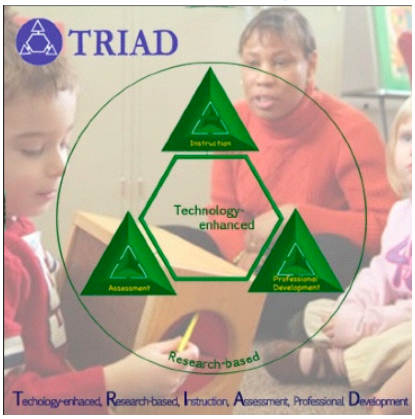
Building Blocks of Early Math

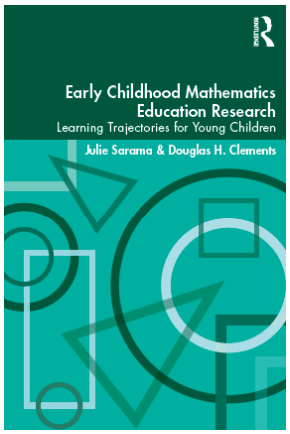
Douglas H. Clements,
SUNY Distinguished Professor

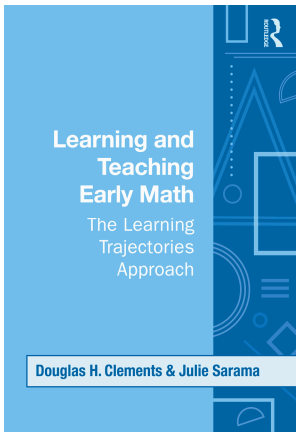
University at Buffalo, SUNY
212 Baldy Hall, Buffalo, NY 14260

clements@buffalo.edu

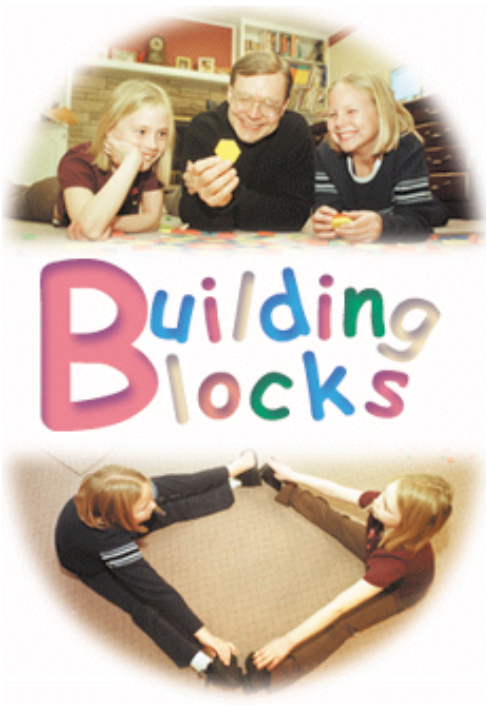
UBTRIAD.org







www.routledge.com/books/Early-Childhood-Mathematics-Education-Research-isbn9780805863093
www.routledge.com/books/Learning-and-Teaching-Early-Math-isbn9780415995924



