

# Promoting High-Quality Math and Science Learning in Kindergarten

February 14, 2023

# Moderator



**Laura Bornfreund**

Senior Fellow and Advisor on Early & Elementary Education  
New America

# Presenters



**Douglas Clements, Ph.D.**  
*Distinguished University Professor  
and Kennedy Endowed Chair in  
Early Childhood Learning*  
University of Denver



**Cindy Hoisington**  
*Project Director*  
Education Development Center  
Waltham, Massachusetts  
[choisington@edc.org](mailto:choisington@edc.org)



**Chih-Ing Lim, Ph.D.**  
*Co-Director*  
STEM Innovation for Inclusion in Early  
Education  
*Senior Technical Assistance Specialist*  
Frank Porter Graham Child  
Development Institute, University of  
North Carolina at Chapel Hill 7

# Presenters



**Lauren Solariski, Ph.D.**  
*School of Education Part-Time Faculty*  
Loyola University Chicago



**Jessica Tilli**  
*Math Curriculum Specialist*  
The School District of Philadelphia

**EDC**

Education  
Development  
Center

# SCIENCE TEACHING IN KINDERGARTEN

From Research to Classroom  
Practice

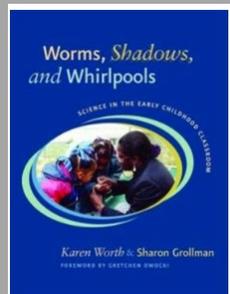
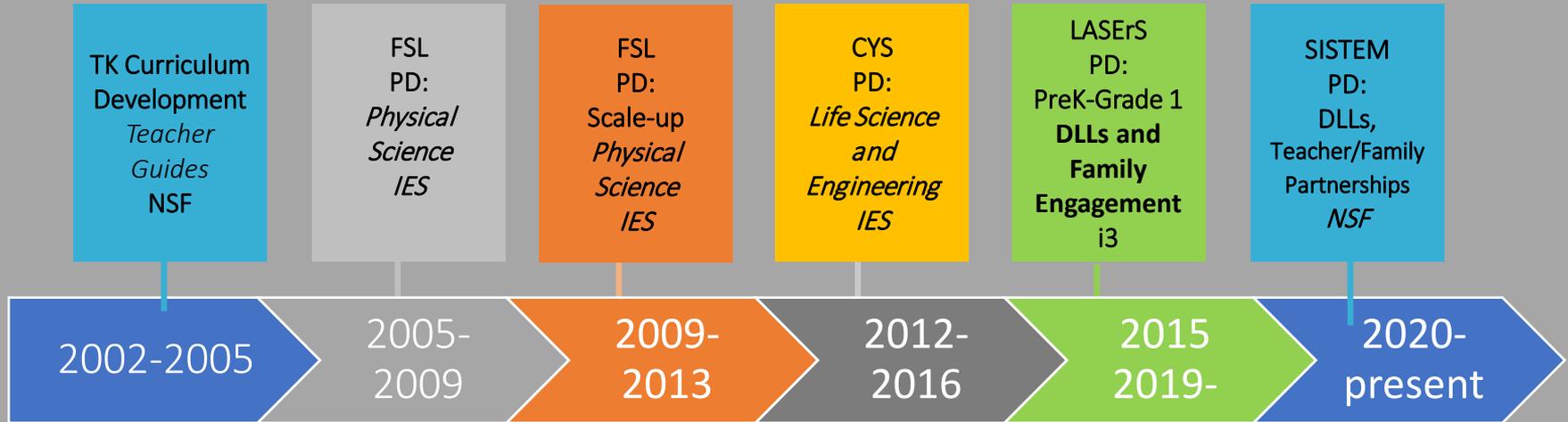
Cindy Hoisington

