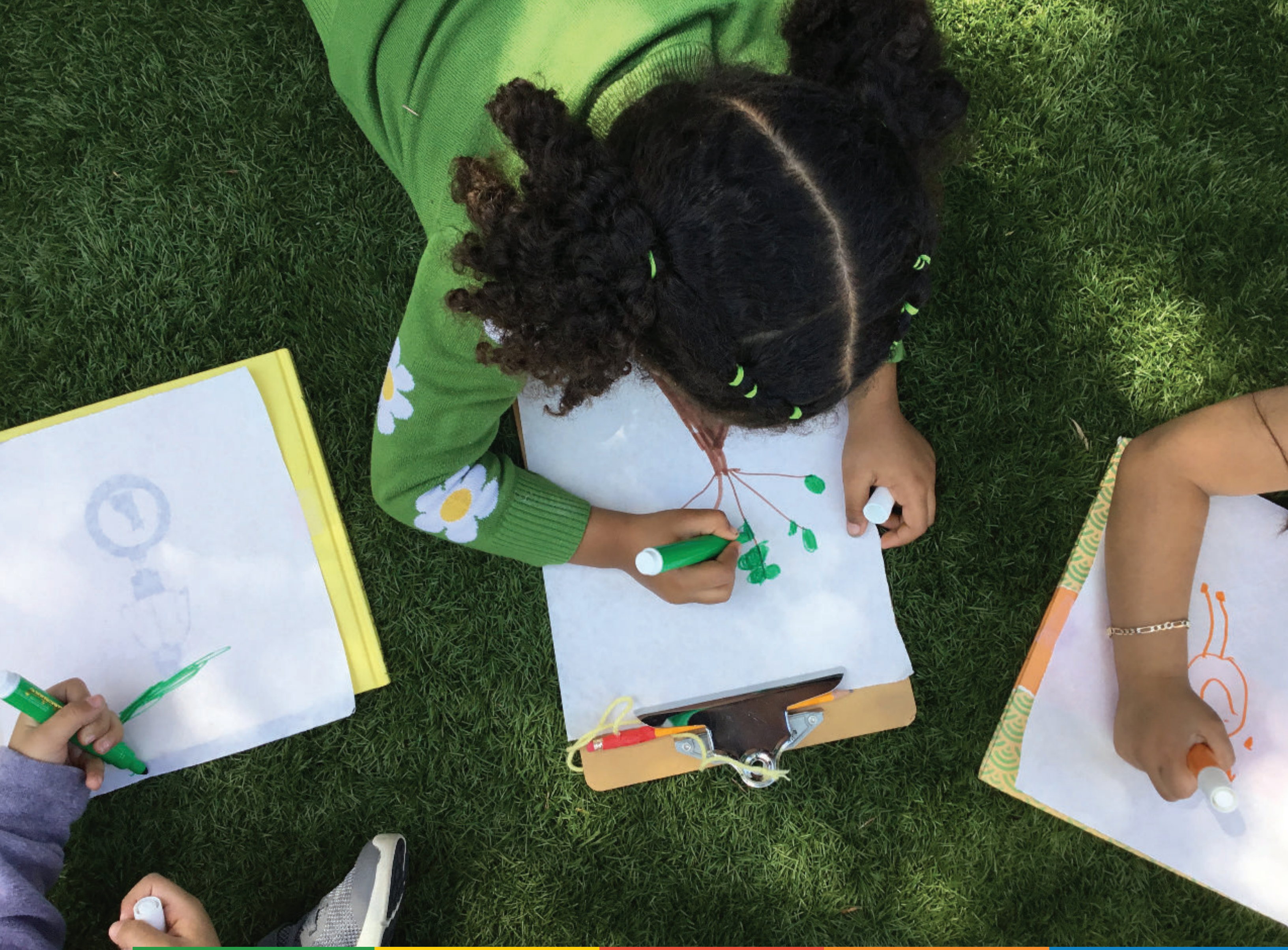

Problem Solvers Teacher's Guide

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Kathy Kinsner, MS, Ed.

Problem Solvers

ZERO TO THREE
Early connections last a lifetime

Authors' Note

ZERO TO THREE Is thrilled to share the *Problem Solvers* curriculum with the early education community, as we continue our work of ensuring all children have access to rich and engaging learning experiences. As with all ZERO TO THREE resources, *Problem Solvers* represents an intentional braiding of research-based learning experiences; joyful play and exploration; and nurturing relationships. We are deeply grateful to the **Honda USA Foundation** and **Dr. Seuss Foundation** for providing the funding to support the development of the math activities and to the **General Motors Foundation** to support the development of the science and engineering activities in *Problem Solvers*.

We have been especially fortunate to have the assistance of **Dr. Sandra Linder**, a mathematics and instructional strategies expert, as our reviewer for the *Problem Solvers* curriculum. Dr. Linder is a Professor of Early Childhood Mathematics Education in the College of Education at Clemson University and reviewed all *Problem Solvers* activities to ensure they were pedagogically sound and age-appropriate for toddlers and preschoolers. We are so grateful for Dr. Linder's thought partnership as we brought *Problem Solvers* to life on the page (and in the classroom!).

The *Problem Solvers* curriculum is unique in that each activity is paired with a specially-composed song. The songs in *Problem Solvers* were the creative brainchild of **Dr. Jennifer McDonel**, Associate Professor of Music and Director of Music Education at Radford University. Dr. McDonel composed and performed the music featured in the *Problem Solvers* curriculum, and was a dynamic collaborator in bringing our math activities to life through song. Her engaging music offers children a new pathway for exploring critical early math concepts while also nurturing their music development through listening and movement.

We also owe our deepest thanks to the *Problem Solvers* Expert Work Group for their guidance in developing this project. Expert Work Group members offered us insight into the theoretical foundations of early STEM development and instructional approaches, and, most importantly, asked the tough questions that helped us understand early STEM as an organic, child-led series of explorations. Our Expert Work Groups for the two phases of *Problem Solvers* were comprised of the following outstanding professionals, and we are deeply grateful to them all:

Art Bardige, MAT of What If Math, Cambridge, MA

Dr. Jie-Qi Chen of the Erikson Institute, Chicago, IL

Dr. Christine Cunningham of the Museum of Science, Boston, MA

Dr. Daryl Greenfield of University of Miami, Coral Gables, FL

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Donna Johnson, MS of the Erikson Institute, Chicago, IL

JoAnna Schofield, MLIS of the Stark County District Library of Canton, OH

Dr. Jennifer Ward of the School of Education at Kennesaw State University, Kennesaw, Georgia

Most importantly, we offer our endless gratitude to the pilot sites who took a chance on testing a brand-new early STEM curriculum. These sites implemented *Problem Solvers'* activities, provided weekly feedback on their effectiveness, collected child data to track learning, and met with us regularly to suggest strengths and improvements.

We are incredibly thankful for the talented teachers below who helped us ensure that *Problem Solvers* was not only an age appropriate, engaging, and rich learning tool for young children, but also user-friendly and informative for educators as well.

Our outstanding *Problem Solvers* educators and pilot sites included:

- The Little Scholars Club, Chicago, IL
  Jeanette Rodriguez, Gladys Armenta, Alaina Luciano, and Selene Gonzalez
- HACAP Head Start – Waterfront, Iowa City, IA
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- HACAP Head Start – Coral Ridge, Coralville, IA
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  - Maria Sandoval, Mia Martinez, and Christian Pou
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  - Rosa Rodriguez
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  Samantha Stevers
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  Sandra Garduno
- SHARE Head Start – Clemson Center, Clemson, SC
  Kathy Morris and Courtney Couch
- SHARE Head Start – North Greenville Center, Travelers Rest, SC
  Sharikea Reddick and Angela Grubbs

Author Biographies

Rebecca Parlakian, MA, Ed, is a child development and parenting specialist who serves as senior director of programs at ZERO TO THREE, where she manages a portfolio of federally and privately funded projects related to healthy child development and high-quality teaching. Rebecca has coauthored five parenting education and professional curricula, including both *Problem Solvers* and *Early Connections*, a parent café curriculum that had demonstrated positive impacts on parent responsiveness and children's social-emotional skills. Rebecca has also developed a wide range of parenting resources on topics related to child development, early STEM skills, challenging behavior, fatherhood, and racial equity. Her written work has appeared in a variety of publications, such as the *ZERO TO THREE Journal* and *Young Children*. Rebecca holds a master's degree in education and human development, with a concentration in infant–toddler special education, from the George Washington University, where she served as faculty for ten years.

Kathy Kinsner, MS, Ed, is the senior manager of family resources at ZERO TO THREE. She has five decades of experience as an educator and producer of nonfiction media for parents, teachers, and children. Her roles range from her Emmy-winning work as a producer on the PBS series *Reading Rainbow* to director of curriculum and instruction for Roads to Success, a nonprofit college and careers program serving low-income secondary students in three states. At ZERO TO THREE, Kathy has developed a variety of parenting and grandparenting resources, including collaborations with the American Academy of Pediatrics, the CDC, Head Start, the Mount Sinai Parenting Center, and NAEYC. She holds a master's degree in education/reading from Bowling Green State University and a master's degree in television, radio, and film from Syracuse University.

The following individuals also contributed thoughts and expertise to the science and engineering components of *Problem Solvers*:

Angela Eckhoff, PhD is Professor of Teaching and Learning, Early Childhood at Old Dominion University in Norfolk, Virginia. She holds a dual PhD in Educational Psychology and Cognitive Science from the University of Colorado at Boulder. Her published writings center on children's interactions in early STEAM learning in formal and informal learning environments, creative thinking in childhood, and the pedagogical practices that support children's deep engagement in thinking and learning.

Summer Jones, MA, Ed., IMH-E is a Senior Writer and Training Specialist for Military Family Projects at ZERO TO THREE. In this role she provides training and consultation for Army New Parent Support Program's Home Visitors. She's worked with ZERO TO THREE for 16 years supporting national programs focused on the mental health and well-being of young children and their families. Summer holds a Master of Arts degree in Education and Counseling, and has achieved Professional Endorsement as an Infant Mental Health Mentor in Policy.

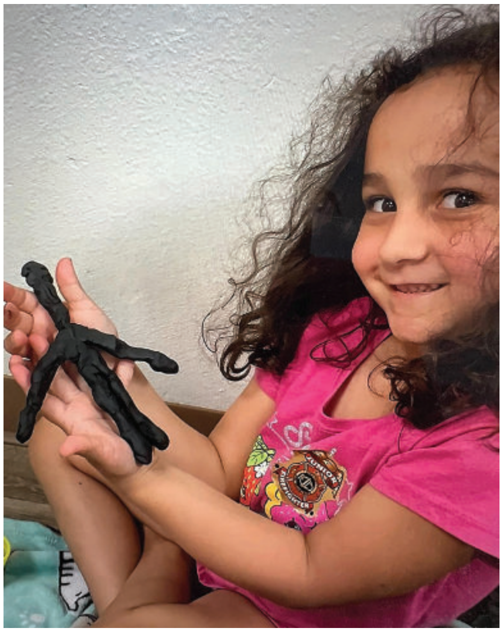
What Is *Problem Solvers*?

