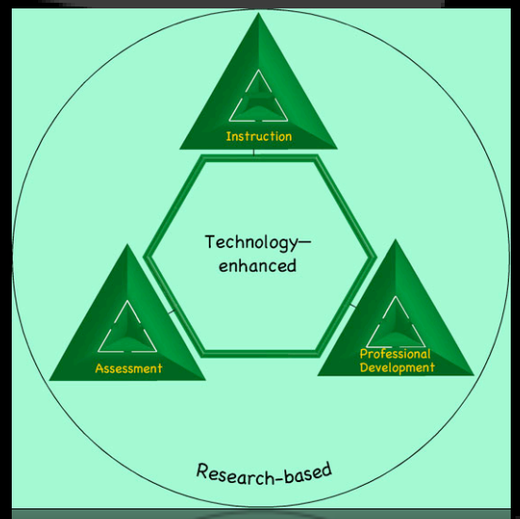
Lessons Learned About the Implementation of Large-Scale Evaluations:

- Outcomes -

Douglas H. Clements
University at Buffalo, SUNY



Research Goals

- Especially given their expense, large-scale evaluations should answer a comprehensive array of questions…

(see Clements, D. H. (in press). Curriculum research: Toward a framework for 'research-based curricula'. *Journal for Research in Mathematics Education*.)

	Practice	Policy	Theory
Effect	Effective in achieving learning goals? Credible relative to alternatives?	Effect size? Curriculum goals important?	Why effective? Why 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 do strategies produce previously unattained results?

Requirements for Outcome Measures

- *Instructional:* Beyond fidelity:
  - extensions of "compliance" fidelity *and*
  - outcome measures of quantity and quality of *environment* and *teaching* for all treatment groups
- *Student:* Valid measures of child outcomes

Measures of Instruction

- 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).
- We reviewed research concerning elements of successful, engaging instruction
- Two related measures:
  - *Proximal:* Fidelity
  - *Distal:* COEMET (Classroom Observation of Early Mathematics Environment and Teaching)

COEMET

- Quality of the mathematics environment, interactions, and activities
- Half-day observation
- Not connected to any curriculum
  - Thus, allows for experimental-comparison contrasts no matter what the source of the enacted curriculum
  - *Distal* (by analogy to transfer, "far fidelity")

COEMET

- Wide variety of items, empirically reduced to most predictive set
- Most Likert (SD D N A SA) or %
- Two sections, Specific Math Activity and Classroom Culture
  - Specific done multiple times as needed; culture once

COEMET

- Culture
  - Environment and interaction (e.g., "interacted with and responsive to children" "used computers")
  - Personal attributes ("knowledgle, confident about math")
- Activities
  - Mathematical focus ("appropriate content")
  - Organization, teaching, interactions
  - Eliciting, supporting, extending understanding, strategies
  - Assessment and instructional adjustment

Item Response Theory

- Rasch model (all instruments)
- True interval scale (especially important for analyses of gains)
- In large-scale data collection, must be robust under conditions of missing items
- Especially for child outcomes, single scale to evaluate change over the duration of the intervention…and beyond

Psychometrics of the COEMET

- Reliability
  - *Inter-rater:* 88% exact; 100% of the disagreements had same polarity
  - *Rasch person reliability:* .96
- Validity
  - *Content:* Research on effective EC math
  - *Concurrent:* Correlation with teacher rankings
  - *Predictive:* Accounted for sig. amount of variance in children's gain scores (correlation: .50)

Fidelity

- Based on same body of research
- *Proximal*, but beyond simple "compliance"
  - to evaluate *quality* and *quantity* of interaction, environment, and activities
  - many approaches require creative, adaptive enactment, not following script
  - so, philosophical foundations influence interpretation of fidelity on a *continuum from compliance to consonance* of enactment to a particular educational vision
- Ours emphasizes the interactions of teachers and children around activities

Child Outcome Measures

- General criteria for large-scale research
  - Standardized instruments chosen or developed as valid measures of the curricular goals
  - May be at least two assessment components:
    - *distal:* shared goals of all curricula + far transfer
    - *proximal:* unique goals + near transfer
      - because comparison curricula ideally selected on a principled basis, and use only of "traditional" curriculum less useful, goals of > 2 possible
  - Instruments should be sufficiently valid, reliable, and differentiated to measure nuanced differences in various content and process areas.