Education Development Center

Waltham, Massachusetts



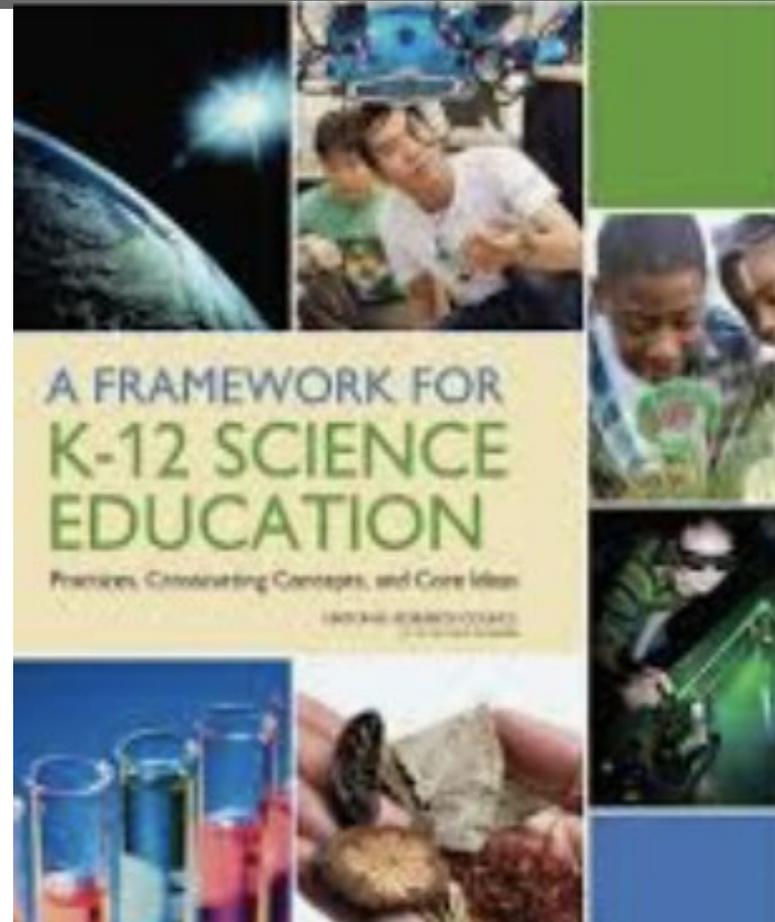
# EDC Stream of Work: Foundations of Science Literacy



- TK: Tool Kit for EC Science (Young Scientist Series (YSS))
- FSL: Foundations of Science Literacy
- CYS: Cultivating Young Scientists (CYS)
- LASERs: Literacy and Academic Development for English Learners through Science
- SISTEM: Supporting Science Inquiry, Interest, and STEM Thinking with Young DLLs

# What does the Research Say?

- Students *learn* science *by doing* it.
- Kindergarten children **are primed to** engage with science practices, crosscutting concepts, and core ideas.
- ***Science*** and ***Literacy*** are better ***together*** and **TALK** is essential.
- ***Science interests, and self-identities*** must be nurtured early or they diminish rapidly.



# What does the Research Say?

## EDC's LASERS Project (Literacy and Academic Success for English Learners through Science)

### Teacher outcomes:

- More student engagement in science
- Presence of high-level adult-facilitated talk
- Greater promotion of children's scientific thinking

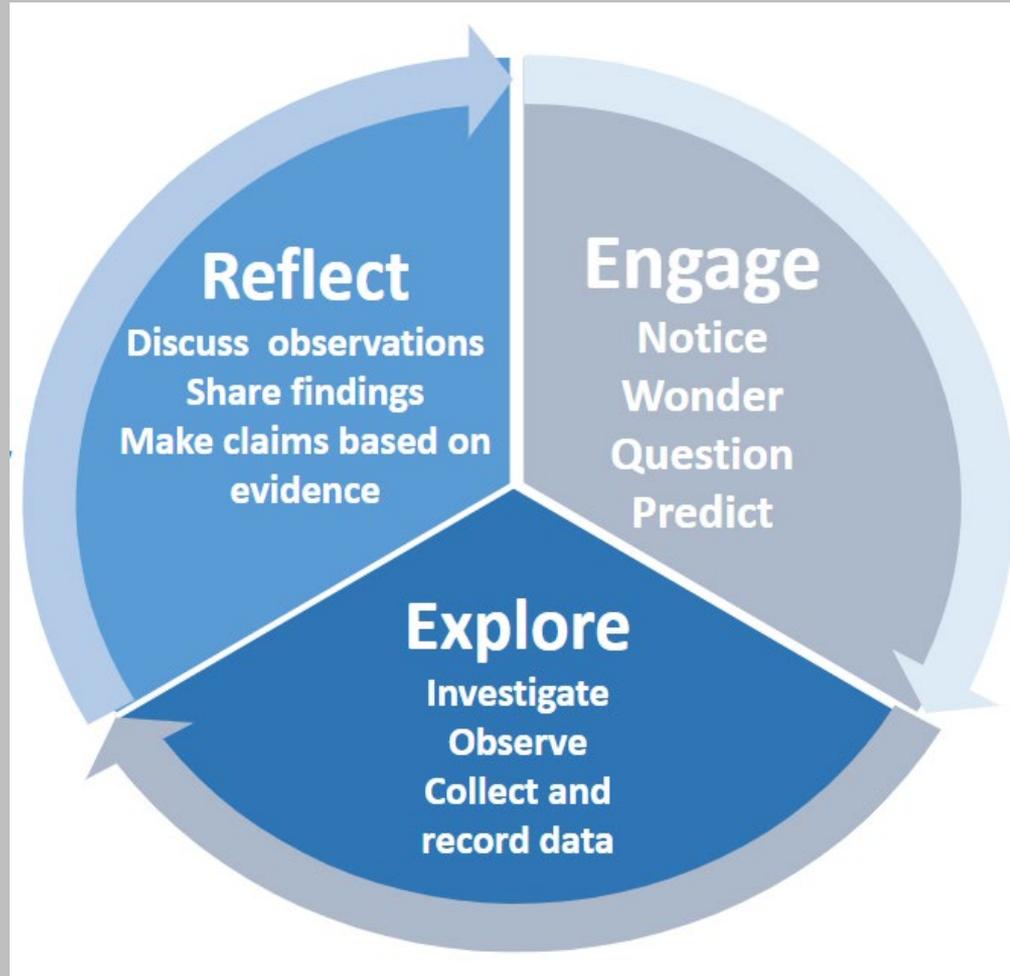
### Student Outcomes:

- Significant improvements in K and Grade 1 students' language and literacy outcomes, as measured by district assessments, including for DLL students.