The *Problem Solvers* Early STEM Curriculum provides early educators with a set of 44 age-appropriate, play-based activities designed to introduce science, engineering, and math concepts to children aged 30 months through 48 months. *Problem Solvers* can be used on its own or in conjunction with other curricula as a tool for increasing children's exposure to early STEM experiences.

Each activity in the *Problem Solvers* curriculum is aligned to one or more early STEM learning objectives. For math activities, these objectives span seven sub-domains including: counting, simple calculations (adding/subtracting), shape awareness, position and direction (spatial awareness), patterns, sets, and measurement/comparison. For science and engineering activities, these objectives span four content areas including: physical sciences, life sciences, earth and space sciences, and engineering design. As recommended by the Next Generation Science Standards (www.nextgenscience.org), science and engineering activities also align to STEM practices such as: asking questions, making observations, making predictions, noticing patterns, exploring cause and effect, and more. STEM objectives are outlined at the top of each activity.

Each activity includes:

- A play-based learning experience that introduces specific early STEM objective(s).
- A song, composed to reinforce the activity's early STEM learning objectives.
- A read-aloud activity that aligns to targeted objectives.
- A family handout (in English/Spanish) that offers suggestions for at-home early STEM activities to share with children.



Aren't They Too Young?

Robust research demonstrates that early math experiences and exposure to math language have positive and lasting impacts on children's math skills, both in preschool and once they enter formal education.[1,2] Children attending preschool can attain higher levels of understanding in math when they are supported through well-planned, stimulating, and developmentally appropriate activities.[3] Student engagement is also high—in fact, "phenomenal"—when preschool teachers deliver STEM activities in the early education setting.[4]

Very young children are not just learning STEM in preschool settings. Home-based STEM learning experiences shape children's early skills and nurture a developing foundation of early STEM knowledge. For example, recent research shows a strong correlation between parents' use of math language in interactions with preschool children and children's later use of math language and their subsequent mastery of math concepts.[5,6,7] As well, parental engagement in science-related learning activities with their children at home is also associated with children's science knowledge at age five years.[8] In developing *Problem Solvers*, our central goal was to create learning experiences that increased the exposure to, and engagement with, STEM concepts in the early learning setting while at the same time inviting parents to participate in similar activities at home. To enhance the partnership between early education professionals and family members, *Problem Solvers* offers send-home resources designed to provide families with ideas to engage their young children in STEM-centered play. Ideally, these resources (and the conversations between parents and teachers that may result) will encourage greater continuity between school and home.

[1] Levine, S. C., Suriyakham, L. W., Rowe, M. L., Huttenlocher, J., & Gunderson, E. A. (2010). What counts in the development of young children's number knowledge? *Developmental Psychology, 46*(5), 1309-1319. http://dx.doi.org/10.1037/a0019671

[2] Levine, S. C., & Baillargeon, R. (2016). Different Faces of Language in Numerical Development: Exact Number and Individuation. In *Core knowledge and conceptual change*.

[3] Aldemir, J., & Kermani, H. (2016). Integrated STEM curriculum: Improving educational outcomes for Head Start children. *Early Child Development and Care*, *187*(11), 1694-1706.

[4] DeJarnette, N. K. (2018). Implementing STEAM in the early childhood classroom. *European Journal of STEM Education, 3*(3), 18.

[5] Pruden, S. M., Levine, S. C., & Huttenlocher, J. (2011). Children's spatial thinking: Does talk about the spatial world matter? *Developmental Science, 14*(6), 1417–1430. http://doi.org/10.1111/j.1467-7687.2011.01088.x

[6] Spatial Reasoning: Why Math Talk is About More Than Numbers | Development and Research in Early Math Education [Web log post]. (2017, December 17). Retrieved from https://dreme.stanford.edu/news/spatial-reasoning-why-math-talk-about-more-numbers

[7] Skwarchuk, S., Sowinski, C., & LeFevre, J. (2014). Formal and informal home learning activities in relation to c children's early numeracy and literacy skills: The development of a home numeracy model. *Journal of Experimental Child Psychology, 121*, 63-84.

[8] Junge, K., Schmerse, D., Lankes, E. M., Carstensen, C. H., & Steffensky, M. (2021). How the home learning environment contributes to children's early science knowledge—Associations with parental characteristics and science-related activities. *Early Childhood Research Quarterly, 56*, 294-305.

Early STEM Learning Objectives

The early math learning objectives used in this curriculum are derived, in large part, from the Head Start Early Learning Outcomes Framework (ELOF): Ages Birth to Five,[9] which is designed to illustrate the continuum of learning for infants, toddlers, and preschoolers across five central domains. The ELOF is grounded in comprehensive research around what young children should know and be able to do during their early years. The Erikson Institute's Early Math Collaborative's seminal work[10] also shaped our understanding of how young children engage with early mathematics concepts and informed our development of activities that reflect typical development while aligning with core mathematical content.

Because the ELOF currently does not touch on science and engineering objectives with specificity (as of this writing), the *Problem Solvers* authors reviewed other national efforts to articulate the developmental pathways associated with science and engineering knowledge acquisition. The Next Generation Science Standards[11] (NGSS) were developed by the National Research Council (NRC), the National Science Teachers Association, the American Association for the Advancement of Science, and Achieve, with input from educators, experts, and business leaders nationwide. These Standards outline learning objectives for science and engineering mastery from kindergarten through high school graduation. The *Problem Solvers* team reviewed the objectives identified for kindergarten students, selected topics and objectives most appropriate for a preschool educational setting, and adjusted the objectives as needed to reflect the typical development of a young child (30 months old through age 4 years).

It is important to note that, in alignment with the NGSS, science/engineering activities in *Problem Solvers* are designed to support the development of science content knowledge as well as cross-cutting science thinking skills (such as the ability to make observations, ask questions, make predictions, and more). The mathematics activities also encourage children to make use of mathematical processes (problem solving, making connections, reasoning and proof) as they explore this content.

Please see **Appendices A and B** to review tables outlining the early math, science, and engineering objectives utilized in this curriculum; these tables also suggest associated STEM vocabulary teachers can share with children to support their learning. **Appendices C and D** indicate the early STEM sub-domains covered by each of *Problem Solvers'* 44 activities and suggest approximate preparation times for each activity. Note that math activities in the curriculum are numbered 1 to 22, while science and engineering activities are numbered with an SE prefix from SE 1 to SE 22.

[9] U.S. Department of Health and Human Services, Administration for Children and Families. (n.d.) I*nteractive Head Start Early Learning Outcomes Framework: Ages Birth to Five*. https://eclkc.ohs.acf.hhs.gov/interactive-head-start-early-learning-outcomes-framework-ages-birth-five

[10] Erikson Institute's Early Math Collaborative. (2014). *Big Ideas of Early Mathematics: What Teachers of Young Children Need to Know*. Pearson Education.

[11] NGSS Lead States. (2013). *Next Generation Science Standards: For States*, By States. www.nextgenscience.org

Instructional Approaches Used in *Problem Solvers*

Problem Solvers activities reflect current best practices in terms of early mathematics, science, and engineering instruction as well as equity principles for STEM instruction. Following are the guiding principles on which the curriculum was based:

1. **STEM is everywhere!** Children and teachers are encouraged to notice math, science, and engineering in the classroom, school, and community. Activities also demonstrate how math, science, and engineering skills and concepts are used in a variety of settings and tasks—from grocery shopping to garbage collection. The goal is to help young children learn and experience how STEM skills and concepts are relevant to their lives.
2. **Honor child development.** Toddlers and preschoolers bring unique skills and abilities to early education programs. This curriculum seeks to provide children with a play-based entry point for exploring and acquiring foundational STEM understandings.
3. **Center children's skills and knowledge**. Each *Problem Solvers* activity begins with a discussion designed to lift up and explicitly value children's background knowledge and experiences. These conversations communicate children's belonginess in *Problem Solvers* activities from the very start.
4. **Ensure each activity has multiple entry points for learning.** Each activity in *Problem Solvers* was designed to provide children with two play-based learning experiences—typically a group activity and a partner activity. In addition, the curriculum includes a specially-designed song (with suggested child engagement) and a book recommendation (with STEM extension activity) for each unit. These different learning pathways allow children many entry points for exploring, practicing, and mastering the STEM objectives addressed across the curriculum.
5. **Encourage students to share their thinking.** Asking children to share their thinking conveys the message that they are valuable contributors to STEM learning experiences and nurtures a positive STEM identity. Throughout the activities, teachers are prompted to use open-ended questions to elicit students' thinking. Each activity also closes with a reflective group discussion in which children share or show what they did, discovered, and learned.
6. **Partner with parents to encourage school-home continuity.** A partnership approach communicates to children and families the central belief of this curriculum: all children can learn and master STEM skills. Sharing the provided family resources also offers parents and caregivers ideas for nurturing STEM learning at home, which helps children generalize their new skills across both their home and school environments.

In addition, we undertook research into equitable STEM instruction that centers Black, Hispanic/Latine and Multilingual students, addresses barriers to equity, and aligns instruction to STEM objectives. Much of the work to date focuses primarily on elementary through high school settings, but several of the foundational principles driving equitable STEM instruction can—and should—be integrated within early education settings. These principles include:[12]

- **Teach rich, thoughtful, complex STEM content.** In *Problem Solvers*, children experience a wide variety of challenging activities that encourage them to explore, imagine, test, and refine their understandings.
- **Nurture children's emerging STEM identity so they see themselves as mathematicians, scientists, and engineers.** Children are engaged as "Problem Solvers" as they explore and experience the curriculum. Teachers reinforce children's growing STEM identity by asking them to share their thinking and by showing respect for children's ideas and understandings. The idea that every child can use math, science, and engineering skills to be a Problem Solver is a repeating theme across the curriculum.