PCER Measures for Math

- Commercial measures
  - E.g., Woodcock-Johnson III: Applied Problems
    - Too few items at youngest items, 8
    - Narrow—7 problems deal with sets of 3 in slightly varying contexts; 1 concrete 3 + 1. No other areas.
    - Gap developmentally—jump to quite advanced, formal knowledge
    - Not all subtests given to youngest children and reliability not reported for math for young ages.
- Need comprehensive, sensitive measure

Additional PCER Measures

- Improvements
  - More sensitive
  - Broader coverage
- Some limitations remained
  - Not all items well connected to later mathematics
  - Need instrument for longitudinal evaluation, a single conjoint scale

Building Blocks Assessment

- Based on theory and consensus regarding content, beyond a single intervention
- And measure the same latent trait throughout the early years

Conference on Early Math Standards

UNIVERSITY AT BUFFALO
Graduate School of Education

ExxonMobil Foundation

NATIONAL SCIENCE FOUNDATION

Engaging Young Children in Mathematics

Standards for Early Childhood Mathematics Education

Edited by
Douglas H. Clements
Julie Sarama

Associate Editor
Ann-Marie DiBiase

Learning Trajectories

- Three components
  - Goal, developmental progression, tasks
    - descriptions of children's thinking and learning in a specific mathematical domain, and a related, conjectured route through a set of instructional tasks designed to engender those mental processes hypothesized to move children through a developmental progression of levels of thinking, created with the intent of supporting children's achievement of specific goals in that mathematical domain (special issue, MTL)
  - For *assessment*, developmental progression
    - explication of the mental constructions (actions-on-objects) constitute children's thinking at each level
    - how they are incorporated in each subsequent level

Building Blocks Assessment

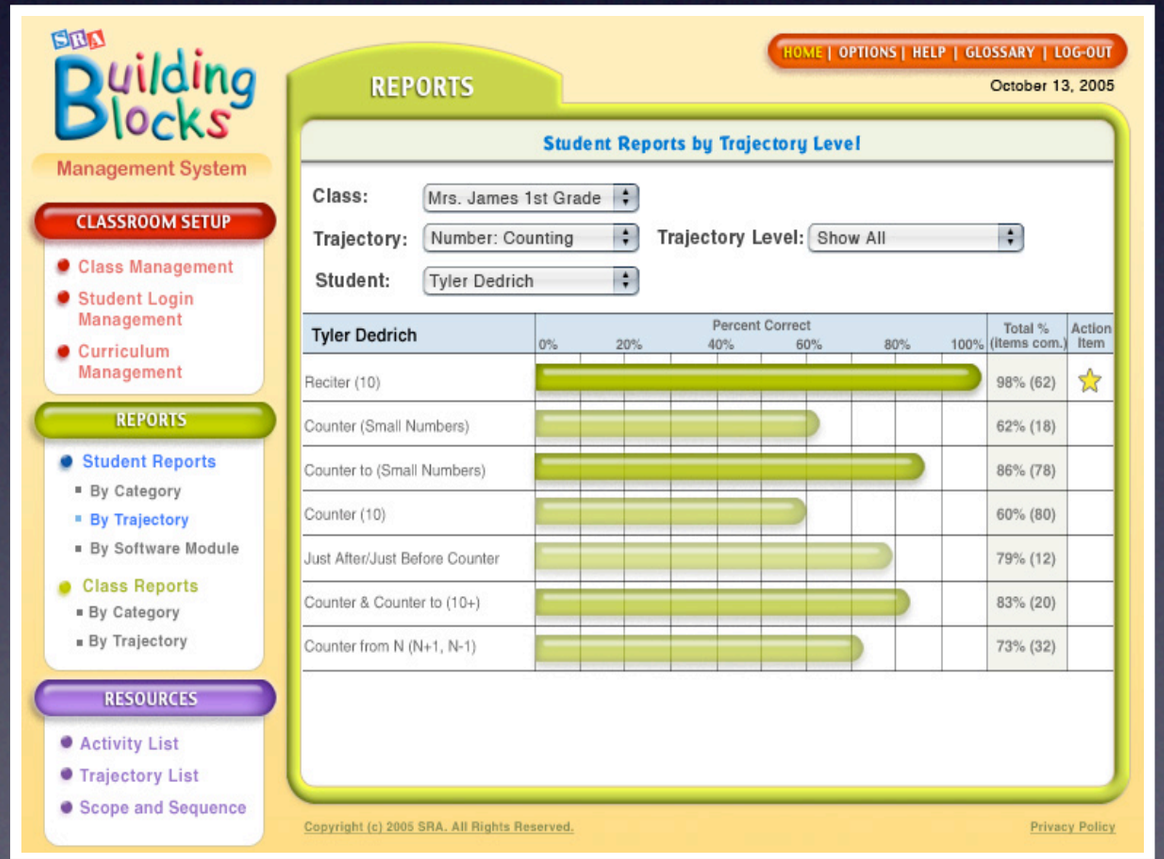
- Individual interview format, with explicit protocol and scoring procedures.
- Abilities assessed according to theoretically- and empirically-based developmental progressions
- Accurate answers *and* solution strategies
- Entry point determined via initial screening
- Floor (4 consecutive correct) and ceiling (4 consecutive errors)
- Appropriate for children with disabilities
  - individually administered
  - no strict time limits on responses
  - provides materials and illustrations
  - allows for varied response formats