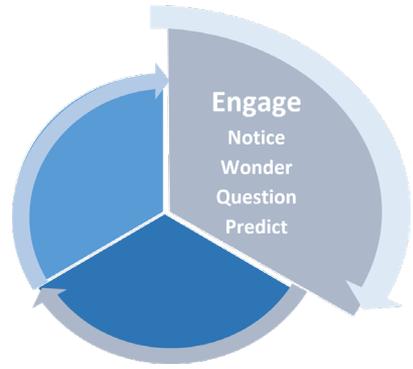
# A Focus on *Doing* Science

- *A hands-on, minds-on process*
- Many opportunities for *sense-making, higher-order thinking, and language.*
- *Incorporates the NGSS science practices*
- *Used in the service of learning concepts and core ideas*





## What does this look and sound like in Kindergarten?



Children and teachers notice, wonder, and raise questions about interesting phenomena.



**Teacher:** *Do you think this cardboard tube will slide or roll? What makes you think so?*



They plan and carry out collaborative investigations and collect and record data.

**Teacher:** *How did you get the bottle cap to roll instead of slide that time? What did you do differently? Let's write it down.*



They share and discuss their findings and look for patterns.



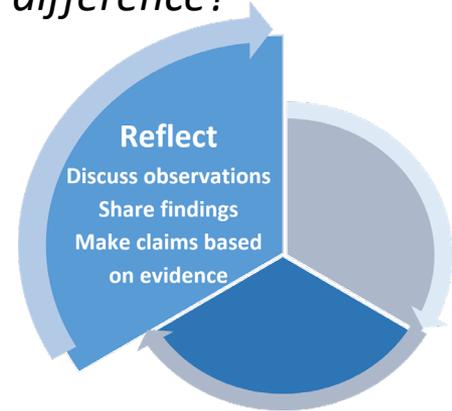
**Teacher:** *Can you tell us what happened when you used the golf ball? How did the two balls roll differently? Why do you think so?*

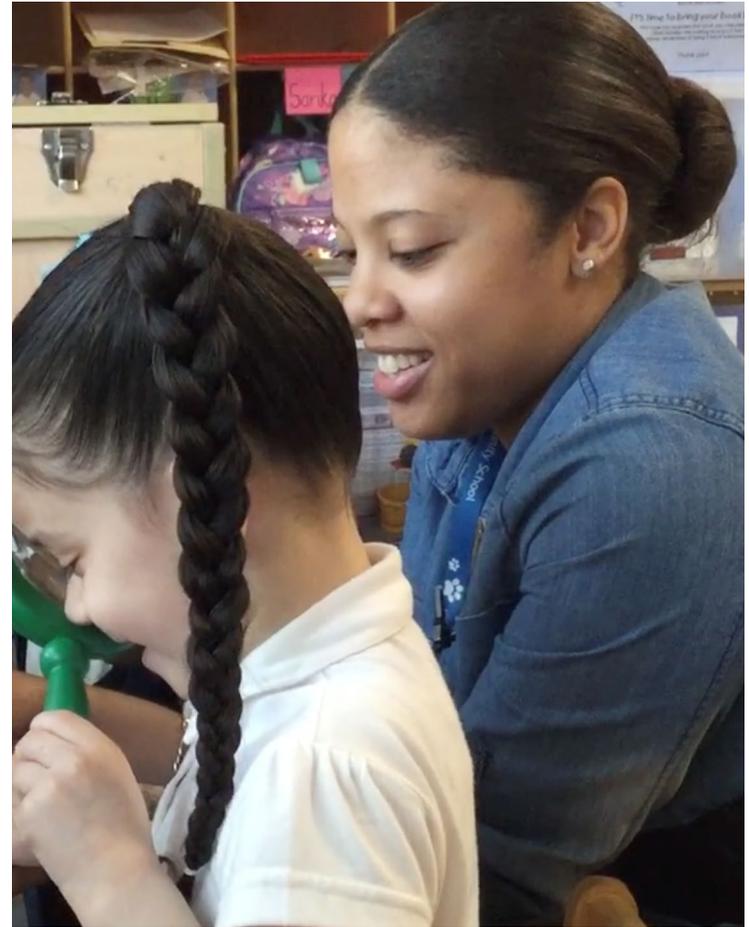
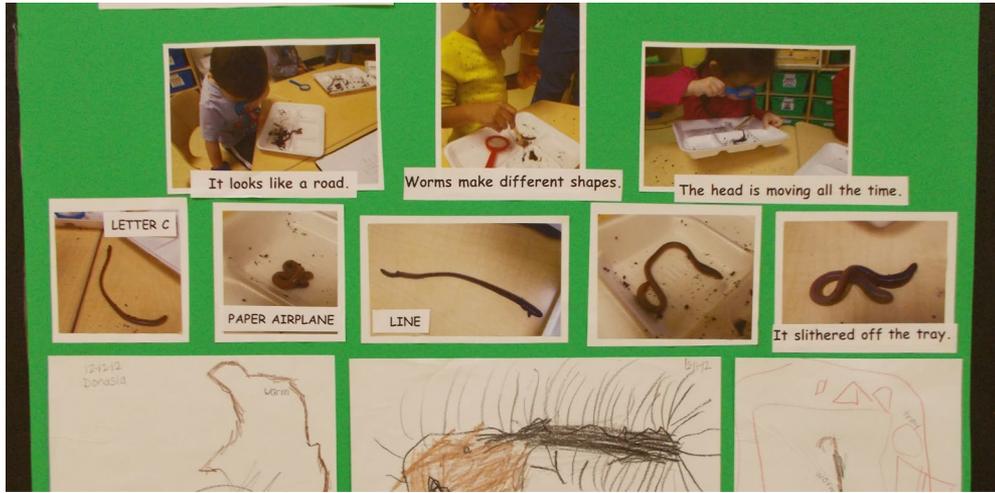