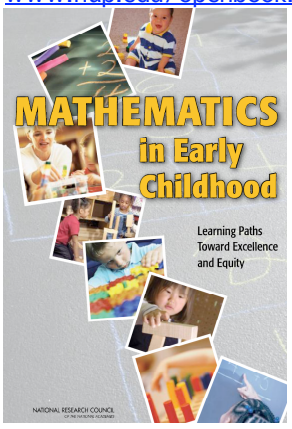
UBBuildingBlocks.org

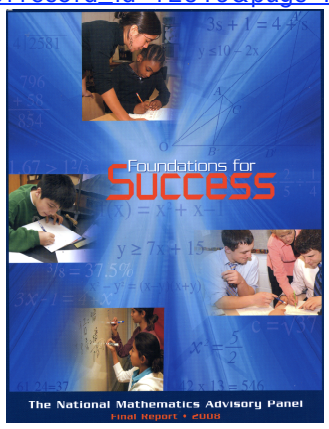
TEAM
TOOLS for EARLY ASSESSMENT in MATH

www.team.mcgraw-hill.com

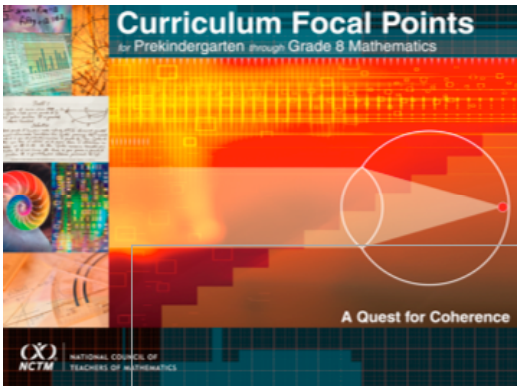
For research, see UBTRIAD.org and UBBuildingBlocks.org & www.realmath.com for the *Building Blocks Real Math PreK* curriculum.

NRC www.nap.edu/openbook.php?record_id=12519&page=R1





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



NCTM — www.nctm.org

Selected Mathematics Resources

Douglas H. Clements and Julie Sarama

Books

Sarama, J., & Clements, D. H. (2009). *Early childhood mathematics education research: Learning trajectories for young children*. New York: Routledge.

Clements, D. H., & Sarama, J. (2009). *Learning and teaching early math: The learning trajectories approach*. New York: Routledge.

Clements, D. H., Sarama, J., & DiBiase, A.-M. (Eds.). (2004). *Engaging young children in mathematics: Standards for early childhood mathematics education*. Mahwah, NJ: Lawrence Erlbaum Associates.

Articles

Sarama, J., & Clements, D. H. (2002). *Building Blocks* for young children's mathematical development. *Journal of Educational Computing Research, 27*(1&2), 93-110.

Sarama, J., & Clements, D. H. (2003). *Building Blocks* of early childhood mathematics. *Teaching Children Mathematics* 480-484.

Clements, D. H., & Sarama, J. (2004). *Building Blocks* for early childhood mathematics. *Early Childhood Research Quarterly, 19*, 181-189.

Clements, D. H., & Sarama, J. (2007). Effects of a preschool mathematics curriculum: Summative research on the *Buildi Blocks* project. *Journal for Research in Mathematics Education, 38*, 136-163.

Clements, D. H., & Sarama, J. (2008). Experimental evaluation of the effects of a research-based preschool mathematics curriculum. *American Educational Research Journal, 45*, 443-494.

Clements, D. H., Sarama, J., & Liu, X. (2008). Development of a measure of early mathematics achievement using the Rasch model: The Research-based Early Maths Assessment. *Educational Psychology, 28*(4), 457-482.

Sarama, J., Clements, D. H., Starkey, P., Klein, A., & Wakeley, A. (2008). Scaling up the implementation of a pre-kindergarten mathematics curriculum: Teaching for understanding with trajectories and technologies. *Journal of Research on Educational Effectiveness, 1*, 89-119.

Sarama, J., & Clements, D. H. (2009). Building blocks and cognitive building blocks: Playing to know the world mathematically. *American Journal of Play, 1*, 313-337.

Clements, D. H., Sarama, J., Spitler, M. E., Lange, A. A., & Wolfe, C. B. (in press). Mathematics learned by young children in an intervention based on learning trajectories: A large-scale cluster randomized trial. *Journal for Research in Mathematics Education*.

