

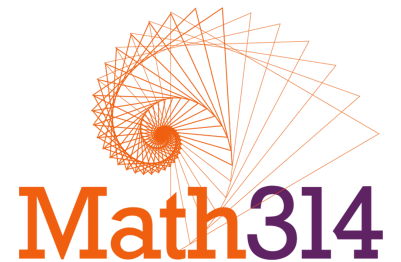
Early Childhood Mathematics:

Findings from a professional learning pilot project

Maia Elkana & Zoe Lehmann
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Introduction

Rigorous early childhood math education is vital for students' future academic and lifelong success, yet many preschool children lack opportunities to engage in math learning. In 2022, Washington University's Institute for School Partnership (ISP) and a district-based Early Childhood Center formed the **Early Childhood Mathematics Research Practice Partnership (ECMRPP)**, a two-year pilot to focus specifically on early mathematics learning.

This research-practice partnership took a systems approach, using improvement science methodology and research-based learning trajectories to develop a professional learning program that yielded encouraging observations, including: increases in positive math mindsets and teacher confidence; more intentional, frequent, and varied math instruction in the classroom; and increased student learning across the developmental math areas. As a result, the project team identified key recommendations for educational leaders who aim to provide high-quality, equitable mathematics instruction for early childhood learners in their schools and/or districts.

Early Childhood Education (ECE) sets the foundation for a child's future educational experiences and success. Research highlights that early math concepts are the strongest predictors of later learning success (Duncan et al., 2007). These early math skills not only predict later mathematics achievement but also reading achievement (Duncan et al., 2007; Jordan et al., 2009; Watts et al., 2014).

For low-income children specifically, weak math knowledge at school entry accounts for their weak math knowledge in elementary school (Jordan et al., 2009). Furthermore, opportunities for young children to engage in math learning are extremely limited in preschool, especially compared to literacy (Bachman et al., 2018, Farran et al., 2017).

Given the importance of early childhood education to a child's future, high-quality ECE programs are vital to promoting more equitable educational experiences. The primary aim of the ECMRPP was to improve the equity of access to quality early childhood education in the St. Louis Region by supporting early mathematics learners from high-needs backgrounds. The Partnership was a natural progression of the ISP's Math314 program, which was designed to equip educators with knowledge and tools to implement quality math instruction in their classrooms.

Through an improvement science methodology (Bryk, Gomez, Grunow, & LeMahieu, 2015) and research-based learning trajectories focused instruction (Clements & Sarama, 2017/2019; Rittle-Johnson et al., 2017) the team identified key levers of ECE mathematics instructional improvement, including professional learning and leadership development for teachers, as well as the development of a practical way for teachers to assess student math learning & knowledge.

Engaging classroom teachers and school administrators as researchers to focus on increased understanding of their own practices and the barriers to high-quality ECE math, the partnership participants developed a professional learning program that prepares and supports teachers to ensure that every student has the opportunity to experience joyful, rigorous math learning.

Development of an Early Childhood Education Math Professional Learning Program through Research-Practice Partnership

A research-practice partnership is a unique form of collaboration designed to improve and transform education by connecting diverse forms of expertise and deconstructing traditional power relations in academic research. The process focuses on systems and relationships that are essential for learning and successful program implementation.

The early stages of the project focused on establishing relationships. The ISP sought first to listen to educators and gain a deep understanding of the nuance and context of their school and the students they serve. ISP and center staff and leadership identified partnership goals, conducted a needs assessment, and developed a motivational aim to guide improvement efforts, establish a shared focus for the work and define how we view and measure success.

Program partners quickly identified a need for more systematic ways to engage teachers as leaders, resulting in the creation of a formal teacher researcher role. The ISP also provided one-on-one teacher coaching, led a book study and peer learning community, and met regularly with school and district leadership to address infrastructure needs and maintain strong leadership buy-in and vision for the project.

Motivational Aim

“We aim to close the achievement gap and prepare children to be healthy and emotionally well-centered and confident mathematical thinkers so they can function successfully in the global world. We commit to finding ways for all our students to express their math thinking (verbally and visually) and embrace and validate all the different ways children learn. Our students will demonstrate that they can think meaningfully and mathematically and develop the confidence and skills to support that thinking.”

Program Components

Professional development and math lesson planning tools

Each month teachers participated in professional development sessions to provide them with the resources, knowledge, and skills needed to support student achievement and build teacher confidence. These sessions were built into the school's regularly scheduled staff meeting structure, reducing the complexities of coordination and teacher attendance challenges.