**They make claims based on evidence and raise new questions.**



*Are you thinking that soft balls roll farther than hard balls on the rug? How could we find out more about how the texture of the ball makes a difference?*





## What Teachers DO in these Classrooms...

- Introduce ***interesting phenomena*** connected to big science ideas for children to investigate
- Ask ***productive questions*** that promote inquiry and thinking
- Observe, co-explore, support, and extend learning
- Provide many ways for children to ***communicate their ideas and thinking***

# What Supports Do Teachers Need?

- PL that builds knowledge of science content, inquiry, and integration
- Explicit strategies for supporting children's inquiry and inclusion
- Concrete materials and resources
- On-going and consistent support from district and school administrators



# Surprise #1: Math's Predictive Power



Large-scale research. (Duncan et al., 2007).



# Math and More

- Develops critical thinking and problem-solving
- Develops executive function (self-regulation)
- Develops social-emotional competencies
- Develops language abilities, including the *language of math...and more*
- Over a lifetime, positive effects of early math compound, and *we all benefit* from investing in children's early math learning—birth through grade 3.

# OK, Really? *Thinking?*

Students who specifically *lack* math education showed *reduced* brain levels involved in reasoning and cognitive learning!

Zacharopoulos, G., Sella, F., & Cohen Kadosh, R. (2021). The impact of a lack of mathematical education on brain development and future attainment. *Proc Natl Acad Sci U S A*, 118(24). <https://doi.org/10.1073/pnas.2013155118>

# OK, Really? Executive Function?

- Yes!
- EF most related to math.
- EF *in* math—2 for 1.
- More effective than specific EF approaches.
- More resources:



### Intentional Teaching Moments

#### Supporting Executive Function Development and Early Mathematics Through a Geometry Activity

Holland W. Basse, Douglas H. Clements, Julie Sarama, Crystal Day-Hess, Marisa Simon, and Candace Jewick

Preschool teacher Alexis hands her 4-year-old student, Tina, a “feely box”—a decorated shoebox with two holes on either side and socks with the toes cut off attached to those holes. This design lets children place their arms inside the box and feel what is in it without peeking. Inside the box, there is a single, three-dimensional triangle. Tina feels the triangle with her hands but cannot see it. Alexis begins to ask Tina questions about what she feels as other children wait for their turns with the feely box.

**Alexis:** How many sides does it have?  
**Tina:** (after a minute, counting quietly) Three!  
**Alexis:** How do the sides feel?

Contents lists available at ScienceDirect

## Early Childhood Research Quarterly

ELSEVIER

Review

### Learning executive function and early mathematics: Directions of causal relations

Douglas H. Clements\*, Julie Sarama, Carrie Germeroth

University of Denver, United States

ORCID iD

ARTICLE INFO

Article history:  
Received 13 May 2015  
Received in revised form 6 December 2015  
Accepted 19 December 2015

Keywords:  
Executive function  
Self-regulation  
Mathematics education  
Intervention  
Early childhood education  
Early childhood centers

ABSTRACT

Although there has been much recent attention to young children’s development of executive function and early mathematics, few studies have integrated the two. Here we review the evidence regarding executive function and mathematics achievement in the early years. After defining the executive function processes we consider, we briefly address the question of whether executive function can be taught in schools. We then turn to the relations between executive function and achievement. We begin with a review of the larger literature on correlations between the two, both concurrent and predictive. This leads to the fewer but more directly educationally-relevant causal studies. We conclude that developing both executive function processes and mathematical proficiencies is essential for young children and suggest that high-quality mathematics education may have the dual benefit of teaching this important content area and developing executive function processes.