Websites

Web home page: http://www.gse.buffalo.edu/FAS/Clements/

TRIAD Project: http://www.ubtriad.org/

716-645-2455 (Ext. 1155) for any project

Building Blocks Project: http://www.ubbuildingblocks.org/

Aligning Stage-Appropriate Evaluation with the Stages of Implementation: Ongoing Monitoring and Scale Up/ Replicability

Douglas H. Clements & Julie Sarama

University at Buffalo
The State University of New York

Building Blocks

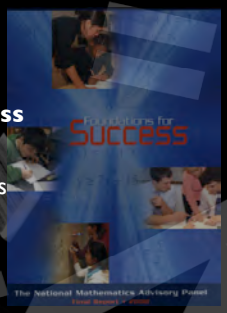
ED.gov

1

National Math Panel

Children from low-income backgrounds enter school with far less knowledge…

gap…progressively widens throughout their PreK-12 years"



2

National Math Panel

"Research that scales up early interventions capable of strengthening mathematical knowledge,

evaluates their utility in Pre-K and K, and examines long term effects

is urgently needed, with a particular focus on at-risk learners"

3

- We need early math.
- We need ways to scale up.
- Must be research based.
- What is a research-based intervention?

4

The *Curriculum Research Framework*

Douglas H. Clements & Julie Sarama
University of Buffalo, SUNY

5

Research Basis

- Many claim a research basis,
  - but claims often vacuous, citing theories or empirical results vaguely.
- Need framework
  - should require answering scientific questions…

6

	Practice	Policy	Theory
Effect	Effective in achieving learning goals? Credible relative to alternatives?	Effect size? Curriculum goals important?	Why effective? Credible relative to alternatives?
Conditions	When and where? Under what conditions? Generalize?	Support requirements for various contexts?	Why do conditions in(de)crease effects? How & why strategies produce previously unattained results?

7

Curriculum Research Framework*

- **A Priori Foundation**
  - General: Broad philosophies, theories, and empirical results
  - Subject Matter
    - substantive contribution, build from past, generative
  - Pedagogical (e.g., computer activities)
- **Learning Trajectories**
  - Goal, developmental progression, instructional tasks

*Clements, D. H. (2007). Curriculum research: Toward a framework for 'research-based curricula'. *Journal for Research in Mathematics Education, 38*, 35–70.

8

Curriculum Research Framework

- **Formative Evaluation**
  - Small Group
    - Learning trajectory's elements evaluated
  - Single Classroom
    - Meaning teachers and students give in progressively expanding social contexts
    - Intended and unintended outcomes; emergent in complex system
  - Multiple Classrooms
    - Diverse group of teachers
    - Support required

9

Curriculum Research Framework

- **Summative**
  - Small Scale
    - 4-10 classrooms
  - Large Scale
    - Scale up, studying moderators and mediators for explanatory power (contextual, implementation variables)

      Fidelity of implementation and sustainability on a large scale (of effects and implementation)
    - Diffusion theory; overlapping spheres of influence models

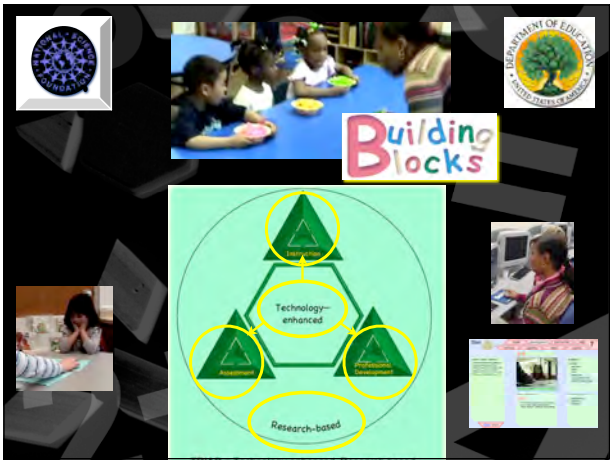
10

TRIAD Model

Also from extensive research review…

…adds specificity to *diffusion theory* and *overlapping spheres of influence theory*, to maintain the integrity of an innovation through increasingly complex socially-mediated filters, throughout phases of introduction, dissemination, adoption, implementation, and institutionalization.