Building Blocks Assessment

- Number
  - verbal counting (forward, back, before/after; identifying mistakes)
  - object counting
  - subitizing
  - comparison
  - sequencing
  - numerals
  - de/composition
  - add/subtracting
  - place value
- Geometry
  - shape identification
  - de/composition
  - congruence
  - construction
  - turns
- Measurement
- Patterns

Computer Assessment and Reporting

- Along the learning trajectories
- Automatic data collection (item level for drills, learning trajectory levels for other)

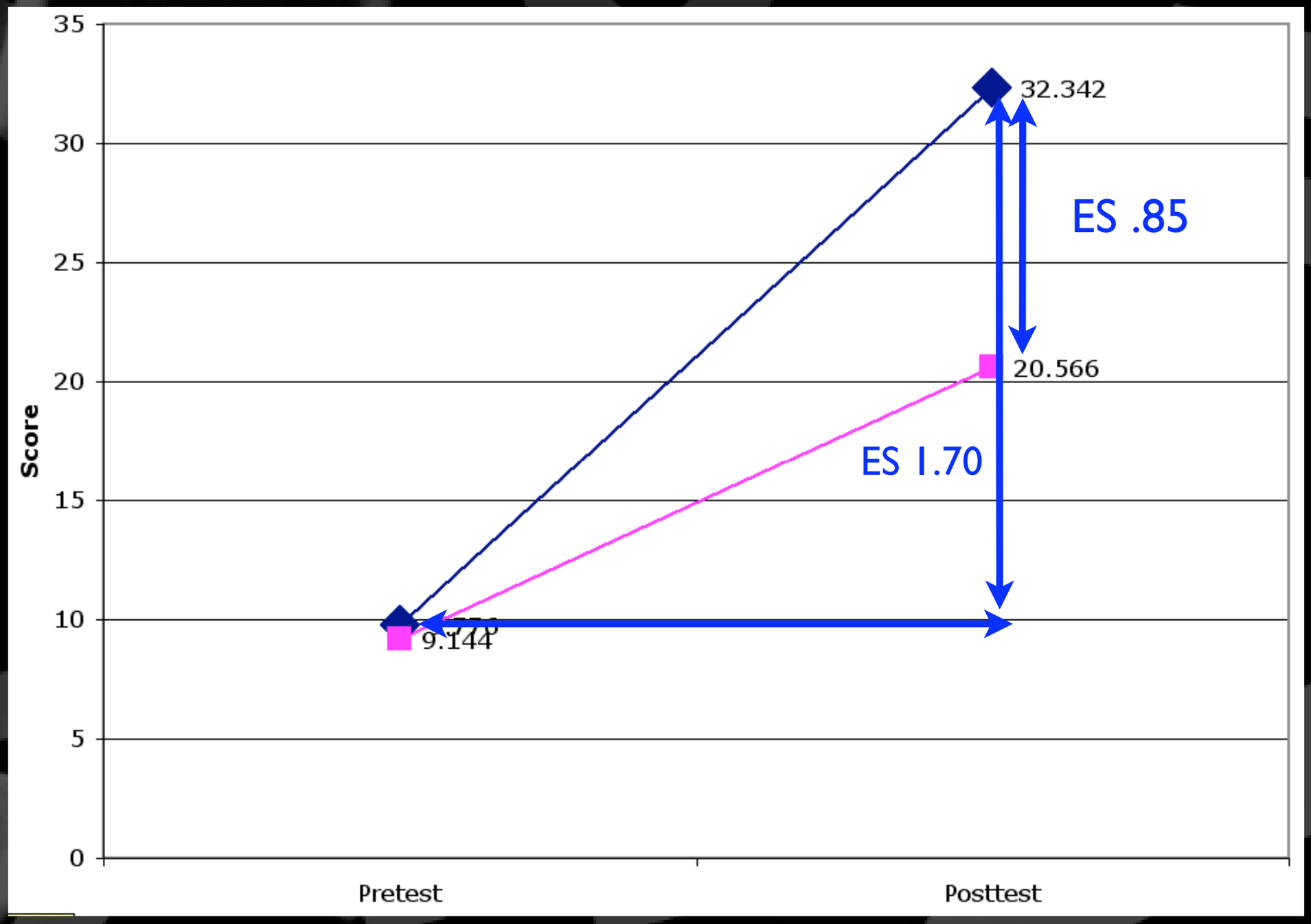


Building Blocks
Research Results

Small-Scale Summative Evaluation

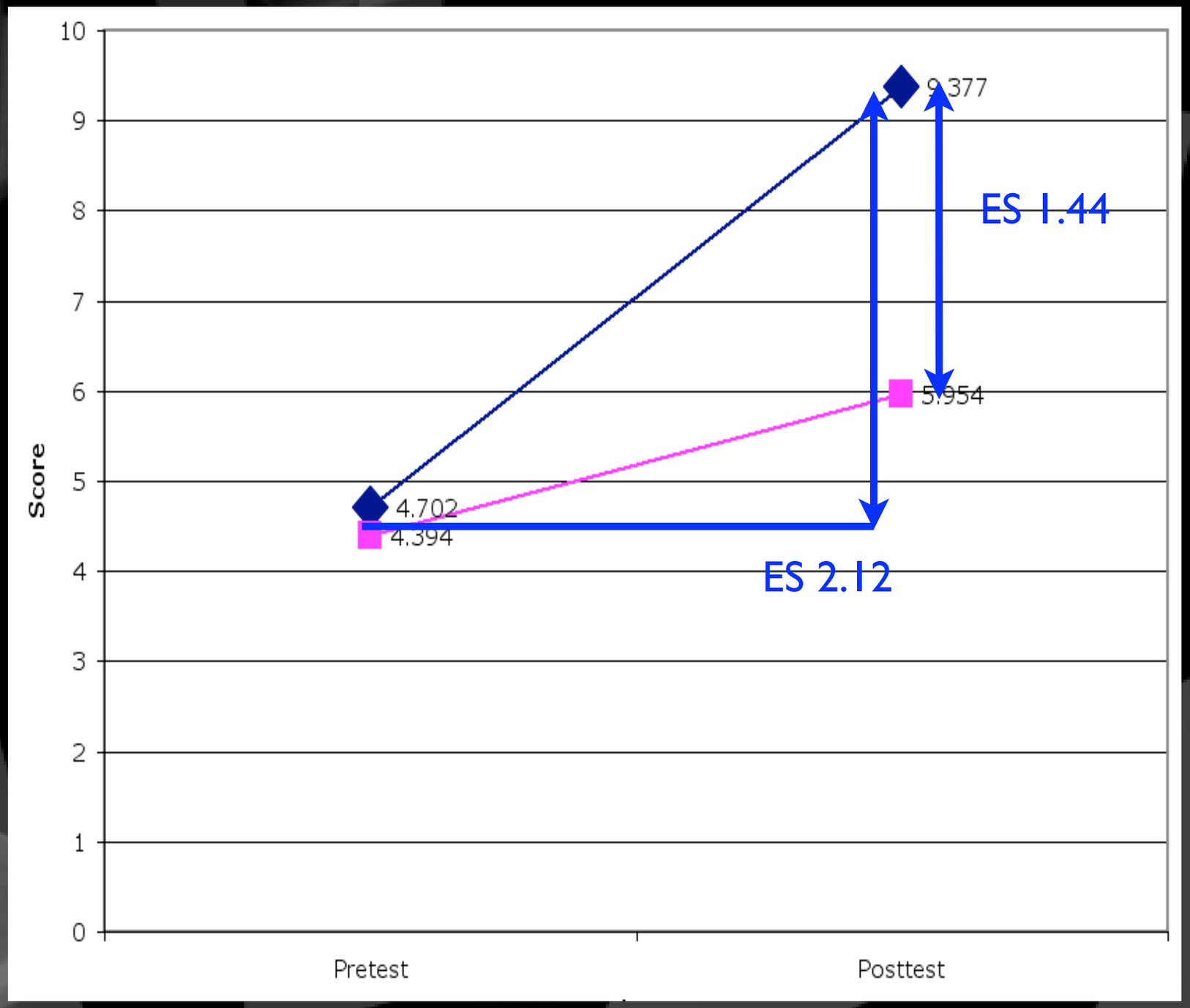
Clements, D. H., & Sarama, J. (in press). Effects of a preschool mathematics curriculum: Summary research on the Building Blocks project. *Journal for Research in Mathematics Education*.