[12] Cintron, S. M., Wadlington, D., & ChenFeng, A. (2021 May). *A pathway to equitable math instruction: Dismantling racism in mathematics instruction*. https://equitablemath.org/wp-content/uploads/sites/2/2020/11/1_STRIDE1.pdf

- **Integrate physical movement in STEM activities.** This principle is particularly important when working with very young children who are driven to move! Many of the activities in *Problem Solvers* invite children to move about the classroom to complete a component of the activity, and all of the 44 songs include movement suggestions for students to try. Young learners thrive when they are touching, lifting, doing and exploring.
- **Allow for engagement in productive struggle.** Activities that are too easy (or too difficult) are not fun or engaging; when children are not engaged, they are not learning. Productive struggle means that children are appropriately challenged and, with scaffolding (support and/or coaching), they can master the task at hand. *Problem Solvers* offers teachers suggestions for increasing (or decreasing) the challenge level of each activity to allow for individualization and to provide an appropriate and rigorous level of challenge to students.
- **Rely on teamwork and collaboration as much as possible, so that students can learn from and teach each other.** Each *Problem Solvers* lesson includes a small group activity followed by a paired activity to extend the learning. This approach encourages peer relationships—as children are beginning to develop their first friendships between 30 and 48 months—and also creates opportunities for children to teach and mentor one another. Pilot sites that implemented the program in mixed-age settings noticed this coaching behavior happening organically as they implemented *Problem Solvers* over a series of weeks.
- **Encourage teacher reflection.** Early educators work hard to meet the emotional and academic needs of multiple children across the day—while juggling a range of other responsibilities, including health, safety, and administrative tasks. It can be challenging to carve out time to reflect on the meaning of children's behavior, consider their curiosities, and wonder about how to build on their current skills, interests, and abilities. Reflective practice is one tool that can help. Reflection can happen in a variety of ways, such as through child observations, individual journaling, sharing with peers, or in discussions with supervisors or coaches. Reflection on children and curricula can provide the time and space that nurtures educators' own learning and development. During these moments, teachers might consider how best to individualize activities, select activities based on children's interests or other factors, and/or respond supportively when children struggle with new skills. Teacher can use the resource in **Appendix G** as a tool to guide their reflection on the use of Problem Solvers (or other) STEM activities in the early education setting.

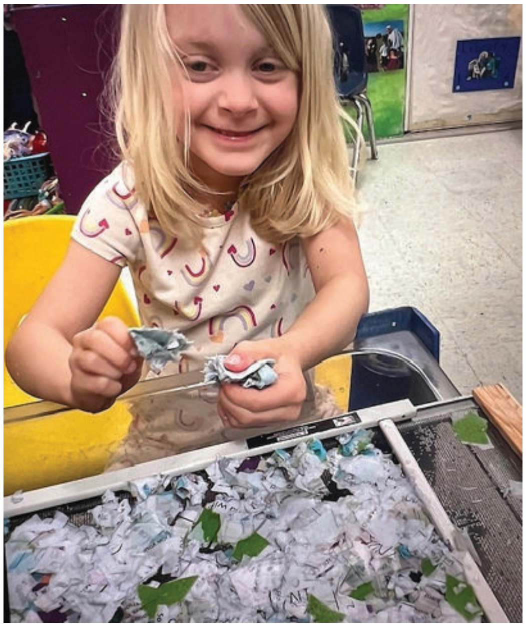
[13] Boaler, J. (2015). *The myth of being "bad at math."* https://www.aspeninstitute.org/blog-posts/myth-being-bad-math/

Welcoming Mistakes

The practice of welcoming mistakes is both a critical instructional practice and an equity principle in STEM instruction. Traditionally, there has been a high value placed on getting the "right" answer in STEM disciplines. Precision is, of course, central to learning and applying mathematics, science, and engineering learning. Too often, though, an emphasis on correct answers can lead students to develop an early (and lasting) sense of themselves as "bad at math"[13] or science and engineering. Yet we know that all children have the potential to succeed in mastering these skills and concepts.

The truth is that *thinking like a mathematician, scientist or engineer* is a messy process. Trying, failing, and trying again (often using a different approach) is an integral part of STEM learning. Often STEM innovation takes years of iterating—trying and failing—until a solution is found. Reframing mistakes as opportunities for learning creates a classroom culture that lifts up all children as effective STEM learners.

In *Problem Solvers*, we de-emphasize the notion of the "right answer." Instead, we encourage educators to first explore the student's thinking or strategies. Teachers are prompted to show curiosity in the children's work, asking them to share or show how they came to their answer, regardless of whether the result is correct or incorrect. This approach makes the child's STEM thinking apparent and creates a natural, relationship-based opportunity to check for misunderstandings, offer coaching/scaffolding, and support mastery over time. Mistakes can be important occasions for learning—but only when they spark an interaction that deepens a child's understanding of the targeted skills.



Structure of Problem Solvers

Each *Problem Solvers* activity includes the following components:

CHILDREN ARE LEARNING TO...

Details the specific early math learning objectives of the activity.

MATERIALS NEEDED

Outlines the materials required for the activity.

PREPARATION

Explains the steps teachers need to complete in order to prepare the activity. Note **Appendices C and D** indicate the approximate preparation time required for each of the 44 activities. As an open-access resource, *Problem Solvers* was designed to require the purchase of as few materials as possible. As a result, most activities require some preparation by teachers/teaching assistants, most often creating materials using provided handouts. This might include, for example, printing and cutting a set of cards to implement a game or collecting materials like cardboard boxes for an open-ended engineering activity. To allow adequate time to prepare, it is a good practice for teachers to review the activity they plan to implement a week in advance.

ACTIVITY INSTRUCTIONS

Engage: The *Engage* section is an opening discussion designed to elicit children's existing knowledge on the targeted topic or skill area. The discussions in *Engage* are typically free-flowing and open-ended with no right or wrong answers. The goal is to engage children and get them excited about what's to come. Additionally, these discussions can provide teachers with some insight into children's prior experiences with, and understandings of, the topic. This context better equips teachers to expand, enrich, or adjust children's understandings within the activity.

Expand: The *Expand* section introduces a math-based game or learning activity for a small group of children. The activity is designed to be playful and participatory. Suggested discussion questions and/or instructional approaches are embedded into teacher instructions.

Explore: The *Explore* section suggests an extension to the *Expand* activity. This is frequently a partner/collaborative activity designed to promote early friendships and peer-based learning as well as to offer children a new way to practice the same learning objectives.

Reflect: As a closing, the *Reflect* section invites children to share their thinking and experiences. This conversation is designed to give children the opportunity to articulate their STEM thinking.

Individualizing the Activity: This section provides teachers with concrete suggestions for making activities more or less challenging to match children's current skills and needs. *Problem Solvers* is intended to be a curriculum tool that meets the needs of a fairly wide age range (2 ½ to 4 years of age). The *Individualizing the Activity* section was designed to provide guidance on differentiating activities for older toddlers (2 ½ to 3 years) and preschoolers (4 years). This section can also offer ideas on modifying activities for children with unique learning needs. Note that some of the "more challenging" adjustments may require additional preparation.

Making Connections Across the Day: Children master new vocabulary through repeated exposure in a range of contexts. The *Making Connections* section suggests ways that teachers can include opportunities to practice new STEM skills in daily routines and through teacher-child interactions. The goal is for STEM vocabulary and concepts to become a part of everyday conversations, play, and routines; this shift increases children's exposure to STEM content, as well as offers them the chance to generalize (apply in new situations) learning they have mastered during the activities.

Song: Here, teachers can access lyrics to the activity's song and review suggestions for involving children in the song (for examples, gestures, prompts, and games to play while listening).

Making Literacy Connections: This section suggests a children's book that reinforces the activity's targeted learning objectives. (Note that all selected books are currently in print as of this writing and available from local and online booksellers.) Teachers can also access discussion questions to use with children during shared reading. These questions focus on narrative aspects of the story (making predictions, describing characters' feelings, etc.) as well as STEM concepts that are embedded in the story. Finally, this section suggests a simple extension activity that builds on the book and supports the targeted early STEM learning objectives.

Handouts: Here educators will find supporting materials to be copied and used as part of the activity.

Just for Families (English/Spanish): Teachers can copy and distribute this resource to families on a weekly basis. *Just for Families* resources invite caregivers to try STEM-based play activities at home that reinforce the skills children are practicing during the day. This resource should be provided when each activity is first introduced in order to (1) communicate what STEM topics are being covered in the classroom and (2) provide parents with tools and information to support early STEM learning at home.

What Age Children Are the Activities Designed For?

The curriculum is designed for children aged 30 months to 48 months of age. Curriculum activities were developed for typically developing three-year-olds. However, teachers can find instructions in the **Individualizing the Activity** section for making each activity more or less challenging to meet the needs of older or younger children, or children with unique learning needs. Note that several pilot sites implemented the activities with children up to age five years and reported that, with minor changes to increase the challenge level, the children remained engaged and challenged.

In What Order Should We Deliver *Problem Solvers* Activities?

The set of 22 math activities begins with simple counting experiences and progresses to more challenging concepts including patterns and measurement. We recommend beginning with the early counting activities as an entry point with students. After that, we encourage you to follow your student's interests: Are they comparing fall leaves during outdoor play in October? You might choose an activity that explores measurement and comparisons. Do you have several birthdays in your classroom this month? The activity *Bear's Birthday* helps children explore counting, quantity, and early addition around a birthday theme.

The set of 22 science and engineering activities (denoted by an SE prefix) touch on broad content areas including: life sciences, earth and space sciences, physical sciences, and engineering design. Because these activities are not designed as a series of increasing complexity, you can enter the curriculum at any point in the sequence based on child interests, seasonality, available preparation time, etc.

In short, *Problem Solvers* is effective in the order provided but can also be adjusted flexibly in response to your students, program, and community. We trust teachers to use their best judgment about what skills and which activities their students might enjoy or benefit from most at a particular point in time.

A final note: The *Problem Solvers* curriculum is designed to "loop"—meaning that once you have completed all activities, you can introduce them again. As children mature, they will engage with the activities in a new way and continue to benefit. As noted above, our pilot of *Problem Solvers* found that children up to age five years enjoyed and were challenged by the curriculum.

How Frequently Do I Implement Each *Problem Solvers* Activity?

Each activity is designed to be delivered to children approximately three times per week, for two weeks. Sometimes teachers are concerned that children will be bored by an activity that repeats, but our pilot sites found the opposite: children asked for *Problem Solvers* activities and requested past activities. In fact, several pilot sites found children wanted to continue their play even after the activity concluded and ultimately offered each unit's materials as a free play choice.

Research indicates that children need repeated experiences with a concept in order to master it.[14] The leveling guidance provided to teachers in *Problem Solvers* (offering tips on making each activity more or less challenging) helps to ensure that the learning experiences are individualized to each child's current and emerging skills.

How Do I Use the Songs in *Problem Solvers*?

The goal of music education for toddlers and young preschoolers is to help them become skilled listeners by exposing them to a range of musical styles, tempos, and melodies. In the early years, the goal is *not* for children to sing along, but to become thoughtful and attuned listeners who respond naturally to music through playful movement.

