Successes and Challenges in Implementing and Scaling an Effective Pre-K Mathematics Intervention

Alice Klein, Ph.D. and Prentice Starkey, Ph.D.

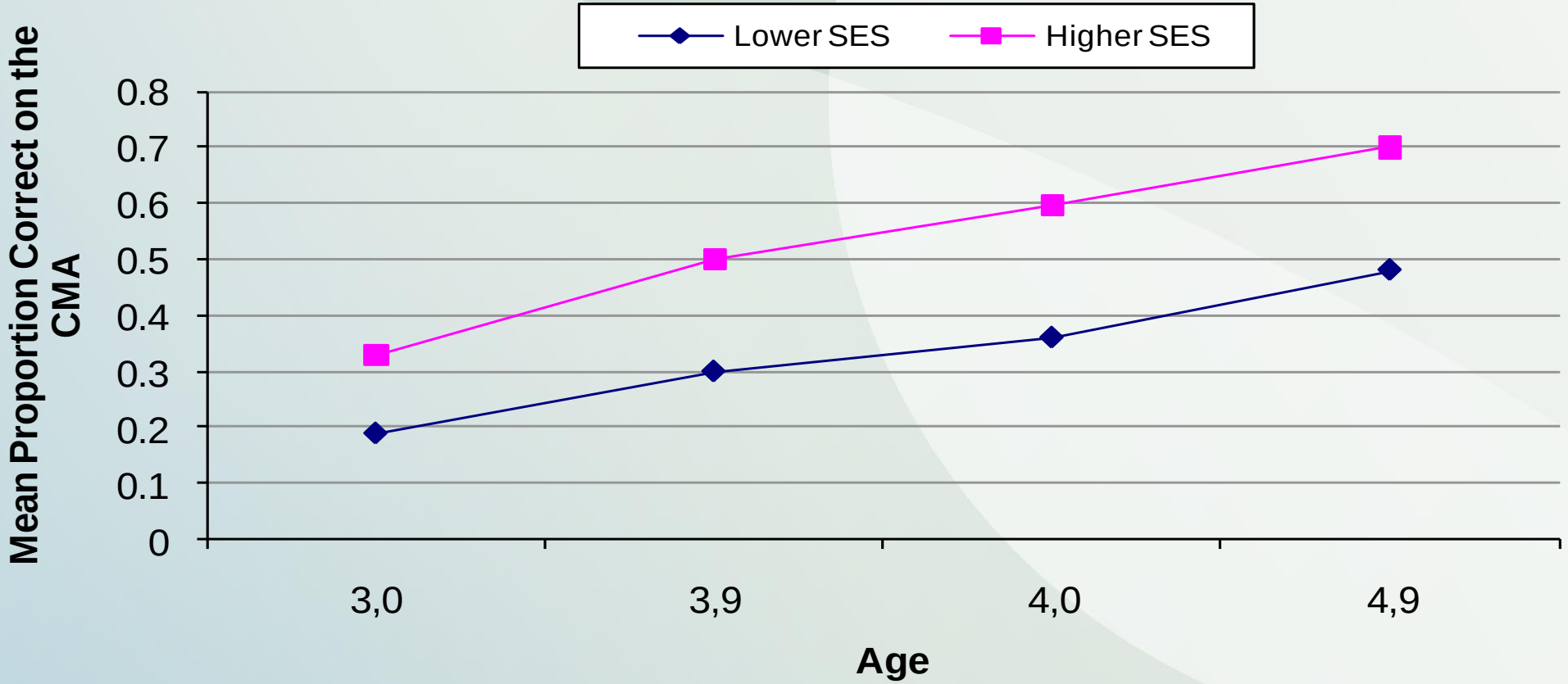
WestEd

This research was supported by grants from the Institute of Education Sciences, the Investing in Innovation/Education Innovation and Research Program, and the National Science Foundation to P. Starkey & A. Klein

The Math Gap (Group Differences) in America's Youngest Learners

- A SES-related math gap emerges in many countries during early childhood (UNICEF, 2016)
- In the U.S., a SES math gap emerges early and is larger than the gaps for other demographic characteristics such as ethnicity/race or gender (Reardon et al., 2011, 2013, 2016)
- This map gap begins to develop by 3 years of age, and it widens to approximately 1 year by the end of pre-kindergarten (Starkey & Klein, 2008)
- In kindergarten, the gap between the lowest and highest SES quintiles is 1.3 SD (Duncan et al., 2011, 2013)
- This is a large gap at such an early age

The SES-Related Math Gap in Preschool Children



The Child Math Assessment (CMA) was administered to a cohort of children in fall and spring of each year of preschool, beginning at 3 years of age.

