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Evaluating Quality Interactions in Preschool Math: Validation of a Video-based Observation Protocol

Joanna Skourletos
Loyola University Chicago, jskourletos@luc.edu

Erin Reid
Erikson Institute, ereid@erikson.edu

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Erin E. Reid[1] & Joanna Skourletos[1,2]
[1]Erikson Institute & [2]Loyola University

Erikson Institute
Early Math Collaborative

LOYOLA UNIVERSITY CHICAGO

LITERATURE REVIEW

Overview

An important determinant of what students are taught is what their teachers know.[5; 17] This is particularly true of mathematics. Although most young children come to school with some informal understanding of mathematics, it takes a knowledgeable and effective teacher to make connections between informal knowledge and the foundational mathematical competencies that will serve children for the rest of their lives. The earlier children are exposed to effective teachers, the better the outcomes.[11] Unfortunately, finding an instrument that can measure the quality of mathematics instruction in preschool classrooms, much less one that has empirical support, is nearly impossible.

Why is it important to develop a reliable and valid measure of mathematics teaching quality in preschool?

1. Math achievement gaps appear before school entry

Mathematical competence has been linked to a variety of short- and long-term outcomes.[1; 3; 7; 13; 14; 15] Recent research suggests that the level of mathematics skills at kindergarten entry is relatively stable beyond first grade, even into eighth grade.[6;10] These initial skill differences may lead children to remain behind their more knowledgeable peers.[2; 8; 18]

Therefore, we need a means for assessing the quality of math instruction in order ensure that children are provided with rich opportunities to engage in math interactions with skilled teachers.

2. Early childhood teachers are not well-prepared to support children's mathematical development

Research indicates that cumulatively, teachers account for up to 35% of the variance in student mathematics achievement over four years of schooling.[12] Unfortunately, in pre-service training, early childhood teachers are exposed to less math content than teachers of higher-grade levels. As a result, early childhood teachers often lack the necessary mathematical content knowledge to deliver effective instruction[9; 16] which leads to inadequate teaching practices.[17] Moreover, professional development for early childhood in-service teachers around teaching math is very limited and largely ineffective[16] which offers a lack of opportunity for teachers to improve their practices.

Therefore, there is a need for an instrument that identifies areas of strengths and weaknesses in teachers' mathematics instruction so that we can effectively support teachers to strengthen their practice around teaching mathematics.

3. There is lack of existing tools that measure preschool math instructional quality

There is an increasing demand for accountability around quality instruction.[4] As a result, teacher evaluations have become "high-stakes" so there is a growing push for empirically validated observation tools from funding sources (e.g., Race to the Top) and initiatives (e.g. Gates Foundation Measure of Effective Teaching project). Unfortunately, the development and validation of observation measures for teaching quality in preschool—and particularly for mathematics teaching quality – is lagging behind those developed for the elementary grades. Few observation tools currently exist that are focused on math instructional quality in preschool.

Therefore, there is a need to create an observational tool that measures math instructional quality for preschool.

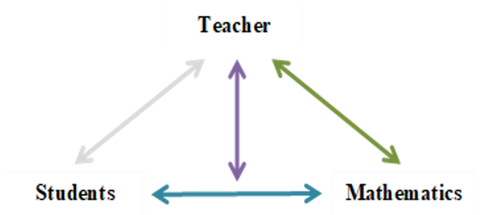
EQUIP-M

Purpose

This tool was designed to measure the quality of mathematical instruction during a video observation of a preschool teacher interacting with students.

EQUIP-M is predicated upon two assumptions:

1. Instructional opportunities for preschool math are embedded in routines, games, play, books, blocks, etc.
2. Mathematical quality of instruction can be assessed by examining the interactions between teacher and students around the mathematics, as illustrated in the instructional triangle below.



EQUIP-M focuses on three interactions: those between the teacher and the mathematics (Teacher Intentionality), the teacher and the students around the mathematics (Teacher Responsiveness), and students and the mathematics (Student Mathematical Sense-making).

Domains	Dimensions
Teacher Intentionality The degree to which the teacher plans, prepares, and implements math learning opportunities for students with intention.	• The context connects to the math, is clear, and provides depth for concept development. • The teacher fosters interest, student agency, and investigation in the mathematical ideas at hand. • The teacher uses language that is descriptive and highlights relationships between terms or ideas to promote concept development.
Teacher Responsiveness The degree to which the teacher adds mathematical value to student contributions, promotes peer collaboration and uses mistakes as a learning opportunity.	• The teacher monitors for student understanding and poses probing questions to ascertain depth of student understanding. • The teacher recognizes and uses student contributions in a way that conveys math learning as a social activity. • The teacher uses student mistakes as opportunities to clarify mathematical ideas without interfering with the student's capability to self-correct.
Student Mathematical Sense-Making The degree to which students are expressing their mathematical thinking and exhibit positive learning behaviors that lead to mathematical sense-making.	• Students communicate their mathematical thinking to others. • Students exhibit learning-related behaviors.

Scoring

Each dimension is scored on a 4-point scale.

- 0 – No evidence of indicators were observed for that dimension
- 1 – Minimal evidence was observed for that dimension
- 2 – Mid-range or mixed evidence was observed for that dimension
- 3 – High level of evidence was observed for that dimension

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PILOT STUDY

Method

Sample: EQUIP-M scores on 1,161 videos collected from 179 teachers who participated in a multi-year professional development program were analyzed for evidence of interrater reliability. A subsample of scores on 479 videos (n = 175 teachers) collected in the fall prior to teacher participation in PD were analyzed for structural validity.

Procedures: Videographers visited classrooms at prearranged times and recorded math activities from beginning to end. Each teacher was recorded leading math activities up to three times during a 2-week period. Certified raters watched videos in their entirety and assigned scores to each dimension. Dimension scores were summed to create a total score. Each video was scored by at least two raters and approximately 10% of videos were scored by all 10 raters.

Analyses: Because each video had multiple sets of scores, the median of the total scores was calculated and used in analyses. To examine inter-rater reliability of scores, we calculated intraclass correlation coefficients (ICCs) using a two-way random effects model. To examine the structure of the dimensions, we conducted a series of principal factor analyses (PFA) with Promax rotation.

Results

- ICCs for videos scored by two raters ranged from 0.53 – 0.67 for individual dimensions and 0.84 for the total score.
- ICCs for videos scored by all 10 raters ranged from 0.76 – 0.91 for individual dimensions and 0.91 for the total score.
- PFA results indicated that the eight dimensions measured one underlying construct. Factor loadings ranged from 0.48 – 0.84.

DISCUSSION

This work represents the first step in validating the use and interpretation of a new observation system that evaluates the quality of interactions around math in preschool classrooms. Preliminary evidence indicates that:

- raters can be trained to apply scoring rubrics accurately and consistently;
- the sum of the dimensions scores is the most reliable score produced; and
- the hypothetical conceptual structure of the tool was not supported. That is the dimensions measured one underlying construct, such as math teaching quality, as opposed to three separate domains – teacher intentionality, teacher responsiveness, and student mathematical sense-making.

Future Implications:
With further development and evaluation, this tool has the potential to identify strengths and weaknesses in preschool math teaching and, ultimately, to inform educational professionals about how they can improve teacher-child interactions around math.

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