Young Mathematicians: A Successful Model of a Family Math Community

BY KRISTEN REED AND JESSICA MERCER YOUNG

Children are born with mathematical minds. Even before children enter kindergarten, they engage in mathematical ways of thinking that help them make sense of the world around them. When children have opportunities to engage in meaningful mathematical interactions, it supports cognitive development, builds brain architecture, and develops skills such as problem-solving and persevering. Providing these mathematics learning opportunities is critically important, given that mathematical knowledge in early childhood is strongly predictive of children’s future success in school (Claessens, Duncan, and Engel 2009). Indeed, at kindergarten entry, mathematics skills predict mathematics achievement through high school (Watts et al. 2014), with kindergarteners’ early mathematics skills building a foundation not only for advanced mathematical knowledge, but also for achievement in science and engineering (Claessens and Engel 2013; National Mathematics Advisory Panel 2008).

However, systemic opportunity gaps create unequal access to high-quality mathematics learning experiences. Analysis of education gaps in the U.S. have shown that young children with limited access to economic resources may start kindergarten with mathematics skills that are up to a full year behind their more economically advantaged peers (DeFlorio and Beliakoff 2015; Garcia and Weiss 2015), and these gaps in mathematics outcomes persist or even increase as children proceed through school (Cross et al. 2009). Research has shown that investing in early childhood education programs and supporting families as education partners can help narrow the gaps between students at the start of school (Bivens et al. 2016; Garcia and Weiss 2017). Here, we explore how we took a community-based partnership approach to align enriching mathematics experiences to create a web of opportunity that ultimately supports children’s school readiness and success.

Young Mathematicians in Worcester Family Math Partnership

The Young Mathematicians (YM) program, developed by the Education Development Center (EDC), has partnered with early childhood education programs and families to create a web of opportunity that supports children's readiness and success in mathematics.
childhood programs for almost a decade to research and develop early childhood mathematics games and educator professional development. The YM intervention program aims to promote the mathematics skills of young children from under-resourced communities through games and short problem-solving stories. In 2015 YM added a family mathematics component designed to support mathematics learning across home and school environments. Grounded in Bronfenbrenner’s (1986) ecological systems theory, YM capitalizes on the interconnectedness of children’s environments by infusing each level of the ecosystem with positive attitudes toward mathematics and opportunities for children to engage in meaningful early mathematics practices.

With the success of this design, the YM team sought to engage additional early childhood stakeholders and form a networked community improvement model. In 2019, with support from Overdeck Family Foundation and Heising-Simons Foundation, the Young Mathematicians in Worcester (YM-W) initiative was established to support preschoolers whose communities have historically been denied access and equitable opportunities to engage in high-quality mathematics experiences. The partnership among early childhood education agencies, families, educators, librarians, and researchers has the goal to establish a “web of opportunity” that breaks down the silos of school, home, and the broader community and aligns young children’s mathematics learning experiences across contexts by providing greater access to high-quality mathematics learning opportunities.

The partnership is based in Worcester, Massachusetts—a unique and richly diverse city, which is the second largest city in New England and a leading refugee resettlement community. Seventy-four languages are represented in the public schools, and 59% of students speak a first language other than English. More than 80% of public-school students are designated as “high need” by the state, and in 2021 only 15% of Worcester’s third-graders met grade-level expectations in mathematics (Massachusetts Department of Elementary and Secondary Education 2021). While there are challenges, Worcester is fortunate to have a highly networked and cooperative community of early childhood organizations that are committed to empowering the community and supporting their needs (see Table 1 in Supplemental Resources).

**Partnership Activities**

To enact change in the community, a key activity of YM-W was the formation of a partnership among Early Childhood Education (ECE) programs and stakeholders. YM-W built upon EDC’s Young Mathematicians program to strengthen and extend its family math component through collaborations among partners and in iterative cycles of improvement that

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**FIGURE 1. PLAN-DO-STUDY-ACT CYCLE**

- Plan
  - Identify specific areas of need for each partner in relation to promoting family math
- Do
  - Improve support to address needs, train staff, test protocols, and either try again or revise.
- Act
  - Refine the family math resources
- Study
  - Solicit feedback, survey participants, measure changes, and study data
included feedback from key stakeholders—children, families, educators, and ECE community partners. We convened regular leadership board meetings to support communication and capacity building to reach educators and families by providing educator workshops and family math leader meetings. In addition, using the YM program as a prototype, we co-designed with YM-W families and educators a broad collection of family and classroom instructional resources, including early mathematics games with easy-to-use instructions, videos, and a robust website with resources available in English, Spanish, and Portuguese. The main partnership activities were leadership board discussions, educator workshops, family math leader meetings, and resource development.