Origins of the SES Math Gap

This gap stems, at least in part, from differential levels of support for math in children's early learning environments

- Ineffective math components in comprehensive curricula used in many public preschool classrooms (see What Works Clearinghouse ratings; PCER Consortium, 2008; IES Final reports)
- SES-related differences in math enrichment in the home learning environment (Elliott & Bachman, 2018; Silver & Libertus, 2022)

The Role of Early Intervention in Closing the SES Math Gap

- To address this disparity in children's opportunities to learn, researchers have developed early math interventions for preschool and the early elementary grades that mathematically enrich children's learning environments

- We have developed and evaluated one of these interventions, *Pre-K Mathematics*, which is a tier 1 curriculum that supplements comprehensive curricula in widespread use in public preschool programs

Objectives and Key Features of *Pre-K Mathematics*

- The principal learning objective is for children to develop a **broad foundation of informal mathematical knowledge**; this knowledge requires the presence or mental representation of sets of concrete objects.
- The content of *Pre-K Mathematics* activities is aligned with broad recommendations about the content of preschool mathematics instruction (National Council of Teachers of Mathematics, 2006; National Research Council, 2009).
- It is a developmental curriculum that addresses needs of individual children
  - Scaffolding, downward extensions, and upward extensions of activities as needed
- Teachers monitor delivery of curriculum dosage and the progress of individual children toward mastery of math activities

Components of *Pre-K Mathematics*

Classroom component:

• *Pre-K Mathematics* small-group activities conducted by teachers

Home component:

• *Pre-K Mathematics* home activities conducted by a parent with their child

Professional development component:

Trainer-of-trainers model

• Teacher workshops

• On-site support by curriculum coaches

• Trainers Institute for training local curriculum coaches

A Small-Group Math Activity

Pre-K Mathematics Home Activity

Help Kitty Count

Child's Goal: With your help, your child will learn to count increasingly large sets of objects. Your child will count objects using number words in their correct order.

Parent's Role: You should play the part of Kitty as you present the problems in the picture strips.

Activity Organizer

Key Mathematical Language

- One, two, three, and so on
- Count

Setup and Materials

Parent (or another adult) and child stand or sit at a table or on the floor to do this activity. Put the picture strip near you so you can use it step by step.

Cut out the four counting strips so you will be able to use one strip at a time.

Use a sock to make a sock puppet (see example in picture). Draw a cat's face on the sock with a black marker. Then, pretend that the puppet is a cat. This will make the activity more entertaining for your child.

Introducing the Activity

Put the puppet on your hand and say, **"This is Kitty. Kitty is learning to count and needs your help. Sometimes Kitty counts in a way that is okay, but sometimes Kitty counts in a way that is not okay and wrong. Watch Kitty count and tell Kitty when the counting is okay or not okay."** Place the strip of 3 objects on the table or floor you are using.

PARENT TIPS

- Give the puppet a special voice when it "talks" to your child. The puppet should clearly touch each object as it is counted.
- Be sure your child watches the puppet while it counts.

How to make it easier. If the 3-object strip is difficult, try using a 2-object strip by covering up one object on the 3-object strip.

How to make it harder. If your child can correctly answer problems 1 and 3 without help, try using the 15-object strip. Later in the year, try the 30-object strip. If you want to try a 20-object strip, cover up some objects on the largest strip.

Another way to make this activity more difficult is to have kitty count backwards, for example, 3-2-1.

Try coins instead of strips because coins can be arranged differently, such as in a circle. That requires children to remember which coin was counted first.

Pre-K Mathematics Home Activity

Help Kitty Count

Problem 2: Kitty slowly, but incorrectly count the objects, starting at the left end of the strip and ending at the right end.