Teachers explored their own math identities to better understand how this may impact their teaching and student learning. The ISP team shared tools and strategies for implementing math lessons into authentic learning environments and made space for teachers to collaborate and share successful strategies from their own classrooms with colleagues. The professional learning sessions also included co-planning time for teachers to try new approaches to lesson planning. Quick reference guides and lesson planning tools were provided, as well as an ISP-led book study of [*Where's The Math?*](#), a guidebook for teaching fundamental early childhood math topics such as matching, pattern recognition, number sense, measuring, and spatial reasoning.

Through feedback surveys, teachers indicated that they were pleasantly surprised by the tone and nature of the professional development learning sessions, reporting that they felt "heard" and valued by ISP staff.

Teacher coaching and co-planning

ISP provided classroom teachers with coaching as well as small group project support work. Instructional coaching provided teachers with continuous feedback and support throughout the partnership. Coaching cycles consisted of one-on-one lesson planning meetings, teaching observations, and lesson debrief conversations. Additionally, coaches met with teachers individually and in small groups to support collaborative lesson planning. These collaborations resulted in the development of project-based learning experiences for students, embedding authentic math experiences into everyday activities. These small groups met monthly to continue improving the projects to best support students.

Teacher leadership and research systems

Working closely with school administrators, the ISP team identified two teachers for the teacher researcher role. Teacher researchers participated in additional meetings and coaching sessions to support their development and skill-building. Teacher researchers worked with the project team to co-plan professional development sessions, review program data, and to co-create lesson planning and student assessment tools. Over the course of this project, the teacher researcher role expanded to include coaching and mentoring.

The teacher researcher model builds on research that demonstrates the value of teacher leadership which is associated with collective efficacy and predictive of student achievement (Goddard et al., 2015). Formalizing the teacher research role allowed the team to document and learn from the knowledge teachers were already generating in their classrooms about what works in early childhood. This strategy proved to be important in building distributed leadership capacity and providing structures for the sustainability of the work.

Development of a practical way for teachers to assess student learning

Measuring and assessing math learning at the early childhood level is challenging, relying upon observation of skills and demonstration of knowledge since young children are not always reliable with answering questions. The research-based assessment tools available require a great deal of staff time and disruption to the classroom, making them not practical in an early childhood setting.

Meeting the need for a practical assessment option that honored the Center's commitment to the Reggio Emilia approach was a priority for the partners. The approach leans heavily on documentation and encourages students to express their knowledge in ways that come naturally to them rather than researcher-developed tools. As a result, a tailored system for teachers to collect, track and understand evidence of classroom learning was developed. As the project progressed, the teacher researchers were able to take on tool development and implementation, ensuring that the new system could be sustained after the project was completed.

How We Measured Our Progress and Impact

Partnership efforts included evaluation of progress across three outcome measures:

1. Teachers' personal perceptions of mathematics, as well as their math instruction skills and knowledge;
2. Frequency, type, and quality of intentional math instruction in classrooms; and,
3. Student math engagement, skills, and knowledge.

Measurement tools included surveys, interviews, and observations, in addition to regular team check-in meetings with Center staff. Teachers completed post-professional development feedback surveys and surveys based on the Early Childhood Teachers' Beliefs and Confidence about Teaching Early Mathematics, which were distributed five times over the course of the program. Data was reviewed regularly by the program team, leading to iterative improvements in program delivery and changes to the instruments used.

Additionally, interviews were conducted in April of 2023 to better understand firsthand experiences teachers had during the partnership, their attitudes towards the program, their growth over the two years and their desires for the future of the partnership or math instruction in their school. The largest gains were seen in teacher confidence in their knowledge of what children know about math