**YM-W Leadership Board.** The YM-W leadership board, along with the external evaluator, met monthly to evaluate progress, respond to challenges, and adapt the program in a cycle of continuous quality improvement. Following a networked community improvement model (Bryk et al. 2015), the board comprised leaders from each of the partner organizations plus two parents who were also family math leaders. Most meetings had a similar structure: (1) updates about successes and challenges over the past month; (2) review of qualitative or quantitative data collected by the external evaluator; (3) discussion of modifications to make based on that data and the partners’ observations; and (4) preparing for next steps, including revising the implementation plan as needed. This networked community improvement model and regular cycle of Plan-Do-Study-Act contributed to the overall success of the project (see Figure 1).

**Educator workshops.** Educators from Worcester Family Partnership (WFP) and Worcester Child Development (WCD) Head Start wanted to learn more about early mathematics content and age-appropriate activities for home and school. In Year 1 (2019–2020), EDC staff facilitated professional learning sessions focused on number and operations (these were in-person at first but when the pandemic began in March 2020 the workshops were provided online). In Year 2 (2020–2021), we explored different topics in early mathematics including geometry, patterns, and spatial reasoning. During each session, we discussed children’s early mathematics development, addressed modifications for different-age children, and discussed the influence of positive attitudes toward mathematics. Educators received materials related to the topic of the session, such as game boards, cards, dice, and other materials; game instructions; related math mini-books; and suggestions for related picture books. When educators were teaching virtually, we provided virtual game ideas as well as materials to send home to families.

Importantly, each session provided time for educators to reflect on their own practice, share their reflections with colleagues, and think together what strategies they might incorporate to improve their practice and enhance their support of children and families. These sessions were a critical tool to align formal education settings such as Head Start with the work of informal education settings such as WFP.

**Family Math Leaders.** Families from WFP and Worcester Head Start were recruited to learn more about early mathematics and help co-design the family math activities and materials. Beginning in October 2019, a group of families met in-person monthly with EDC staff to learn about ways to engage in fun and playful mathematics, explore what they were already doing at home that supported children’s mathematics learning, learn about the mathematics learning happening in preschool classrooms, and brainstorm ways to connect informal and formal learning environments. Parents and caregivers contributed to the design process, helping us revise existing games and materials and create new ones. Importantly, the family math leaders reached out to other families to share their enthusiasm for the project and were inspired to make new connections to local community organizations.

**Resource development.** Using the original YM activities as prototypes, we co-designed with families and educators a collection of family math games with directions, videos, and other resources available in English, Spanish, and Portuguese. In addition, we focused on creating games and resources that would meet the needs of children at different developmental stages, and could be implemented in classrooms, homes, virtually, and in home-visiting contexts.

**The Young Mathematicians in Worcester Approach to Family Math**

The YM-W project uses games and problem-solving activities to support young children’s foundational mathematics development in number sense, number operations, geometry, patterns, data, and spatial reasoning. Mathematics games provide the perfect context for these objectives as play can spark children’s interest in mathematics, enhance their skills, and extend their conceptual understandings. In this way, we provided educators and families from WCD Head Start and WFP with concrete examples of the mathematics that children can learn through daily activities and deepened educators’ and families’ understanding of early mathematics concepts, emphasizing the similarities between early mathematics and language development.

Through this approach we were able to successfully create a model with resources and supports that: (1) addressed the need
for high-quality mathematics instructional materials for educators and families; (2) broadened participation for families traditionally underrepresented in STEM; and (3) addressed educators’ and families’ attitudes toward mathematics.

**Mathematics Games Spread Across the Community**

Below we illustrate how one of the YM games—a number path game—was adapted with input from families and educators. During the professional learning sessions and family math workshops, educators and families played a tabletop version of *Jumping on the Lilypads*. This game was originally designed with Head Start teachers (see *Play Games, Learn Math! Number Path Games*) to include children ranging in age from 2.9 to 5 years old. After playing the game, educators and families discussed the mathematics they noticed while playing and watched a video of children playing the game. All the families and educators took these ideas and tried them out, modified them as needed to fit their context, and then discussed their experience at our next meeting. Below we provide some examples of how the game was successfully adapted to be played in a range of contexts across Worcester, including home, school, and community. We believe that this helps illustrate the “web of opportunity” provided for children as they engaged in joyful mathematics learning opportunities that supported their school readiness skills.