Summative Research: Effect Sizes—Number



Summative Research: Effect Sizes—Geometry

(Bloom's famous "2-sigma effect")



Measures

- Assessed reliability, validity of all instruments
- Quantitative analyses to eliminate non-predictive and redundant items, yielding a parsimonious instrument
- Qualitative observations to triangulate, evaluate validity

Limitations

- Small scale
  - low *n*; 4 classrooms
  - child was unit of analysis
- Ideal conditions
  (Cronbach's "Hyper-realization")
- Therefore…

Building Blocks

Large-Scale Research

(see Web sites at end for papers)

Research Questions

- Can *Building Blocks* be implemented with high fidelity?
- Does *Building Blocks* have substantial positive effects on the quality of the mathematics environment and teaching?
- On children's mathematics achievement?
- If so, does 2 mediate 3?

Results—Fidelity

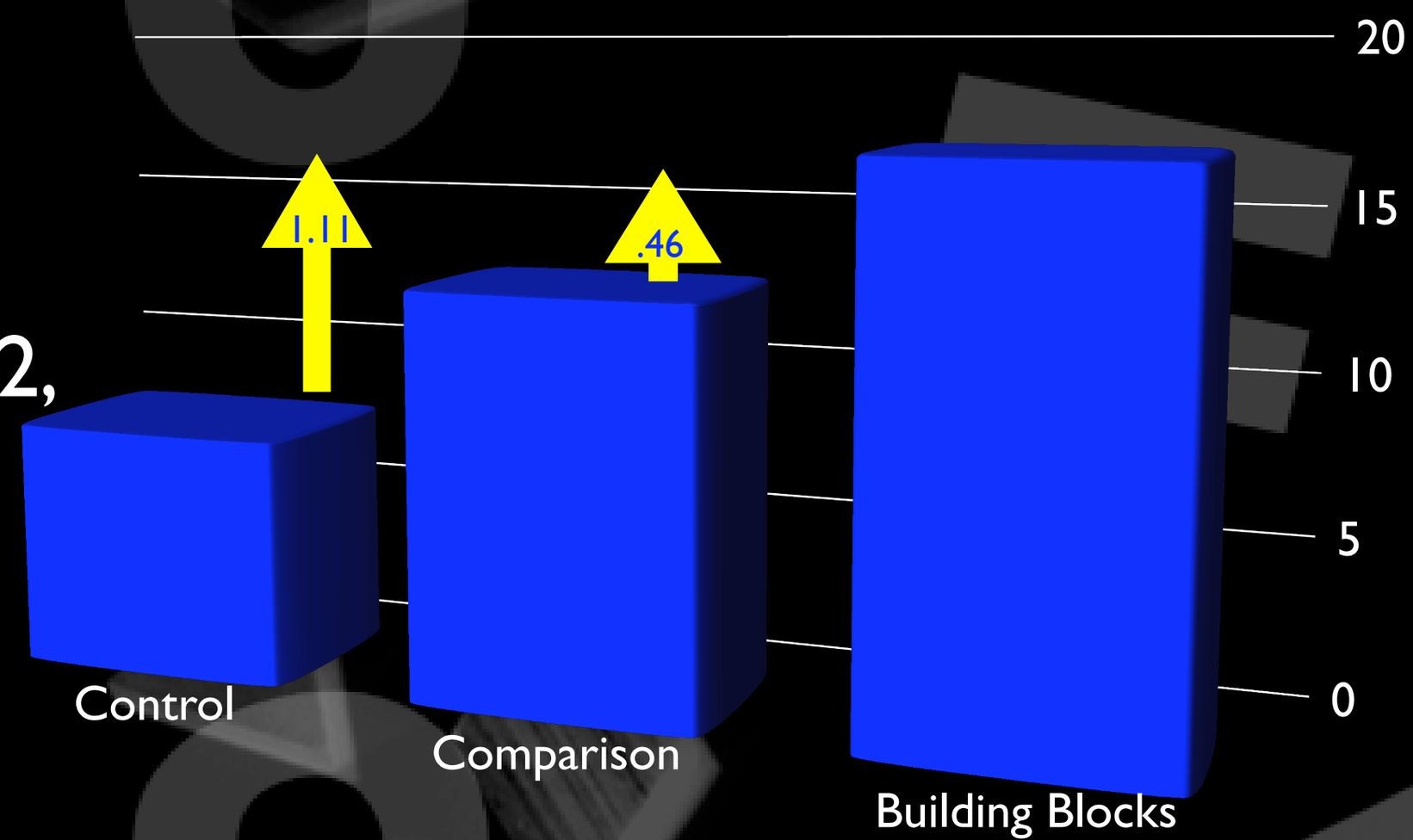
- BB averaged 3.0 on Likert Scale (Comparison was 2.8)
- Rasch T Score showed no sig. difference by treatment, time, or interactions.
- Correlated positively, but not sig., with child gain (but volunteers...wait for TRIAD II; e.g., our phantom teacher)

Classroom Observation

- No sig. change over time or interactions—differences from beginning were maintained
- *Building Blocks* sig. more math, higher quality math, than control ($p < .001$, ES = 1.25), marginally than Comparison ($p = .06$)
- Predictive of child gain: $r = .50$
  - Highest: % teacher active, built on/elaborated children's ideas/strategies, and facilitated children's responding