Try These: Use sets of 3, 7, 15, or 30.

Kitty clearly misses the final object as he counts. For example, on the 3-object strip, "One, two. There are two things here."

Kitty counts an object twice, for example, in the 3-object strip, "One, two, three, four. There are four things here."

Kitty uses number words in the wrong order, for example, "One, three, two. There are two things here."

Kitty reports the wrong number for the set, for example, "One, two, three. There are four things here."

Made with Pixton Pro.

Date: _____

School Name: _____ Teacher Name: _____

Parent and Family Feedback

Home Math Activity: Help Kitty Count

Child's First Name: _____ Child's Last Initial: _____

How many days did your child do this activity? _____ days

How long did your child do the activity? _____ minutes per day

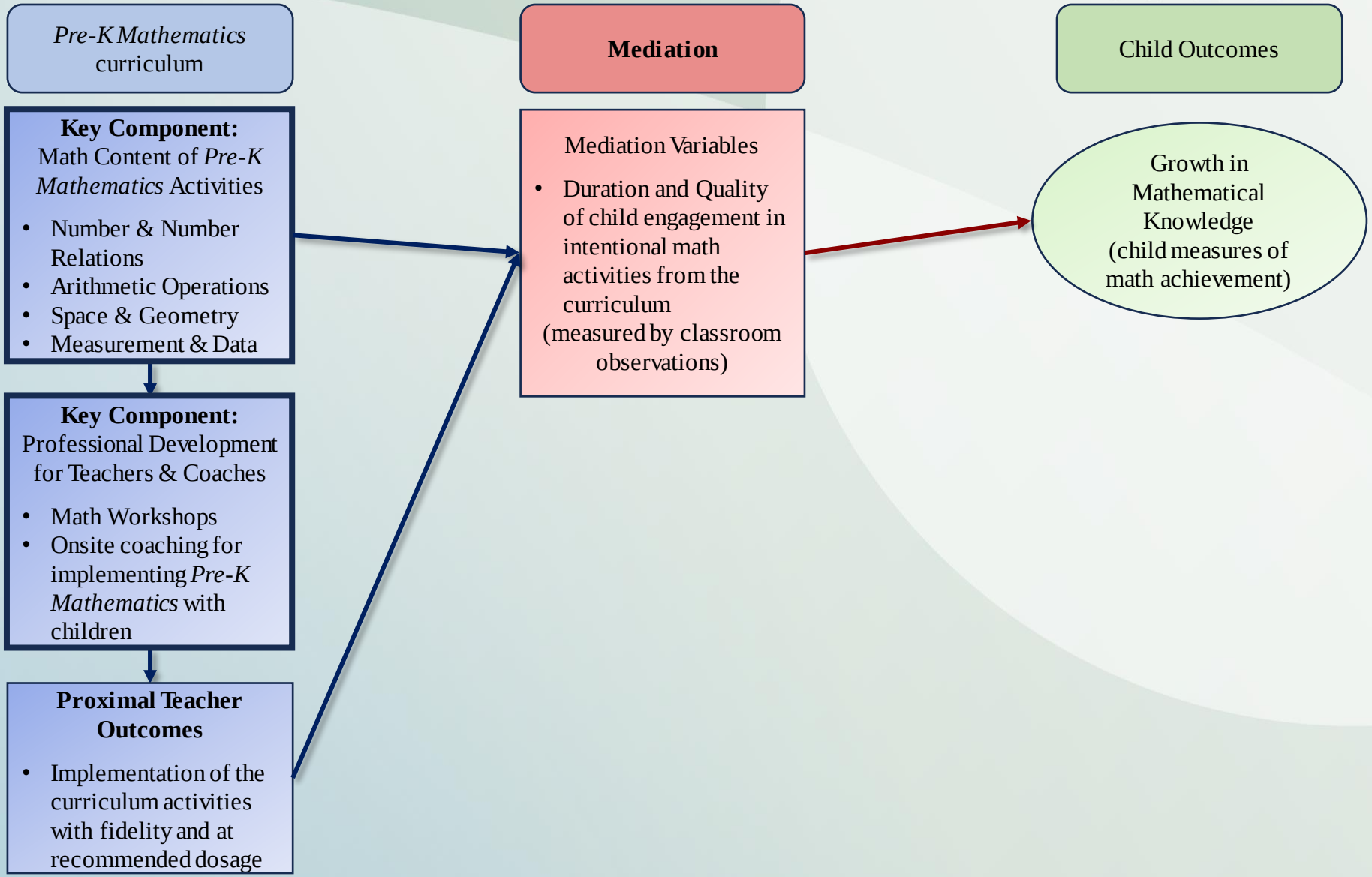
Did your child enjoy and learn from the activity? _____

Comments?