11



12

10 Research Guidelines

1. Involve, and promote communication among, key groups
   - emphasizing a shared understanding of, and connections between, the project's goals, national and state standards, and greater societal need
2. Promote equity
3. Plan for the long term

13

10 Research Guidelines

4. Place research-based learning trajectories at the core
   - so that curriculum, materials, instructional strategies, and assessments are aligned with each other, research, standards
5. Build expectation and camaraderie to support a consensus around adaptation

14

10 Research Guidelines

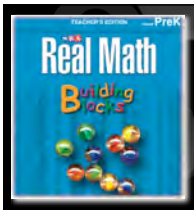
6. Provide professional development that is
   - multifaceted,
   - extensive, ongoing,
   - reflective,
   - focused on common actions and problems of practice and especially children's thinking,
   - grounded in particular curriculum materials,
   - as much as possible, situated in the classroom.

15

10 Research Guidelines

7. Give latitude for adaptation to teachers and schools, but maintain follow-through, integrity
8. Maintain frequent, repeated communication
9. Give teachers continuous feedback from sources they trust
10. Provide incentives for all participants

16



Building Blocks

TRIAD Instruction

17

Building Blocks / TRIAD

- http://www.thebostonchannel.com/news/15776035/detail.html

18

TRIAD Assessment

19

Small Group Record Sheet

Week 2 Activity—Find and Make Groups

1 Small Collection Namer
3 Maker of Small Collections
4 Perceptual Subitizer to 4
5 Perceptual Subitizer to 5

Child's name:	Finds groups to:	Strategies/Trajectory Level:	Comments:

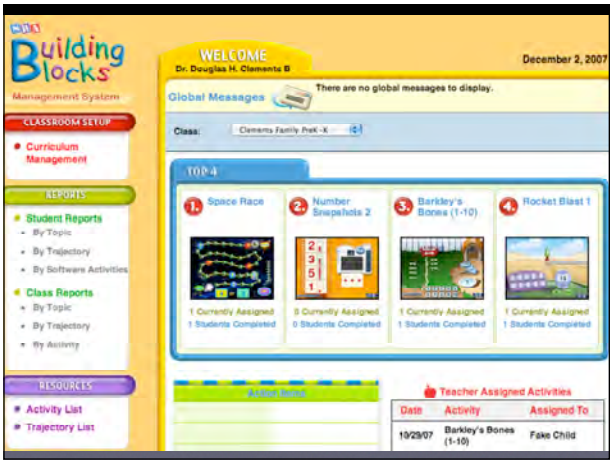
20

TEAM

TOOLS for EARLY ASSESSMENT in MATH

21

22



23

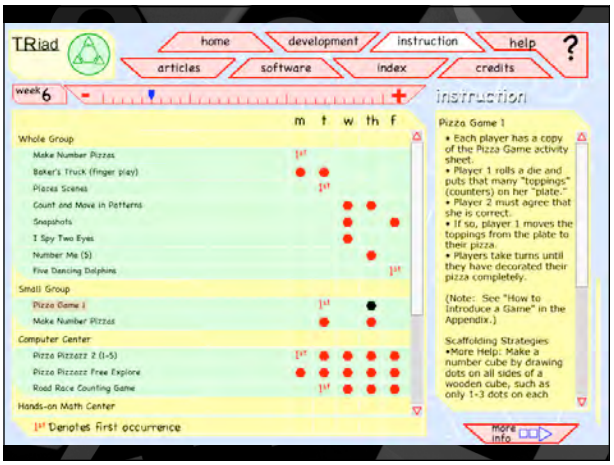
TRIA**D**

(Professional) **D**evelopment

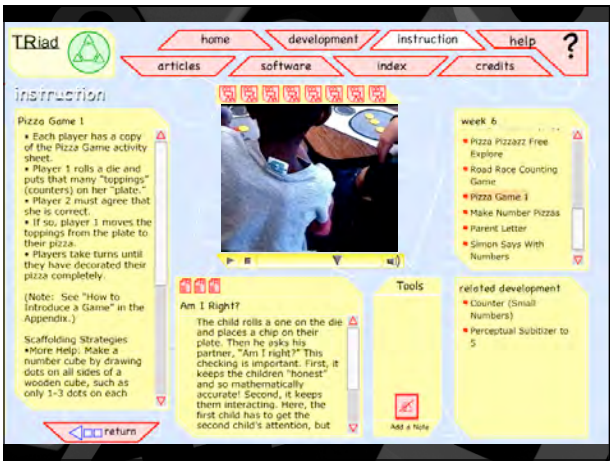
24

Teachers' Representations of Learning Trajectories: Developed Simultaneously with *BB*