The songs composed for *Problem Solvers* are tonally and rhythmically diverse and invite children's participation through listening and movement. While the lyrics build on the activity's learning objectives, the songs stand on their own as distinctive and varied musical experiences. With repeated exposure to the songs, children may begin to sing portions of a song or join in the refrain. However, this is not the expectation or the goal. (Nor do teachers need to learn/sing all the songs!) Rather, teachers should regularly share the music with children to give them experience with *listening*. "Listening" doesn't mean sitting still and quietly—children are encouraged to respond spontaneously to the music through movement and, over time, vocalizations as they begin to anticipate a refrain or phrase.

Teachers can utilize the songs in the curriculum in a variety of ways and settings. For example, they might:

- Play the song to cue the start of the *Problem Solvers* activity time
- Play the song to cue the close of the *Problem Solvers* activity time
- Play during Circle Time as a whole-group activity
- Play the song during free play as "background" music
- Play during pick-up/drop-off to share this element of the curriculum with parents
- Provide the songs to parents as a digital playlist to create connections between school and home learning experiences

There is no right or wrong way to use the music element of *Problem Solvers*, though the goal is to provide children with frequent exposure to each song over the two weeks you are implementing the activity.

[14] LoBue, V. (2019). *Why children like repetition, and how it helps them learn*. https://www.psychologytoday.com/us/blog/the-baby-scientist/201907/why-children-repetition-and-how-it-helps-them-learn

How Do I Use the Book Recommendations in *Problem Solvers*?

The intent of the *Making Literacy Connections* section of each activity is to reinforce the concept that **STEM learning is everywhere**. Specifically, teachers can use the everyday routine of shared reading to notice, discuss, and explore STEM concepts with children.

Each activity in *Problem Solvers* recommends a STEM-focused children's book for shared reading with children. The books suggested for use in the curriculum represent a range of high-quality literature for toddlers and preschoolers. (Please see **Appendices E and F** for the curriculum's suggested book lists.) In each activity, the *Literacy Connections* section outlines a series of discussion questions that teachers may ask during the shared reading experience. These questions are designed to engage children in a dialogue about the story and concepts presented within; research indicates this dialogic approach to shared reading can positively impact a wide range of language and literacy skills for children under 5 years.[15] Shared reading and discussion of STEM-centered children's literature also increases children's exposure to targeted STEM vocabulary and concepts.

Finally, the *Literacy Connections* section outlines an optional extension activity for each book. This activity provides an additional entry point for children to build on the book and deepen their understanding of the activity's learning objectives. Generally, these activities require little preparation and are designed to be introduced following the story.

Tips for Implementation

Our pilot sites suggested the following strategies for making *Problem Solvers* a success in the early childhood setting:

- **Create file folders for each activity.** Sites suggest that once each activity is prepared, it's wise to put all the materials (plus the read-aloud book) into a labeled folder. Other teachers can then "check out" the activity and return it once done. This practice also keeps all materials for each activity together and organized for the next time the classroom teacher wants to use it.
- **Allow time for preparation.** Allow time to gather materials and become familiar with each activity. Activities in the curriculum require different amounts of preparation (see Appendices C and D). Reviewing the selected activity and preparing materials a week in advance is recommended. If possible, collaborate with colleagues to prepare activities, share materials, and address questions.
- **Make songs available to parents.** Parents whose children participated in *Problem Solvers* at our pilot sites often asked what songs their children were coming home singing! One of our pilot sites made the songs available to parents over the program's social media channel. Sharing the song files via email/text or providing parents with a digital playlist is another option for sharing this element of the curriculum.
- **Share children's learning with parents.** Pilot sites provided ZERO TO THREE with photos of students engaged in the activities; they also shared these images with parents and noted how thrilled parents were to see their children's learning in action. Documenting children's exploration through the *Problem Solvers* activities can be an important contribution to a child's portfolio and/or to daily communications with families.
- **Make activities and books available to children during free play.** Pilot sites explained that children often requested *Problem Solvers* activities during free play or choice time. Children also asked for "the math books" during story time. Framing *Problem Solvers* as play—and making activities and books available to children as playtime—emphasizes the notion that all children are mathematicians and scientists, and that STEM is enjoyable and relevant to their lives.

[15] Pillinger, C., & Vardy, E. J. (2022). The story so far: A systematic review of the dialogic reading literature. *Journal of Research in Reading, 45*(4), 533-548.

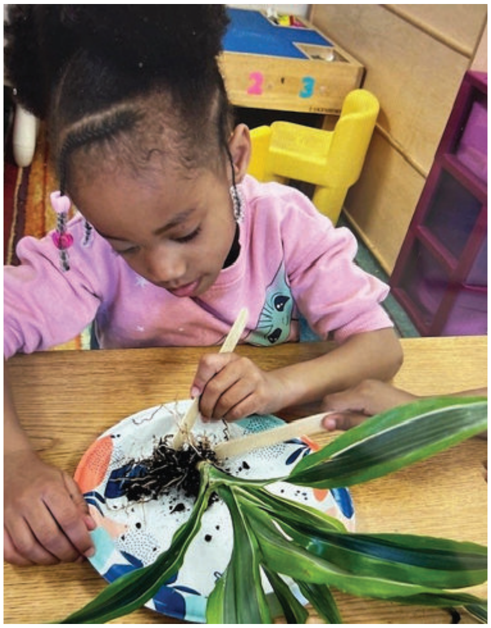
Evaluation

The math component of *Problem Solvers*, inclusive of all 22 activities, was examined at five treatment sites and three control sites in upstate South Carolina over a 23-week period during the 2023-2024 school year. Eighteen treatment classrooms in the five treatment sites (representing 158 children) participated in the curriculum implementation. In addition, there were 3 control sites (including 4 classrooms and 48 children) in which teachers delivered the typical math curriculum provided by their program or school district.

Findings from the evaluation established:

- Significant differences in math skills for three-year-old students in the treatment group and when examining individual treatment sites by age.
- Students in public 3k/4k treatment sites scored significantly higher in math skills than students in public 3k/4k control sites.
- Students with teachers who implemented the curriculum with greater fidelity showed higher levels of mathematics understanding than students whose teachers implemented the curriculum with low fidelity.
- Teachers expressed overall satisfaction with the curriculum and demonstrated positive instructional practices (determined through a series of 54 observations) when using *Problem Solvers*.
- Family/caregiver feedback on the take-home resource *Just for Families* indicated that the adults in children's lives believe the suggested activities were fun and helpful for their children's learning. Most stated they would use these activities again.

Overall, the evaluation team for *Problem Solvers*—representing 8 instructors and professionals from Clemson University—concluded: "These outcomes provide a rationale for continued exploration of this cost-free resource for early childhood teachers."



Additional Resources

To learn more about the development of early STEM skills and instructional strategies, we recommend the excellent resources below:

BOOKS

Clements, D. H., & Sarama, J. (2014). *Learning and teaching early math: The learning trajectories approach* (2nd ed.). Routledge.

The Early Math Collaborative Erikson Institute (Brownell, J. O., Chen, J-Q., & Ginet, L.). (2014). *Big ideas of early mathematics: What teachers of young children need to know*. Pearson Education, Inc.

Hynes-Berry, M., Chen, J-Q., & Abel, B. (2021). *Precursor math concepts: The wonder of mathematical worlds with infants and toddlers.* Teachers College Press.

Lange, A, Mano, H., and Brenneman, K. (2019). *Teaching STEM in the preschool classroom: Exploring big ideas with 3- to 5-year-olds.* New York: Teachers College Press.

Lind, K. K. (2004). *Exploring science in early childhood education.* Pearson.

WEBSITES

A World in Motion PreK-12 Program: https://www.sae.org/learn/education/a-world-in-motion-teachers

Development and Research in Early Math Education (DREME): https://dreme.stanford.edu/

Early Math Counts: https://earlymathcounts.org/

Erikson Early Math Collaborative: https://earlymath.erikson.edu/

***Finding Math* from the Institute for Learning & Brain Sciences, University of Washington:**
https://modules.ilabs.uw.edu/finding-math/

Incorporating Knowledge from Children's Homes and Communities:
www.naeyc.org/resources/pubs/yc/dec2020/incorporating-knowledge-communities

Learning and Teaching With Learning Trajectories: Early Math Birth to Grade 3:
https://www.learningtrajectories.org/

STEMIE: Innovation for Inclusion in Early Education: https://stemie.fpg.unc.edu/

National Center for Family Math: https://nafsce.org/page/familymath

Next Generation Science Standards: www.nextgenscience.org

Nurturing Early Math Play and Discovery:
www.naeyc.org/resources/pubs/yc/fall2022/nurturing-early-math-play

STEMIE Learning Trajectories: https://stemielearningtrajectories.fpg.unc.edu

Wee Engineers: https://yes.mos.org/unit/wee-engineer/

Appendix A
Early Math Skills Emerging From 30 to 48 Months

The table below highlights *some* of the early math concepts that children are beginning to practice, learn, and master at age two and beyond. While every child learns at their own pace, these skills include some of the math concepts that often emerge in young children's play and that are included in the *Problem Solvers* curriculum.

Topic	Math Concepts	Vocabulary Teachers Can Use in the Classroom	Activity
Number Knowledge Understanding numbers and the relationships between numbers	• Subitizing (Ability to immediately recognize and name - *without counting* - the total number of items in a set) • Counting • Number names • Stable Order Principle (number names occur in a specific order) • One-to-one Correspondence (counting one object as you say one number) • Order Irrelevance (it doesn't matter how we count objects, as long as each is only counted once) • Cardinality (understanding that the total quantity of the set is the last number counted)	• Number words: one, two, three, etc. • More / less • Bigger / smaller • Fewer • A lot / a little • Quantity • mount	1, 2, 3, 4, 5, 6, 7
Operations (Addition and Subtraction): Changing an existing collection by making it larger or smaller	• Concepts of "more" and "less" • Ability to compare small collections of 1-3 objects and determine which collections have fewer or more objects • Simple addition and subtraction	• More / less • Bigger / smaller • Fewer • Add • Combine • Take away / subtract • Remove • Equal • Quantity	5, 8, 9, 10, 17

Topic *(continued)*	Math Concepts	Vocabulary Teachers Can Use in the Classroom	Activity
Spatial Awareness: Relative position of objects and people.	• Understanding that objects/ people have a position and an orientation in space • Describing the relative position of an object or person	• On top / under • Over / below • In front / behind • Up / down • Around • Next to • In / out • Between	11, 12
Shape Awareness: Ability to recognize and identify simple shapes.	• Discovering and describing the attributes of shapes (number of sides, corners), straight or curvy lines • Recognizing and naming shapes • Combining shapes and discovering relationships between them (like two right triangles can make a square)	• Circle • Triangle • Square • Heart • Corner • Side • Line • Straight • Curved • Long / short	14, 15
Patterns: Identifying and creating patterns.	• Recognizing a pattern as a repeating sequence based on a rule • Describing a simple pattern • Extending (continuing) a pattern • Making a pattern of one's own	• Pattern • Descriptive words that help children describe the patterns they see in the world – think about: shape, size, and color words • First, second, third, last	13, 16, 20