Results: Child Assessment

- $F(1, 32) = 40.52$, $p = .000+$
- T Scores:
  - 50 Mean
  - 10 SD



Mediational Hypothesis

- Does Classroom Observation mediate the effects of treatment on child gain scores?
  - Baron and Kenney…
- Not strong evidence, but reduced variance, so evidence for partial mediation

Research Q&A

- *Building Blocks* can be implemented with high fidelity in diverse settings; no changes
- *Building Blocks* has a positive effect on the quality of the mathematics environment and teaching
- *Building Blocks* has a substantial positive effect on mathematics achievement
- Some evidence that 2 mediates 3

Conclusions

- Large-scale evaluations should answer a comprehensive array of research questions
- To do so, need both *instructional* and *student* levels
- Measures should be
  - sensitive
  - comprehensive, connected to proximal and distal goals
  - theoretically grounded (e.g., research base for observation of instruction; developmental sequences for student outcomes)…

Conclusions: Observations

- Need both *proximal* and *distal* measures
- Both address "deep change" and
- *Related, b*oth based on common research foundation

Conclusions: Observations

- Full individual observations (not "pieced together") more important than frequency
  - 2-3 observations adequate for evaluation
  - although more frequent mentoring/coaching visits are promote professional development (especially analysis) and fidelity