**Preschool Classrooms**

Head Start teachers incorporated the game into small groups, classroom math centers, and gross motor activities, and they sent materials home for families to use. Teachers made different number paths depending on the classroom theme for the month (e.g., frogs on lilypads, butterflies on path of flowers, and dinosaurs walking on dinosaur prints).
Family Playgroups and Family Literacy Night
WFP hosts family playgroups and literacy nights, and most of the families who attend have two- and three-year-olds. WFP educators focused on making the number path game engaging for toddlers. They made a number path on the floor and had children roll dice to move. They held potato sack races on the number path and used the number path to play hopscotch. Playing with the number path in a variety of ways gave children lots of opportunities to practice the number concepts while continuing to maintain high engagement. All the while, WFP educators made sure to discuss with parents why it’s important for children to practice these skills and how they can incorporate math talk and math games into their own routines at home.

At Home
After being introduced to mathematics games, parents implemented them in a variety of ways. For the number path game, one family drew a number path on the floor of their kitchen (with washable markers). Another family drew a number path in chalk outside on the sidewalk. Some families used dice, some made spinners, and some drew numeral cards to play with. Families with elementary school-age children made longer number paths, and the older siblings often helped the younger ones. Some families played cooperatively so that each player jumped the same number each time rather than competing to see who would get to the end first.

At the Library
The Worcester Public Library (WPL) incorporated family math kits into their in-person and online summer reading events. The kits included Jumping on the Lily Pads game boards, directions for how to play, and a math “mini-book” about jumping to 10. The Jump to 10 mini-book is available in English, Spanish, and Portuguese.

### Table 2. Retrospective Pre-Changes in Educators’ Attitudes Toward Mathematics

<table>
<thead>
<tr>
<th></th>
<th>Year 1 (N = 59)</th>
<th>Year 2 (N = 57)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Before YM</td>
<td>Mean End of Year 1</td>
</tr>
<tr>
<td>Understanding importance of family math and early math learning***</td>
<td>4.05</td>
<td>5.51</td>
</tr>
<tr>
<td>Interest in early math activities and early math learning***</td>
<td>3.98</td>
<td>5.29</td>
</tr>
<tr>
<td>Comfort engaging in math with young children***</td>
<td>4.10</td>
<td>5.32</td>
</tr>
<tr>
<td>Comfort supporting families in early math***</td>
<td>3.47</td>
<td>4.88</td>
</tr>
<tr>
<td>Avoidance of math activities*** (Year 2; Not Significant in Year 1)</td>
<td>2.31</td>
<td>1.91</td>
</tr>
</tbody>
</table>

* p < .05; ** p < .01; *** p < .001.
In the Park
The number path idea extended beyond the partnership members. Worcester’s Recreation Department; Pow! Wow! Worcester; a community development organization; and WFP partnered with MathTalk to design and install a giant number path in a local park. The number path included family math signage with QR codes to bring families to apps and websites with more information.

Evaluation and Findings
During the 2019–20 and 2020–21 school years, an external evaluator administered surveys and conducted focus groups and interviews with families, educators, and project leadership (Manning 2022).

Educator Surveys
Educators were surveyed at the beginning and end of each year. Nearly half of the educators had more than 10 years of experience in early childhood education. Sixty-four percent of the educators were White, 11% were Latino, 7% were Black, 5% were Asian, and 9% did not report. Thirty-one percent of educators were bilingual, most commonly Spanish and English.

Educators Attitudes Toward Mathematics
On the end-of-year surveys, educators rated their current math attitudes and reflected back to their math attitudes at the beginning of the year. As you can see in Table 2, educators showed statistically significant increases in their positive attitudes toward mathematics. Reflecting on teachers’ experience in the program, the education manager said that the professional development allowed teachers to easily understand the mathematics concepts children are learning and they left each session feeling like they could “Do Math” themselves and with their students.

Educator Attitudes Toward Teaching Mathematics
In addition to having a positive effect on educators’ attitudes toward mathematics, their attitudes about teaching mathematics also improved, as shown in Figure 2.

Educator Confidence in Supporting Family Math
Educators also reported statistically significant increases in their confidence to support families in early mathematics (see Figure 3).

The project leadership board unanimously agreed that there was a positive cumulative effect of the PD provided to educators, which also supported children and families’ understanding of children’s early math knowledge and the importance of engaging them in playful math activities to support school readiness.