Topic *(continued)*	Math Concepts	Vocabulary Teachers Can Use in the Classroom	Activity
Measurement: Making direct comparisons.	• Understanding that it is the attributes of an object that are measured (size, height, weight, etc.) • Understanding that each object has many different attributes (height, weight, length, etc.) • Discovering differences in characteristics like size or weight when comparing two (or more) objects • Describing these comparisons using measurement language	• Size (big, medium-sized, small) • Comparative words (big, bigger, biggest; small, smaller, smallest) • Length (long, short) • Height (short, tall) • Weight (heavy, light) • Capacity (full, empty) • Distance (far away or close by) • Similarity (same, different) • Speed (fast, slow) • Temperature (warm, cold)	18, 19
Sets and Sorting: Ability to organize collections into sets based on their attributes.	• Noticing attributes (features) of objects • Sorting objects with the same attributes into sets • Comparing sets • After an initial sort, re-organizing a collection by a different attribute—for example, first sorting by color and then by shape	• Descriptive words that help children describe attributes–shape, size, and color words • Words to describe types of objects (e.g., forks vs. spoons)	6, 14, 17, 21, 22

This table was developed using the following resources:

ZERO TO THREE. (2020). *Math4Littles: A User Guide*. https://www.zerotothree.org/resources/3298-math4littles-a-user-s-guide

Erikson Institute's Early Math Collaborative. (2014). *Big Ideas of Early Mathematics: What Teachers of Young Children Need to Know.* Pearson Education.

Appendix B
Early Science Content Knowledge Emerging From 30 to 48 Months

The table below highlights some of the early science concepts that children are *beginning* to practice, learn, and master at age 30 months and beyond. However, science is not only a body of knowledge. Science is also a way of thinking, a systematic way of examining the world around us. This way of thinking results in a curious stance in which individuals are open to augmenting, or revising, previously held beliefs as a result of new information or evidence.

The **cross-cutting scientific thinking skills** featured in this curriculum include: making observations, asking questions, making predictions, noticing patterns, exploring cause and effect, collecting/analyzing data, developing models, and constructing/testing solutions.

Topic	Targeted Science Concepts	Vocabulary Teachers Can Use in the Classroom	Activity
Earth and Space Sciences: Shadows	• Make the connection between light and shadow • Discover that shadows are the dark shapes that form when an object or person blocks light • Explore cause and effect • Observe patterns	• Shadow • Shade • Light • Sun • Dark/darkness • Create, make, form	SE 1
Life Sciences: Seeds	• Living things need water, air, and resources from the land • Plants live in places that have the things they need • Plants need water and light to live and grow • Make predictions • Ask questions	• Seed • Soil • Sprout • Plant (verb and noun) • Roots • Grow	SE 2
Life Sciences: Plant Parts	• Discover the names and functions of different parts of a plant (root, stem, leaf, flower) • Ask questions • Develop and use models	• Root • Stem • Leaf • Flower • Alive • Grow	SE 3

Topic *(continued)*	Targeted Science Concepts	Vocabulary Teachers Can Use in the Classroom	Activity
Life Sciences: Tree Observations	• Understand the activities humans can do to help the environment • Ask questions • Make observations • Create a model	• Seeds • Roots • Trunk • Branches, twigs • Leaves • Bark • Alive • Plant • Model	SE 4
Earth & Space Sciences: Weather Discovery	• Weather is the combination of sunlight, wind, snow or rain, and temperature at a particular place and time • Weather emerges in patterns over time • Humans can prepare for weather	• Weather • Sunlight • Wind • Snow • Rain • Forecast • Weather report • Meteorologist	SE 5
Earth & Space Sciences: What Is the Wind?	• Wind is air in motion • Air is all around us, even though we can't see it • The force of the wind can move objects	• Wind • Movement, In Motion • Forceful • Heavy • Light	SE 6
Earth & Space Sciences: The Pattern of Seasons	• Seasons are changes in weather and temperature throughout the year • Seasons have an effect on nature—including humans, animals and plants • Humans and animals prepare for the weather in each season • Seasons unfold in a predictable pattern	• Season • Pattern • Summer • Fall/Autumn • Winter • Spring • Prepare	SE 7

Topic (continued)	Targeted Science Concepts	Vocabulary Teachers Can Use in the Classroom	Activity
Earth & Space Sciences: Exploring Ice	• Sunlight warms the Earth's surface • Ice melts faster when exposed to sunlight and/or heat • Water can be both a solid (ice) and a liquid (water)	• Sunlight • Heat • Ice • Liquid • Water • Melt • Shade • Warm • Cool • Fast/slow	SE 8
Physical Sciences: Sink or Float	• Floating means that an object remains on the surface of the water • Sinking means an object falls below the surface of the water	• Float • Sink • Surface • Heavy • Light	SE 9
Life Sciences: Animal and Plant Needs	• Living things need water, air, and nutrients from their environment • Animals and plants have some needs that are the same and some needs that are different	• Animal • Plant • Water • Air • Nutrients / Food	SE 10
Life Sciences: We All Have a Habitat	• A habitat is a place where an animal lives • A habitat has everything an animal needs to survive: food, water, shelter, and space • Different animals live in different habitats	• Habitat • Food • Water • Shelter • Air • Safety • Needs	SE 11
Engineering Design: Shade Structures	• The properties of objects are related to how they are used • Problems can be solved through the development of a new/improved object or tool	• Sunlight • Shade • Protect • Explore • Create / Build • Improve • Test • Engineering design process	SE 12

Topic *(continued)*	**Targeted Science Concepts**	**Vocabulary Teachers Can Use in the Classroom**	**Activity**
Life Sciences: The Five Senses	• Observe and describe objects using the five senses • Recognize that we need to use our senses safely	• Sensory descriptive words (see activity) • Sight/seeing • Touch • Smell • Hearing • Taste	SE 13
Life Sciences: Bodies Have Bones	• Bones are the hard parts of our body under the skin • Bones give our bodies form and structure and protect our body parts • Bones can be visible through x-rays • Some animals have no bones inside their bodies; instead, their bodies are protected by an exo-skeleton	• Bone • X-ray • Radiologist • Skeleton • Exoskeleton • Skull • Rib • Spine • Femur • Patella • Phalanges • Model	SE 14
Physical Sciences: Ramp and Roll	• A ramp is a surface with one end higher than the other • Objects may roll, slide or stay in place on a ramp • The shape of an object affects how it moves on a ramp • Pushing can have different strengths and directions • Pushing can change the speed/ direction of an object's motion • Pushing can start an object's motion • A bigger push makes things move more quickly • The steeper the ramp, the more quickly an object rolls down the ramp	• Ramp • Incline / Inclined plane • Roll • Push • Steep • Direction • Fast/slow • Roll • Slide • Motion / Move	SE 15

Topic *(continued)*	Targeted Science Concepts	Vocabulary Teachers Can Use in the Classroom	Activity
Physical Sciences: So Slow	• Friction slows or stops the movement between two objects that are touching • The properties of objects affect how they function • Interactions between two rough surfaces produce more friction • Interactions between two smooth surfaces produce less friction	• Friction • Rough • Smooth • Slow • Fast	SE 16
Engineering Design: Stop It	• Different surfaces can affect the speed of an object's motion on a ramp or on a flat surface • People can solve problems through engineering • It is useful to compare/test designs	• Surface • Speed • Fast • Slow • Motion / Move • Ramp • Incline • Flat • Surface • Test	SE 17
Physical Sciences: Bowling and Rolling	• Pushes can have different strengths and directions • Pushing an object can change the direction/speed of its motion • When objects collide, they push on one another and can change direction • A bigger push makes things speed up more quickly	• Push • Move / Motion • Predict • Collide / Bump Into • Direction • Force	SE 18
Physical Sciences: Pull, Pull, Pull!	• Pulls can have different strengths and directions • Pulling an object can change its direction/speed • Heavier objects require more force to pull than lighter objects	• Pull • Force • Strong / Gentle • Heavy / Light • Direction • Speed	SE 19
Earth & Space Sciences: Let's Make Paper	• Paper can be recycled • Materials can be recycled/reused to help the environment • Recycling helps the environment	• Wood / Trees • Recycle • Paper • Pulp • Rip / Tear • Soak	SE 20

Topic *(continued)*	Targeted Science Concepts	Vocabulary Teachers Can Use in the Classroom	Activity
Engineering Design: Building Together	• Designs can be conveyed through sketches, drawings, or physical models • The shape of objects is related to how they are used • Models are used to represent structures or objects	• Explore • Create / Build • Draw • Plan • Goal • Improve • Engineering Design Process • Design Plan	SE 21
Engineering Design: Waking Walter	• Properties of objects are related to how they are used • A tool/object can be developed to solve a simple problem • It is possible to test/assess the effectiveness of a new tool/object	• Noisy • Quiet • Engineering Design Process • Problem / Goal • Test • Explore • Create/Build • Improve	SE 22

Appendix C
Problem Solvers Math Activities, Skill Areas, and Preparation Time

Activity Number	Counting	Adding and Subtracting	Shapes	Position and Direction	Patterns	Sets	Measuring and Comparing	Prep Time
1	X							*
2	X							**
3	X							*
4	X							**
5	X	X						**
6						X		**
7	X							*
8		X						*
9		X						***
10		X						***
11				X				**
12				X				***
13					X			**
14			X			X		**
15			X					*
16					X			*
17		X				X		*
18							X	*
19							X	*
20					X			***
21						X		*
22						X		*

Note: Asterisks (*) indicate the approximate level of preparation necessary for each activity, with one asterisk (*) indicating a shorter preparation time and three asterisks (***) indicating that more time is required.