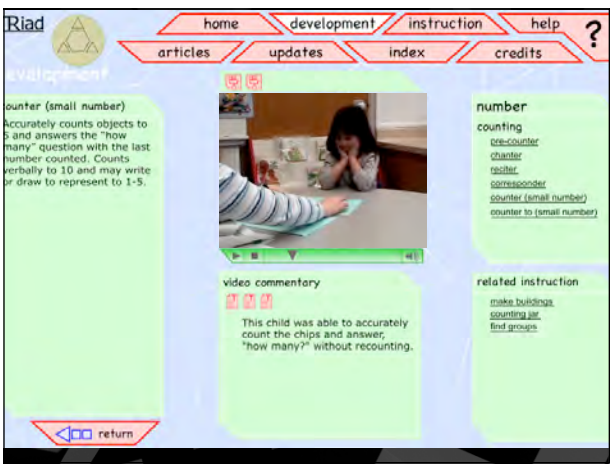
25



26

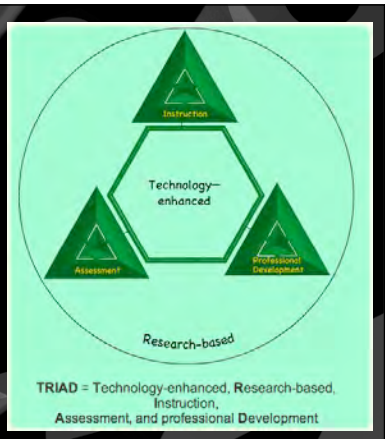


27



28

TRIAD II: Large-Scale Evaluation



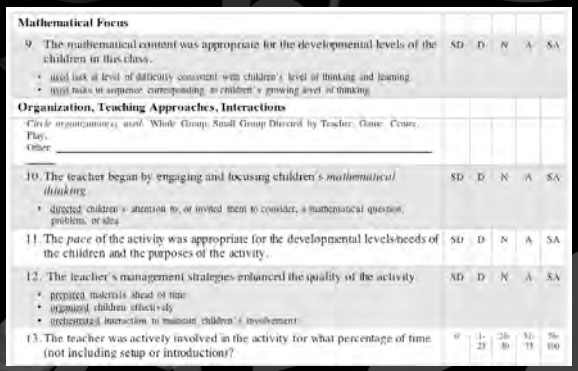
29

Research-based Observation

- Address "deep change" that "goes beyond surface structures or procedures… to alter teachers' beliefs, norms of social interaction, and pedagogical principles" (Coburn, 2003, p. 4).
- Large research review of elements of successful, engaging instruction
- Fidelity and COEMET (Classroom Observation of Early Mathematics Environment and Teaching)

30

COEMET



Mathematical Focus

9. The mathematical content was appropriate for the developmental levels of the children in this class. — SD D N A SA
   - most task at level of difficulty consistent with children's level of thinking and learning
   - most tasks in sequence corresponding to children's growing level of thinking

Organization, Teaching Approaches, Interactions

Circle organization(s) used: Whole Group; Small Group Directed by Teacher; Game; Center; Play; Other: _____

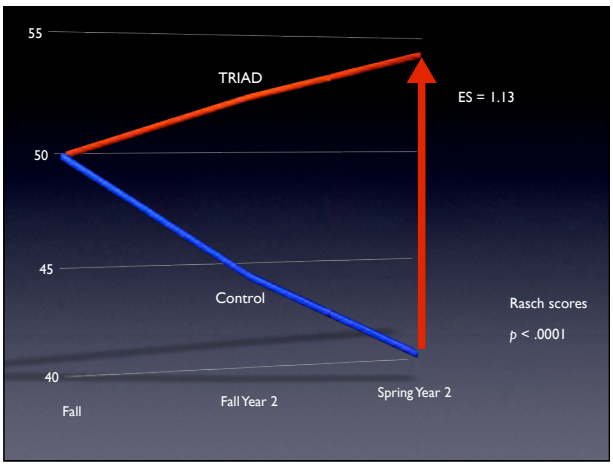
10. The teacher began by engaging and focusing children's *mathematical thinking*. — SD D N A SA
    - directed children's attention to, or invited them to consider, a mathematical question, problem, or idea