Scan with smartphone to fill out via Google Forms:

Home Activity: Help Kitty Count
Pre-K Mathematics Activity: Watch Me Count

Logic Model for *Pre-K Mathematics*



Our Sequential Approach to Scaling *Pre-K Mathematics*

- **Efficacy:** Does an intervention produce positive outcomes under more controlled conditions in which the developer is involved in implementation and evaluation?
- **Replication:** Can you replicate the positive outcomes of an efficacy trial under similar conditions, but in different geographical sites with different demographics?
- **Effectiveness:** Is the intervention still effective when implemented under less controlled conditions that approximate application in the real world and on a broader scale?
- **Statewide Scale:** Does a successfully evaluated intervention continue to be effective when implemented with a purposively selected sample of individuals and sites from a specific population within a state?
- **National Scale:** Evaluate an effective intervention with a nationally representative sample of target population (Current EIR Expansion grant in four regions of U.S.)

Efficacy and Replication

- Efficacy (Klein, Starkey, Clements, Sarama, & Iyer, 2008)
  - 40 classrooms; 316 children; CA and NY
  - Urban locations
  - Project staff train teachers

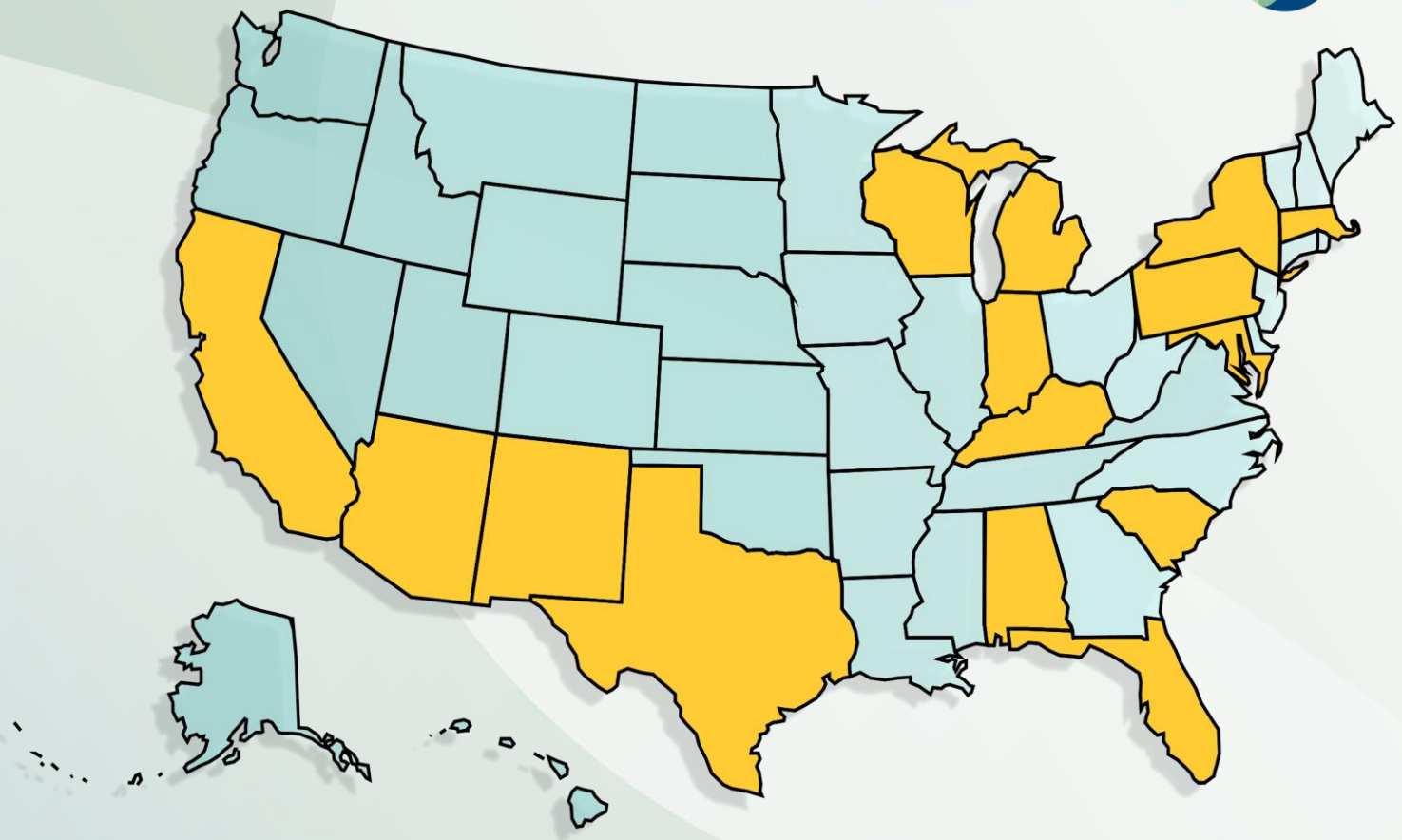
- Replication (Starkey, Klein, Clarke, Baker, & Thomas, 2022)
  - 41 classrooms; 389 children; CA (Bay Area and Central Valley)
  - Rural and suburban locations
  - Project staff train teachers