Appendix D: *Problem Solvers* Science & Engineering Activities, Skill Areas, and Preparation Time

Activity Number	Physical Sciences	Life Sciences	Earth & Space Sciences	Engineering Design	Prep Time
SE 1			X		*
SE 2		X			***
SE 3		X			**
SE 4		X			*
SE 5			X		**
SE 6			X		***
SE 7			X		**
SE 8			X		*
SE 9	X				*
SE 10		X			*
SE 11		X		X	***
SE 12				X	***
SE 13		X			**
SE 14		X		X	***
SE 15	X				***
SE 16	X				***
SE 17	X			X	***
SE 18	X				**
SE 19	X				***
SE 20				X	***
SE 21				X	**
SE 22				X	***

Appendix E
Problem Solvers: Suggested Children's Books for Math Activities

Activity Number	Title	Author
1	*Wheels on the Bus/ Las ruedas del autobus*	Melanie Williamson
2	*Big Fat Hen*	Keith Baker
3	*Ten Black Dots*	Donald Crews
4	*Big Fat Hen*	Keith Baker
5	*Fish Eyes: A Book You Can Count On*	Lois Ehlert
6	*How Many Snails? A Counting Book*	Paul Giganti, Jr.
7	*What Comes in 2's, 3's, and 4's?*	Suzanne Aker
8	*Mouse Count*	Ellen Stoll Walsh
9	*The Gingerbread Man*	Catherine McCafferty
10	*Quack and Count*	Keith Baker
11	*Rosie's Walk*	Pat Hutchins
12	*Rosie's Walk*	Pat Hutchins
13	*Ten Little Rabbits*	Virginia Grossman
14	*Shapes, Shapes, Shapes*	Tana Hoban
15	*Mouse Shapes*	Ellen Stoll Walsh
16	*Rap a Tap Tap: Here's Bojangles -- Think of That!*	Leo Dillon and Diane Dillon
17	*Is Your Mama a Llama?*	Deborah Guarino
18	*You Are (Not) Small*	Anna Kang
19	*A Beach for Albert*	Eleanor May
20	*Too Much Noise*	Ann McGovern
21	*Five Creatures*	Emily Jenkins
22	*A Pair of Socks*	Stuart J. Murphy

Appendix F: *Problem Solvers:* Suggested Children's Books for Science & Engineering Activities

Activity Number	Title	Author
SE 1	*Moonbear's Shadow*	Frank Asch
SE 2	*A Seed Grows*	Antoinette Portis
SE 3	*Plant the Tiny Seed*	Christie Matheson
SE 4	*10 Things I Can Do To Help My World*	Melanie Walsh
SE 5	*When the Storm Comes*	Linda Ashman
SE 6	*Gilberto and the Wind*	Marie Hall Ets
SE 7	*A Tree for All Seasons*	Robin Bernard
SE 8	*Ice Boy*	David Ezra Stein
SE 9	*Who Sank the Boat?*	Pamela Allen
SE 10	*What Do Animals Eat?*	Katerina Gorelik
SE 11	*Nesting*	Henry Cole
SE 12	*The Contest Between the Sun and the Wind: An Aesop's Fable*	Heather Forest
SE 13	*I Hear a Pickle (and Smell, See, Touch, and Taste It, Too!)*	Rachel Isadora
SE 14	*Bones*	Stephen Krensky
SE 15	*Inclined Planes*	Martha E. Rustad
SE 16	*The Big Slide*	Daniel Kirk
SE 17	*Roll, Roll Little Pea*	Cécile Bergame
SE 18	*Oscar and Cricket*	Geoff Waring
SE 19	*My Truck Is Stuck!*	Kevin Lewis and Daniel Kirk
SE 20	*Snowballs*	Lois Ehlert
SE 21	*Building a House*	Byron Barton
SE 22	*The Three Little Pigs: An Architectural Tale*	Steven Guarnaccia

Appendix G
Using STEM Instructional Practices: A Reflective Tool

Reflect on your use of STEM instructional practices by answering the questions below. Consider where you want to grow. Choose one practice area to focus on and try a few changes in your approach. Be curious: see what happens!

WHEN CONNECTING WITH STUDENTS INDIVIDUALLY, DO YOU...	Not At All	Rarely	A Few Times A Week	Daily
Ask about their thinking, for example, Show me how you figured that out. Or, Tell me what you did to discover that.				
Normalize errors: Making mistakes and trying again is how we learn				
Observe and build on children's experiences, interests, and curiosity				
WHEN FACILITATING GROUP WORK, DO YOU...	Not At All	Rarely	A Few Times A Week	Daily
Create diverse student groups (gender, race, ethnicity, etc.)				
Ensure all children have an opportunity to lead/participate in the activity and use tools/equipment				
Promote age-appropriate collaboration skills				
WHEN ADDRESSING THE WHOLE CLASS, DO YOU...	Not At All	Rarely	A Few Times A Week	Daily
Nurture a sense of STEM identity and community: We are Problem Solvers (mathematicians/scientists/engineers)!				
Promote a growth mindset—We get better with practice—emphasize that children are learning everyday				
Ensure that ALL children are engaged through questions, discussion, or comments/observations				
WHEN PLANNING ACTIVITIES, DO YOU CONSIDER HOW TO...	Not At All	Rarely	A Few Times A Week	Daily
Include movement and manipulatives				
Engage dual/multi-language learners				
Adapt/modify activities for children with special needs				
Embed STEM concept(s) across the curriculum (through music, arts, literacy, daily routines, etc.)				
Feature STEM-based children's books with diverse characters (gender, race/ethnicity, ability level, etc.)				
WHEN YOU ARE WITH FAMILIES, DO YOU...	Not At All	Rarely	A Few Times A Week	Daily
Share information about STEM curriculum content				
Offer ideas for at-home learning experiences				
Discuss families' beliefs about STEM instruction				
Explore families' experiences with STEM topics; what could/would they like to share with students?				
WHEN ASSESSING THE EFFECTIVENESS OF AN ACTIVITY, DO YOU...	Not At All	Rarely	A Few Times A Week	Daily
See children actively engaged (moving, doing, showing)				
Observe children sharing/showing their thinking, predictions, discoveries				
See children using STEM practices (observing, asking, noticing patterns, testing ideas, etc.)				
Observe children discussing/using/applying STEM content and vocabulary				

Using STEM Instructional Practices: A Reflective Tool

Reflect on your use of STEM instructional practices by answering the questions below. Consider where you want to grow. Choose one practice area to focus on and try a few changes in your approach. Be curious: see what happens!

WHEN CONNECTING WITH STUDENTS INDIVIDUALLY, DO YOU...	Not At All	Rarely	A Few Times A Week	Daily
Ask about their thinking, for example, Show me how you figured that out. Or, Tell me what you did to discover that.				
Normalize errors: Making mistakes and trying again is how we learn				
Observe and build on children's experiences, interests, and curiosity				
WHEN FACILITATING GROUP WORK, DO YOU...	**Not At All**	**Rarely**	**A Few Times A Week**	**Daily**
Create diverse student groups (gender, race, ethnicity, etc.)				
Ensure all children have an opportunity to lead/participate in the activity and use tools/equipment				
Promote age-appropriate collaboration skills				
WHEN ADDRESSING THE WHOLE CLASS, DO YOU...	**Not At All**	**Rarely**	**A Few Times A Week**	**Daily**
Nurture a sense of STEM identity and community: We are Problem Solvers (mathematicians/scientists/engineers)!				
Promote a growth mindset—We get better with practice—emphasize that children are learning everyday				
Ensure that ALL children are engaged through questions, discussion, or comments/observations				
WHEN PLANNING ACTIVITIES, DO YOU CONSIDER HOW TO...	**Not At All**	**Rarely**	**A Few Times A Week**	**Daily**
Include movement and manipulatives				
Engage dual/multi-language learners				
Adapt/modify activities for children with special needs				
Embed STEM concept(s) across the curriculum (through music, arts, literacy, daily routines, etc.)				
Feature STEM-based children's books with diverse characters (gender, race/ethnicity, ability level, etc.)				
WHEN YOU ARE WITH FAMILIES, DO YOU...	**Not At All**	**Rarely**	**A Few Times A Week**	**Daily**
Share information about STEM curriculum content				
Offer ideas for at-home learning experiences				
Discuss families' beliefs about STEM instruction				
Explore families' experiences with STEM topics; what could/would they like to share with students?				
WHEN ASSESSING THE EFFECTIVENESS OF AN ACTIVITY, DO YOU...	**Not At All**	**Rarely**	**A Few Times A Week**	**Daily**
See children actively engaged (moving, doing, showing)				
Observe children sharing/showing their thinking, predictions, discoveries				
See children using STEM practices (observing, asking, noticing patterns, testing ideas, etc.)				
Observe children discussing/using/applying STEM content and vocabulary				

Equity and Early Math Experiences

Equity-Based Instructional Practices in an Early Math Curriculum for Toddlers and Preschoolers

Rebecca Parlakian, ZERO TO THREE, Washington, DC

Abstract
The learning that happens before school entry provides children with a strong foundation on which to build new conceptual understandings. In particular, mathematical skills predict later math and reading outcomes in elementary school. This article summarizes existing research on equity-based math instructional approaches and provides a rationale for translating and applying 10 of these teaching practices to toddler/preschool early learning settings.

While traditionally math instruction has begun in kindergarten, all learning—including the development of math knowledge—begins at birth. Age-appropriate early learning experiences offer children the opportunity to build foundational skills that predict their academic performance into elementary school (Duncan, et al., 2007; Watts et al., 2018). For young children, this important learning must happen through play and exploration, and through activities that engage their curiosity and drive to understand the world around them. Taking a joyful and play-based approach to learning yields dividends: research shows that the more curious children are prior to school entry, the better they do academically in reading and math once they enter school (Shah et al., 2018).

The learning that happens before school entry provides children with a strong foundation on which to build new conceptual understandings. Early mathematics skills, in particular, have strong predictive power for both math and reading outcomes in elementary school (Duncan et al., 2007). A longitudinal study that followed 4-year-olds through elementary school found that preschool math skills (specifically, nonsymbolic quantity, counting, and patterning knowledge) predicted fifth-grade mathematics achievement (Rittle-Johnson et al., 2016). These and other studies are often used to argue for the importance of early mathematics in early childhood education and care settings (ten Braak et al., 2022). In short, early advantages pay dividends. Critical math learning is happening in the years prior to kindergarten entry—but only if children have access to the rich learning experiences that promote exploration and mastery.

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In 2021–2022, ZERO TO THREE received funding support to develop an age-appropriate, play-based early math curriculum. *Problem Solvers*, released in September 2022, is a free, downloadable set of 22 early math activities and songs, designed to support emerging math knowledge across six domains of math for children from 2.5 through 4 years old. This curriculum resource is available free of charge, as one of ZERO TO THREE's goals was to support those community-based early education programs that may otherwise be unable to acquire research-based math curricula. This article explores the ways in which equity issues are central to how, and how often, mathematics is part of early education experiences and outlines the equity-centered principles the curriculum authors used in developing *Problem Solvers*.

Exposure to Early Math Experiences as an Equity Issue

Research has established significant race-based gaps between the reading and math skills of both White and Asian children and the reading and math skills of Black and Hispanic children at kindergarten entry (García, 2015). Yet these race-based data don't tell the whole story. Rather, they convey a powerful narrative of access, rather than race and ability.