11. The *pace* of the activity was appropriate for the developmental levels/needs of the children and the purposes of the activity. — SD D N A SA

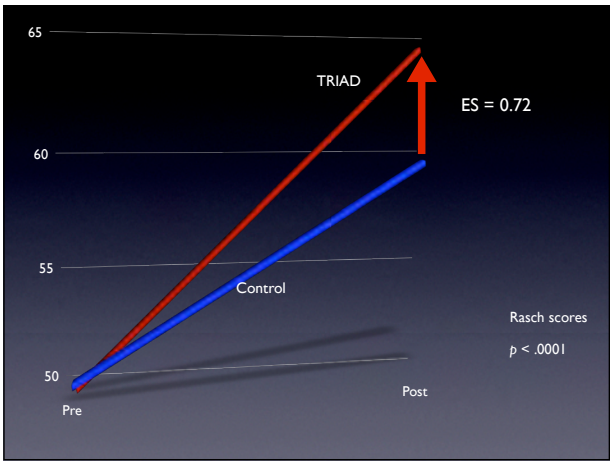
12. The teacher's management strategies enhanced the quality of the activity. — SD D N A SA
    - prepared materials ahead of time
    - organized children effectively
    - orchestrated interaction to maintain children's involvement

13. The teacher was actively involved in the activity for what percentage of time (not including setup or introduction)? — 0 | 1–25 | 26–50 | 51–75 | 76–100

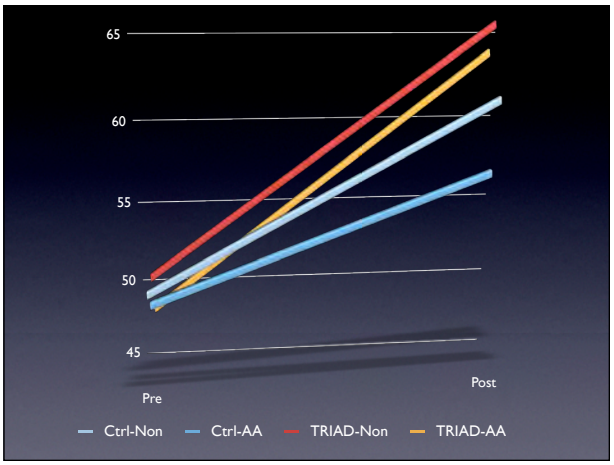
31



32


65
60
55
50
TRIAD
ES = 0.72
Control
Rasch scores
p < .0001
Pre
Post

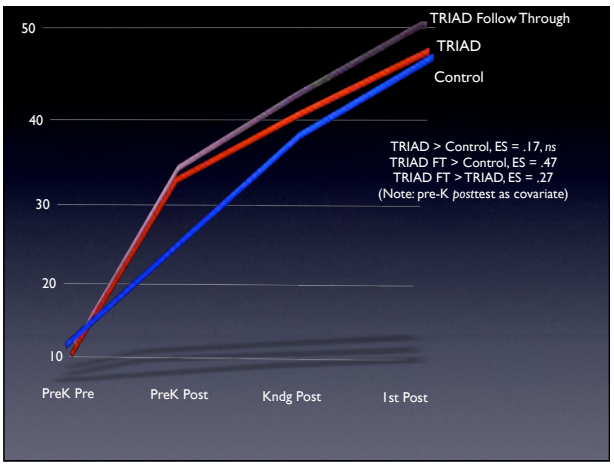
33


65
60
55
50
45
Pre
Post
Ctrl-Non
Ctrl-AA
TRIAD-Non
TRIAD-AA

34


Follow Through

35


50
40
30
20
10
TRIAD Follow Through
TRIAD
Control
TRIAD > Control, ES = .17, ns
TRIAD FT > Control, ES = .47
TRIAD FT > TRIAD, ES = .27
(Note: pre-K posttest as covariate)
PreK Pre
PreK Post
Kndg Post
1st Post