Effectiveness and Statewide Scale

- Effectiveness (Starkey, Klein, & DeFlorio, 2014)
  - 94 classrooms; 744 children; CA and KY
  - Urban and rural locations
  - Program coaches train and support teachers (Train-the-trainer delivery model)

- Statewide Scale (Thomas, Cook, Klein, Starkey, & DeFlorio, 2018)
  - 140 classrooms; 1373 children; CA (balanced between Northern and Southern CA)
  - Unique feature is **heterogeneous and purposive sampling** of Pre-K programs and classrooms to represent all low-income families in CA with a Pre-K child.
  - Urban, suburban, and rural locations
  - Program coaches train and support teachers

Scaling studies of *Pre-K Mathematics* have been conducted in urban and rural pre-K programs in 15 states



LEGEND:
States where Pre-K Mathematics studies have been conducted

Evidence of Effectiveness of *Pre-K Mathematics*

- The most recent evaluation of *Pre-K Mathematics* conducted at a statewide level of scale found that this intervention had consistently positive effects, and these effects did *not* differ by the racial/ethnic background or pretest performance of the children or by the urbanicity of the settings.

- This set of rigorous scaling studies conducted over the past 20 years has shown that *Pre-K Mathematics* is robustly effective in improving children's math knowledge despite many sources of variation in student attributes, settings, time (secular trend), and outcome measures of math achievement.

- IES's What Works Clearinghouse determined that this intervention meets the highest rating of effectiveness for General Mathematics Achievement (++, Evidence Tier 1 (strong)) (WWC, 2023) https://ies.ed.gov/ncee/wwc/

Barriers to Scaling in Public Early Childhood Programs and Strategies to Address These Barriers

Barrier 1. Prekindergarten teachers have insufficient professional preparation to teach mathematics effectively

- ***Strategy to remove the barrier***. Provide pre-k teachers with in-service PD and coaching that will enable them to teach mathematics effectively

Barrier 2. The professional development staff in local pre-k programs have insufficient preparation to provide math curriculum coaching. Trained coaches help teachers integrate math instruction in their classrooms and weekly schedules. They also help teachers sustain implementation long-term.

- ***Strategy to remove the barrier***. Provide local professional development staff with training in curriculum coaching

Barrier 3. Many local Pre-K programs do not prioritize the adoption of effective math curricula or math professional development for their teaching staff

- ***Strategies to remove the barrier***.
  - Earmark funding to cover the costs of training teachers and coaches
  - Incentivize or require the use of effective curricula