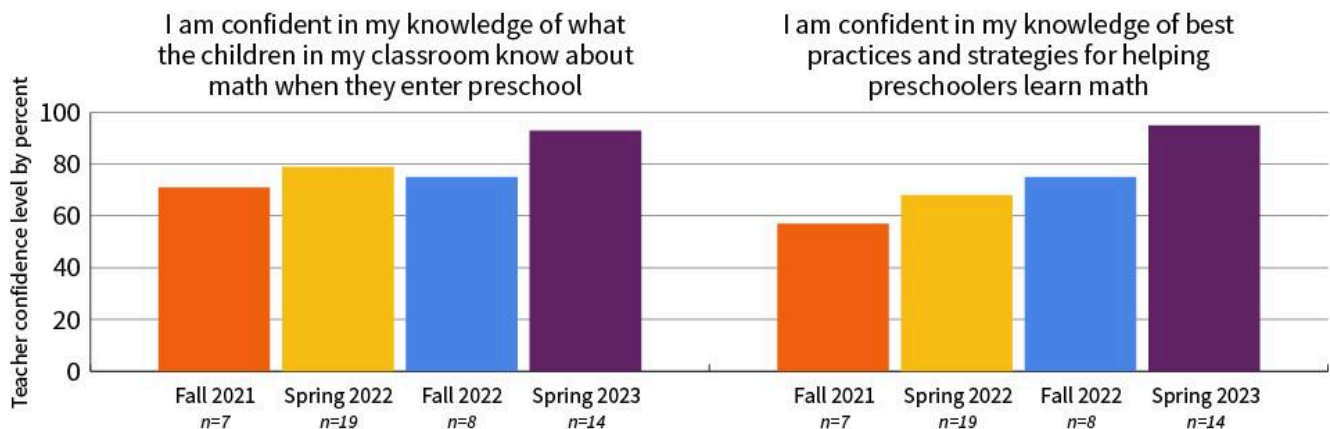
when entering preschool and knowledge of best practices for teaching math, including incorporating math into common preschool situations such as dramatic play. Teachers reported feeling less nervous about the subject in general and demonstrated increased comfort with common math tasks such as rotating an object, converting fractions into percentages, estimating distance, and finding patterns in data.

“Talking about math through play has been so helpful - it’s pointing out to me how math shows up and how we can document it. Like, I have a picture of [a student] holding two lego trucks, and yeah, it just looks like a kid holding trucks and smiling which doesn’t really mean anything, but I can look at that picture and remember what happened. I took that picture after [the student] really made the connection and he said ‘Look! I have one more now!’ That’s huge! Just changing the way we’re talking about math, it’s changed my perspective.”

– ECE Classroom Teacher

Intentional Math Teaching

As teachers became increasingly confident in their abilities to incorporate math into their practice, the frequency and quality math activities similarly increased. Teachers incorporated structured math lessons into their classes and were able to support students as they explained mathematical ideas in their everyday play. Rather than separating subjects, we encouraged embedding math lessons into the classroom throughout the day.



Qualitative analysis revealed that teachers grew in their confidence to incorporate math into literacy, free play time, and other projects, and that the frequency with which they did so also increased. Examples throughout the partnership included:

- **The Mud Kitchen**, a school-wide project for students to participate in weaving dramatic play and sensory learning into mathematics instruction and a variety of student-led development of board and role-playing games that involved costumes, setting up food shops, thinking about shapes and spatial relationships, and asking students to consider for themselves how math could be incorporated into lessons.
- **The Bad Guys Game**, an activity designed to engage students who are interested in video games to expand their sense of play by designing a board game that incorporates role play and dress up.
- **The Noodle Shop**, an activity designed for a special needs-integrated classes of students across a spectrum of developmental delay and growth by starting with their love of noodles, then progressing to math-rich restaurant play.

“[The students] were creating their own currency and dollar amounts and writing numbers to create these dollar bills for the register. When they served the noodles, they worked on shaking the right amount of spice into the bowls, and then they were comparing the noodle sizes. There’s a lot of math talk. You know, like, comparing the measuring cups and saying ‘I need a bigger one!’ It’s still dramatic play, but there’s so much math!”

– ECE Classroom Teacher

Recognition for Teacher Expertise and Leadership

In addition to developing a formal teacher leader role, this project provided participants with opportunities to share their work beyond their school & district. A teacher researcher presented the school’s Mud Kitchen project at the [Add It Up conference in July 2023](#) to help regional teachers develop similar projects in their own schools. Not only was she able to spread the impact of the project, but this positioned her as a regional leader in early childhood mathematics.

Classroom teachers at the center were also invited to present their work at the [ISP’s Math Improvement Showcase](#) in May 2023 alongside secondary teachers and administrators from other regional districts. Five teachers presented classroom projects including ‘The Bad Guy Game,’ a Black History Month book written & illustrated by students, and a lego village project where students built and mapped their neighborhood using legos.

These opportunities engage teachers as learners as well as professionals, allowing them to gain recognition for their work which is all too often overlooked. Mutual understanding, trust, and respect are vital conditions for implementing and sustaining instructional improvement efforts.