We have had richer conversations amongst staff, and this has translated directly into our work with families. We have had more intentional conversations with caregivers and play with children.

These data provide promising evidence that this type of program can have significant positive effects on educators’ attitudes toward math, attitudes toward teaching math, and confidence supporting families to engage in math with young children.

Family Survey
To capture the experience of families involved with the partnership, we administered a survey at the end of each year. The data presented here is from the survey administered

![Chart showing educator attitudes about teaching math]

N = 59–61. Scale: Strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree

FIGURE 2. EDUCATOR ATTITUDES ABOUT TEACHING MATH

www.nsta.org/connected-science-learning
spring 2021 at the end of Year 2. It was available in English and Spanish. Of the 59 parents who responded, three-quarters of respondents were people of color and about half spoke a language other than English at home (17% Spanish; 5% Arabic; 5% Twi; 3% Albanian; 3% Urdu; and 2% for Bengali, French, Haitian Creole, Japanese, Mandarin, and Portuguese). More than two-thirds had children entering kindergarten in fall 2021; the rest were either entering public preK or continuing in Head Start or WFP.

Families’ Attitudes Toward Mathematics

On the end-of-year family survey, families rated their math attitudes and reflected on their feelings about math at the beginning of the year. Findings showed significant positive increases in families’ mathematics attitudes on all questions but one, nervousness about helping their child with mathematics (see Figure 4). While parents’ nervousness went up slightly, it was not a significant change, and it could be explained by children having spent a year in remote or hybrid instruction during the pandemic. Many parents were feeling more nervous about their children’s mathematics learning after a year and half of the pandemic.

Family Use of YM-W Games and Materials

Families were asked about their use of the YM-W games and materials as well as about the impact of the materials (Table 3). Of families who responded to the Year 2 survey, 82% used the YM materials that they received, and 74% of parents used them once a week or more.

As shown in Figure 5, nearly all the parent survey respondents (90%) who used the materials agreed that the materials helped them talk with their children about math, while 88% also agreed that the games and books helped them feel less anxious about math.

These findings provide evidence that the partnership promoted an increased understanding of the importance of early mathematics among educators and families and an increase in positive attitudes toward mathematics. Importantly, these findings help illustrate that a family math learning community can spark adults’ interest in early mathematics and increase adults’ comfort and knowledge of how to help young children learn math. In addition, the results suggest that playful early mathematics learning materials can support families’ math talk with children, while also reducing families’ math anxiety. The
program supports the adults in children’s lives to see the mathematics in everyday life and intentionally capitalize on these “math moments” to support children’s learning.

Lessons Learned From a Successful Family Math Community

In this section, we discuss some of the key lessons we have learned from this partnership.

Responding and Adapting

A key component of the success of the partnership was our willingness to quickly change strategies in response to data and the ever changing COVID-19 crisis while keeping a clear focus on the overall mission. The leadership team met monthly to review qualitative and quantitative data from families and educators and revised our plans based on their needs. For example, when in-person classroom instruction for Worcester Head Start Programs and playgroups for the Worcester Family Partnership were shut down in March 2020 due to the COVID-19 pandemic, educators were concerned about how to work remotely with families who depend on their programs. Within a few weeks, we began virtual PD sessions and shared and discussed virtual mathematics instructional strategies and practices to keep children and families learning math at home. We used a web-based Learning Management System to provide online access to resources, discussion forums, and recordings of PD sessions.

Family-School-Community Triangle of Support

The partnership aligned children’s informal and formal environments by recognizing the importance of their interconnectedness and building on each other’s strengths. This teacher from Head Start recognized the key role that families play in children’s learning and how teachers can provide the needed ingredients:

- **Families are fundamental in shaping children’s interest and skills in math...**
- We can give families ingredients, and motivation to support their young children’s mathematical development effectively.
- Families can...provid[e] environments that are rich in learning. Families can teach children to see and name small quantities, count, add, subtract, and point out shapes.

By strengthening the connections between home, school, and community learning environments, we can provide a more robust learning ecosystem for children.