© 2015 Elsevier Inc. All rights reserved.

Journal for Research in Mathematics Education  
2020, Vol. 51, No. 3, 301–333

### Effects on Mathematics and Executive Function of a Mathematics and Play Intervention Versus Mathematics Alone

Douglas H. Clements and Julie Sarama  
University of Denver

Carolyn Layzer  
ABI Associates

Fatih Unlu  
RAND Corporation

Lily Fesler  
Stanford University

Early education is replete with debates about “academic” versus “play” approaches. We evaluated 2 interventions, the *Building Blocks* (BB) mathematics curriculum and the BB synthesized with scaffolding of play to promote executive function (BBSEF).

# OK, Really? Social-emotional?

- Yes!
- Collaborative thinking, turn-taking in games...and
- Sharing! Counting competence *strongly* related to sharing



The screenshot shows the top portion of a journal article page. On the left, there is a blue header with the text 'CHILD DEVELOPMENT' and a logo. Below this, it says 'EMPIRICAL ARTICLE' and the title 'A counting intervention promotes fair sharing in preschoolers'. The authors are listed as 'Nadia Chernyak, Paul L. Harris, Sara Cordes'. On the right, there is a thumbnail of the journal cover for 'Volume 93, Issue 5', 'September/October 2022', 'Pages 1365-1379'. At the bottom right, there are two icons: 'Related' (a network icon) and 'Information' (an 'i' icon).

**CHILD DEVELOPMENT**

EMPIRICAL ARTICLE

**A counting intervention promotes fair sharing in preschoolers**

Nadia Chernyak, Paul L. Harris, Sara Cordes

**CHILD DEVELOPMENT**  
Volume 93, Issue 5  
September/October 2022  
Pages 1365-1379

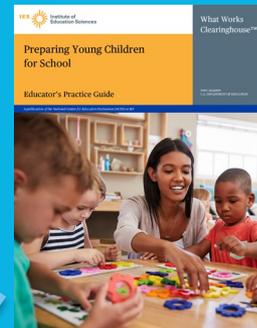
Related Information

# All Dependent on *High-quality Math*

- Asset-based, grounded in knowledge of children's thinking and *learning*:

## **Learning Trajectories**

- Children engaged, active, inventive, talking math
- Content that is *challenging but achievable...*



# Teaching Kindergarteners What they Already Know

*Educational Evaluation and Policy Analysis*  
June 2013, Vol. 35, No. 2, pp. 157–178  
DOI: 10.3102/0162373712461850  
© 2013 AERA. <http://eepp.aera.net>

## Teaching Students What They Already Know? The (Mis)Alignment Between Mathematics Instructional Content and Student Knowledge in Kindergarten

Mimi Engel  
*Vanderbilt University*

Amy Claessens  
*University of Chicago*

Maida A. Finch  
*Salisbury University*

### Mathematics Content Coverage and Student Learning in Kindergarten

Mimi Engel<sup>1</sup>, Amy Claessens<sup>2</sup>, Tyler Watts<sup>3</sup>, and George Farkas<sup>3</sup>

Analyzing data from two nationally representative kindergarten cohorts, we examine the mathematics content teachers cover in kindergarten. We expand upon prior research, finding that kindergarten teachers report emphasizing basic mathematics content. Although teachers reported increased coverage of advanced content between the 1998–1999 and 2010–2011 school years, they continued to place more emphasis on basic content. We find that time on advanced content is positively associated with student learning, whereas time on basic content has a negative association with learning. We argue that increased exposure to more advanced mathematics content could benefit the vast majority of kindergartners.

**Keywords:** achievement; descriptive analysis; early childhood; educational policy; mathematics education; regression analyses; secondary data analysis



**[LT]<sup>2</sup>** Learning and Teaching with Learning Trajectories  
Early Math - Birth to Grade 3

SIGN IN / SIGN UP    STUDENT SIGN IN

EXPLORE LTS    EXPLORE GAMES    ABOUT US    RESOURCES    HELP / HOW TO



**Explore Counting**  
ENUMERATION, CARDINALITY, & COUNTING STRATEGIES

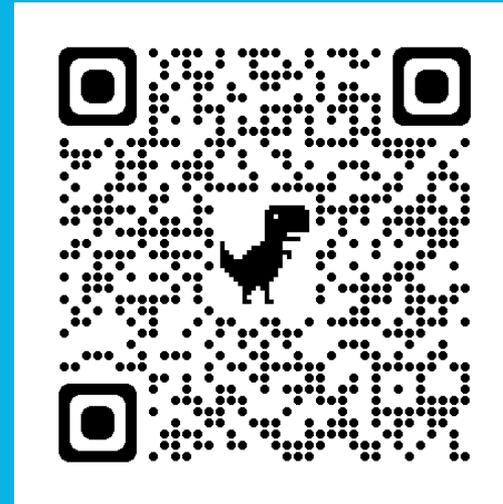
## Learning & Teaching with Learning Trajectories