The Improvement Showcase gave teachers the opportunity to share their learning and success with a broader audience and positioned them publicly as experts in their field.

Student Math Learning

The overarching goal of this partnership was increasing the frequency, rigor, and cultural relevance of mathematics learning opportunities for young children to ultimately increase their math skills and knowledge, setting them up for success in later schooling and life.

Math Evidence of Learning Tracking ¹												
Counting with 1:1 Correspondence												
Date	Student Name	0	1	2	3	4	5	6	7	8	9	10+
Sorting Objects by Attributes												
Date	Student Name	Not Sorting			Sorting by 1				Sorting by 2			
Graphs & Graph Comprehension												
Date	Student Name	Cannot Read	Most	Least	Demonstrating							
Number Identification												
Date	Student Name	0	1	2	3	4	5	6	7	8	9	10+
Shape Identification												
Date	Student Name	Circle	Square	Triangle	Diamond	Oval	Rectangle	Star	Heart			

The project team found that while teachers were comfortable with teaching counting, they had less comfort incorporating other “big ideas” of mathematics development such as matching and sorting, patterns, measuring, and spatial relationships. Through the increase in teacher confidence, skills and knowledge, as well as support for more frequent, intentional math learning in the classroom, the team observed strong evidence of increased student engagement with mathematics concepts, skill building, and knowledge acquisition.

Through the development and implementation of the Evidence of Learning tool, teachers were better able to track student learning and amassed documentation including photos and videos demonstrating learning that was taking place in the classroom and explaining the specific topics and skills expressed. A majority of learning happens in the moment and thus, documentation is vital to understanding and advancing student mastery.

Evidence of student learning in ECC classrooms included demonstrated mastery of skills with “in the moment” student activities:

- **Matching and sorting** by students sorting and counting pictures of classmates who were at school
- **Patterns** by stacking blocks at a light table into color patterns and noticing
- **Counting and number sense** by counting pages of books, and playing games with dice and game pieces
- **Measuring** by students filling cups and tubes with water for pets and comparing towers of blocks as taller and shorter

- **Spatial relationships** by how students use toys as with a student setting up barriers for a horse figurine to jump over and between

"[My students] knew numbers and counting and all that, but now you see [number sense] starting to appear more in their free choice time, especially when they're doing writing. If you look around the room, the different pictures have numbers, and because they're thinking about it and they know their numbers, they can write their numbers and sometimes they even write equations! You can tell that they're more aware of numbers in the world."

– ECE Classroom Teacher

Key Takeaways for Math Instruction Improvement

1. Engage early childhood teachers intellectually and promote professional excellence.

All teachers need ongoing professional development and support to provide high-quality learning opportunities for their students, especially in math. Early childhood educators often only receive the minimum, safety-focused training or professional development that feels infantilizing. By investing in intellectually stimulating professional learning experiences, including traditional professional learning sessions, book studies, co-planning work, coaching, and providing teachers with replicable resources, the project team was able to translate teacher knowledge gains into changes in classroom practice.

Early childhood teachers are certified and many of the teachers who participated in this project hold masters or doctoral degrees in early childhood education. They are experts. It is critical that we continue to lift up their voices and provide space for them to share their learning and gain recognition.

2. Take a systems approach, aligning professional learning services with the school leadership and vision.

What happens in the classroom begins with school and district leadership and any instructional improvement program must be in alignment with administrative structures and visions. Some key strategies and activities include regular meetings with school leaders, building on the school's curriculum and learning philosophy (e.g. the Reggio Emilia approach), scheduling professional learning activities into the regular school day, and creating /supporting a formal teacher researcher role.

3. Develop a new funding model for instructional improvement initiatives in early learning.

Throughout the two-year project, the ISP worked to expand partnerships with early childhood education centers. Consistently, potential partners expressed a desire to support mathematics teaching and learning in their schools, but struggled to make math instruction a priority with limited resources. In the standard instructional support funding model for K-12 education, school and district administrators earmark funding for professional development, coaching, curricular supports, and programming for staff; however, since early childhood education, including Kindergarten, is not mandatory in the State of Missouri, there is not regulatory pressure or comprehensive funding mechanisms to support preschool learning programs. Furthermore, many grant and private funding mechanisms in the ECE space are not focussed on instruction.

As many stakeholders are better understanding the value of high-quality early childhood education, the state's Department of Early & Secondary Education (DESE) created the Office of Early Childhood in January 2021. This new office is solidifying the learning standards for early childhood which may bring increased interest in instructional quality.

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