Accessible and Engaging Mathematics for a Wide Range of Ages

Early in the partnership, we learned that for mathematics games to be engaging and easy to implement for families, they must be accessible and engaging for all members of the family—toddlers, preschoolers, elementary school–age children, caregivers, and grandparents—who want to play together. This was a design challenge that the members of the family math leaders and WFP educators were eager to take on. Starting with a prototype, they redesigned games to work better in multi-age environments. Learning from these lessons, we improved our design strategies with a focus on accessibility and adaptability. In addition, we found that playing mathematics games with adults can support their understanding of important foundational mathematics. For example, playful mathematics resources can remove some of the pressure of “doing it right” that teachers and

![Graph showing retrospective pre-changes in families’ attitudes toward mathematics](image)
families often feel about mathematics and provides an intuitive way of understanding and engaging children with mathematics. Mathematics games can also spark families’ interest and enjoyment of mathematics and we noticed that they played an important role in helping families to see and intentionally capitalize on the mathematics in everyday moments, such as noticing shapes and patterns on a walk, using spatial language at the playground, or sharing treats fairly among friends.

**Equitable Access to Mathematics for All Families**

The partnership has worked on many strategies to provide access to more families. The Young Mathematicians website has game direction sheets and how-to-play videos in English, Spanish, and Portuguese, as well as other resources that visitors can browse and download at no cost. We are expanding a collection of family math text messages that provide family math ideas on a weekly basis. WFP and Head Start send home family math kits that are aligned with the scope and sequence of what they are teaching. In addition, based on their experience during the pandemic, they will continue to offer a mix of online and in-person learning opportunities to make it easier for families to attend.

The model we have developed supports adult learning about important early mathematical ideas through mathematics games and can be replicated by other programs. When thoughtfully implemented, mathematics games can provide a context for educative materials that provide a context for educators and families to practice and learn more about children’s mathematical thinking.

**Next Steps**

The partnership has entered Year 3, and we are focused on sustainability and expansion. Two of the key components of sustainability are (1) including family math in curriculum planning throughout the school year and (2) coaching current and new staff. Both WFP and Head Start have included family math in their scope and sequence for the year and are planning family math kits to align with their lessons. We are working together to design a coaching program that can continue to be used once the project is over.

In terms of expansion, the partnership is going through a planning process to hear from families about the supports, tools, and touchpoints they currently engage with or would like to engage with to support their children’s early mathematics learning. Expanding our work with the public school is a particular priority that we have identified.

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**TABLE 3. FREQUENCY WITH WHICH RESPONDING FAMILIES USED YM-W MATERIALS**

<table>
<thead>
<tr>
<th>Frequency of use</th>
<th>% of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Used materials (82%)</td>
<td></td>
</tr>
<tr>
<td>Almost every day</td>
<td>8% (n = 4)</td>
</tr>
<tr>
<td>2-4 times a week</td>
<td>32% (n = 16)</td>
</tr>
<tr>
<td>Once a week</td>
<td>34% (n = 17)</td>
</tr>
<tr>
<td>Less than once a week</td>
<td>8% (n = 4)</td>
</tr>
<tr>
<td>Had not (yet) used</td>
<td></td>
</tr>
<tr>
<td>materials (18%)</td>
<td></td>
</tr>
<tr>
<td>Planned to use</td>
<td>12% (n = 6)</td>
</tr>
<tr>
<td>Did not use</td>
<td>6% (n = 3)</td>
</tr>
</tbody>
</table>

N = 50 (who responded and recalled receiving the materials)

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**FIGURE 5. FAMILIES’ ASSESSMENT OF THE IMPACT OF THE YM-W MATERIALS**

- **The math materials helped me talk with my child about math.**
  - Disagree: 10%
  - Agree: 90%

- **The math materials helped me feel less anxious about math.**
  - Disagree: 12%
  - Agree: 88%

N = 41
Concluding Thoughts

As a family math community, we set a goal to foster positive attitudes toward mathematics and transform the way that families engage with their children around mathematics—making it a common and doable family activity, so that all children see themselves as STEM learners. The achievement of this goal may be best illustrated by one of our parent participants, Shemekia Pearson, who said as she reflected on her experience with Young Mathematicians:

"Playing these games was quality time with my child, but it was quality time that I felt was beneficial to his today and to his future... I see how confident he is in math, and it makes me feel proud."

The YM-Worcester family math learning community exemplifies our strong belief in the benefit of bringing early childhood programs and families together in partnership so that all children have the opportunity to engage in meaningful mathematics across home, school, and community contexts. We hope that the model we have created can be useful to other communities seeking to promote these connections and increase learning opportunities for all children.

Author Note

For the sake of brevity, we sometimes use the word parent to refer to children’s primary caregivers, but we recognize families come in many configurations, and the primary caregivers may be grandparents, aunts, uncles, older siblings, other family members, or guardians.

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References


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