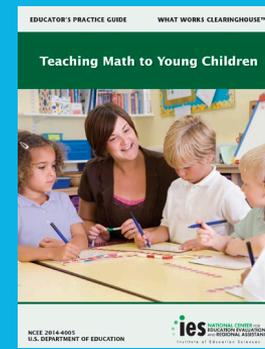
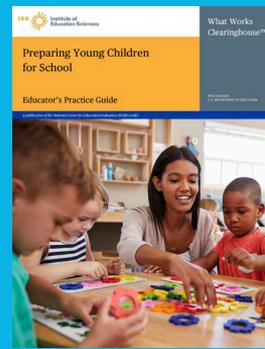
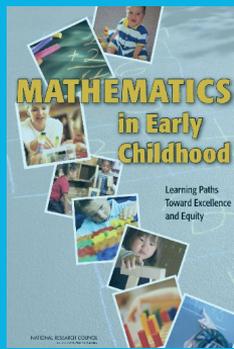
Learn about how children think and learn about mathematics.  
Try our math activities for young children (birth to age 8)!  
Get started supporting early childhood math learning!

SIGN IN OR SIGN UP



# LTs





# Learning Trajectories Work



EURASIA Journal of Mathematics, Science and Technology Education

ISSN: 1305-8223 (online) 1305-8215 (print)

2018 14(4):1263-1272

DOI: 10.29333/ejmste/82537

MATHEMATICAL THINKING AND LEARNING  
2017, VOL. 19, NO. 4, 237-259  
<https://doi.org/10.1080/10986065.2017.1365222>



## A Comparative Points

dah<sup>3</sup>

er 2017

## Using Learning Trajectories for Teacher Learning to Structure Professional Development

Anna E. Bargagliotti<sup>a</sup> and Celia Rousseau Anderson<sup>b</sup>

<sup>a</sup>Loyola Marymount University; <sup>b</sup>University of Memphis

ABSTRACT

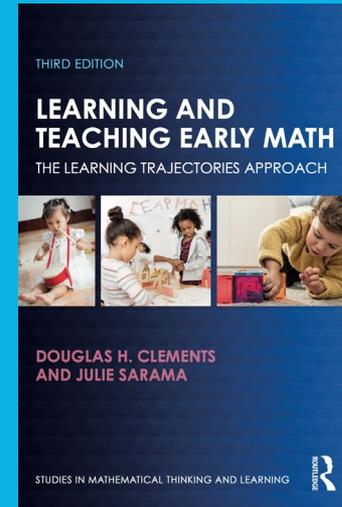
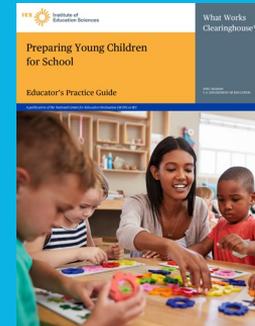
levels are in

ly  
ge  
re  
in  
ze  
ol  
id  
re  
ip  
to  
d.

[LT]<sup>2</sup>

# Contributions

- Practice-based evidence of success, scalable
- Clear guidelines
- Asset-based, grounded in knowledge of children's thinking and learning: Learning Trajectories (LTs)
- Children engaged, active, inventive, talking
- Content that is challenging but achievable...
- [www.LearningTrajectories.org](http://www.LearningTrajectories.org)

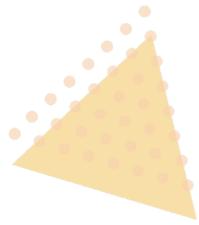


# Start with children's thinking: Learning Trajectories Approach

- Children's thinking follows a path or *developmental progression*
- Foundational levels to more and more sophisticated ways of thinking as the path moves ahead



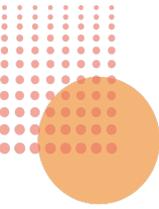
# Goal areas for young children



- Cause and effect
- Stability and change
- Compare/contrast
- Light and shadow
- Patterns
- Forces and motion
- Living and non-living
- Spatial Orientation
- Structure and Function
- Debugging
- Looping
- Causation
- Sequencing
- Repetition
- Sound
- Counting

And so much more!!!