Poverty is a powerful and shaping influence on children's development. An Economic Policy Institute report framed the issue in this way, "Race-based skills gaps shrink significantly" when children's social class/family income is taken into account (García & Weiss, 2015). The authors explained:

> *In real life we cannot disentangle black and Hispanic children's race and ethnicity from the contexts in which they live, which put them at a major disadvantage relative to their average white and Asian peers. It is not race itself, then,*

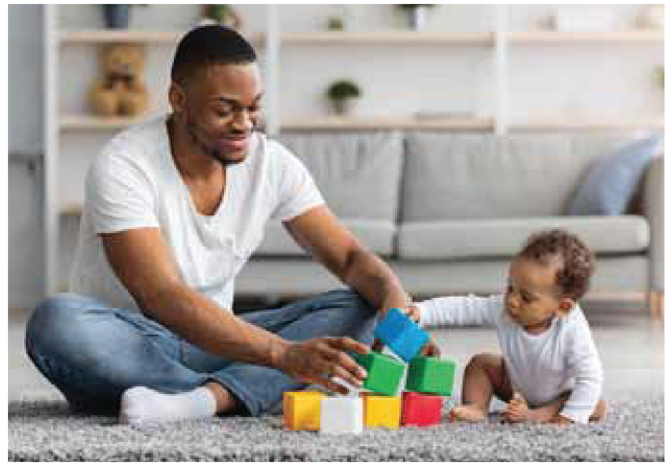
but the poverty and other things that too often go along with being a minority child in America, that compound disadvantage *(emphasis added).*

To examine the impact of growing up in underserved, under-resourced communities, the Brookings Institution (Isaacs, 2012) analyzed school readiness patterns from a nationally representative sample of children from birth through kindergarten entry. Nearly one quarter (23%) of children in the sample were born into families living in poverty, another quarter (25%) of children fell into the near-poverty group, and the remaining half (52%) were classified as having moderate or higher income. Children who were members of families living in poverty were much more likely than other children to score very low on math and reading skills. In fact, 26% of children living in poverty and 19% of children living in near poverty lacked the math skills they needed to be considered "school ready" at kindergarten entry (Isaacs, 2012). Yet research indicates that early risk can be mitigated or remediated through high-quality early learning experiences and instructional strategies (Presser et al., 2015). Furthermore, research demonstrates that preschool children can attain higher levels of understanding in mathematics, with gains maintained into kindergarten, when they are supported through well-planned, stimulating, and developmentally appropriate activities (Starkey et al., 2022).

Yet early educators often receive little formal training in designing meaningful and age-appropriate foundational math experiences for children across the first 5 years. How does this gap in professional preparation impact practice? The *Transforming the Workforce* report (Institute of Medicine & National Research Council, 2015) asserts that subjects such as mathematics and science usually are underemphasized for young children. One study—in which researchers coded the time spent on various academic activities in preschool settings—found, on average, children spent only approximately 8 minutes per day in math and science learning activities (Connor et al., 2006); another study focused specifically on preschools serving working- and middle-class families, and found that 60% of settings offered 3-year-olds no mathematical experience of any kind across 180 observations (Tudge & Doucet, 2004). A more recent study of 65 preschool classrooms (Piasta et al., 2014) found that children experienced an average of 24 minutes of math learning opportunities per day. Too often, a lack of knowledge about early math instructional practices translates to a lack of exposure to math experiences in the early education setting.

Equity-Centered Early Math Instructional Practices

Increasingly, there has been a focus on integrating equity-based practices with math instructional approaches, for many of the reasons outlined in the previous section. This effort initially focused on elementary math instruction (Aguirre et al., 2013; Gutiérrez, 2012; Jackson et al., 2021; Polly, 2021) but increasingly, professionals in early childhood systems have begun considering the ways in which equity-centered



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The learning that happens before school entry provides children with a strong foundation on which to build new conceptual understandings.

instructional practices can support children's mathematics learning even before formal schooling begins. In developing *Problem Solvers*, my co-creators and I reviewed science, technology, engineering, and mathematics (STEM) education frameworks and recommended practices for equity-based instruction in STEM domains (Equitable Math, 2021; Gutiérrez, 2012; Jackson et al., 2021; National Council of Teachers of Mathematics, 2014) and identified those approaches we felt were most appropriate for early education environments.

Ultimately, the following 10 equity-based math instructional approaches shaped the development of the *Problem Solvers* curriculum. Each describes a specific teacher action, approach, or stance that seeks to meet learners' diverse needs and lived experiences, and centers children's cultural assets and strengths (Delpit, 2012). These instructional practices are also appropriate for early childhood settings, specifically those classrooms serving children 2.5 to 5 years old, and reflect the developmental capacities of older toddlers and preschoolers. The following list of instructional practices is not exhaustive. It is an initial effort to articulate the ways in which early educators can consider, respond to, and nurture the rich and diverse lived experiences, cultures, perspectives, and languages children bring with them when designing and implementing early math curricula.

Practice 1: Provide every child with rigorous math instruction (Aguirre et al., 2013; Equitable Math, 2021). For too long, math aptitude has been perceived as the result of innate ability (i.e., the notion that one is "good at math" or "bad at math"), rather than the result of rigorous, organized learning experiences. For children whose identities (e.g., race, class, gender, ethnicity, language) place them outside the mainstream culture's perception of those who are "good at math," the risks are high: researcher Lisa Delpit (2012, p. 6) explained, "What happens when we assume that certain children are less than brilliant? Our tendency is to teach less, to teach down, to teach for remediation." To disrupt this cycle, Practice 1 asserts that every child in every early childhood program has the right to

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Early educators often receive little formal training in designing meaningful and age-appropriate foundational math experiences for children across the first 5 years.

experience rigorous math curricula and learning experiences. Equitable teaching unfolds in environments where children access, apply, and explore rigorous mathematics in age-appropriate ways that build deep conceptual understanding.

Practice 2: Differentiate instruction to allow for productive struggle (Equitable Math, 2021). Building on Practice 1, Practice 2 explicitly acknowledges that all learners (even infants) enter their early childhood settings with some understanding of mathematics. Observing children's strengths, understanding their next-expected skills, and remaining attuned to their interests and needs help educators provide learning experiences that are appropriately challenging (rigorous but achievable) and, when needed, implement accommodations that are "truly (and not overly) helpful" (TERC, 2021). Taking a strengths-based approach begins to dismantle the "deficit discourse" around mathematics. *Deficit discourses* focus on students' "academic and intellectual shortcomings with little to no recognition of their existing understandings and strengths" and attribute these shortcomings to "deficiencies located in students themselves, their families or their culture" (Adiredja & Louie, 2020, p. 42). How are deficit discourses connected to math? Media messaging, policy documents, research, and other groups have promoted and repeated a consistent message of race-based "achievement gaps," which is a prominent deficit discourse that "has produced a false and oppressive racial hierarchy of mathematics ability" and one that positions students of color as "less deserving of meaningful, prestigious, and lucrative learning opportunities" (Adiredja & Louie, 2020, p. 43). In this way, deficit discourses about what is acceptable demonstrated math learning merge with deficit discourses about the abilities of children from historically marginalized groups, resulting in learning environments where, too often, students of color are not offered the rich and challenging curricula they need and deserve in order to thrive as learners.

In response to this dynamic of deficit discourses, the authors of *Problem Solvers* sought to ensure all toddlers and preschoolers have access to challenging math curricula. To achieve this, typical age-based developmental expectations are provided for each activity in *Problem Solvers*. The authors then developed each activity to meet a typical 3-year-old's skill set and provided strategies that educators could use to increase or decrease the level of difficulty for children to make the process of individualization easier and more transparent. In post-pilot interviews with teaching staff, participating educators noted that this final element—guidance on individualization—was particularly useful. In one program, teachers explained that they had a 3-year-old who was more advanced than his peers in math skills, so the curriculum's clear guidance on how to offer more rigor was a support for teachers and a source of excitement for the child. One child's parents also shared, "We get information about early literacy a lot, but almost never get information about math. He loved the [*Problem Solvers* parent-child] activities."

Practice 3: Approach errors as opportunities for learning (Equitable Math, 2021). This practice also works against the deficit discourse approach by framing errors as opportunities to better understand the knowledge and thinking a child is using in a particular activity. The *Problem Solvers* curriculum normalizes errors as an expected part of the learning process and prompts teachers to invite children to show or tell what they were thinking about a question or activity. This practice offers teachers a window into students' existing funds of knowledge and helps them apply the constructivist principle of building new skills on a foundation of current skills. Educators can invite discussions about children's thinking so they can clarify miscommunicated knowledge (Equitable Math, 2021) and provide targeted opportunities for mastery. Normalizing errors also models persistence and curiosity, both approaches to learning that are central to mathematics mastery. Creating this culture of co-discovery in the early education setting can lead to a dynamic in which children and adults together use errors as opportunities for reflection and knowledge growth. In the curriculum, guidance to teachers often prompts them to ask children to share their thinking. For example, one activity asks children to observe several sets of objects and prompts teachers to ask, "Are there any sets that have the same number? Tell me how you know." Or, "What can we do to make sure there are the same number of cars in each set? Show me what you'd like to try." In another activity, the teacher is prompted to ask questions like, "When [we added to our line], we added one more. What can we do to find out how many we have in our line now? What has happened to our line since [we added items to our line]? Does the line look different to you? What's different?" Questions like these offer insight into children's existing knowledge and problem-solving strategies. When errors or misunderstandings cease to be a source of embarrassment or shame, children are freed to consolidate new knowledge and master increasingly complex skills.

Practice 4: Affirm children's math identities (Aguirre et al., 2013; Equitable Math, 2021). All children have the right to see themselves as confident problem solvers who can make valuable mathematical contributions. At every age, children should be lifted up as skilled math thinkers with the capacity to learn and grow within the discipline; to contribute to the mathematics understanding of their learning community; and to have their ideas viewed as meaningful contributions to the classroom discourse (TERC, n.d.). This notion of identity is central to learning, as many students experience classrooms as "racialized spaces, where Black and Latina/o students are subject to negative stereotypes about their ability to do mathematics" (Nasir, 2016, p. 11). Existing research on the presence of implicit bias in early education lends support to the notion that birth-to-5 learning environments are also racialized spaces for very young children (Gilliam et al., 2016). As mentioned previously, discourses on math learning often frame this domain as one in which there are those who "can and those who cannot do mathematics" and individuals are "left to identify with one of these two groups, positioning themselves within—or outside of—the mathematics community" based on feedback and messages they receive about their ability (Cribbs et al., 2022, p. 70). These messages often begin even before children enter formal schooling, but they are deepened through teacher–child interactions. Teachers communicate to children "what mathematics is, what learning mathematics entails, and who is considered a doer of mathematics" (Barba, 2022, p. 7). The results of these messages over time are powerful: A survey of more than 10,000 students found that "recognition—perceiving that others think one can succeed in mathematics—was a strong predictor of developing mathematics identity" (Cribbs et al., 2015; 2022, p. 6).