36

Conclusions

- TRIAD and *Building Blocks* can be brought to scale
- Especially important for some subgroups
- Follow Through is *necessary*

37

Necessity of Follow Through

- Only TRIAD Follow-Through maintained gains.
- Common conclusion that preschool effects fade *reifies* such effects, as if the effects' independent evanescence could be judged.
- Instead, we believe children's trajectories must be studied as they experience different educational courses.

38

Necessity of Follow Through

- Most educational contexts are unintentionally and perversely aligned against early interventions.
- Kndg., 1st grade curricula assume little competence, thus only low-level skills are taught.
- Teachers often required to rigidly follow curricula & remain unaware of what students have mastered…

39

Necessity of Follow Through

- Held accountable for largest number passing minimal competency assessments, engendering belief that higher performing are "doing fine."
- Thus, *early gains are "lost."*
- U.S. educational system *unintentionally but insidiously re-opens the gap*

40

Lessons Learned: Overwhelming

- Coaches and mentors demonstrate the implementation of all components of the curriculum, doing activities right in the classroom
- Establish a strong, flexible, responsive system of coaching and mentoring

41

Lessons Learned: Lack of Time

- Use coaches and mentors to demonstrate, on-site, in real classroom situations, the ease with which these math activities fit into the child's natural everyday activities, and to the natural routines of the classroom, using traditional early childhood materials (the "ah-ha" moment for teachers).
- Have teachers note, at PD, how long curriculum activities actually take.
- Reassure teachers that time issues fade during the year as teachers get a sense of the actual time demands of the curriculum.
- Have teachers observe other teachers on website teaching activities with an eye on the time.

42

Lessons Learned: Diverse Program Schedules

Build flexibility into schedules:

half day programs,

4 day per week programs

early schools, late schools

Other time constraints

Help teachers to recognize and work with this flexibility.

43

Lessons Learned: Difficulty of PD Material

- Recognize that teachers, by self-report, have limited math content knowledge (although they report that this limited knowledge is adequate).
- Learning trajectories framework consistent
- Recognize that teachers will find the LTs difficult at first (hate me in Nov. and Dec.); later, the LTs will make much more sense, and become a useful tool for the teachers (love me in Jan. and Feb.).

44

Lessons Learned: Technological Problems

- Recognize that some teachers have limited technological experience.
- Provide a technical mentor
- Use the "teach a person to fish" rather than the "give the person a fish" approach.

45

Randomized Trials… and Tribulations

- Teacher sharing
  (We needed the COEMET)
- IRB — Who is the subject?
  (district vs. teacher)
- Principal—My teachers are fine, so…
- Seniority/union rules—teachers moving in the middle; limited observations

46

Randomized Trials… and Tribulations

- Superintendent change: 2 stories…
  - New American Schools
  - TRIAD in Boston
- Administration support *and* stability important

47

Research Challenges

- Inchoate. Needs testing, elaboration, but…
- Ubiquity and multifariousness of claims —"research-based"—discourages science
- Domination of market "research" + post hoc
- Bias against design sciences in academe
- Unfortunate dichotomies (basic/applied, quantitative/qualitative)
- Funding timelines and structures

48

Diffusion

- Building Blocks adopted as the official mathematics curriculum for Pre-K in both Boston and Buffalo
- Mentors worked with the same districts
- That work has flourished, with the effect that every preschool teacher in the two city school districts have received the TRIAD intervention, including the Building Blocks curriculum

49

Diffusion

- Surrounding districts
  - Have begun professional development and implementation efforts

50

Limitations

- Even districts that helped support the data collection…push to limit the PD and support.

51

Web Sites (and article download)

UBTRIAD.org

UBBuildingBlocks.org

52