# Use of adaptations and teaching practices can ensure children with disabilities can fully participate in science and math learning



Environment,  
activities, and routines



For example, room set-up, equipment, how an activity is done, length of time)

STEP  
01

Materials

For example, modifications to toys, materials, AT devices)



STEP  
02

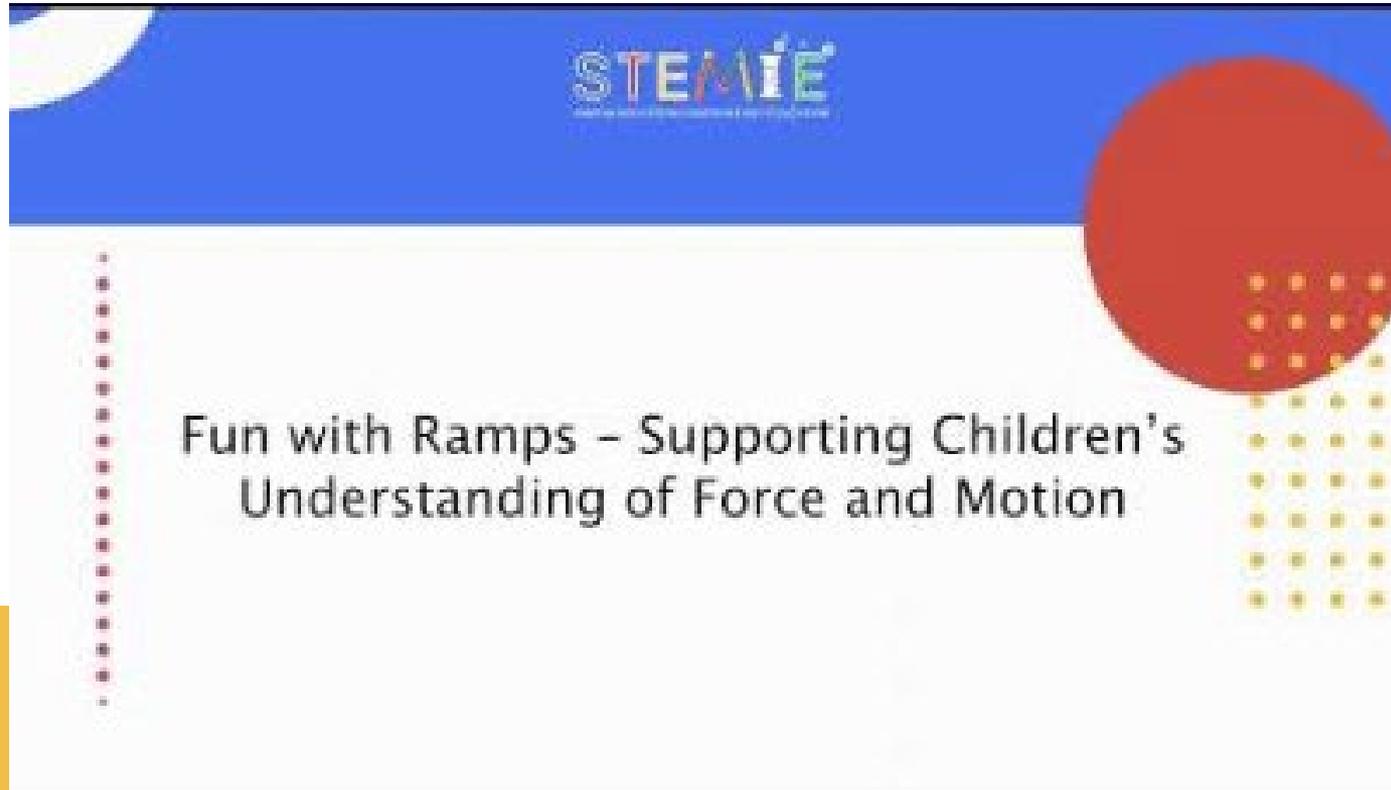


Instruction

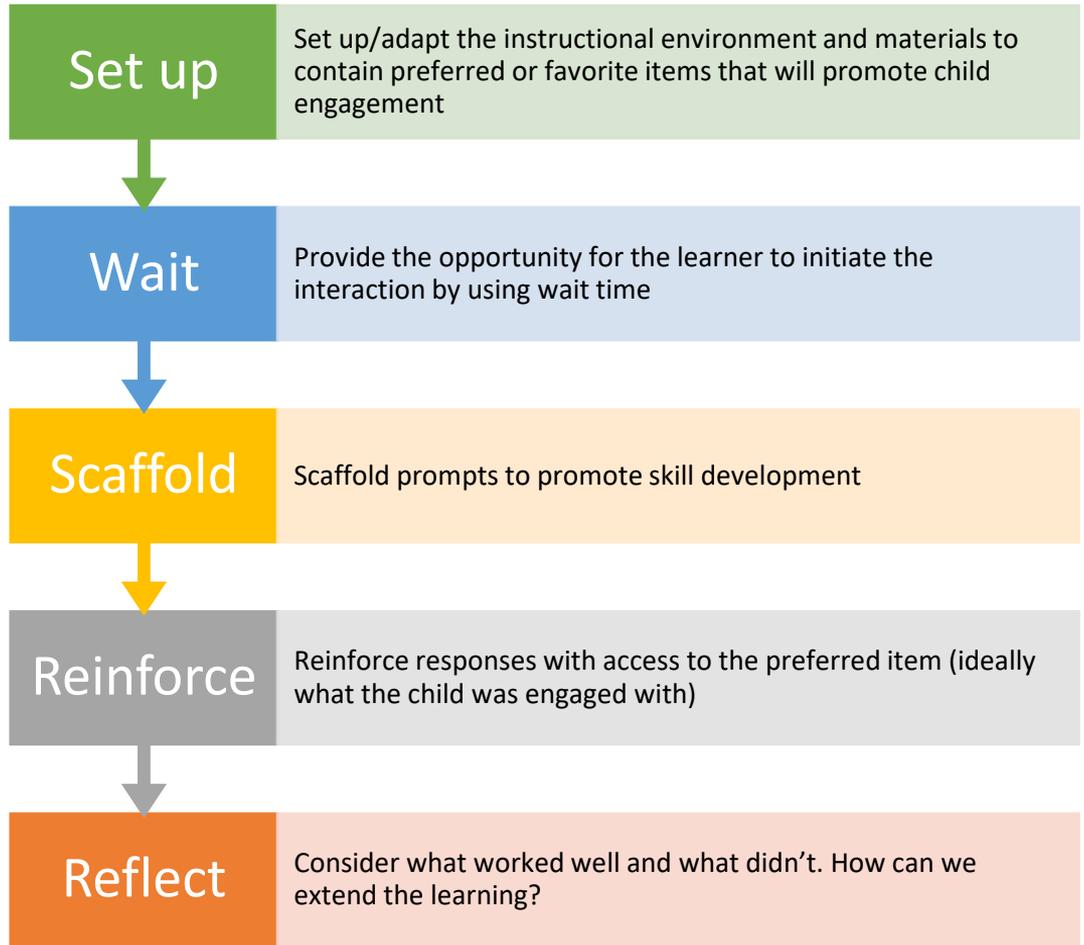
For example, adding information, reducing steps

STEP  
03

What this can look like

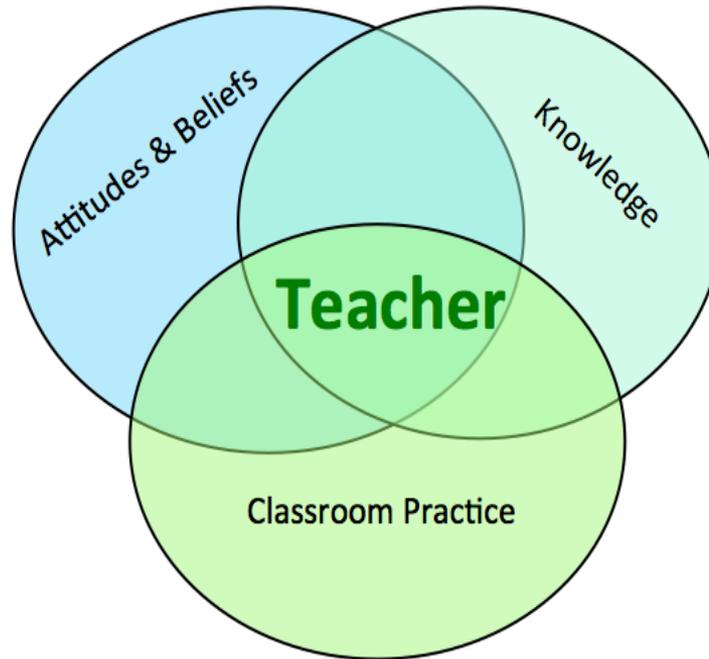


Providing  
inclusive  
science and  
math  
opportunities



# The Whole Teacher Approach

(Chen & McCray, 2013)



# Questions & Discussion

# Upcoming GLR Learning Tuesdays Webinars:

## COMMUNITY OF PRACTICE SALON

Bringing Digital Equity to All Students in the Community

Tuesday, March 14, 12:30–2:00 p.m. ET/9:30–11:00 a.m. PT

## GLR LEARNING TUESDAYS: LEARNING LOSS RECOVERY CHALLENGE

Summer and OST: Smart Investments Outside of School to Accelerate Learning

Tuesday, March 14, 3–4:30 p.m. ET/12–1:30 p.m. PT

Join us!

[gradelevelreading.net](https://gradelevelreading.net) [@readingby3rd](https://twitter.com/readingby3rd) [#GLReading](https://twitter.com/GLReading) [#LearningTuesdays](https://twitter.com/LearningTuesdays) [#GLRKeepers](https://twitter.com/GLRKeepers)





GLR 2023:  
What's Working Xchange (WWX)

The Campaign for  
**GRADE-LEVEL  
READING**

INVITATION

**This invitation to share is open to everyone!**

We are gathering information about a few strategies related to **learning loss recovery**.

The form is quick and easy to complete. This information will help all of us understand what's happening in our communities and support engagement that will unfold later this year.

Here is the link to complete your responses:  
[WHAT'S WORKING QUESTION FORM](#)