The act of intentionally communicating that every child is a valued contributor and thinker in terms of mathematics is central to Practice 3. In fact, the curriculum name, *Problem Solvers*, was selected to communicate from the outset that all children engaging in these learning experiences possess the curiosity and capacity to master key mathematics concepts. Furthermore, Barba (2022) suggested a range of methods to foster positive mathematical identities, including several that were embedded into *Problem Solvers*. These include the use of meaningful tasks that include open-ended questions, allow children to develop and test strategies, and focus on explanations (Barba, 2022). In *Problem Solvers*, children are encouraged to share their thinking and experiment with different approaches. Teachers are prompted to explore children's ideas through conversations: "What can we do to make a set of four fruits?" Another best practice is to establish classroom norms centered on discourse—where collaboration is encouraged and the teacher is the facilitator of these discussions (Barba, 2022). Each *Problem Solvers* activity includes a group learning experience and a paired learning experience, where children can work with peers to explore and experiment with new math concepts. For example, in one activity, a child creates a small set of objects (e.g., three objects) and their partner creates a set with "one more." A third best practice for fostering positive mathematical identity is to provide opportunities for students to reflect on their mathematical journey (Barba, 2022). Each activity concludes with a reflective discussion with children that prompts them to think about

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Every child in every early childhood program has the right to experience rigorous math curricula and learning experiences.

and share their learning. For example, the teacher debriefs a counting and comparison activity by asking reflective questions like, "What was tricky about figuring out which sets of cars had more? What did you do to figure out which sets had more and less? What did you do to make a set of blocks with 'one more'?"

Practice 5: Ground learning within students' lived experiences (TERC, 2021). When educators tap into the language, experiences, and understandings children bring with them into an early learning setting, toddlers and preschoolers are able to better engage with the curriculum content and access deep and meaningful learning opportunities. To do this, educators can plan learning experiences where children are positioned "as sources of expertise" for solving math problems and develop curricula that taps into, and builds on, children's existing funds of knowledge related to their culture, community, family, and history (TERC, 2021). In the *Problem Solvers* curriculum, each activity opens with a discussion of what children know or think about a particular topic. For example, in an activity that uses birthday candles as a means to explore quantities, cardinality, and early addition, the opening discussion invites children to share how they celebrate birthdays with their families.

Practice 6: Integrate math learning across the curriculum (Jackson et al., 2021). Sanders (2009) described integrated STEM education as "approaches that explore teaching and learning between/among any two or more of the STEM subject areas, and/or between a STEM subject and one or more other school subjects" (p. 21). Teaching integrated STEM lessons with older children (K-12) has been found to be a more effective teaching pedagogy when compared with individually teaching the siloed disciplines (Becker & Park, 2011). In *Problem Solvers*, integration is a natural strategy as young children explore, play, and wonder about the mathematical patterns and relationships they observe in the world around them. In *Problem Solvers*, early math concepts are embedded into arts (specifically, music) experiences, literacy experiences, and in the case of

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Normalizing errors also models persistence and curiosity, both approaches to learning that are central to mathematics mastery.

several activities, science experiences. The songs composed for *Problem Solvers* prompt children to sing phrases, perform actions, and move their bodies in ways that support early math skills as well as promote early music education outcomes. In the Sorting Our Class song, children are prompted to sort themselves into sets using the rules in the song (*"If you are wearing sneakers today, stand right over here. If you are wearing other shoes today, stand right over there."*). In between verses, the teacher pauses the audio and counts the number of children in each set. The books suggested for the literacy component of the curriculum invite use of rich math language around comparisons (e.g., size, color, attributes of shapes); descriptions (e.g., location in space, patterns); and early calculations (e.g., sets of objects or characters increasing or decreasing in size). Science-centered activities include, for example, a learning experience that invites children to explore and recreate the patterns apparent in birdsong. These integrated experiences proved to be some of the most popular components of the curriculum; for example, teachers shared that children often asked for the "math books" even on days when teachers had not planned to read them. Teachers also reflected it was helpful that the "math activities fit into other parts of our curriculum like science."

Practice 7: Intentionally build physical movement into math activities (Equitable Math, 2021). Equitable math environments offer children a range of ways to participate and engage—for example, through work in small groups, or by incorporating music, song, and movement into learning experiences (Equitable Math, 2021). This practice is especially appropriate for early childhood environments where, developmentally, children have shorter attention spans and a drive to use their new and emerging physical skills to explore the world. *Problem Solvers* was developed in partnership with an associate professor of music and director of music education, Dr. Jennifer McDonel of Radford University. Dr. McDonel composed and performed a song to align with each of the 22 curriculum activities; this collection of songs offered a secondary pathway for children to experience and explore math concepts. *Problem Solvers* units describe how to implement each of the songs (also available for free download). Furthermore, almost all of the activities in *Problem Solvers* invite children to move and explore—whether they are pretending to be birds (in a unit that explores patterns through sounds) or exploring the classroom as garbage trucks on their route (in a unit that explores spatial relationships).

Practice 8: Encourage student-to-student interaction (TERC, 2021). Students become confident learners and develop a strong mathematics identity when they have opportunities to collaborate in solving problems, to learn from one another, and to be supported by their peers in the learning process. Practice 8 asserts that all students have the right to share their ideas and thinking about mathematics, to have others listen respectfully and engage with them around mathematical questions and ideas, and to be seen as valuable contributions to the classroom discourse on mathematics (TERC, 2021). *Problem Solvers* uses both large-group and partner activities to encourage collaboration and to nurture the "first friendships" that emerge in the toddler/preschool years. In addition, an unexpected but positive outcome of the curriculum pilot (which took place in six early education programs across the United States) was that, in programs that included mixed age (3- to 5-year-old) classrooms, older children were frequently observed mentoring and supporting the math learning of young children. Learning from "more knowledgeable others" (Vygotsky, 1978) offers opportunities for children to exchange ideas and learn from each other's perspectives and experiences. Furthermore, peer-based interactions have been tied to greater conceptual understanding and language development in subject areas including mathematics (Alanis, 2018; Zippert et al., 2019). Math talk with a peer also has been found to promote a positive math identity (Fuson et al., 2015).

Practice 9: Build partnerships with families and primary caregivers as sources of critical math learning for children (National Council of Teachers of Mathematics, 2022). Mathematics is already a part of children's lives and communities (Souto-Manning & Rabadi-Raol, 2018), and at-home experiences with math play and math language help children build a strong foundation in these concepts. In fact, home-based early numeracy play in early childhood is significantly and positively related to developing a positive math attitude through fourth grade (Clerkin & Gilligan, 2018). Exposure to math language in the toddler years found that the frequency of math words spoken by the family predicted a child's understanding of number concepts at 46 months old; similar findings were established for exposure to spatial language at home (e.g., *on top of, next to, behind*; Levine et al., 2010; Pruden et al., 2011). To spark math play and the use of math language in the home, *Problem Solvers* provides a parent–child activity handout in English and Spanish that is aligned to the math objectives of each unit; these 22 resources were designed to build bridges with families as well as invite discussions about family math experiences and beliefs.

Practice 10: Support teacher reflection (McLeod, 2015). Opportunities for reflection can support teacher insight, development, and learning as they observe students engaging with math learning experiences. Reflection can take place during the activity itself as the teacher considers minute-to-minute observations and decides how best to scaffold a child's learning. Reflection can also be part of the planning process for instruction (considering past experiences/observations when planning new curricula) or take place after an activity's completion to understand what worked/didn't work about the learning experience and spotlight ways to adjust instructional approaches. This process of reflection "in, on, and for" action (Schön, 1991) offers teachers an opportunity to step back and think deeply about their work with young children. While few early education settings offer the luxury of time to support such reflection (with the exception of those programs that offer teacher coaching or regular reflective supervision), *Problem Solvers* includes reflective prompts for teachers to observe the presence or absence of a problem-solving approach or behavior used by the children and then provides developmental context for why these behaviors may be observed. The prompts that are provided for adjusting the challenge level of the activities also encourage teachers to observe and reflect on children's level of participation and mastery and then adjust the activity in response. These prompts support teachers' ability to individualize activities and ensure all children experience activities that were appropriately challenging—rigorous but not overwhelming (see Practices 1 and 2).

One area in which the curriculum authors would have liked to provide more guidance is reflection supports for teachers on the (often harmful) dominant social narratives around mathematics learning and teaching, in order to scaffold personal insight into the ways these narratives do (or do not) make their way into instruction (Willey & Livers, 2018). Teacher reflection can serve the goals of equity when this practice is structured to invite greater understanding of how "considerations of power undergird, frame and distort" educational processes and interactions (Shandomo, 2010, p. 104). The authors hope to expand this reflective component in future iterations of the curriculum, in order to promote teacher learning, insight, and changes in practice that ensure equitable learning environments for the very youngest learners. The National Council of Supervisors of Mathematics (NCSM) and TODOS: Mathematics for All (2016) underlined this critical juncture of social justice and mathematics instruction, asserting that:

> *There must be acknowledgment of the unjust system of mathematics education, its legacy in segregation and other forms of institutional systems of oppression, and the hard work needed to change it. The actions taken must be driven by commitments to re-frame, re-conceptualize, intervene, and transform mathematics education policies and practices that do not serve to promote fair and equitable mathematics teaching and learning. And there must be professional accountability to ensure these changes are made and sustained.* (NCSM & TODOS, 2016, p.1)

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Opportunities for reflection can support teacher insight, development, and learning as they observe students engaging with math learning experiences.

Conclusion

Author Gholdy Muhammad (2020) has promoted "historically responsive literacy," an instructional approach for all domains that supports child identity, skills, intellect (building student knowledge), and criticality (how instruction can engage children's thinking about power, equity, and disruption of oppression). Importantly, Muhammad's approach also includes an element that is rarely called out in traditional activity plans: Joy.

Early educators spark joy in young children by creating learning activities that build on the rich lived experiences they bring to education settings, by designing explorations that ignite their curiosity and build from their strengths, and by honoring the unique ways in which they think about the challenges they encounter. The National Council of Teachers of Mathematics position statement (2022) on mathematics in early childhood explained that "by capitalizing on the wonder and joy children naturally bring to their learning and to their observations of the world, teachers can cultivate and extend children's mathematical sense and interest" (p. 2). Without joy, there is no engagement. Without engagement, there is no learning. The *Problem Solvers* curriculum offers early educators a starting point for introducing meaningful and joyful early math experiences into older toddler and preschool settings. More importantly, perhaps, the underlying practices of equitable math instruction that are embedded throughout the activities

Learn More

Download the *Problem Solvers* activities, songs, and teacher's guide at: www.zerotothree.org/ProblemSolvers may offer guidance and inspiration to early educators who wish to design their own curricula—in any domain—that honors the lived experiences of the children and families they serve.

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