Conclusions

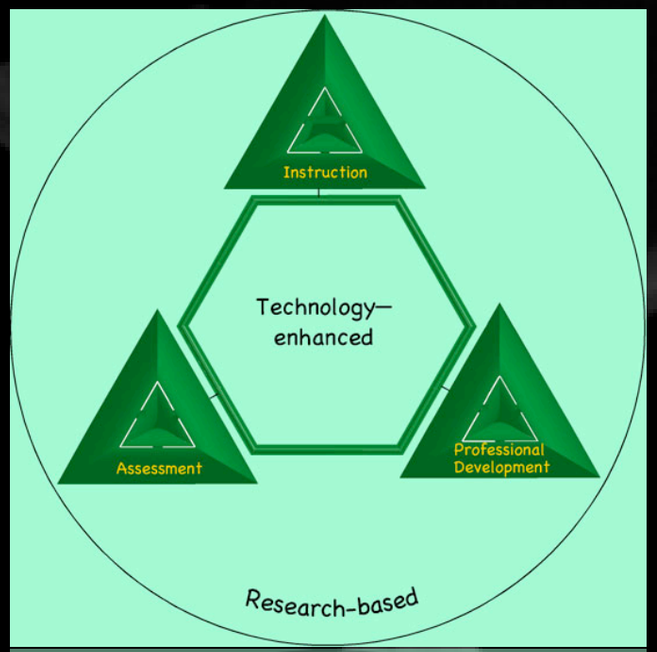
- Measure coherent, unidimensional latent traits, producing interval measures that are linear and additive.
- True interval scale important for analyses of gains
- Robust under conditions of missing items
- Single scale to evaluate change over the duration of the intervention

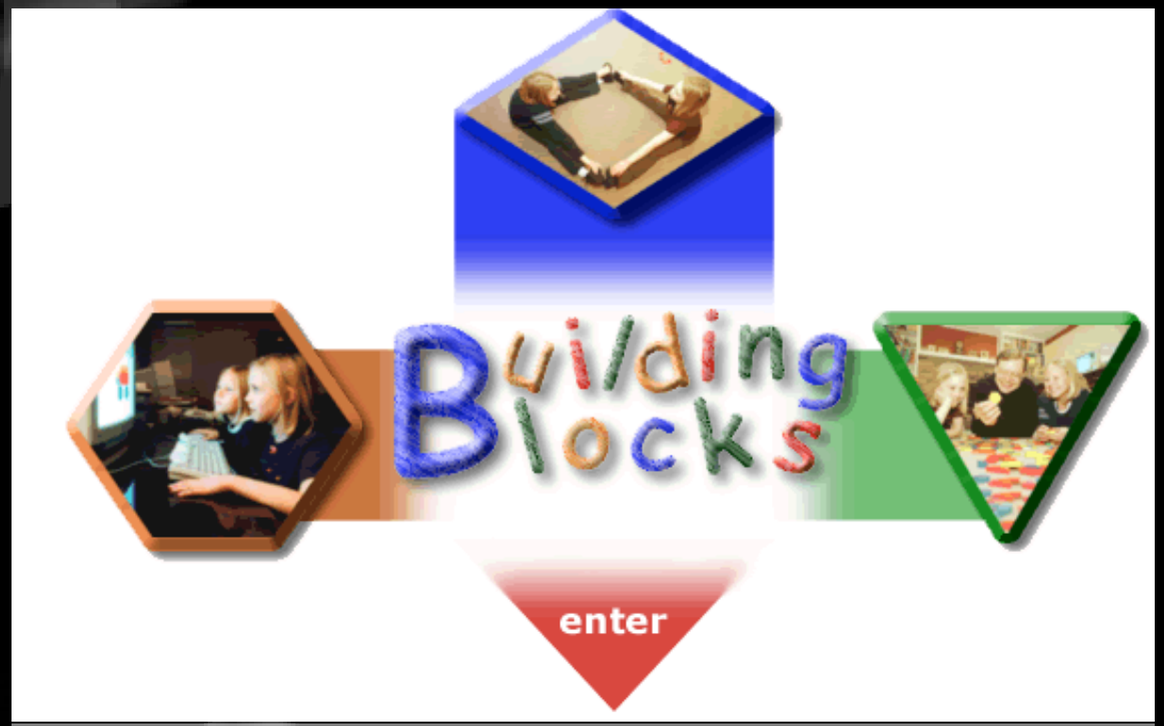
Conclusions

- Connections among measures; otherwise, inadequate basis for contributing to theories of learning and teaching in complex settings

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





UBTRIAD.org

UBBuildingBlocks.org