tip.

58%

Percent that cannot

explain how to compute the interest paid on a loan.

71%

Percent that cannot calculate miles per gallon

on a trip.

78%

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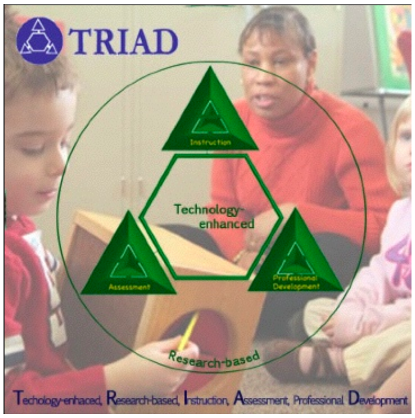
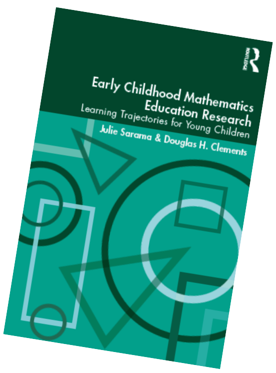
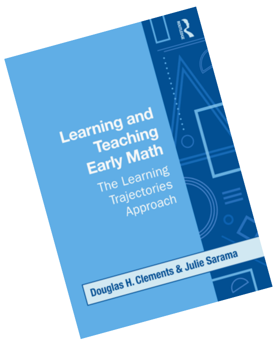
http://www.triadscaleup.org/







www.routledge.com/books/Learning-and-Teaching-Early-Math-isbn9780415995924

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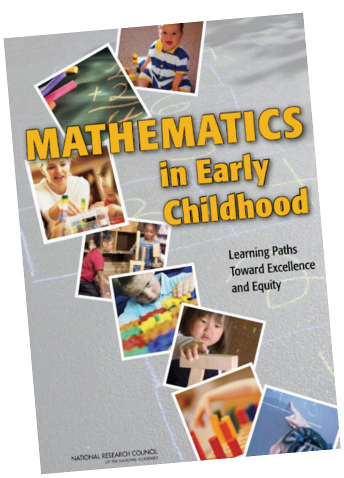

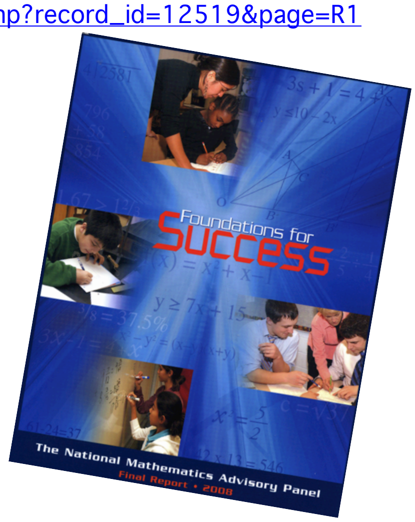

National Math Panel—http://www.ed.gov/

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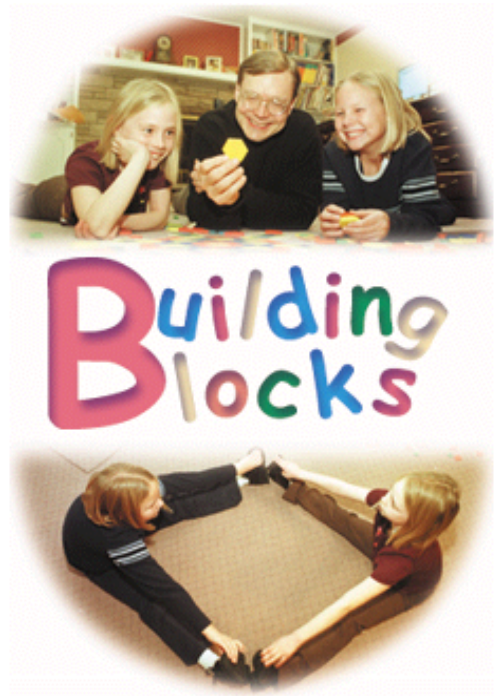

www.mheonline.com/earlychildhoodconnection/

http://www.buildingblocksmath.org/

for research, http://www.triadscaleup.org/

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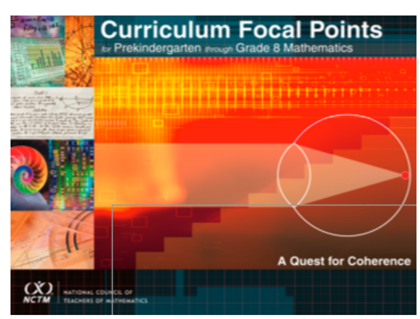

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